

2013 Annual Merit Review Results Report

October 2013

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Introduction

The 2013 U.S. Department of Energy (DOE) Fuel Cell Technologies Office (FCTO) and Vehicle Technologies Office (VTO) Annual Merit Review and Peer Evaluation Meeting (AMR) was held May 13-17, 2013, in Crystal City, Virginia. The review encompassed all of the work done by the FCTO and the VTO: a total of 287 individual activities were reviewed for VTO, by a total of 187 reviewers. A total of 1,382 individual review responses were received for the VTO technical reviews.

The objective of the meeting was to review the accomplishments and plans for VTO over the previous 12 months, and provide an opportunity for industry, government, and academia to give inputs to DOE on the Office with a structured and formal methodology. The meeting also provided attendees with a forum for interaction and technology information transfer.

The peer review process followed the guidelines of the *Peer Review Guide* developed by the Office of Energy Efficiency and Renewable Energy (EERE). Each activity is reviewed every three years, at a minimum. However, the Office strives to have every activity reviewed every other year. The reviewers for the technical sessions were drawn from a wide variety of backgrounds, including current and former vehicle industry members, academia, government, and other expertise areas. Each reviewer was screened for conflicts of interest as prescribed by the *Peer Review Guide*. A complete list of the meeting participants is presented as Appendix A.

In the technical sessions, these reviewers were asked to respond to a series of specific questions regarding the breadth, depth, and appropriateness of the DOE VTO activities. The technical questions are listed below, along with appropriate scoring metrics. These questions were used for all formal VTO project reviews, including any American Recovery and Reinvestment Act (ARRA) reviews.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts. (Scoring weight for overall average = 20%)

Scoring: 4=outstanding (sharply focused on technical barriers; difficult to improve approach significantly); 3=good (generally effective but could be improved; contributes to overcoming some barriers); 2=fair (has significant weaknesses; may have some impact on overcoming barriers); 1=poor (not responsive to project objectives; unlikely to contribute to overcoming the barriers).

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals. (Scoring weight for overall average = 40%)

Scoring: 4=outstanding [excellent progress toward objectives, suggests that barrier(s) will be overcome]; 3=good (significant progress toward objectives and overcoming one or more barriers); 2=fair (modest progress in overcoming barriers, rate of progress has been slow); 1=poor (little or no demonstrated progress towards objectives or any barriers).

Question 3: Collaboration and coordination with other institutions. (Scoring weight for overall average = 10%)

Scoring: 4=outstanding (close, appropriate collaboration with other institutions; partners are full participants and well-coordinated); 3=good (some collaboration exists; partners are fairly well coordinated); 2=fair (a little collaboration exists; coordination between partners could be improved); 1=poor (most work is done at the sponsoring organization with little outside collaboration; little or no apparent coordination between partners).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways. (Scoring weight for overall average = 10%)

Scoring: 4=outstanding (plans clearly build on past progress and are sharply focused on barriers); 3=good (plans build on past progress and generally address overcoming barriers); 2=fair (plans may lead to improvements, but need better focus on overcoming barriers); 1=poor (plans have little relevance toward eliminating barriers or advancing the program).

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not? (Scoring weight, not included with overall average = 20%)

Responses: yes, no.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Responses: excessive, sufficient, insufficient.

Reviewers were asked to provide numeric scores (on a scale of 1-4, as indicated above) for Question 1 through Question 4 of each formally reviewed activity. For each reviewed project, the individual reviewer scores for Question 1 through Question 4 were averaged to provide information on the project's question-by-question scoring. Scores for each of these four criteria were weighted using the formula below to create a weighted average for each project. This allows a project's question-by-question and final overall scores to be meaningfully compared against another project:

Weighted Average =

$$[\text{Question 1 Score} \times 0.20] + [\text{Question 2 Score} \times 0.40] + [\text{Question 3 Score} \times 0.10] + [\text{Question 4 Score} \times 0.10]$$

Each reviewed activity has a corresponding bar chart representing that project's average scores for each of the four designated criteria. As demonstrated in Figure 1, a bullet and red error line are included within the green bars representing the corresponding average and standard deviation of criteria scores for all of the reviewed projects in the same subprogram.

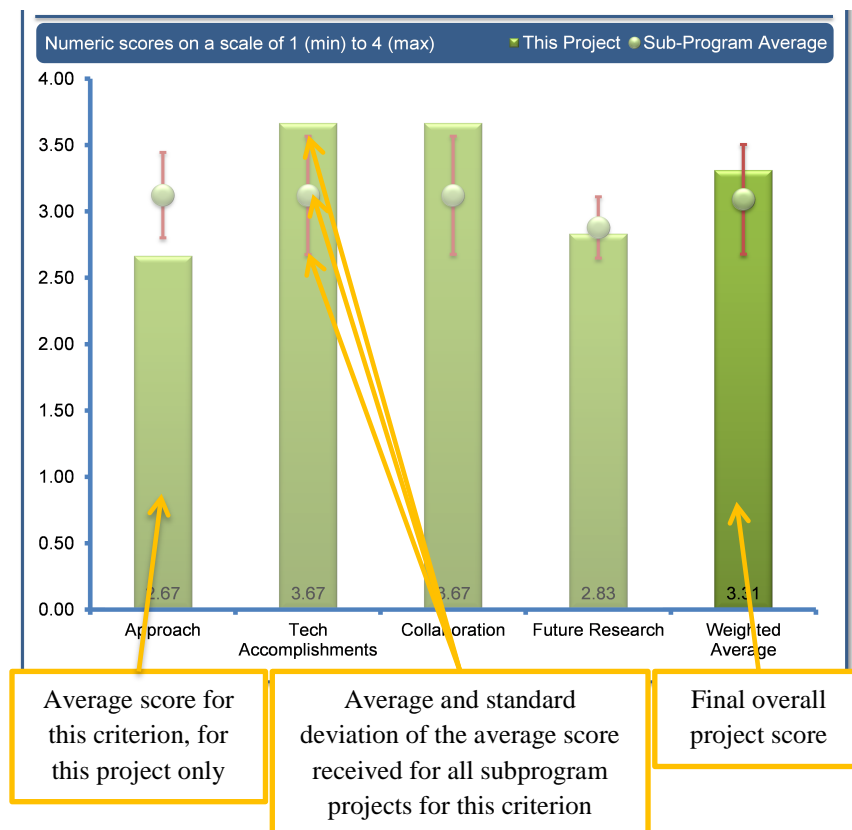


Figure 1. Question 1 through Question 4 score averages and standard deviations as well as overall Weighted Average for a given project

Reviewers were also asked to evaluate a given project's relevance and funding through Question 5 and Question 6, which were each scored on a different scale than Question 1 through Question 4. Question 1 through Question 4 was rated on a 1 to 4 scale, whereas Question 5 was rated on a yes or no scale, and Question 6 was rated on an excessive, sufficient, or insufficient scale. Subsequently,

Question 5 and Question 6 results were excluded from the Weighted Average calculation because the scoring scales are incompatible. Alternately, as demonstrated in Figure 2, each reviewed activity has pie charts representing that project's population distributions for each reviewer rating associated with Question 5 and Question 6:

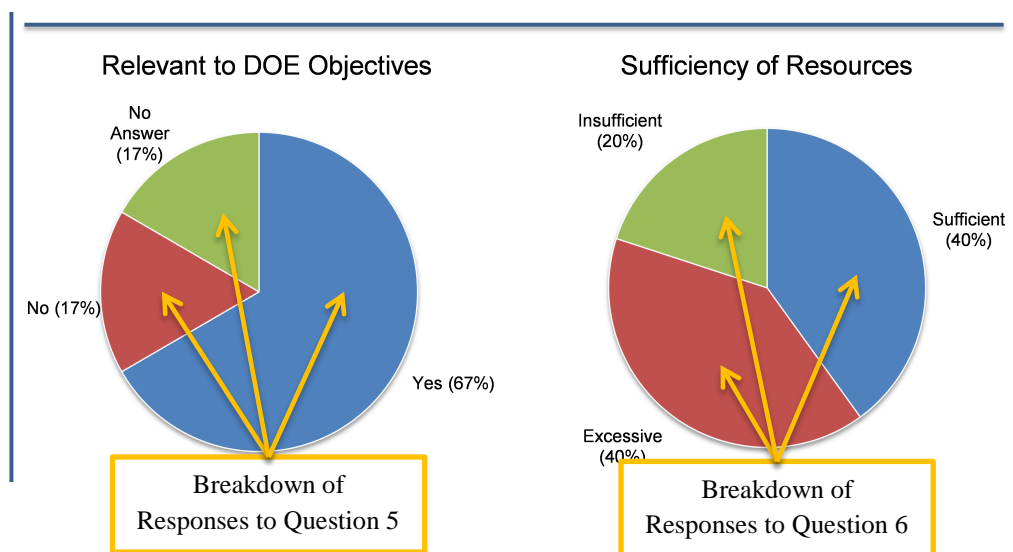


Figure 2. Question 5 and Question 6 population distributions

Text responses and numeric scores to the questions were submitted electronically through a web-based software application, PeerNet, operated by the Oak Ridge Institute for Science and Education (ORISE). Database outputs from this software application were analyzed and summarized to collate the multiple-choice, text comment, and numeric scoring responses and produce the summary report.

Responses to the questions are summarized in this report, with summaries of numeric scores for each technical session, as well as text and graphical summaries of the responses for each individual technical activity. For each project, the reviewer sample size is identified. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that for each question the order of reviewer comments may be different; for example, for each specific project the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc. Not all reviewers provided a response to each question for a given project.

The report is organized by technical subprogram area. Each technical area section includes a summary of that subprogram, voluntary reviewer feedback received specific to the subprogram overview presentation(s) given by DOE, a subprogram activities score summary table (and page numbers), and project-specific reviewer evaluation comments with corresponding bar and pie charts.

1. Hybrid and Vehicle Systems Technologies

Hybrid and vehicle systems research provides an overarching vehicle systems perspective to the technology research and development (R&D) activities of the U.S. Department of Energy's (DOE's) vehicle research programs, and identifies major opportunities for improving vehicle efficiencies. The effort evaluates and validates the integration of technologies, provides component and vehicle benchmarking, develops and validates heavy hybrid propulsion technologies, and develops technologies to reduce the parasitic losses from heavy vehicle systems. Analytic and empirical tools are used to model and simulate potential vehicle systems, validate component performance in a systems context, benchmark emerging technology, and validate computer models. Extensive collaboration with the technology development activities is required for success. The results of hybrid and vehicle systems activities are used to estimate the national benefits and impacts of DOE-sponsored technology development, and successfully transfer developed technology to industry.

In August 2009, the DOE announced the selection of ten projects totaling \$425 million for development, deployment, and validation of hybrid vehicles, and deployment of charging stations across the nation. American Reinvestment and Recovery Act (ARRA)-funded transportation electrification activities will aid in the deployment of technologies that help to reduce petroleum consumption. Activities include deployment of 18,000 public and private charging stations in major metropolitan areas across the country, and deployment of truck stop electrification infrastructure at 50 sites across interstate corridors. Additional deployment activities include development, validation, and deployment of light- and medium-duty electric drive vehicles.

Subprogram Feedback

DOE welcomed optional feedback on the overall technical subprogram areas presented during the 2013 AMR. Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area who volunteered to provide subprogram overview comments responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE Vehicle Technologies Office (VTO) subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1: Was the subprogram area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Question 3: Does the subprogram area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Office's needs?

Question 4: Other Comments.

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc., as reviewer responses were optional.

Subprogram Overview Comments: Lee Slezak (U.S. Department of Energy) – vss000

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer believed that DOE (Slezak) and other staff had done an excellent job in developing programs to further electric propulsion technology integration into production vehicle fleets.

Reviewer 2:

The reviewer said well done.

Reviewer 3:

The reviewer asserted that the presentations comprehensively covered the work underway. Year-over-year progress was shown through completed vehicle tests.

Reviewer 4:

The reviewer expressed that yes, it was adequately covered. The deployed commercialized version of the Autonomie vehicle modeling and simulation platform was a good service to the U.S. Automotive industry. This reviewer added that the Vehicle and Systems Simulation and Testing (VSST) and large database were very useful.

Reviewer 5:

The reviewer simply stated yes.

Reviewer 6:

The reviewer expressed that this was a general VTO overview presentation with an emphasis on new program activity for 2013. The overview adequately covered the VTO program activity.

Reviewer 7:

The reviewer would have liked to see more information on trucks and what ideas the group had for post-SuperTruck efforts.

Reviewer 8:

The reviewer indicated a good overview of Vehicle and Systems Simulation (VSS), including the important issues. This reviewer did not attend the plenary but saw the overview presentation at the start of the VSS sessions on May 14th. Recent accomplishments were noted, but this reviewer did not recall a specific comparison between Fiscal Year (FY) 2013 and FY 2012.

Reviewer 9:

The reviewer reported that all main components of the sub-program were addressed. However, this reviewer added that there was no clear identification of the risks, challenges, and issues with the program. In addition, there was no differentiation between current and previous year accomplishments. This person concluded that more explanation of the different areas of accomplishments would have been helpful.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Reviewer 1:

The reviewer voiced that the FY 2013 Emphasis slide was a good summary of plans to address vehicle efficiency improvement and electrification. The focus areas seemed to cover the gamut.

Reviewer 2:

The reviewer stated well done.

Reviewer 3:

The reviewer noted that the testing plans were focused on real-world issues and that the work was well prioritized.

Reviewer 4:

The reviewer thought the programs were very broadly scoped and saw no real gaps.

Reviewer 5:

The reviewer remarked that plans had been identified and gaps had not been observed.

Reviewer 6:

The reviewer mentioned big trucks.

Reviewer 7:

The reviewer commented that the gaps were based on budgetary limitations. However, the use of the available budget was advancing research on critical technological challenges.

Reviewer 8:

The reviewer asserted that there were plans identified for addressing issues and challenges. This person also noted that there were gaps, and stated that modeling for the wireless charging of magnetic fields, etc. [along with analytical work and testing support for Society of Automotive Engineers (SAE) J2954 validation], would have been beneficial to add.

Reviewer 9:

The reviewer observed that there was a mention of areas for emphasis, but that there were no such clear plans that addressed issues and challenges.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program R&D needs?

Reviewer 1:

The reviewer observed that the program covered a wide range of activities and did so comprehensively. The projects were very focused on objectives supportive of the overall program.

Reviewer 2:

The reviewer said that Slezak and this group had proven a high level of competence and execution delivery. This reviewer added that it was a great team.

Reviewer 3:

The reviewer asserted that yes, it was properly focused.

Reviewer 4:

The reviewer stated yes.

Reviewer 5:

The reviewer affirmed that yes, the sub-program area appeared to be focused, well managed, and effective in addressing the DOE VTO R&D needs.

Reviewer 6:

The reviewer asserted that the programs were well managed to the extent that the contractors would allow. From this reviewer's experience, it was believed that some of the big original equipment manufacturers (OEMs) were unmanageable.

Reviewer 7:

The reviewer agreed that, in general, the managers were accomplishing quite a lot in addressing DOE needs, given the overall budget. One concern would be the total number of projects becoming too large, given how many different activities were underway.

Reviewer 8:

According to this reviewer, it was the overview of the VTO Program, so it set the R&D agenda. This person added that individual programs needed to be evaluated to answer this question.

Reviewer 9:

The reviewer indicated that the program had identified to some extent the areas of focus. This reviewer needed more information on how the program was managed. The program needed to better highlight its accomplishments in the different areas of interest.

Question 4: Other Comments**Reviewer 1:**

The reviewer acknowledged that DOE was making a positive difference and further encouraged DOE to keep up the good work.

Reviewer 2:

The reviewer highlighted that much could be done that was not able to fit into the current budget limitations. This program has provided useful research that has attacked and found solutions for many vehicle challenges. It should be expanded, as there are many additional challenges to overcome to continue to reduce imported petroleum.

Reviewer 3:

The reviewer voiced that supporting the VSS activity was generally money well spent by DOE, especially in the benchmarking, electrification, and heavy-duty truck research areas.

Reviewer 4:

The reviewer stated that the VSS program included an impressive portfolio of projects related to plug-in vehicle technologies. These focused on both passenger and heavy-duty commercial vehicles. Developments under these programs would certainly help to reduce dependence on imported oil and reduce pollution.

Reviewer 5:

Without being overly critical, the reviewer hoped that the contractors were giving significantly more information directly to DOE than was presented in these 20-minute reviews. This reviewer saw such a difference in presentation detail between the Advanced Power Electronics (APE), Energy Storage (ES), and true technology development programs when compared to the VSS type. This reviewer believed it had more to do with the contractors than DOE, as they were trying to keep too much confidential, which led this reviewer to query why public funds would be spent. This reviewer understood the stimulus or seeding functions necessary to promote the technology growth, and added that DOE was doing a good job and should keep it up.

Reviewer 6:

The reviewer noted some general comments. In the current climate, with the OEMs unable or unwilling to make significant investments in developing and validating many of the advanced technologies, this sub-program funding performed a vital function in helping the United States maintain its edge in the automotive sector. Understandably, the focus was primarily on hybrids, plug-ins, and the like, but this reviewer wondered if the goal of petroleum displacement could also be served by including (in the test matrix) other vehicles with conventional powertrains equipped with advanced features such as adjustable grille shutters, active warm-up strategies, etc. If true benefits of these features could be quantified, especially in comparison with hybrid powertrains, it might help validate some of the analyses' (such as Autonomie's) predictions while also providing consumers with useful, unbiased data on the true benefits of the various technologies. In general, the National Laboratories have been very eager to share the knowledge gleaned from the various DOE-funded projects. In interactions with various universities, this reviewer seemed to find several projects that had very similar goals and content to DOE-funded projects. These projects were funded by other government agencies such as the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC). Perhaps wishful thinking, but this reviewer

would love to ensure that there was no needless repetition of the same project. This reviewer did not necessarily agree entirely with Argonne National Laboratory's (ANL's) decision to let LMS handle Autonomie. This person was hoping that it did not go the way of the Advanced Vehicle Simulator (ADVISOR), adding that time would tell.

Reviewer 7:

The reviewer noted that the presentation could have added more background information on the objective of the program (e.g., what was done and why, what was achieved, the management plan, and future goals).

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (*on a scale of 1 to 4*). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
‡ Electric Drive Vehicle Demonstration and Vehicle Infrastructure Evaluation	Tom Garetson (ECOtality North America)	1-9	3.50	3.75	3.75	3.00	3.59
‡ Advancing Transportation Through Vehicle Electrification – PHEV	Abdullah Bazzi (Chrysler LLC)	1-13	3.40	3.60	3.60	3.20	3.50
‡ Interstate Grid Electrification Improvement Project	Jon Gustafson (Cascade Sierra Solutions)	1-17	3.17	3.17	3.17	2.67	3.10
‡ Advanced Vehicle Electrification and Transportation Sector Electrification	Greg Cesiel (General Motors)	1-21	2.80	3.20	3.20	3.00	3.08
‡ Smith Electric Vehicles: Advanced Vehicle Electrification + Transportation Sector Electrification	Robin Mackie (Smith Electric Vehicles)	1-25	3.50	3.17	3.17	3.20	3.25
‡ ChargePoint America	Kumar Gogineni (ChargePoint, Inc.)	1-30	2.75	3.00	3.00	2.25	2.84
‡ Class 8 Truck Freight Efficiency Improvement Project	Derek Rotz (Daimler Trucks North America LLC)	1-33	3.80	3.40	3.40	3.60	3.53
‡ Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks	Scott Newhouse (Peterbilt)	1-36	3.80	3.60	3.60	3.80	3.68
‡ SCAQMD: Plug-In Hybrid Electric Medium-Duty Commercial Fleet Demonstration and Evaluation	Matt Myasato (SCAQMD)	1-39	3.00	3.17	3.17	2.67	3.06
Medium and Heavy-Duty Vehicle Field Evaluations	Kevin Walkowicz (National Renewable Energy Laboratory)	1-43	3.50	3.25	3.25	3.25	3.31
DOE's Effort to Reduce Truck Aerodynamic Drag through Joint Experiments and Computations	Kambiz Salari (Lawrence Livermore National Laboratory)	1-46	3.25	3.25	3.25	2.50	3.16
Plug-in Hybrid (PHEV) Vehicle Technology Advancement and Demonstration Activity	Greg Cesiel (General Motors)	1-49	2.75	2.75	2.75	2.25	2.69
Ford Plug-In Project: Bringing PHEVs to Market	Julie D'Annunzio (Ford Motor Company)	1-52	3.60	3.60	3.60	3.40	3.58
Idaho National Laboratory Testing of Advanced Technology Vehicles	Jim Francfort (Idaho National Laboratory)	1-56	3.25	3.75	3.75	3.25	3.56
Advanced Vehicle Testing & Evaluation	Tom Garetson (ECOtality North America)	1-59	2.75	3.25	3.25	2.75	3.06
Advanced Technology Vehicle Lab Benchmarking - Level 1	Henning Lohse-Busch (Argonne National Laboratory)	1-62	3.83	3.67	3.67	3.33	3.67
Advanced Technology Vehicle Lab Benchmarking - Level 2 (in-depth)	Eric Rask (Argonne National Laboratory)	1-66	3.67	3.50	3.50	3.00	3.48

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Electric Drive and Advanced Battery and Components Testbed (EDAB)	Barney Carlson (Idaho National Laboratory)	1-70	2.50	2.75	2.75	3.00	2.72
Codes and Standards to Support Vehicle Electrification	Ted Bohn (Argonne National Laboratory)	1-73	3.80	3.40	3.40	3.00	3.45
SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer	Dale Oehlerking (Navistar)	1-77	2.40	2.40	2.40	2.20	2.38
Vehicle Mass and Fuel Efficiency Impact Testing	Jim Francfort (Idaho National Laboratory)	1-80	3.50	3.00	3.00	3.00	3.13
CoolCab Test and Evaluation and CoolCalc HVAC Tool Development	Jason Lustbader (National Renewable Energy Laboratory)	1-83	3.17	3.33	3.33	2.83	3.23
Development and Demonstration of a Fuel-Efficient Class 8 Highway Vehicle	David Koeberlein (Volvo)	1-87	3.40	2.80	2.80	3.20	3.00
Improving Vehicle Fuel Efficiency Through Tire Design, Materials, and Reduced Weight	Timothy Donley (Cooper Tire)	1-90	3.50	2.50	2.50	3.25	2.84
A Materials Approach to Fuel-Efficient Tires	Peter Votruba-Drzal (PPG)	1-93	2.75	2.75	2.75	3.00	2.78
System for Automatically Maintaining Pressure in a Commercial Truck Tire	Robert Benedict (Goodyear)	1-96	3.75	3.75	3.75	3.50	3.72
Next Generation Environmentally Friendly Driving Feedback Systems Research and Development	Matthew Barth (University of California at Riverside)	1-99	3.25	2.75	2.75	2.33	2.82
Look-Ahead Driver Feedback and Powertrain Management	Rajeev Verma (Eaton Corporation)	1-102	2.75	2.50	2.50	2.75	2.59
Advanced HD Engine Systems and Emissions Control Modeling and Analysis	Zhiming Gao (Oak Ridge National Laboratory)	1-105	3.17	3.00	3.00	2.67	3.00
HEV, PHEV, EV Test Standard Development and Validation	Mike Duoba (Argonne National Laboratory)	1-109	4.00	3.50	3.50	3.25	3.59
Grid Connectivity R&D	Ted Bohn (Argonne National Laboratory)	1-112	3.75	3.50	3.50	3.25	3.53
INL Efficiency and Security Testing of EVSE and DC Fast Chargers	Jim Francfort (Idaho National Laboratory)	1-115	3.00	3.00	3.00	3.00	3.00
Electric Drive Vehicle Climate Control Load Reduction	John Rugh (National Renewable Energy Laboratory)	1-117	3.25	3.50	3.50	3.75	3.47
Advanced Transmission Impact on Fuel Displacement	Namdoo Kim (Argonne National Laboratory)	1-120	3.00	3.25	3.25	3.25	3.19
Government Performance and Results Act (GPRA)	Jake Ward (Department of Energy)	1-123	3.25	3.25	3.25	3.25	3.25
Thermal Electric Generation Study with GM - Phase 2	Ram Vijayagopal (Argonne National Laboratory)	1-126	3.33	3.00	3.00	3.00	3.08
Wireless Charging	Allan Lewis (Hyundai)	1-128	2.80	2.80	2.80	2.40	2.75
Wireless Charging	John Miller (Oak Ridge National Laboratory)	1-131	3.40	3.20	3.20	3.00	3.23
Dynamic Wireless Power Transfer Feasibility	Perry Jones (Oak Ridge National Laboratory)	1-134	2.67	2.67	2.67	2.50	2.65
Analysis of In-Motion Power Transfer for Multiple Vehicle Applications	Jeff Gonder (National Renewable Energy Laboratory)	1-138	3.40	3.40	3.40	3.20	3.38
Autonomous Intelligent Plug-in Electric Vehicles (PEVs)	Andreas Malikopoulos (Oak Ridge National Laboratory)	1-141	3.17	3.00	3.00	2.67	3.00

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Heavy Duty Powertrain System Optimization and Emissions Test Procedure Development	Paul Chambon (Oak Ridge National Laboratory)	1-145	4.00	3.00	3.00	3.00	3.25
PHEV Advanced Series Genset Development/Demonstration Activity	Paul Chambon (Oak Ridge National Laboratory)	1-147	2.75	3.25	3.25	2.75	3.06
Battery Energy Availability and Consumption during Vehicle Charging across Ambient Temperatures and Battery Temperature (conditioning)	Eric Rask (Argonne National Laboratory)	1-150	3.00	2.80	2.80	2.60	2.83
Fuel Consumption Benefits from Low Temperature Combustion (LTC) of Gasoline CI Technology using EIL	Neeraj Shidore (Argonne National Laboratory)	1-153	2.80	3.00	3.00	2.60	2.90
Nanofluids for Cooling Power Electronics for HEV	Dileep Singh (Argonne National Laboratory)	1-156	3.50	2.75	2.75	3.25	3.00
DC Fast Charge Impacts on Battery Life	James Francfort (Idaho National Laboratory)	1-159	3.25	3.33	3.33	3.00	3.27
Fast Charge Technology Adoption Challenges	Anthony Markel (National Renewable Energy Laboratory)	1-162	3.00	3.00	3.00	2.75	2.97
Zero Emission Heavy Duty Drayage Truck Demonstration	Brian Choe (SCAQMD)	1-164	3.40	3.20	3.20	3.00	3.23
Zero Emission Cargo Transport - Houston #1	Christine Smith (Houston-Galveston Area Council)	1-167	3.25	3.50	3.50	3.25	3.41
Zero Emission Cargo Transport - Houston #2	Christine Smith (Houston-Galveston Area Council)	1-169	3.25	3.25	3.25	3.00	3.22
† EV Roadmap V2.0	Fred Wagner (Energetics, Inc.)	1-171	3.50	3.50	3.50	3.50	3.50
† Fleet DNA	Kevin Walkowicz (National Renewable Energy Laboratory)	1-174	2.50	3.00	3.00	2.00	2.75
† AC Model Development	Jason Lustbader (National Renewable Energy Laboratory)	1-177	4.00	2.50	2.50	3.50	3.00
† APEEM Components Analysis and Evaluation	Paul Chambon (Oak Ridge National Laboratory)	1-180	3.33	2.67	2.67	2.33	2.79
† Vehicle to Grid Communications Field Testing	Richard Pratt (Pacific Northwest National Laboratory)	1-183	3.00	3.00	3.00	2.00	2.88
Overall Average			3.25	3.14	3.14	2.94	3.14

† denotes poster presentations

‡ denotes ARRA funded projects

Electric Drive Vehicle Demonstration and Vehicle Infrastructure Evaluation: Tom Garetson (ECOTality North America) - arravt066

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

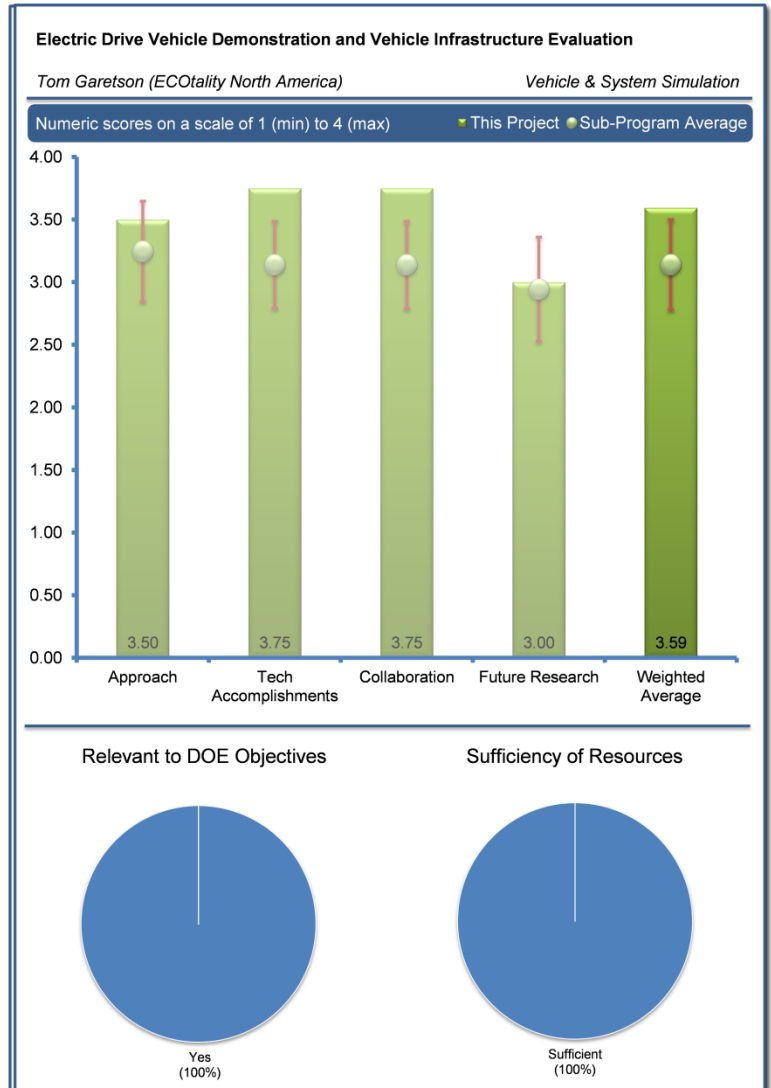
This reviewer noted that the Electric Vehicle (EV) Project has incorporated a very good approach, starting with a significant amount of upfront planning, including organization of regional stakeholders, developing long-range plans, and establishing EV microclimates for each deployment area. The reviewer felt that the use of a certified contractor network was a good decision to develop a cadre of skilled and experienced installers and to leverage their experience within the project to better understand, resolve, and communicate barriers to installation of EVSE (EV supply equipment). The project is placing EVSE in a wide variety of geographic locations with Level 2 EVSE in residential, commercial, and public applications as well as direct current fast chargers (DCFC) in public applications. A wireless, internet-based network is used to cost-effectively collect vehicle and charging infrastructure data and send it to Idaho National Laboratory (INL) for compilation. The project is also coordinating with elements of the Smart Grid to help identify and resolve issues therein with regards to electric vehicle charging and control.

Reviewer 2:

The reviewer commented that the principal investigator (PI) provided an excellent overview of the project and descriptive statistics on installations, vehicles, and chargers in a very clear presentation. The reviewer appreciated the clear description of barriers, but would have liked to hear more about how the barriers were resolved, or not resolved.

Reviewer 3:

The reviewer noted that the PI spoke on a very large and complex project that appeared to be well-managed in its implementation. On the other hand, the reviewer did not get a sense that the speaker was presenting an overall objective like the lessons learned for deployment of EVs or market drivers that could encourage EV use. The reviewer critiqued the PI's presentation in that it appeared to be focused on the intimate details of the day-to-day operations of the project. This reviewer indicated that while that is extremely important, it is not a result that is important to the taxpayer for investing in such a venture. The reviewer suggested that in the next presentation, the PI should seek to consolidate the tons of excellent data, experience, lessons learned, etc., into a transferable lesson package that could be used to assist DOE, state governments, commercial ventures, and other stakeholders in understanding what works or does not work in the world of EVs.



Reviewer 4:

The reviewer was very impressed with the data collection and analysis aspects of this project, despite commenting that the tables and figures on the slides were too small to read at the original size, and too low-resolution to read when magnified. The reviewer did criticize two aspects. First, the reviewer said that there was no information provided in the presentations about what locations were chosen for public charging. The reviewer said that a sample map showed many stations located at sites that this reviewer considered less than ideal. The reviewer admitted to having a general concern about siting on all infrastructure deployment projects, claiming to have seen very poor siting choices in the field. Second, the reviewer expressed a concern that driver behavior in the study will be taken as typical. The reviewer observed that early adopters of EVs may behave differently from mass-market consumers, citing that the EV-related research at University of California (UC) Davis have observed EV drivers playing range games.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the EV Project has deployed cars and chargers and has been collecting interesting data, which the reviewer commented is an effective use of Federal funds.

Reviewer 2:

The reviewer observed that the project appears to be on track, and that the logistical and technical work on this project is very impressive.

Reviewer 3:

This reviewer said that there was huge progress in implementing a demonstration program, with lots of data venues and excellent ideas.

Reviewer 4:

The reviewer cited that the EV Project is roughly on schedule despite suffering delays from slower than expected vehicle sales and adoption. An impressive amount of data has been and is being collected to the tune of 68 million miles accumulated on vehicles, over 1.6 million charging events, and 14.1 gigawatt-hours (GWh) of electrical energy consumed. The reviewer also noted that upwards of 12,000 EVSE have been installed including 73 DC fast chargers collecting data on nearly 6,000 Nissan LEAFs® and 2,000 General Motors (GM) Volts. A broad communications network has been established with web portals and mobile applications. Quarterly reports have been issued for nearly two years looking at compiled data in a variety of ways. A number of white papers have been developed and posted on topics of importance and interest. A number of barriers to deployment of EVSE have been identified, studied, and in some cases largely resolved. However, the reviewer indicated three questions of interest. First, it is mentioned that EVSE access fees (time-based) are now being studied to demonstrate value to charger hosts and evaluate business model sustainability. The reviewer asked whether other types of potential fee structures, such as those based purely on energy transferred, mixed time or energy transferred fees, etc., were also being considered. According to the reviewer, it seemed that the most beneficial type of fee structure may vary significantly depending upon the host application. Second, the reviewer also said that it is mentioned that fast charger connector standards and demand charges are barriers. The reviewer inquired ECOTality's recommendations for potential solutions or workarounds for these problems were, and suggested examples such as lower power ratings for DCFC or possibly some local energy storage. Third, according to the reviewer, in last year's presentation, it was mentioned that commercial permitting was a barrier, but it was not mentioned this year. The reviewer wanted to know whether permitting is still a problem or has largely been solved.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that in addition to the research partners, who appear to interact seamlessly, the job of getting businesses, consumers, and municipal agencies all working together has been done extremely well.

Reviewer 2:

Partners appear to be well integrated into the project, according to the reviewer.

Reviewer 3:

This reviewer cited an excellent set of stakeholders.

Reviewer 4:

The reviewer observed that the EV Project is working on Smart Grid evaluation with San Diego Gas and Electric (SDG&E) including submetering, the impact of EV charging on distribution infrastructure, and communication strategies for demand response. The reviewer also noted that the EV Project team is also working with the Oregon and Washington State Departments of Transportation (DOTs) on signage issues, as well as thousands of plug-in EV (PEV) drivers and hosts. According to the reviewer, it is mentioned in the Overview that ten utilities and two universities are also part of the collaboration, but that no supporting documentation is provided. The reviewer observed that a significant number of presentations and publications have been developed and presented. The reviewer advised that it may be good to consider broadening ties with various end user communities such as commercial building and mall owners, large retail establishments and corporations, municipal planning entities, etc. Additionally, the reviewer also suggested that it is probably good to periodically probe the end user community to determine if the information being provided is as useful and convenient to use as possible.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the project is nearly complete, but project management and future plans seem solid.

Reviewer 2:

The reviewer observed that the future plan seems to be to continue to collect data, which is good, because people might behave differently once the bloom is off the rose. The reviewer expressed some concern as to how ten-year projections are to be made.

Reviewer 3:

The reviewer claimed not to understand the future work here, other than put more vehicles on the road (in this demo).

Reviewer 4:

According to the reviewer, future work appeared to be largely focused on Smart Grid-related barriers including utility generation and demand response including geographic information system (GIS) -based data for distribution and clustering effects. Additionally, a significant amount of effort is to be put into information dissemination, noted the reviewer. The reviewer noted that this is all good, but if not already planned, it seems very important to continue putting considerable effort into resolving other aforementioned barriers and identifying, developing, and communicating the best business case scenarios.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the way to see if something is going to work is to get out there and try it, and that this project is doing that in a big way. It should be interesting to see petroleum savings per vehicle long-term, according to the reviewer.

Reviewer 2:

The reviewer wrote that this project directly supports the overall DOE objective of petroleum displacement, by encouraging use of electric vehicles in multiple cities across the U.S.

Reviewer 3:

The reviewer noted that it was an excellent project that just needs to realize its full potential as a national demonstration leading the way for EV expansion.

Reviewer 4:

The reviewer commented that PEVs have the potential to significantly reduce the Nation's dependence upon oil for transportation. The reviewer added that the development of a cost-effective, ubiquitous, self-sustaining EV charging infrastructure is a key enabler to achieving this vision. Understanding PEV and charge infrastructure utilization is a key to building market momentum for PEVs, the reviewer wrote.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer observed that this was a big project financially and by scale. The reviewer noted that it was not possible to evaluate the efficiency of spending without seeing detailed accounts, but that it seems pretty good.

Reviewer 2:

The resources appeared to be sufficient, according to this reviewer.

Reviewer 3:

The reviewer noted that the project is 50% cost shared and sufficiently funded.

Advancing Transportation Through Vehicle Electrification - PHEV: Abdullah Bazzi (Chrysler LLC) - arravt067

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer summarized that the project was to leverage advanced vehicle technologies to reduce vehicle fuel consumption and emissions. Bi-directional grid connectivity was established along with an export 40 ampere (A) [6.6 kilowatt ()] auxiliary power panel, the reviewer cited, also noting that a fleet of 140 pickup trucks were deployed in Phase I of the effort. Phase II upgraded 24 of the vehicles with new lithium-ion (Li-ion) batteries and demonstrated them in diverse geographies and climates.

Reviewer 2:

The reviewer said that this project at least learned something, though not discussed in this presentation.

Reviewer 3:

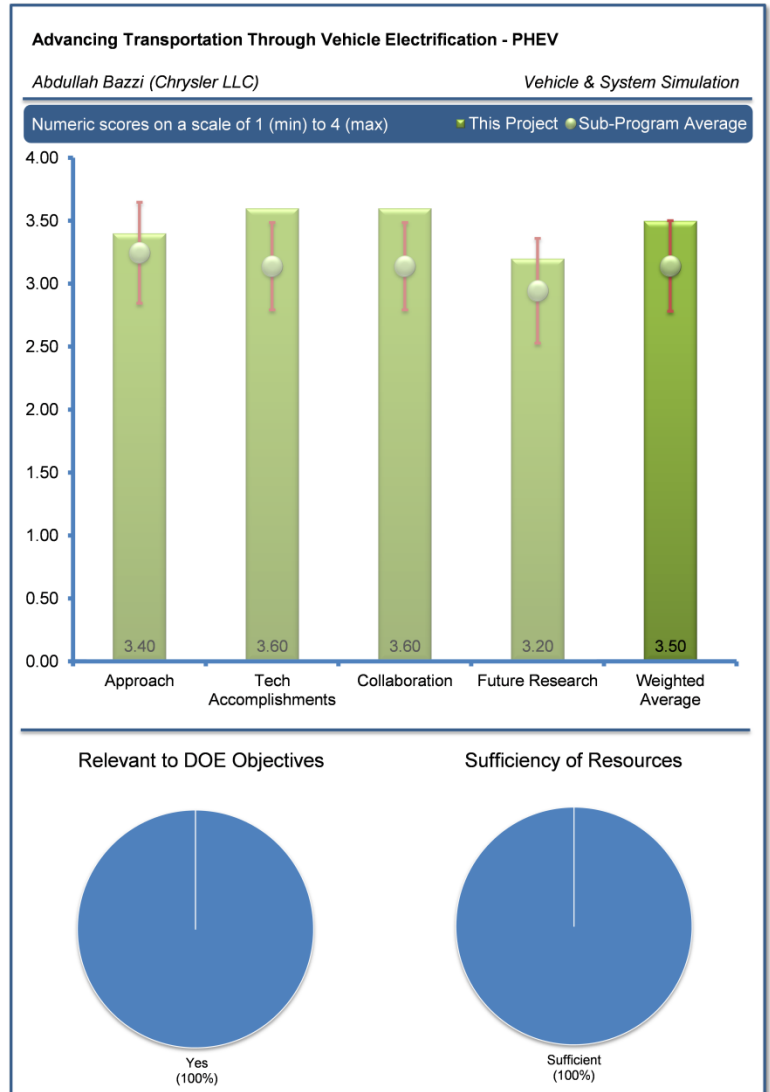
The reviewer assessed the project approach to build a set of demonstration vehicles, acquire real-world data and analyze these data to determine where design improvements can be made, and then building a second set of vehicles, to be a good approach. The reviewer warned that it was not clear, however, why there is such a large difference between the planned fleets for Phase I and Phase II, and asked why there would be more vehicles built for Phase I. Also, the reviewer wondered why there was a plan to have 140 vehicles but there are data from only 111 vehicles. The reviewer indicated that there is also a skew towards charge-sustaining (CS) mode driving by the vehicle users. The reviewer said that having it well over half the time is different from real-world data from other data sets for personal vehicles, and so these data are slightly less applicable, according to the reviewer.

Reviewer 4:

The reviewer commended a great approach but noted that the organization of the presentation made it difficult to get the full-approach picture early on. By the end of the presentation, the reviewer claimed to have achieved a better idea of the details of the approach and what Chrysler was hoping to accomplish. The reviewer noted that Chrysler is developing a significant number of vehicles and acquiring an impressive amount of data to better understand use and opportunities. The reviewer felt the Gantt chart was helpful but that there was not significant time for the presenter to go into the details of each task.

Reviewer 5:

The reviewer noted that it is unfortunate that the battery cell voltage/temperature imbalance issues occurred, but good that lessons learned from Phase 1 are being used to improve the design in Phase 2. The reviewer commented that perhaps in hindsight the overall approach could have benefited from more bench testing of candidate battery cells and management systems over a variety of



environmental conditions prior to vehicle deployment. The reviewer said that it is also good that significant experience is being gained working with utilities on reverse power flow and smart charging research, development and demonstration. The reviewer cautioned that it is unclear, though, how well the demonstration partner mix aligns with the expected customer distribution for a potential full production run.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

According to the reviewer, deployment partners have driven a significant number of miles which contributes significantly to better understanding of the usage characteristics of these vehicles as well as the behavior of the advanced technologies in the vehicles. The reviewer felt this data will feed well into Phase II. The reviewer cited as an example that the project team was able to track cell imbalance issues in the field and provide important information for better battery cell technology and control for Phase II. The reviewer noted that 111 out of 140 vehicles have been deployed, and that the reasons for not deploying all 140 seem reasonable. The reviewer concluded that everything else seems on target with initial fuel economy (FE) results exceeding projections.

Reviewer 2:

The reviewer applauded good mileage accumulation and on-road experience obtained with deployed vehicles. The reviewer noted that it is also good that supplemental functions (charge scheduling, reverse power flow and map-based FE system) were developed. Regarding vehicle performance, the reviewer felt it would be nice to know how well adjusted laboratory FE predictions aligned with the real-world experience. The reviewer also deemed it important to quantify the real-world/adjusted FE penalty from the lower-power replacement battery cells in Phase 2. The stated FE improvements from the map-based system are quite high, according to the reviewer, who deemed this a good achievement, though it also suggests that there might be room for improvement of the baseline control strategy (in the absence of driving route information). The presenter stated that green jobs were created and sustained thanks to this project funding, but that it would have been nice to have the number of jobs quantified.

Reviewer 3:

The reviewer applauded that the vehicle fleet has impressive participation and frequent utilization, as well as that a new Phase II battery has been implemented, helping resolve the issues experienced in the Phase I battery system. The reviewer noted that significant lessons learned can be extracted from the data analysis from the Phase I battery pack, but that unfortunately, the reduction in capacity reduced the equivalent all-electric range from 20 miles to 14 miles. This vehicle is the only V8 pickup truck to achieve Advanced Technology Partial Zero Emissions Vehicle (AT-PZEV) compliance, according to the reviewer. The reviewer pointed out that the program has helped the Chrysler/Fiat group nurture their in-house expertise in hybrid electric/plug-in/vehicle electrification technologies, which are core-competency areas for the company.

Reviewer 4:

The reviewer indicated that it appeared as though Phase I met its milestones and objectives, although an explanation for why 29 vehicles were not built is warranted. The reviewer went on to say that it appears as though Phase II is meeting its milestone targets. The reviewer advised that some more analysis being presented on the relative performance between the vehicles deployed in hot and cold regions would have been very interesting.

Reviewer 5:

The reviewer was uncertain about which of this project's technical accomplishments had not already been learned by others before, with the exception of the reverse flow capability.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer praised an outstanding collaboration with development partners, suppliers, and demonstration partners. The reviewer sought to learn whether the collaboration with Michigan State University (MSU) leveraged the Energy and Automotive Research

Laboratory. A Chrysler/Cummins powertrain was recently integrated into one of MSU's test cells to perform hybrid electric research, comparing conventional, series, and parallel hybrid configurations, the reviewer added.

Reviewer 2:

The reviewer noted significant partnerships on development as well as demonstration, and that the collaboration was a nice and important mix to maximize success. More specifically, Chrysler has leveraged the expertise of universities and others for the development of technologies and collection of data, according to the reviewer, who went on to cite that Phase 2 deployment partners were also extensive and included 24 vehicles.

Reviewer 3:

Chrysler appears to have engaged with a variety of partners and the collaborative efforts have largely been successful, according to the reviewer. The reviewer said that it would have been informative to understand what transpired in the relationship with the first battery manufacturer (perhaps by keeping the company anonymous), but it is understandable why these details had to remain private.

Reviewer 4:

The reviewer highlighted that the project included a significant number of partners and collaborators, and overall coordination seems to be very good. The reviewer cautioned that it was not clear how well the demonstration partners represent the target customer mix for a production version of the vehicle. Also, according to the reviewer it was stated that feedback from the UC Davis driver and fleet manager interviews resulted in design improvement recommendations, but it was not clear what those were or if they were acted upon.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the majority of future work will be in Phase 2, and that the plan forward looks very good and right on track. The Phase 1 findings are leading to improved technology to be evaluated in Phase 2, according to the reviewer.

Reviewer 2:

The reviewer felt that the plans for Phase II appear to be sound and there will likely be good information on plug-in hybrid electric vehicles (PHEVs) derived from this phase of the project. The reviewer said it would have been useful to know what the future plans are for the PHEV design developed during this project specifically.

Reviewer 3:

The reviewer observed that 24 vehicles are being upgraded with the Phase II battery packs. The reviewer suggested that it may be beneficial to try to determine the discrepancy between the real world FE observed and that determined using the federal test procedures due to the magnitude of the difference.

Reviewer 4:

The reviewer summarized that future work plans include upgraded battery implementation and deployment in 24 of the demonstration vehicles, and continued system optimization/refinement/lessons learned through testing and field deployment. The reviewer stated that one of the system design objectives identified as complete in the summary was proving that the system solution represents optimal cost-benefit trade-offs, however the reviewer claimed that the presentation did not include details of what this involved or whether the optimized design would next be implemented into a production vehicle.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that PHEVs have a significant fuel savings potential, and this project reported achieving a roughly 50% real-world FE improvement relative to the FE from comparable conventional vehicle operation.

Reviewer 2:

The reviewer opined that once again, we need products to support technology growth.

Reviewer 3:

The reviewer affirmed that the work is providing new knowledge and data which are very important for more widespread introduction of this technology.

Reviewer 4:

The reviewer said that trucks are an interesting application of PHEV technology, and there is certainly substantial opportunity to reduce petroleum consumption in this area. The reviewer stated that it will be interesting to follow Chrysler's plans to see how this project informs future vehicle programs.

Reviewer 5:

The reviewer noted that the PHEV developed under this effort has demonstrated a significant reduction in fuel consumption and includes all-electric mobility as well. The reviewer felt that more details on the electric drive system would be beneficial to gain a better understanding of the powertrain architecture.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The cost of developing such a large number of prototype vehicles and all of the included systems is large and probably warrants the large expenditure for this project, according to the reviewer.

Reviewer 2:

The reviewer said the project is on track, and that a lack of resources is not apparent from the presented material.

Reviewer 3:

According to the reviewer, the project has been supported by very significant DOE as well as cost share contributions. The reviewer opined that the expenditure seems sufficient, or perhaps on the high side given the battery issues encountered, limited deployment and uncertain production future for the developed vehicles.

Reviewer 4:

The reviewer said that it is difficult to understand whether resources are sufficient or insufficient for such a large project with only a 20-minute presentation, but went on to assume that the resources are sufficient.

Interstate Grid Electrification Improvement Project: Jon Gustafson (Cascade Sierra Solutions) - arrvt070

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the approach is systematic and likely to achieve the objective of installing these systems in areas where they are most useful and likely to be utilized.

Reviewer 2:

The reviewer commented that in this effort, plug-in receptacles at up to 50 truck stops, and electrified accessories on up to 5,000 heavy duty trucks, are being deployed. The reviewer went on to add that rebates are being used as incentives for adopters of these technologies, and collected data is being analyzed to determine how many gallons of fuel were saved per trip mile and overall.

Reviewer 3:

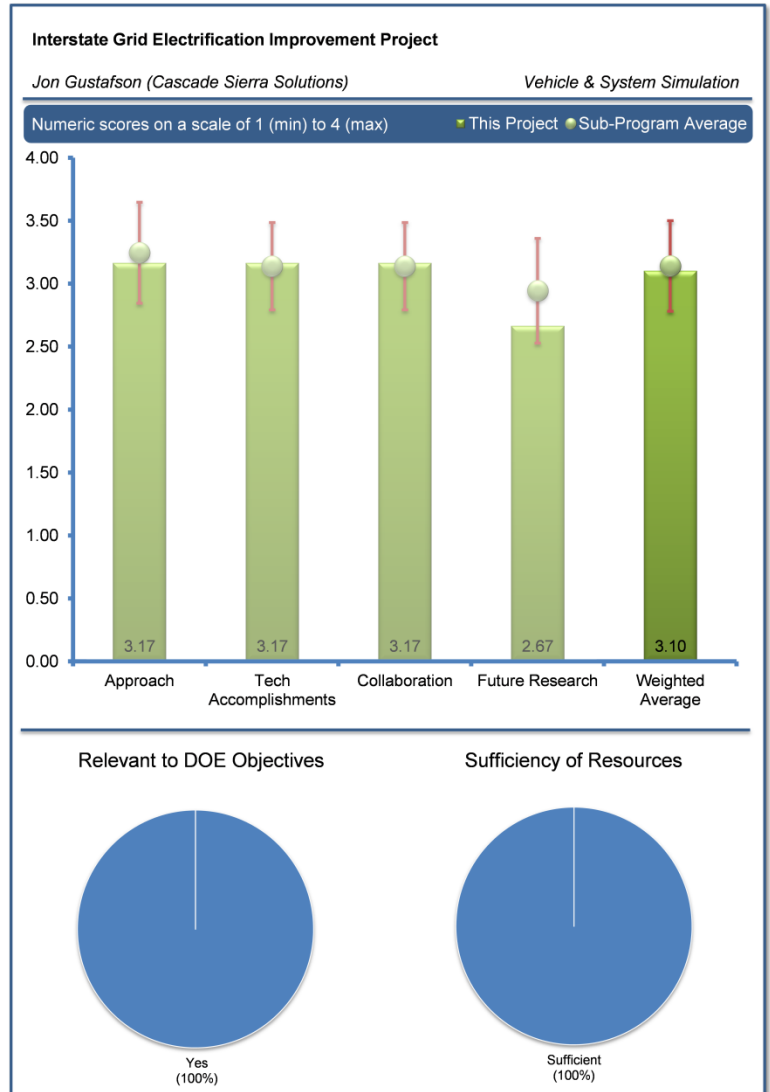
The reviewer observed that the project is about idle reduction using on-board technology (5,000 rebates) and electrified sites (50 sites). According to the reviewer, the project does not have a means to capture the usage of on-board technology that does not plug in into shore power sites. The reviewer suggested that a statistical sampling of the non-plugged in technology should be included to assess the petroleum displacement. The reviewer also noted that the project should identify a baseline fleet for comparison so that improvements can be quantified. The reviewer pointed out that it is also unknown if trucks are completely off idle when plugged in, for example, when a trailer refrigeration unit (TRU) is being engaged.

Reviewer 4:

The reviewer said that the project approach is sound, and that ensuring that sites around the country and of different types are included should allow for meaningful results. The reviewer noted that one area that could be improved upon is the suite of vehicle technologies that were selected for the project and the associated rebates, asking whether the technologies could be ranked and targets for adoption created. The reviewer noted that the rebates could be manipulated to incentivize the vehicle owners to purchase the technologies in which the DOE has the most interest.

Reviewer 5:

The reviewer commented that the Year 1-4 goals and approach address barriers and appear to enlist the necessary partners to further this technology. Cascade Sierra Solutions (CSS) is recruiting truck stops and owners of 5,000 heavy-duty (HD) trucks to ensure sufficient users for statistical evaluation of new technologies enabled by grid power, which the reviewer characterized as a very comprehensive plan. However, the reviewer also noted that it was confusing that the slides in the presentation were different from those supplied to reviewers.



Reviewer 6:

The reviewer remarked that this project is organized well and executing per the approach, but cautioned that the PI did not seem to provide sufficient proof of the data being collected and how it will be analyzed.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer expressed that progress appears to be good and proceeding well.

Reviewer 2:

The reviewer cited good progress on site installation and rebates.

Reviewer 3:

The reviewer commented that most equipment and truck stop receptacles have been installed, which are technologies that permit the truck drivers to keep their engines off while parked and still enjoy climate control and other amenities in their vehicles, reducing overall fuel consumption and emissions. According to the reviewer, to date, utilization of the equipment is reported to be very low, leading the reviewer to suggest that the PI consider restricting some of the best parking spots for users of the technology. The reviewer also asked what else could be done to increase user awareness and further promote adoption of the new technologies.

Reviewer 4:

The reviewer observed that all milestones appear to have been met. However, the reviewer did note that the progress on the Year 3 task is unclear, and wondered about the status of the outreach and collaboration with utilities and highway planners.

Reviewer 5:

The reviewer commended CSS for using the team extremely well in setting this important project up for success, and noted that truck stop electrification (TSE) is a technology that needs this attention as it is a sound, viable solution that has not been getting attention. The reviewer expressed concern about how to improve the use of the parking spots during the project.

Reviewer 6:

The reviewer noted good progress on having sites up and running, 92% up and running with about 80% of target trucks outfitted with onboard systems, and promotion underway to get the word out on this program. The reviewer also applauded a nice technology mix summary, and suggested that more information on the reasoning behind the selection and deployment of technologies would be very helpful, citing possibilities such as technology deployment based on routes or other factors and truck owner interest. The reviewer also cautioned that U.S. maps with current and future truck stops seem inconsistent with 92% up and running, and that the confusion may be attributed to the difference between the data in the presented talk and the presentation supplied to reviewers.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer agreed that numerous partnerships have been established with equipment manufacturers and truck stops for adoption of these technologies.

Reviewer 2:

The reviewer noted that recruitment of truck stops and truck owners is excellent and on track. The reviewer added that nice partnerships across the U.S. include major truck stop owners which if successful have potential to enable penetration of this technology.

Reviewer 3:

The reviewer applauded a really good accomplishment on this project.

Reviewer 4:

The reviewer observed that there appears to be good collaboration with project partners. The reviewer then opined that it was a bit unclear from the presentation what the division of labor on the data analysis and reporting will be between National Renewable Energy Laboratory (NREL) and Cascade Sierra Solutions.

Reviewer 5:

The reviewer said that the team should try to better coordinate with non-rebate users of electrified truck stops and also coordinate with rebate users to assess on-board technology.

Reviewer 6:

The reviewer commented that collaboration does not appear to be a major feature of this project and should be pursued more strongly.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The proposed future work seems to address previous concerns, according to the reviewer.

Reviewer 2:

The reviewer noted that the cost effectiveness of these technologies needs to be determined and perhaps this project is a good way to do so.

Reviewer 3:

The reviewer noted that the Future Work slide has a comprehensive list of future plans. The reviewer asked whether there is any work being done on the policy side to make the return on investment (ROI) more attractive to vehicle owners and truck stop owners. The reviewer also wondered about the effect if the ROI business modeling results in too long a period of return.

Reviewer 4:

The reviewer indicated that the ROI for each technology will be computed and reported for truck owners, truck stops, and utility power providers. The reviewer went on to ask whether demand for the new technologies is expected to continue without the rebates.

Reviewer 5:

The reviewer wanted to know more details on the future plans, commenting that they appeared only on a single slide which was passed through very quickly. More specifically, the reviewer desired to know about more details on statistics planned for understanding future opportunities and market penetration.

Reviewer 6:

The reviewer referred to earlier comments on analysis of data and ensuring good understanding of the availability of the parking spots for electricity.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that any technology which substitutes another energy source (electricity) does contribute to the DOE petroleum displacement goal.

Reviewer 2:

The reviewer commented that the project most definitely addresses the introduction of technologies which would have a direct impact on reducing use of oil and emissions.

Reviewer 3:

The reviewer noted that the project should enable a large decrease in truck stop idling if adopted on a large scale.

Reviewer 4:

The reviewer stated that the trucking industry is a huge consumer of petroleum, and this project is a productive addition to the effort to reduce this consumption through electrification.

Reviewer 5:

The reviewer cited that this project is helping to promote anti-idle technologies for heavy truck applications, explaining that user loads while at truck stops are supported by grid electricity rather than by idling the engine, consuming fuel.

Reviewer 6:

The reviewer agreed that the project supports DOE's petroleum displacement goal absolutely. However, the reviewer also noted that TSE is perceived as not a good solution by truckers and many fleets with which the reviewer has interacted, speculating that this is due to past failures and the barrier of needing to have the infrastructure match the tractor availability. Today, auxiliary power units (APUs) and other solutions do not require parking in a designated place, according to the reviewer. The reviewer opined that the DOE is right to support an alternative technology that is promising.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that the resources for this project are substantial and appear sufficient to meet the schedule in a timely manner.

Reviewer 2:

The reviewer said the resources seem sufficient, with no reason to think otherwise.

Reviewer 3:

The reviewer noted that the funding seems sufficient.

Reviewer 4:

The reviewer commented that the resources appear to be appropriate for the scope of the project.

Reviewer 5:

The reviewer affirmed that the project is on track, and that a lack of resources is not apparent from the presented material.

Reviewer 6:

The reviewer felt that it was very difficult to evaluate whether the funding resources for this activity are excessive or insufficient, because with a project this size, that would take more than a 20-minute presentation.

Advanced Vehicle Electrification and Transportation Sector Electrification: Greg Cesiel (General Motors) - arravt071

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer applauded the excellent presentation, organized approach, and clear objectives, deeming it a very good project.

Reviewer 2:

The reviewer commented that there was more data available thru OnStar telematics that would be useable by analysis operations outside of GM that could help to develop usage models of EV or EREV (extended-range EV) operators, and that also would not be considered critical information. The reviewer questioned that this information is not available through the project.

Reviewer 3:

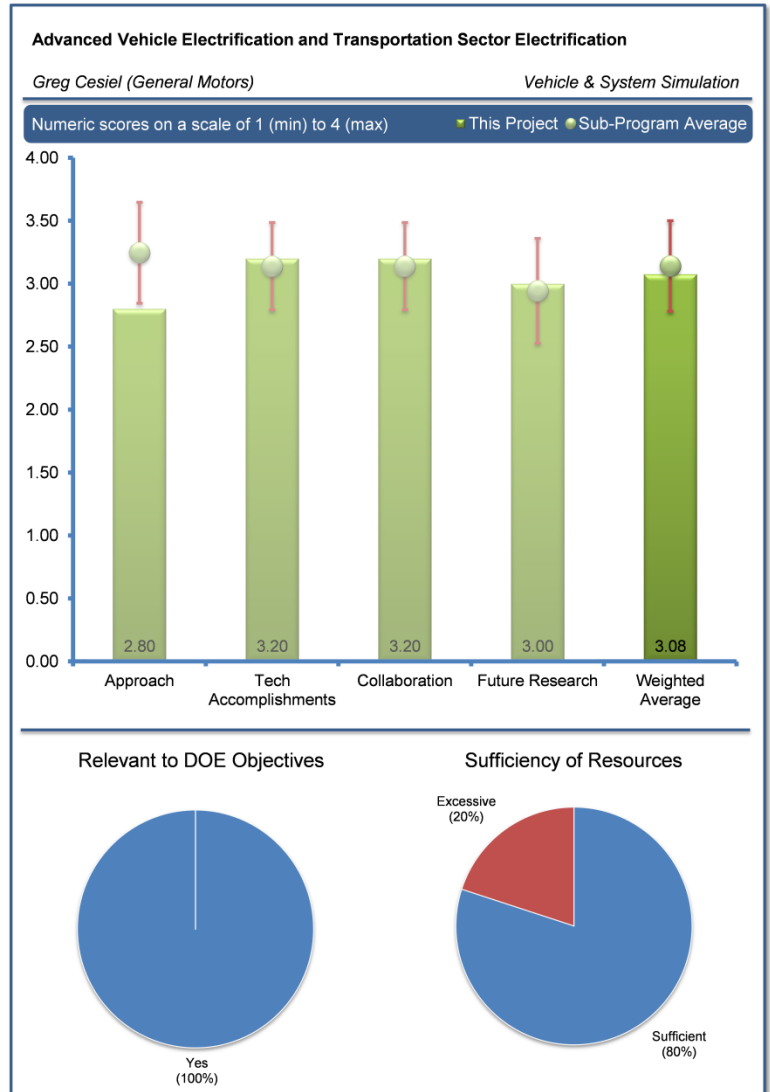
The reviewer felt that the approach of using the unique features in OnStar to acquire data is interesting. The reviewer said that comparison with data from other projects should provide insight to how PHEVs are used in a variety of applications. The reviewer noted that the smart charging aspect of the project is complementary; however, because PHEVs, and the Volt in particular, are not expected to use fast charging, it seems inapplicable to this project to conduct this investigation.

Reviewer 4:

The reviewer summarized the project as a broad-ranging task covering diverse areas including vehicle components and subcomponents, telematics, and EV charging infrastructure placement, and special projects including battery secondary use assessment, fast charging including standards development support, and smart grid charging/communications. The reviewer commented that the areas being assessed are good and ones in which more understanding is truly needed: infrastructure is being assessed in home, business, and public applications and includes Level 1 and Level 2 charging. The reviewer characterized this as good, as Level 1 may be a satisfactory (and more cost-effective) option in many deployment scenarios and has not been looked at much in other studies. Nonetheless, the reviewer commented that only relatively superficial information is provided to truly assess the overall task approach. The reviewer cited that, for example, not much is provided to assess the degree to which specific technical barriers are being addressed (or even what they actually are), nor to understand the degree to which the project is integrated with other efforts.

Reviewer 5:

The reviewer asserted that it is very difficult to evaluate this project, because it is unclear what GM actually did, beyond modifying the OnStar software to enable INL to collect appropriate data to evaluate Volt performance and charging data. The reviewer felt that there



was insufficient information to be able to tell what was done in the vehicle-to-grid (V2G) test. The reviewer opined that the presentation was a cross between a GM commercial and a rehash of data processed by INL, and the presenter was unable to answer technical questions.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that grid impacts understanding would fundamentally improve the general understanding of EV grid impacts.

Reviewer 2:

The reviewer noted very promising results and the creative means to access the data, but feared that the privacy concerns of OnStar could interfere with the overall project effectiveness.

Reviewer 3:

The reviewer commented that it appears as though all of the vehicles have been deployed, the data are being collected, and the secondary usage sub-projects are complete, with the smart charging nearing completion. The reviewer added that more details are warranted on how the fast charging sub-project is expected to be conducted and completed in 2013.

Reviewer 4:

The reviewer summarized how the project has achieved a number of technical accomplishments, including validation of key vehicle components and subcomponents, completion of Federal Motor Vehicle Safety Standards (FMVSS) and compliance testing, and development of the Volt's smartphone application. The reviewer also noted that the study on battery secondary uses has been completed, demonstrating technical feasibility, and that installation of charge stations was completed in February 2013. The reviewer reported that GM is looking at two methods for smart charging, including a non-AMI (advanced meter infrastructure) solution and the other a home area network (HAN) solution using AMI, programmable logic controller (PLC), and OnStar. According to the reviewer, a particularly interesting activity under smart charging development is the effort of GM/ Onstar to work with other OEMs to create an OEM server concept to allow automakers to come to agreement on the best standardized approach to communicate with their respective EVs. The reviewer opined that this is a significant issue which if solved would dramatically facilitate roaming and control of EVs across networks as well as associated authentication, authorization, and accounting issues. However, the reviewer indicated that no cost breakdown is provided for specific activities, which makes it difficult to truly assess progress achieved in relation to cost expenditures.

Reviewer 5:

The reviewer reported that modification of the OnStar system and integration with INL data collection was successfully accomplished. The reviewer also opined that the real-world data collected will certainly help GM optimize their vehicle designs. The reviewer speculated that the data would probably be used to help GM design another car, but that there was too much proprietary information that the presenter could not divulge for the reviewer to evaluate progress or the utility of the work.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commended the PI on great coordination with appropriate resources, calling it nice work.

Reviewer 2:

The reviewer observed that there appeared to be good cooperation with utilities and INL on data collection.

Reviewer 3:

The reviewer noted that this project is coordinating with Electric Power Research Institute (EPRI) and nine different utilities in various capacities (not well elaborated), as well as North Carolina (NC) State University for charging infrastructure analysis in a parking structure. The reviewer observed that the utilities appear to be involved in a number of smart grid, smart charging, demand

response, battery secondary use, and renewable related activities in support of EV infrastructure and GM. For the targeted activity areas of this project, collaboration seems sufficient, according to the reviewer.

Reviewer 4:

The reviewer stated that it appears as though substantial collaboration with utility partners has taken place, and the addition of INL and EPRI along with NC State University make the collaborative partnerships diverse.

Reviewer 5:

Although the reviewer noted that a number of partners are listed, the reviewer inquired whether there is more interaction and sharing of pertinent data within the partner community. Citing that the funding for this program was to support electrification of vehicles, with data from the program being valuable, the reviewer felt that at a minimum GM should provide comparison of the DOE program results to non-program vehicles. This would greatly improve the return on investment of the DOE's funding, according to the reviewer.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that standards development and secondary use of the battery are interesting as well as bi-directional power flow.

Reviewer 2:

The reviewer felt the proposed future work seems largely on point, and that the emphasis should remain on lowering the cost and improving the performance of the vehicle and improving interoperability through the smart grid while driving down costs.

Reviewer 3:

The reviewer opined that the plans for future work are sparse. The reviewer commented that the project objectives will be met and the Gen 2 of the Volt will be developed, but that details on the latter are warranted.

Reviewer 4:

The reviewer would like to see additional refinement of data to reflect in-design changes to the second-generation (Gen 2) Volt and general information made available to the public for all EV manufacturers to benefit.

Reviewer 5:

The reviewer noted that the project team will continue what the team is already doing, which the reviewer deemed was not very informative.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer agreed that the program absolutely aligned with the goals of petroleum displacement.

Reviewer 2:

The reviewer said the Volt is a superior embodiment of the DOE's goal for petroleum displacement in personal vehicles, and this project appears to be supporting further development of the Volt and further understanding of customer behavior and preferences with respect to PHEVs.

Reviewer 3:

The reviewer noted that the availability of fully tested/vetted/demonstrated vehicles is a pre-requisite for mass market adoption of vehicles that do not depend on petroleum.

Reviewer 4:

The reviewer commented that PEVs have the potential to significantly reduce the Nation's dependence upon oil for transportation. Continued technology advances in plug-in vehicles, cost reductions, and improvements in interoperability of the smart grid are essential to the continued penetration of PEVs into the marketplace, according to the reviewer. The development of a cost-effective, ubiquitous, self-sustaining EV charging infrastructure is also a key enabler to achieving this vision, the reviewer said, adding that understanding PEV and charge infrastructure utilization is a key to building market momentum for PEVs.

Reviewer 5:

The program aligns with DOE petroleum displacement goals, according to the reviewer.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources appear to be adequate.

Reviewer 2:

The reviewer said this project is 50% cost shared and that resources are sufficient.

Reviewer 3:

The reviewer trusted that all of the development and validation GM did not describe was worth the money.

Reviewer 4:

The reviewer felt that the cost of providing 146 vehicles and 278 EVSE units that were already in or nearing production at the onset of the project appears (to this reviewer) to be less than that the funding established for the project. The reviewer expressed that the project will likely result in useful outcomes and provide interesting data, but that it could probably have been done for less money.

Smith Electric Vehicles: Advanced Vehicle Electrification + Transportation Sector Electrification: Robin Mackie (Smith Electric Vehicles) - arravt072

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer praised an excellent presentation, well-rounded project, and a good niche market application for EVs. The reviewer cited that the PI appeared experienced and well in control of a complex project that has good objectives and vision for application of government funds.

Reviewer 2:

The reviewer applauded a unique business funding strategy to pass the grant to coalition members, but satisfies the need to expand the fleet to meet the 510 vehicle deployment. Battery updates mid-project will provide an additional opportunity to compare previous field testing, according to the reviewer.

Reviewer 3:

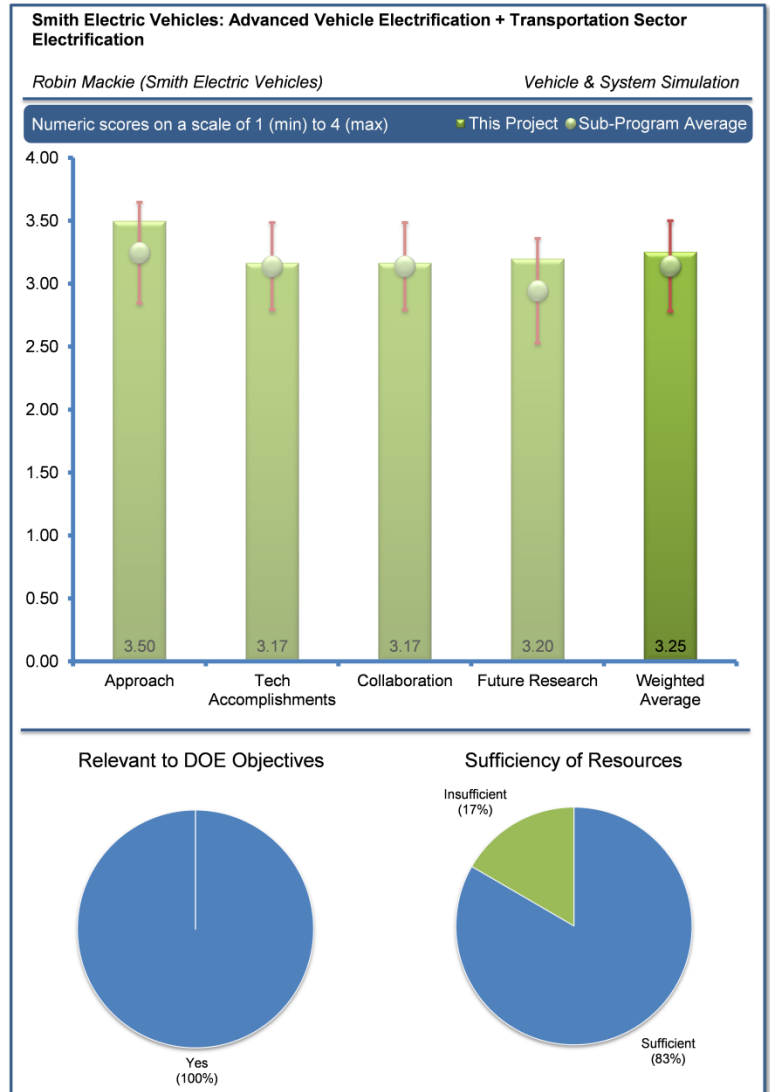
The reviewer noted that the outstanding feature of this work, in contrast to other projects, was made clear in the presentation: the customer needs dictated the capabilities that were provided in the vehicle. This sensible tactic enabled optimum performance for each use and avoided the mismatch that would have caused significant technical difficulties, according to the reviewer. The reviewer also praised the volume of data being collected as the other excellent feature. The reviewer suggested that these data be retained for more detailed analysis than required for the project, as they should provide useful insights into details about EV operation.

Reviewer 4:

The reviewer commented that the approach for this project is well-explained and delineated, covering financial, business, technical, knowledge transfer, and regulatory elements. A clear definition of the DOE funding allocation is provided, according to the reviewer, and a broad geographic deployment of vehicles has been established. The approach seems very logical and well-focused, said the reviewer.

Reviewer 5:

The reviewer commented that the company is performing the work and are capable of addressing the technical barriers. According to the reviewer, the project is well designed with respect to deployment of vehicles, Smith Link, Smith Drive, and Smith Power. The reviewer summarized that the company's approach was to maintain fundraising activity to support corporate goals; complete knowledge transfer from Smith UK to Smith USA; secure U.S. purchase commitments and participation agreements to support the



demonstration project; establish technical teams and U.S. team; and compliance. The reviewer noted the company was successful in its approach but did not know how well it has succeeded in the fundraising activity. The reviewer did voice a criticism that there was not a clear picture on the financing or how the company will complete the project.

Reviewer 6:

The reviewer stated the technical approach for this project appears sound. However, the reviewer noted it appears as though Smith was depending on the initial public offering (IPO) for additional funding for the project. The reviewer criticized that the project success and schedule should not have been dependent on such an unreliable funding source.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer said that getting hundreds of electric vehicles into successful commercial operation is an impressive accomplishment. The vehicle design is being improved and optimized based on early experience, according to the reviewer.

Reviewer 2:

The reviewer stated that, considering setbacks from various supply chain partners, the accomplishments are acceptable. The reviewer did cite the success with driving down the cost utilizing funding to make the vehicle cost-competitive is a very good use (and aligns with the intended use) of the program.

Reviewer 3:

The reviewer summarized the project as a commercial deployment of a commercial vehicle fleet with an operating data collection system planned for vehicle and customer information.

Reviewer 4:

The reviewer noted that the project is basically on track except for some slippage due to the listed reasons. However, the reviewer acknowledged that Smith appears to have worked through the issues and are achieving project milestones, if somewhat delayed.

Reviewer 5:

The reviewer judged that the technical targets for this project are very well delineated and detailed. The reviewer noted that 422 of the scheduled 510 vehicles have been delivered, with the remaining 88 having received order commitments. The level of vehicles supplied (82%) and project expenditures (85%) are largely in harmony, said the reviewer, and the Gen 2 Smith Drive and Smith Power supply chain established- production level Smith Drive components have been received from a volume supplier to help drive down costs. The reviewer further noted that the shuttle bus and stepthrough van vehicles have been developed and introduced. Smith Link established and utilized across Smith for service support, engineering, business development, R&D, duty cycle analysis, diagnostics, and customer fleet performance, according to the reviewer. The reviewer also cited that the project is somewhat behind schedule do to the Smith IPO, supplier quality and commercial issues. Redesign of the Smith Power Batteries Strategy is underway to accommodate an interim generation solution to reduce reliance on a previous supplier, according to the reviewer, and the cell-agnostic modular battery system has been delayed due to existing supplier quality issues. Finally, the reviewer observed that jobs created are somewhat lagging at 58% of project target.

Reviewer 6:

The reviewer noted that the company successfully introduced the Newton Shuttle bus and delivered Newton step-through van; developed and improved the Global Positioning System (GPS)-based operational monitoring system and Gen 2 all-electric vehicle (AEV) drive and battery systems; created 131 new U.S. jobs; and a cost reduction strategy is in place. The company is making progress towards accomplishing the overall project and DOE goals, according to the reviewer, who went on to describe the main concerns as follows. First, the reviewer questioned whether going forward the company has enough financing to complete the project, observing that the company still has to deploy 88 vehicles with the approximate cost of each vehicle at \$54,000 and the remaining \$4.7 million budget as just enough to deploy the stations. Second, the reviewer said that the company will run into issues if they are

not successful with the cost reduction. Third, the reviewer noted that the goal is to create 225 jobs but questioned whether the company can create jobs with the remaining budget. The reviewer indicated that the picture on the financing and how the project team will complete the project was unclear.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer cited excellent and broad ranging collaborations with multiple entities in the United States and United Kingdom (UK) for duty cycle forecasting modeling, E-van ultra-efficient system development, electric motors using non-rare earth magnets, hydrogen fuel cell range extender for an AEV, AEV school buses, and V2G charging systems and performance analysis. The reviewer described this as tapping a wide variety of partners for collaboration in academia, industry, National Laboratories, government agencies, and in at least one case, leveraging funding from another program [i.e., UK., Department for Transport (DFT), and Technology Strategy Board (TSB) funded program].

Reviewer 2:

The reviewer stated that the project has collaborations on the research side as well as on the utilization side.

Reviewer 3:

The reviewer described commendable cooperation with the UK as well as a nicely broad base in the United States, including universities, key suppliers and the federal government.

Reviewer 4:

The reviewer noted how the company has collaborated and coordinated with other institutions on the project, listing the following: work on the Duty Cycle Forecast Model with the Kansas University Center for Research; the E-Van Ultra Efficient System development with the UK, DFT, and TSB-funded program; the high-efficiency drivetrain, with Bristol University (UK); the controller programming, with Leicester University (UK); collaboration with QM Power on an Advanced Research Projects Agency - Energy (ARPA-E) project to develop electric motors using non-rare earth magnets; a Smith, DOE, NREL and GM joint project to demonstrate a hydrogen fuel cell range extender on an AEV; partnership with Trans Tech to deliver AEV school buses to school districts; the partnership with NREL, Burns & McDonald, Schneider Electric, and TARDEC to develop Vehicle-to-Grid charging systems; and finally, TARDEC V2G Performance Analysis, done in collaboration with the Missouri University of Science and Technology.

Reviewer 5:

The reviewer noted that big data acquisition and recording allows partners to look at vehicle usage and operating procedures (driver skill) to be analyzed and return information to users to increase efficiency and raise adoption.

Reviewer 6:

The reviewer mentioned a variety of collaborations, especially for ancillary programs of the project, but cautioned that there does not appear to be much in the way of collaborations on the main project, the re-design of the Smith EV. The project would perhaps benefit from more partners in this area, according to the reviewer.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the most commendable part on the future work is the training of 95 new workers that go on to spread the training to other potential users, builders and suppliers.

Reviewer 2:

The reviewer indicated the company has a plan in place for future work for deployment of vehicles, Smith Link, Smith Drive and Smith Power, but that again the main concern is financing.

Reviewer 3:

The reviewer reported that the project work will continue on its current course. However, the reviewer indicated that the real question is future economics, questioning whether anybody would buy one of the vehicles without a hefty DOE cost share.

Reviewer 4:

The reviewer observed that Smith appears to have a vision for completing its redesign and how to achieve market success. The reviewer also warned that the battery, motor, and data collection/presentation development will all be required to make this vehicle attractive to the consumer.

Reviewer 5:

The reviewer voiced that the proposed future work appears on target. Overall, the thrust is to continuously improve the performance of Smith Drive and Smith Power components; drive down costs by improved design, modularity/flexibility/scalability, and supplier competition, according to the reviewer. The reviewer noted the move toward prismatic and pouch configurations while reducing reliance on single cell providers. A significant cost reduction (28%) is targeted by Q4 2013, cited the reviewer, who characterized it as overall, a classic engineering design and implementation project. The reviewer warned that it is important to keep this focus on continuous quality and cost improvements throughout the entire system. As one outside area for possible consideration in the future, the reviewer asked whether it would be feasible to explore some element of DC fast charging (different levels of DCFC are becoming available) coupled with very conducive driving cycles that may permit vehicles to meet some customers' requirements / expectations with significantly lower battery pack capacity. The reviewer suggested this may be worth exploring especially as the Federal funding for vehicle purchases is expended and the cost challenges become more acute.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer applauded excellent work on a niche market with what appears to be a well-designed quality product.

Reviewer 2:

The reviewer remarked that not only does the use of these vehicles directly displace petroleum, but old diesels, such as school buses, are being displaced, reducing criteria pollutant emissions.

Reviewer 3:

The reviewer offered that deploying the 510 EVs will reduce the dependence on oil.

Reviewer 4:

The reviewer said that the slide depicting the 23 tanker trucks of diesel nicely showcases the impact of this program and highlights of the opportunity of optimizing this area of the industry with appropriate driveline optimizations.

Reviewer 5:

Plug-in electric vehicles, including medium-duty (MD) electric vehicle commercial applications, have the potential to significantly reduce the nation's dependence upon oil for transportation and improve air quality, especially in congested urban areas, according to the reviewer. The reviewer noted that medium-duty commercial vehicles are subject to a wide variety of duty cycles and applications with many potential niches suitable to electric drive. Continued technology advances in the performance of medium-duty electric vehicles and most especially cost reductions are key to enabling this market, the reviewer said.

Reviewer 6:

Electrification of delivery vehicles supports the overall DOE goals of reduction in petroleum consumption, said the reviewer, adding that this project is a positive step towards these goals.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources appeared to be sufficient, according to this reviewer.

Reviewer 2:

The reviewer said that hopefully appropriate numbers of staff will help to identify quality risks in supply chain issues without continued impact to the deliverables of this project.

Reviewer 3:

The reviewer said there is substantial re-design and development occurring during this project, and the funding of the project appears appropriate for this endeavor.

Reviewer 4:

The reviewer noted this project is 54% cost shared, with 87% of DOE funding going to AEV buyers participating in the DOE Electric Fleet Data Collection Program; only 13% of DOE funding goes to support project development costs. The reviewer advised that if necessary, it may be reasonable to consider additional targeted funding to support this project if continued project progress is achieved and market interest is clearly demonstrated.

Reviewer 5:

The reviewer highlighted that most of the money subsidized vehicle purchases. The reviewer also asked how much costs will come down so that companies/school districts can afford such vehicles in the future.

Reviewer 6:

As per the presentation, the company seemed to have enough resources to complete the project, according to the reviewer, but going forward, the reviewer could not gauge whether the company has enough financing for resources.

ChargePoint America: Kumar Gogineni
(ChargePoint, Inc.) - arravt073**Reviewer Sample Size**

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked on being impressed by the number of charging units installed, and clearly the residential ones went to people who bought vehicles. The reviewer extended this observation to note that similarly, commercial establishments either bought vehicles or thought chargers would draw customers, and asked whether there is a tabulation of which of each kind. The reviewer asked how the public locations were chosen, and professed to be very concerned that insufficient attention is being paid to where stations would really be needed and what type they should be. The reviewer considered Level 2 charging in airport long-term parking to be an example of poor planning. According to the reviewer, given the cost, there should be some concern for utilization, unless the chargers are just to give EV owners confidence (as the UC Davis study implies).

Reviewer 2:

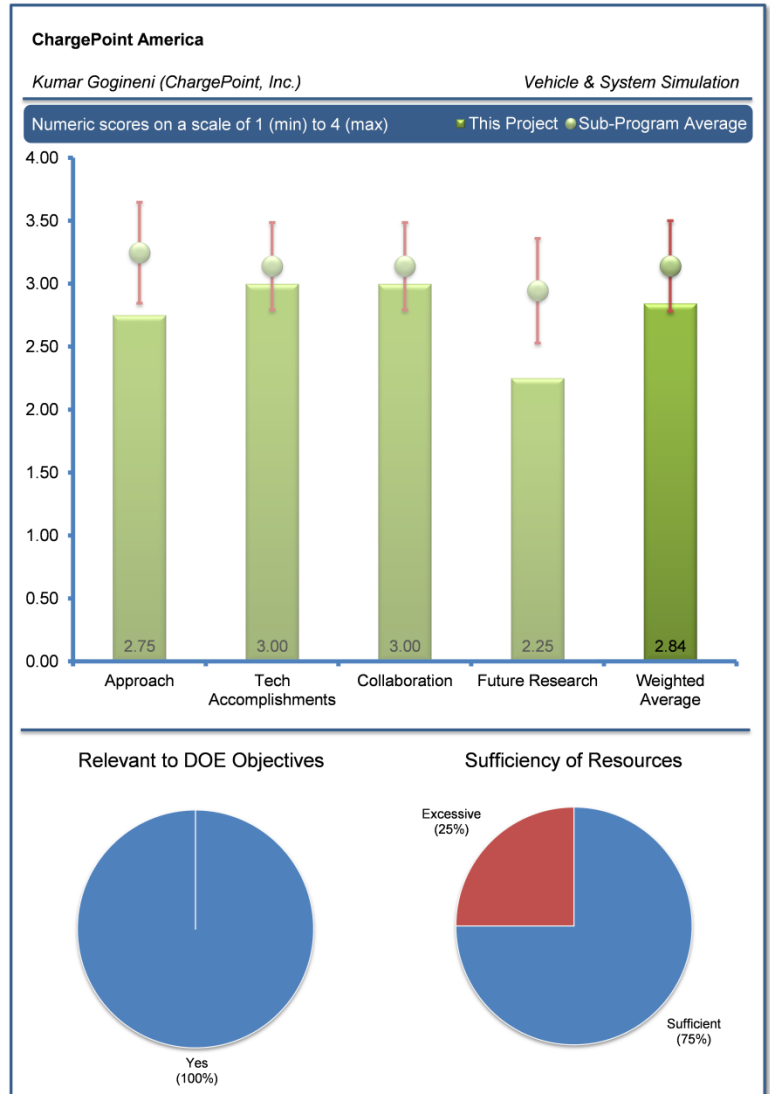
The reviewer commented that the approach to this effort seems reasonable although only a modest amount of information is provided in this regard. The reviewer summarized that deployments in 10 metro areas have been conducted including residential, commercial, and public installations. The reviewer noted that the project includes an excellent distribution of deployment applications including public parking and garages, workplace, retail, utilities, airports, educational institutions, and multi-family dwelling units, with all data sent to INL for collection and analysis, and quarterly reports provided on project results.

Reviewer 3:

The reviewer reported that varied markets with low percentages in any one area forced them to learn the implementation process in many different areas, which is inefficient, and adds to the initial cost.

Reviewer 4:

The reviewer criticized a somewhat uninspiring presentation, noting that similar to one other project this appears to be focused on the details of managing the project or task of installing 4,600 charging stations and reporting back the usage. The reviewer felt unsure if the objective of accelerating the development and production of electric vehicles has been met, or whether it is an expensive charge station installation program at nearly \$7,250 per station. The reviewer asked whether this did not just prove that the payback for a station cannot be met at any reasonable period. The reviewer commented that certainly it shows that improvements must be made to make EV charging viable.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer pointed out that the idea was to deploy chargers, which are out there, collecting data.

Reviewer 2:

The reviewer affirmed an interesting deployment and impacts for multi-dwelling units, and added that this may be an area of interest for DOE national permitting activity.

Reviewer 3:

The reviewer acknowledged reasonable technical progress in achieving the goal of 4,600 charging stations, but inquired as to the recommendations for reducing the infrastructure costs on a global as well as local basis.

Reviewer 4:

The reviewer observed that the project is on schedule with all deployments (approximately 4,600) completed, 900,000 charging events recorded, and 6,355 megawatt-hours (MWh) of energy consumed. An interesting synopsis of observations is provided for residential, commercial, and multi-dwelling unit applications, according to the reviewer, who added that this is the type of information for which more understanding is needed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commended a good job obtaining additional funding from partners.

Reviewer 2:

The reviewer observed that the project has collaborations with a variety of vehicle manufacturers but does not mention any coordination with utilities, municipalities, nor other broad groups of end users. The project secured a \$3.4 million dollar grant from the California Energy Commission (CEC) for residential, commercial, and multiple-dwelling unit (MDU) installations, as well as a small grant from the Association of Bay Area Governments for deployment of ports in MDUs.

Reviewer 3:

The reviewer wanted to know whether the many organizations involved in the project were satisfied.

Reviewer 4:

The reviewer noted that the data coordination seems to be working quite well, and that everyone seems to have the same graphs. The reviewer opined that unfortunately, many of them are illegible, and there is insufficient explanation of the differences between them or their significance. The reviewer asked whether time-of-day pricing or free charging were in effect, and wanted to know how charge taken compared to battery capacity. Another question from the reviewer was about what types of sites were used most. The reviewer expressed concern with getting all of the useful insights possible from the data.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer offered that the project could use analysis that includes lessons learned on the installations, operations, design for lower cost, etc.

Reviewer 2:

The reviewer commented that the team was going to do more of the same, and that there was nothing more to add.

Reviewer 3:

The reviewer observed that with the project in its final phase, the only plans are to collect more data, with no comments on how to utilize data to help overcome barriers observed in the future.

Reviewer 4:

The reviewer opined that the plan for future work is very sketchy beyond data collection. The reviewer felt it would be beneficial to know what ChargePoint's specific plans are for data analysis (what is going to be focused on) and information dissemination. The reviewer asked whether there is a specific strategy underway, who are going to be the principal target audiences, and what is going to be the focus. Additionally, the reviewer inquired as to whether any thought has been given to ways to further improve the form and usefulness of information and dissemination approaches for specific end user communities.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that PEVs have the potential to significantly reduce the nation's dependence upon oil for transportation. The development of a cost-effective, ubiquitous, self-sustaining EV charging infrastructure is a key enabler to achieving this vision, according to the reviewer, who went on to state that understanding PEV and charge infrastructure utilization is a key to building market momentum for PEVs.

Reviewer 2:

The reviewer pointed out that the vehicles need to be charged to displace petroleum, so installing chargers is important, although many users would be just fine plugging into the wall at home, so Level 2 may not be needed for PHEVs.

Reviewer 3:

The reviewer expressed that it would be good for the VTO to provide a level comparison between the EVSE provided from various vendors, and how locations or other parameters might have an impact on their public use.

Reviewer 4:

The reviewer commended good relevance, but requested that the result be used to return more to the sponsor than tons of data.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer cited that the money for this project was needed to support the installation of lots of equipment.

Reviewer 2:

The reviewer pointed out that as the deployment of the project appears to be complete, the resources required to continue the project seem adequate.

Reviewer 3:

The reviewer stated that this task is 50% cost shared, and the resources are sufficient.

Reviewer 4:

The reviewer cited a high cost on average per station installation.

Class 8 Truck Freight Efficiency Improvement Project: Derek Rotz (Daimler Trucks North America LLC) - arravt080

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer expressed that Daimler has reached an excellent balance of work done on this project and available funds, particularly using this project to complete not otherwise planned in their normal R&D efforts. The reviewer applauded the team taking commercialization very seriously and not just throwing a bunch of technologies in to meet the 50% goal. The reviewer also cited how this team appears to be taking these concepts more quickly into their product launch plans than others, ensuring one of the program goals of creating jobs in the United States.

Reviewer 2:

The reviewer described a straightforward engineering approach using simulation analyses in the early phases of the work to be followed by actual hardware truck builds.

Reviewer 3:

The reviewer noted a comprehensive technical approach to the entire vehicle system using a number of computational tools, with the project on schedule.

Reviewer 4:

The reviewer cited a good evaluation (analytical roadmap) to quantify opportunities of all options.

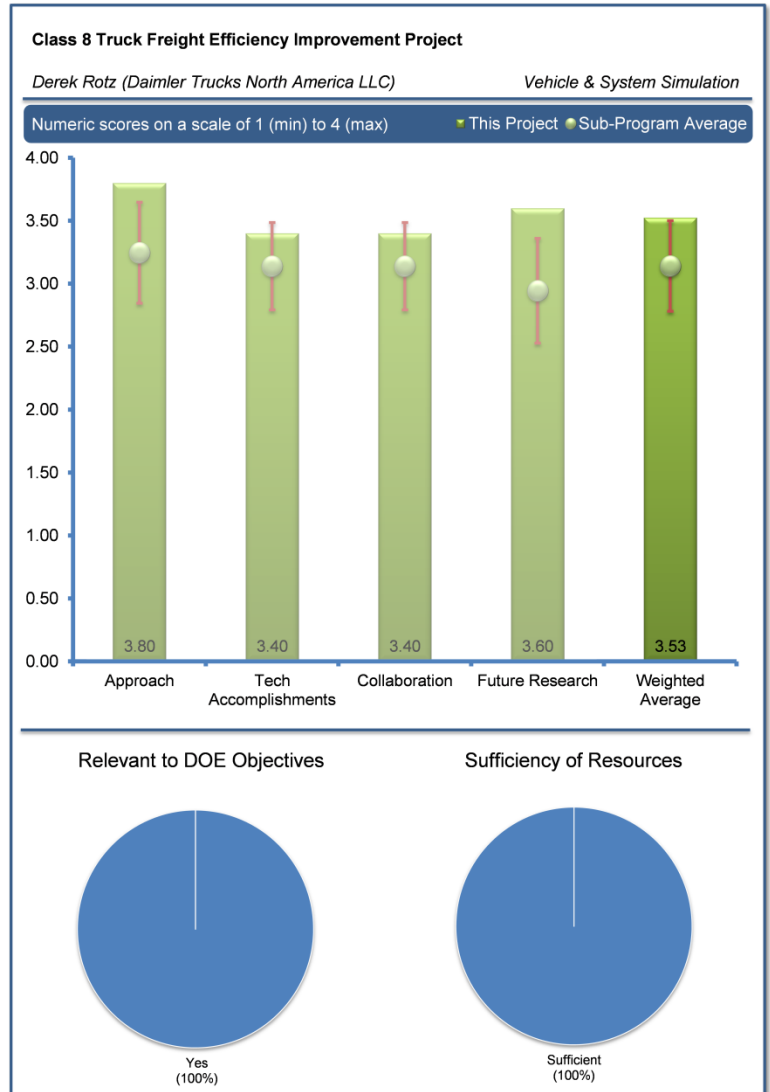
Reviewer 5:

The reviewer agreed that the project offers a complete technology package covering detailed aerodynamic improvement plan, hybrid, and vehicle and powertrain integration plan. The reviewer noted it should be on the way to meeting the targets. However, the reviewer felt it is not clear how a hybrid can help an on-highway truck operation.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer found that the team is making decisions and progressing on designs well. The reviewer observed that the project team used its tinker trucks to confirm subsystems before putting them onto the final vehicle. The reviewer also noted that the team engaged R&D in Germany sufficiently.



Reviewer 2:

The experimental validation of expected results is progressing, according to the reviewer.

Reviewer 3:

The reviewer mentioned that a comprehensive technical plan allowed Daimler to meet the key program milestones in time. The aerodynamic improvement with the inclusion of a tractor and trailer is impressive, the reviewer said, adding that truck assembly with many technologies is moving forward.

Reviewer 4:

The reviewer applauded an excellent utilization of computational tools for system design and integration. In addition, the reviewer cited that the physical system testing has met milestones. As mentioned in the presentation, hybrid system key-on is a couple of months behind, but barriers appear well managed, according to the reviewer.

Reviewer 5:

Progress appears to be adequate to overcome one or more barriers albeit rather slow to occur, according to the reviewer.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer commended a comprehensive and binned list of collaborations within their respective expertise.

Reviewer 2:

The reviewer indicated that Slide 16 shows key collaborations are in place. The reviewer commended the nice utilization of work with the university and laboratories.

Reviewer 3:

The reviewer noted that many partners are involved in the program, but that each party's involvement in the program would be clearer if each were properly acknowledged in a slide that is associated with its contribution.

Reviewer 4:

According to the reviewer, collaboration apparently does exist among the partners, albeit again somewhat slow.

Reviewer 5:

The reviewer observed that this is always a challenge and appears that the team Daimler put together is doing this. The reviewer professed to being slightly concerned that this team is driving much if not all of the work and maybe not completely utilizing all the expertise at the supplier organizations, but the reviewer admitted that there was no solid evidence to confirm this.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that Daimler has a good plan to evaluate the technologies and is utilizing their fleet partner to ensure data collection and feedback on the designs.

Reviewer 2:

The reviewer stated that the technology benefits are well understood and laid out. The plan is in motion and should be achieved, according to the reviewer.

Reviewer 3:

The reviewer said that actually building the trucks will show that indeed the barriers are being overcome and the presentation should be improved to clarify which results are from simulations and which are from actual truck system level builds.

Reviewer 4:

The reviewer commended a good plan to continue to validate aero, powertrain and engine and waste heat recovery (WHR). The reviewer added that a build-up of demonstrator vehicles is needed.

Reviewer 5:

The reviewer observed that the future plan shows the roadmap of how the final program target can be reached.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer commented that improving truck FE does indeed support the overall DOE objective of petroleum displacement.

Reviewer 2:

The reviewer said that from the work completed, and the work proposed, it appears that the stretch goals may well be met and demonstrated.

Reviewer 3:

The reviewer stated that Daimler is number one in market share and is already demonstrating leadership in this area, citing the Revolution truck at 9+ miles per gallon (mpg).

Reviewer 4:

The reviewer claimed that if successful, the project could result in commercial product(s) that will improve freight efficiency.

Reviewer 5:

The reviewer cited the 50% improvement in freight efficiency as the best indication of the project supporting the overall DOE objectives of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The resources appear sufficient, according to the reviewer.

Reviewer 2:

The reviewer opined that 40% of the remaining funding should be adequate to complete the program and meet the program targets.

Reviewer 3:

The reviewer observed that the resources for this project are substantial and do appear sufficient to achieve the stated milestones, although perhaps not in a timely fashion.

Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks: Scott Newhouse (Peterbilt) - arravt081

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that this was the most complete technical package seen for a long time.

Reviewer 2:

The reviewer indicated that targets had been met and/or exceeded, and were on schedule. The reviewer added that more than 60% gains in freight efficiency were shown using near to production technologies. The approach, which focused on production capable technologies, has shown to be effective.

Reviewer 3:

The reviewer said that the approach was a straightforward and systematic engineering approach but with added risk from the utilization of optional advanced devices such as the solid oxide fuel cell and Li-ion start battery. The reviewer noted that this apparently has been rewarded by gaining operational experience with such advanced systems as well as enabling achievement of the project objectives.

Reviewer 4:

The reviewer noted that there was good collaboration with engine OEMs. The reviewer added that other suppliers and collaborators were involved for a comprehensive approach.

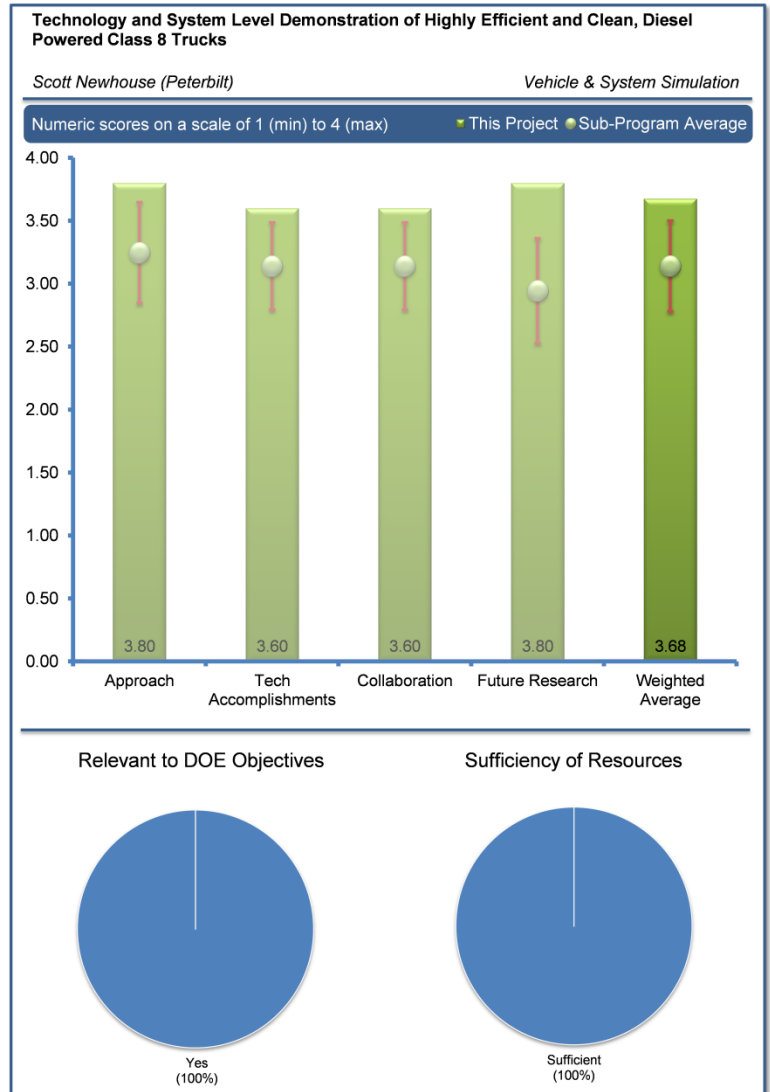
Reviewer 5:

The reviewer observed much better understanding of the approach this year compared to prior ones. Peterbilt shared much more about their concepts and the results were impressive. The reviewer described using the fleet to a high extent, and their drivers in particular, as outstanding.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that the results of this program were absolutely outstanding.



Reviewer 2:

The reviewer said that all goals were met (or exceeded) and were on time.

Reviewer 3:

The reviewer indicated that to date, technical objectives have been achieved and are on schedule. This means that the barriers were being addressed and overcome.

Reviewer 4:

The reviewer noted that demonstration of efficiency targets were ahead of schedule.

Reviewer 5:

This reviewer seeks confirmation of the vehicle level goals a bit more. The reviewer thought that the 68% freight efficiency improvement was impressive in that the changes to the vehicle were not so dramatic, and encouraging that there was this much opportunity without huge, but still big, change.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that from the successful results, it appeared that the proper tier suppliers were selected (results are indicative of sufficient coordination).

Reviewer 2:

The reviewer said that the overall project has required intensive collaboration among many suppliers as well as involvement of the end users for acceptability. The reviewer went on to say that this was the primary reason for the successful achievement of the objectives.

Reviewer 3:

The reviewer pointed out that the team seemed to be reaching a good balance of collaboration and progress. The reviewer said that the project used specific skill sets of partners rather than doing too much on its own. The reviewer also noted that it seemed that there was less coordination between Peterbilt and Cummins in the presentations, but added that this could be due to the powertrain integration having been mostly done last year.

Reviewer 4:

The reviewer noted that Slide 4 showed good collaboration with suppliers.

Reviewer 5:

The reviewer noted that Slide 4 on participants was misleading with such a long list. The reviewer added that it should list partners that were supported as subcontractors funded by the program, like all other competitor programs.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the Demo 2 vehicle appeared to be on track and solid oxide fuel cell (SOFC) dropped in favor of lithium battery. The reviewer added that the project should be sure to include detailed plans on battery sizing and durability.

Reviewer 2:

The reviewer said that the future plan pointed to the direction that the program goals would be delivered.

Reviewer 3:

The reviewer indicated that the focus on refining production capable technologies was largely promising.

Reviewer 4:

The reviewer noted that the follow-on work planned to conduct cost/benefit analyses of individual devices and technologies to enable earliest commercial introduction.

Reviewer 5:

The reviewer suggested to exploit the relationship with the fleet partner as the final prototype is tested, being sure to collect solid data as well as quantitative driver inputs.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer pointed out that greater than 60% freight efficiency gains have been demonstrated and that these were outstanding numbers.

Reviewer 2:

The reviewer noted that the project was very relevant and that Cummins, with the largest engine market-share, could use their knowledge to influence all truck-makers.

Reviewer 3:

The reviewer said that improvement of freight delivery FE does indeed support the DOE objective of reducing petroleum consumption.

Reviewer 4:

The reviewer said that well over DOE's 50% improvement targets on freight efficiency absolutely supported the overall DOE objectives of petroleum displacement.

Reviewer 5:

The reviewer noted that if successful, the project could provide a commercial product which increases freight efficiency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer commented that the resources for this project were substantial and appeared totally capable of meeting the milestones in the time schedule laid out.

Reviewer 2:

The reviewer said that the results relative to the promise of production viability indicated success.

Reviewer 3:

The reviewer said that the remaining funding should be adequate to deliver the final program goals.

SCAQMD: Plug-In Hybrid Electric Medium-Duty Commercial Fleet Demonstration and Evaluation: Matt Myasato (SCAQMD) - arravt083

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the objective of a nationwide demonstration of 400 trucks using a production ready, commercialize-able PHEV system and developing a production ready smart charging capability would provide for an excellent set of data on this technology.

Reviewer 2:

The reviewer said that it was really nice to see a project that combined a propulsion hybrid with a worksite hybrid. The reviewer hopes that the vehicle deployments and the data analysis will both exploit the different features and clarify for users and others, just what features are most beneficial in different uses and situations.

Reviewer 3:

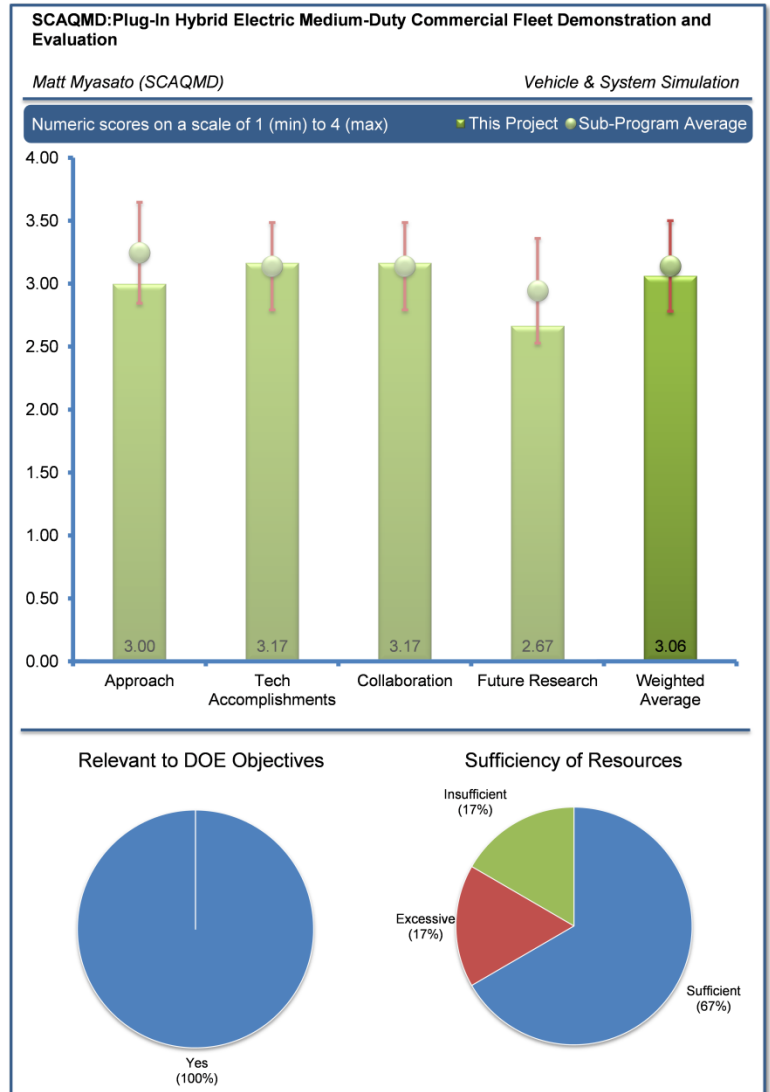
This reviewer noted that the project had a good approach to identify the impact on a number of vehicle applications, but that the actual efficiency improvements would be difficult to quantify without laboratory environment testing. The reviewer said that simulation results would have been nice prior to vehicle and application selection to ensure appropriate selections of applications.

Reviewer 4:

This reviewer indicated that the original project plan appeared to have been infeasible, and thus there had not been much progress in four years. The reviewer said that the current plan uses a VIA design that is already proven for a part of the project, which should make the objectives more attainable. The reviewer added that the Odyne system also appeared feasible and that the barriers to project success do not appear insurmountable.

Reviewer 5:

The reviewer indicated that the organization has an approach to deploy 280 MD PHEVs and develop production ready Class 2-7 PHEV system. The reviewer added that the organization has identified the technical barriers but does not know if the project will be able to address the barriers. The reviewer noted that three-and-a half years have passed since the project got started, and that based on the presentation it showed that the project was not well-designed.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer noted that the PHEV systems have been developed and that the project is currently evaluating prototypes in the field.

Reviewer 2:

This reviewer pointed out that the organization has made some progress towards achieving overall project and DOE goals; but that based on the presentation, it was clear that the organization did not make much progress in the last three-and-a-half years. The reviewer went on to say that the organization did not present any performance indicators that were met.

Reviewer 3:

This reviewer noted that the program delays due to multiple supplier issues have reduced the project's accomplishments. The reviewer added that good program recovery planning would still enable adequate vehicle numbers and appropriate vehicle use.

Reviewer 4:

This reviewer acknowledged that the setbacks (that could have been provided in more detail during the presentation) have limited the progress of this project severely. The reviewer added that the VIA design was already complete outside of this project, and so this aspect of the project appeared to be on course for success. The reviewer noted that it was not clear from the presentation what the progress of the Odyne hybrid system was, and so it was difficult to gauge the level of progress there.

Reviewer 5:

This reviewer indicated that it was difficult to do much evaluation at such an early project stage. The reviewer said that the hope is that the uses for these trucks will be appropriately selected so that sufficient power is available without the need for over-design.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the team, as assembled, covered the development and deployment aspects of the truck development quite well. The reviewer added that it would be important to select appropriate users or utilities and collect the data required to optimize future vehicles based on lessons learned.

Reviewer 2:

The reviewer noted that collaborations and partnerships had been formed in this project with a variety of private and public entities that should provide for success of the project.

Reviewer 3:

This reviewer said that the project collaborations seemed extensive and appropriate. The reviewer added that the hardware developers were proven in the industry but that it was not clear, however, who the fleet partners would be.

Reviewer 4:

This reviewer identified that the organization has collaborated and coordinated with other institutions: CEC – Funding Partner; EPRI – Program Management and Fleet Coordinator; VIA Motors – Hybrid System Developer; Odyne Systems – Hybrid System Developer; So Cal Edison – Battery and Vehicle Testing; JCS – Battery Supplier; Pathway Technologies – Smart Charging Router; and the Electric Utility Industry.

Reviewer 5:

This reviewer noted that leveraging the use of fleet partners to obtain data on nearly 400 vehicles would help to quantify emissions reduction as well and petroleum displacement in the many applications represented. The reviewer went on to say that gathering supplemental funding from partners indicated value to industry.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that there appeared to be a sound project plan to move forward. The reviewer then asked what media would be used to disseminate the project findings.

Reviewer 2:

The reviewer pointed out that the team planned to complete the project as planned. The reviewer urged the team to take care in matching users to vehicles, and to assure sufficient data collection for analysis.

Reviewer 3:

The reviewer stated that the organization has shown a plan for future work to: complete system and calibration validation testing for the VIA Motors and Class 6/7 applications; initiate deployment of VIA Vans and Class 6/7 PHEV's; install cellular based data acquisition systems and set-up download servers to acquire in-use performance data; install Level 2 vehicle charging infrastructure; complete the deployment of VIA trucks, vans and Class 6/7 PHEV's; evaluate and analyze the vehicle operation in the field; conduct laboratory emissions and FE tests; and identify opportunities for cost reductions. The reviewer added that even though the company has shown a future plan, and based on the work that has been completed so far in three and-a-half years, it is going to be hard for the organization to complete the project.

Reviewer 4:

The reviewer commented that data acquisition will be limited to one year based on delays in the program. Future plans should be included in the re-scope, to ensure the best results of the project.

Reviewer 5:

The reviewer noted that since the project started in 2009 and that the first truck had not been delivered yet, that it was very important that the trucks start to be put into use later this year and that data start to be collected. The reviewer added that the analysis of data from vehicles in the field and laboratory emissions and FE tests would be excellent information to help promote the use of this technology in the future.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said that work trucks were an ideal application for vehicular electrification and that this project certainly supported the DOE goals of petroleum displacement in all areas of transportation.

Reviewer 2:

This reviewer stated that this project supported the DOE goal of petroleum displacement through the use of hybrid technology, which will reduce greenhouse gas emissions, criteria pollutants and displace petroleum.

Reviewer 3:

The reviewer commented that deployment of medium-duty PHEVs will reduce petroleum consumption.

Reviewer 4:

This reviewer believes that PEVs will directly displace petroleum.

Reviewer 5:

This reviewer stated that the use of PHEVs reduces petroleum use if the users bother to charge them (sometimes a problem for commercial vehicles). The reviewer then added the displacement of petroleum in trucks often means a reduction in criteria pollutant emissions from the old diesels they replace.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that resources were sufficient.

Reviewer 2:

This reviewer could not gauge how many resources were working on the project based on the presentation and could not figure out whether the lack of progress was due to resources.

Reviewer 3:

This reviewer said that this was very hard to judge with no breakdown of costs provided.

Reviewer 4:

This reviewer said that with the VIA design already developed independently of this project, the project funds were likely excessive for the deployment of this vehicle, the development and deployment of the Odyne trucks, the deployment of the infrastructure and then the data collection and analysis.

Medium and Heavy-Duty Vehicle Field Evaluations: Kevin Walkowicz (National Renewable Energy Laboratory) - vss001

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the approach was on target and current with the new partnerships being evaluated yearly.

Reviewer 2:

The reviewer believes that it seems like a reasonable approach.

Reviewer 3:

This reviewer stated that the data collected provided great insight. Unfortunately, the insight was that electric trucks (e.g., Smith EVs) do not perform in practice anywhere close to what the manufacturers claim. While the slides do not reflect improved vehicle performance, the presenter noted that there had been positive movement toward the advertised vehicle specifications. As noted during the presentation, the NREL would soon conduct a deeper analysis of the data to determine what factors influenced vehicle performance. The reviewer added that without that type of analysis, it was impossible to know if this was strictly a bad news story or if there were actionable measures that could be taken to bring these trucks into the realm of financially (and operationally) viable products. The manufacturers' response to these concerns is to focus on more rigid route planning, but the reviewer hoped that NREL does not fall into this trap. The reviewer commented that ultimately, electric trucks need to perform like any other trucks if they are going to be broadly adopted. In the reviewer's opinion, NREL ought to be focusing its attention on improving the technology to reach comparable capabilities with internal combustion engine (ICE) vehicles rather than continuing to define parameters where the current underperforming technology could be good enough.

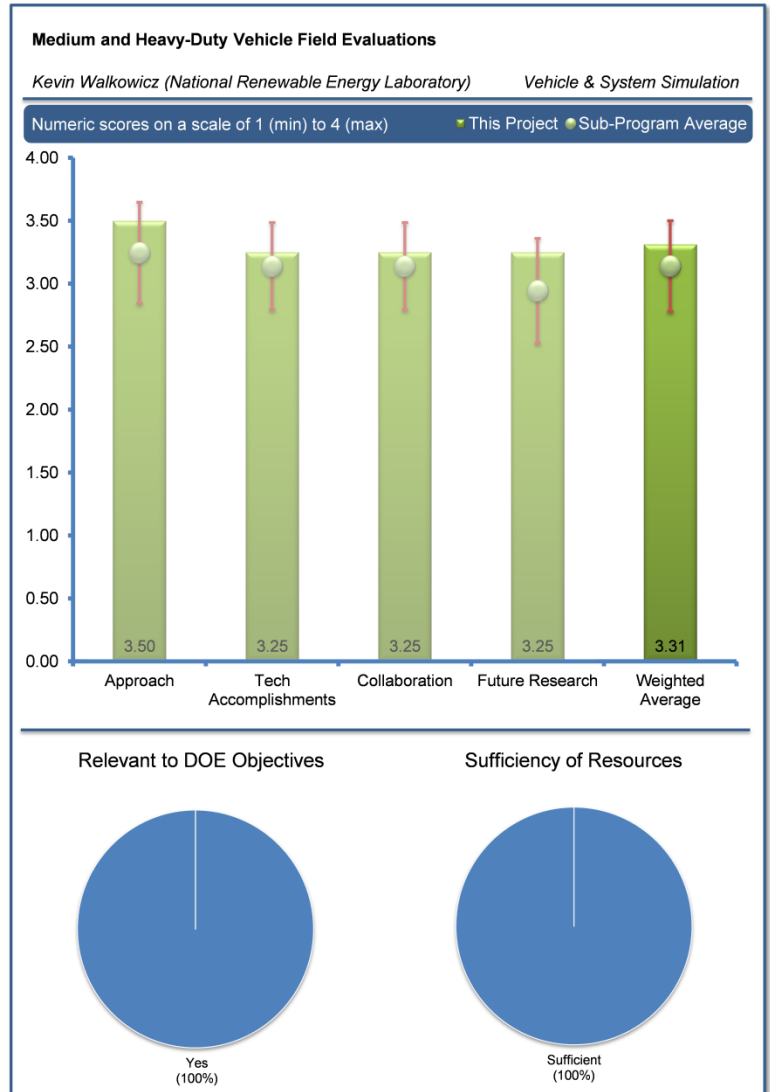
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer said that the technical accomplishments in new analytical tools and methods were well-founded to address the diverse variable vehicle usages.

Reviewer 2:

The reviewer said that the goal seemed to be to collect data on a range of technologies which was being done. The analysis of the data was where the reviewer questioned if enough was being done. Since these were MD and HD trucks, the reviewer said that it would be



nice to see the major metrics be fuel consumption normalized by work, like the greenhouse gas (GHG) regulations use. The reviewer would have liked to see more analysis of the variability of the data. The reviewer wanted to know what really was driving the variability. If it was driver behavior, vehicle mass, ambient conditions, the reviewer asked if a metric could be created that included those items.

Reviewer 3:

The reviewer said that as noted previously, the work appeared incomplete without actionable items to improve the technology; but that the work to date had clearly defined the current status of the technology.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that it looked like there was good collaboration with the industry to collect the data.

Reviewer 2:

The reviewer commented that the project technology diversity and mix of vehicle applications evaluated demonstrated collaborative efforts across partnership OEMs. Data collection, reporting and database development activities also demonstrated effective collaborative and coordination efforts within NREL.

Reviewer 3:

This reviewer stated that there ought to be a partnership with the General Services Administration (GSA) to provide this performance data directly to government fleet managers interested in procuring EVs. Ideally, the data could be provided as part of AutoChoice (the system by which fleet managers procure vehicles from GSA).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that looking for the new technologies seems like the right thing to do, but indicated that the project should keep an eye on even the standard technologies and use patterns that might be changing over time.

Reviewer 2:

The reviewer indicated that now with the FE or freight efficiency bar being raised at most every vehicle OEM to meet regulations, the baseline bar is also improving, but not necessarily with the adoption of revolutionary technology. The evolutionary technology needs to be assessed, such as advanced transmissions and improved brake thermal efficiency (BTE) powertrains by this project, which will be a more cost-effective market entry before the revolutionary technology is adopted. The reviewer stated that the approach was generally good but suggested improving the evaluation of baseline vehicle with a better understanding of underlying variables that affect differences found between dynamometer and in field testing. The industry needs better vehicle FE analytical prediction tools to displace costly field testing.

Reviewer 3:

The reviewer was looking forward to a deeper analysis of the EV performance data for lessons learned. As stated previously, the reviewer was primarily hoping for suggestions to improve the technology and secondarily was interested in operational best practices to improve the performance of the existing technology.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that there was no more comprehensive dataset for EV performance, so these data are absolutely essential to advancing the industry.

Reviewer 2:

This reviewer stated that having these data and making it available for analysis by all of those evaluating technologies and vehicle use habits is in line with the DOE objectives.

Reviewer 3:

The reviewer noted that the project provided a pertinent variety of competing technologies an unbiased comparison of FE attributes in actual real world drive cycles. However, with respect to overall petroleum displacement, the reviewer stated that a measurement of total fuel displaced for the vehicle class, and the impact that the specific vehicle technology would project when broader adoption occurred, needed further examination.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer said that it seemed current funding levels were sufficient to support this work. At least, there was no indication from the presenter that additional resources would be necessary.

Reviewer 2:

This reviewer stated that sufficient resources were applied in meeting both overall and technical objectives. Although, NREL's adaptation of Fleet Analysis Tool (FAT) code to specific OEM data does push a portion of technical accomplishments out in time.

Reviewer 3:

This reviewer said that it was very hard to tell and asked if there was a goal for how much data to collect and how much money that would take.

DOE's Effort to Reduce Truck Aerodynamic Drag through Joint Experiments and Computations: Kambiz Salari (Lawrence Livermore National Laboratory) - vss006

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that there was an excellent PI, a well written research plan, and joint collaboration with the industry.

Reviewer 2:

The reviewer said that the program rightly used a mix of analytical and experimental work towards aerodynamics evaluation, which allows for correlating the results from two separate sources, namely computational fluid dynamics (CFD) with experimental measurements. This reviewer added that the presentation also mentioned that an integrated tractor/trailer approach was taken. However, the focus appeared to be heavily trailer focused, with limited tractor analysis (apart from tractor trailer gap seals).

Reviewer 3:

This reviewer said that the approach looked sound. The reviewer asked if there was opportunity for scale model testing in addition to all the full-size wind tunnel activity.

Reviewer 4:

The reviewer did not see a good overall plan for tankers and for evaluating data from the fleets. The reviewer was quite disappointed in the answer to why the fleet data did not match that in the wind tunnel. The reviewer expected an analysis of how different data collection methodologies and data match.

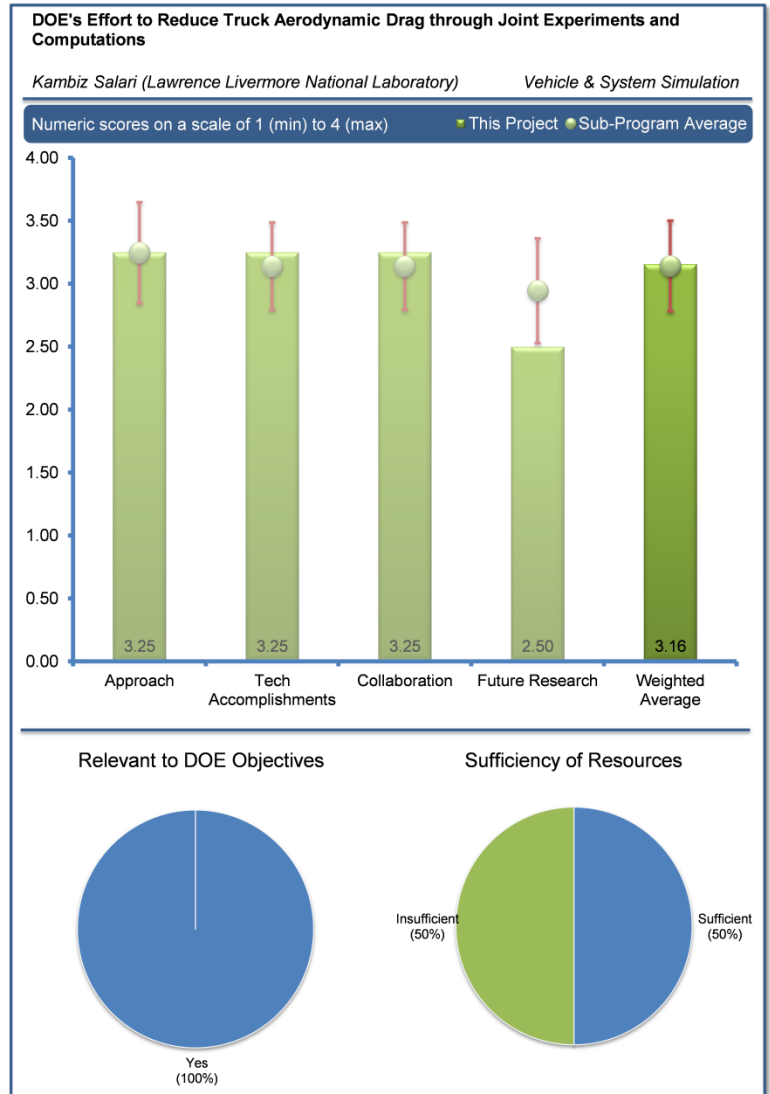
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer commented that the project did a full scale wind tunnel testing and track testing, and was collecting on the road data. The reviewer concluded that the project improved the aerodynamics of the trailer.

Reviewer 2:

The reviewer indicated that the progress since 2012 seemed to be modest. There was some CFD work on tankers and some on corrugated trailers. The analysis work seemed pretty repetitive including the following: identifying some form of trailer equipment and running baseline CFD (dry van trailer, corrugated trailer, tanker); sealing the gap and adding skirts; and comparing the results.



The reviewer commented that aerodynamic development work was worthy of research funding due to its impact on fuel consumption, but that this area of research deserved more fresh thinking than this program provided. The reviewer continued that there are complex topics within experimental and computational aerodynamics that are not well understood, and should be addressed within this work, namely high turbulence areas. The reviewer added that high turbulence areas were characterized by high degrees of separation, which are caused by fast moving parts and are a significant contributor to drag. For example, airflow around and through the wheel well of the steer (front) tractor tire; spinning steer tires currently cause significant drag, but the industry has not found ways for reducing drag in this area. Secondly, air moving underneath the tractor and trailer with a moving road; here the boundary layer is significantly disrupted and air impinges on many parts under the chassis of the tractor and also under the trailer, despite the presence of trailer skirts.

Reviewer 3:

The reviewer stated that this was a little difficult to assess when accomplishments were logged. The milestones were not very specific as to what was expected when except a broad description of activities.

Reviewer 4:

This reviewer did not see much progress year over year. The reviewer was not sure if funding dropped off significantly, but the reviewer was expecting more technical progress to have been achieved.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that the presenter had reported on collaborations with both manufacturers and fleets Spirit and Frito Lay and in the past, has collected data for vehicles operating in service. This reviewer further emphasized to keep up the effort.

Reviewer 2:

This reviewer said that the collaboration with the industry looked solid including on-road tests.

Reviewer 3:

This reviewer observed that the project was collaborating with the National Aeronautical and Space Administration (NASA) and industrial fleets.

Reviewer 4:

This reviewer observed that the project was winding down and not so much coordination was planned; but asserted that if collaboration was strong, that the reviewer would have expected to have seen more analysis on the fleet data. Also, the reviewer stated that the presenter's answer that fleets needed to take better data and deal with new trailer designs from an efficiency versus safety inspection perspective was not appropriate. Commercialization barriers for technology are expected at least at some level in these projects.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer stated that future research was important work and the project needed a return on investment.

Reviewer 2:

The reviewer strongly recommended to direct future aerodynamics work towards the study of high turbulence areas (wheel well of the tractor steer tire, under body of tractor and trailer). This reviewer also recommended ceasing research on tankers. It was mentioned that a national fleet of 200,000 tankers operate in the United States, which is a very small percentage when compared to dry van trailers, which is on the order of millions. Lastly, the reviewer recommended keeping focused on the trailer types that form the largest part of the national fleet.

Reviewer 3:

This reviewer opined that no real plan was suggested and contributed to why the reviewers maybe could not evaluate progress year over year.

Reviewer 4:

This reviewer did not see much of a roadmap beyond FY 2013 in any degree of specificity.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer commented that this work was highly relevant to DOE's objectives.

Reviewer 2:

This reviewer said that trailers were significant to fuel efficiency.

Reviewer 3:

This reviewer agreed that yes, tractor trailer aerodynamics developments play an important part towards displacing foreign oil. Further investments should continue, particularly if it is directed in the correct areas of focus.

Reviewer 4:

This reviewer stated that HD aerodynamics may be one of the highest points of leverage in reducing fuel consumption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer pointed out that this was low hanging fruit and commented that the project needed to speed up efforts. However, the reviewer said that this was excellent work. The reviewer observed that there was a top team working on this and said that there was an excellent PI.

Reviewer 2:

This reviewer stated that generally more research funding should be devoted to tractor/trailer aerodynamics in some form, given the large contribution of aerodynamic drag to losses. The reviewer would like to see a different focus from the planned working direction (i.e., shift away from tankers). Regarding the \$600,000 resources allocated, which would be in excess of two man-years of engineering work, the reviewer frankly expected more outcome as well as a fresh approach to addressing the aerodynamic problem (i.e., tackling high turbulence areas). One idea suggested by this reviewer was to have manufacturers (tractor and/or trailer) play more of a leading role in aerodynamics research.

Reviewer 3:

This reviewer stated that it was difficult to judge given the broad statements of future activity (planned milestones were not too specific).

Reviewer 4:

This reviewer said that it seemed that this program should conclude or be funded with specific goals.

Plug-in Hybrid (PHEV) Vehicle Technology Advancement and Demonstration Activity: Greg Cesiel (General Motors) - vss018

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that a good rigorous testing strategy was defined for the battery development, including both laboratory and in-vehicle components. However, quantitative performance targets were not shown, and go/no-go decision points did not seem to have been established and followed to serve as gates for distribution of project funding (at least none of this was clear from the presentation).

Reviewer 2:

This reviewer commented that there was a very structured approach which addressed component and integration challenges. The reviewer added that the inclusion of E85-capable flex-fuel (FF) engine technology was very good. However, the reviewer said that it was difficult to evaluate the overall approach of an activity of this magnitude with a 20 minute presentation. With that said, the overall approach seemed right on target.

Reviewer 3:

The reviewer said that the project concept of developing components and sub-systems for integration into a production-intended vehicle was solid, and appeared to have been feasible. However, the choice of base vehicle for the PHEV design appeared to have been poor with Saturn no longer existing. Perhaps this could not have been foreseen in 2008, but suggested that the selection of a more established brand would have been advantageous.

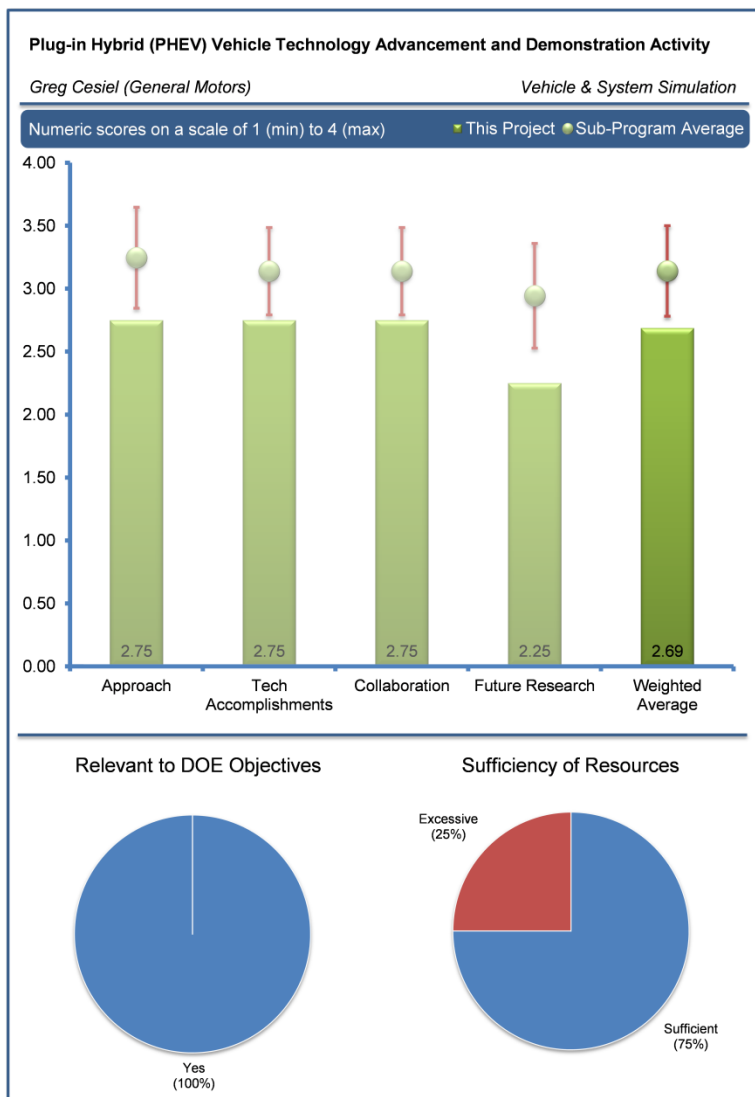
Reviewer 4:

The reviewer said that conceptually the project appeared good, but asked if this was stand-alone or in conjunction with the Volt program. The reviewer added that it was unclear and this presentation lacked many technical details.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the milestones appeared to all be on schedule and/or completed on time. The project was 88% complete and appeared on track to overcoming technological barriers and integration challenges. The reviewer observed that more than 50 vehicles had been built and 180,000 miles driven and that the project included cold weather testing with conventional and E85 fuel.



Reviewer 2:

The reviewer observed that the presentation described qualitative progress on the battery development and indicated that 50 or more vehicles were built and driven over 180,000 miles at GM. However, due to the scant details included, the presentation demonstrated little or no progress toward the identified objectives/barriers.

Reviewer 3:

This reviewer observed that prototype vehicles were built and that the battery module design and testing appeared to be on schedule. However, the project objective was to develop a production-intended vehicle; yet the more than 50 vehicles built were for internal GM usage only, and no transfer to a vehicle intended for production appeared to be occurring. The development of the battery thermal management system (TMS) was a useful endeavor; however, it was relatively modest in light of the project objective, scope, and budget.

Reviewer 4:

The reviewer could not tell this based on the presentation and the presenter.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer observed that good collaboration was made and use of the diverse expertise. More information would have certainly been helpful for better understanding the nature of relationships and contributions. Also as the reviewer mentioned that it was hard for the presenter to really represent a project of this magnitude in 20 minutes.

Reviewer 2:

This reviewer stated that an OEM is often understandably reluctant to collaborate with partners on design and development. However, in this case, GM may have benefitted with more project partners. It was not made clear in the presentation what the role of the University of Michigan was in the project. The FEV, Inc. collaboration appeared to be useful and providing results.

Reviewer 3:

This reviewer observed that the collaboration included work with a supplier (FEV, Inc.) on development of the battery module TMS. A cooperative agreement between the University of Michigan and GM was also identified, but there was no specific University of Michigan coordination detailed with respect to this project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that the project was near completion and focused on finalization of successful project. The reviewer added that an extension seemed reasonable.

Reviewer 2:

This reviewer indicated that based on the presentation, nothing left them thinking of future research questions.

Reviewer 3:

This reviewer said that the slides only listed dates for reviews in the Future Work section. The reviewer observed that the oral comments indicated that the vehicle would not be going forward to production, but that the learning would be applied to other vehicle projects.

Reviewer 4:

The reviewer observed that the Future Work Slide contained nothing about the vehicle design resulting from this project being carried over to other programs. The battery module work appeared to be transferrable, and that was a positive outcome.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said most definitely. This project is addressing improvements in enabling this important technological path for potentially significant improvements in vehicle FE.

Reviewer 2:

The reviewer noted that the project, as designed, definitely helps reduce petroleum consumption. The reviewer added that even the modified project of only battery module development advances DOE objectives as long as the module design is used or at least informs other vehicle programs at GM.

Reviewer 3:

The reviewer said that PHEVs had significant fuel displacement potential relative to conventional vehicles.

Reviewer 4:

This reviewer stated that developing products was essential for technology integration.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that the internal GM investment in the project has been considerable.

Reviewer 2:

Based on the presentation, the reviewer did not see the separation from a vehicle program at GM, which would have went on anyway.

Reviewer 3:

This reviewer said it was very hard to evaluate what was sufficient or insufficient from the information available.

Reviewer 4:

This reviewer explained that with the project outcome being only the battery module, the project resources appeared to be excessive. The vast majority of the funding came from GM, but the \$9.5 million that came from DOE and Michigan Economic Development Corporation (MEDC) was probably not put to best use.

Ford Plug-In Project: Bringing PHEVs to Market: Julie D'Annunzio (Ford Motor Company) - vss019

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer commented that the project was well-explained and that there was a well-developed program, and a very good near-end summary.

Reviewer 2:

This reviewer observed a well-balanced and well-presented project. The reviewer noted a good balance between technical and programmatic objectives relating to increasing the application (sales) of the PHEV.

Reviewer 3:

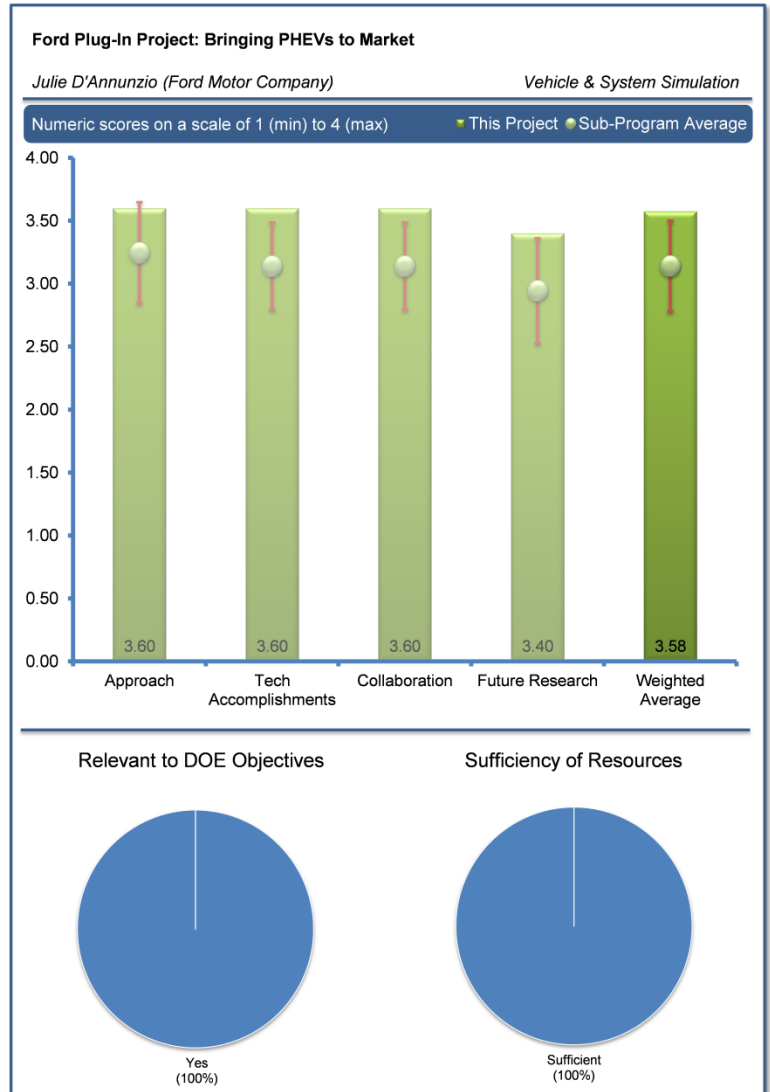
The reviewer stated that the approach was very well-defined and focused successfully on completing the defined objectives of the work. The reviewer appreciated how well the author laid out the approach/status table and said it was very helpful.

Reviewer 4:

The reviewer said that the approach was well organized, and that the five phases presented a measured methodology for achieving the project objectives. As a reviewer from last year mentioned, the reviewer said that an increase in the diversity of vehicle users would improve the quality of the data. Specifically, the driving mode breakdown includes a higher percentage of charge sustaining (CS) driving than is seen in other data from personal vehicles, and thus the project data are slightly less valuable.

Reviewer 5:

This reviewer said that Slide 6 mentioned that the majority of the demonstration vehicles did not leverage electric air conditioning (A/C). It was not clear how the heating system worked from the slides. The FE versus the temperature graph on Slide 6 seemed to indicate that the use of the heating ventilating and air conditioning (HVAC) system resulted in a severe reduction in FE. This area may be an opportunity for improvement. The reviewer asked if the impact of HVAC strategies had been evaluated. The reviewer said that it was not clear how the Cloud Connectivity Architecture was related to the DOE objectives for this effort. The discussion indicated that the cloud computing was less expensive than adding the needed CPU power to the vehicle and the reviewer asked if this been substantiated. The reviewer also asked if customers were showing interest in the Location Based Energy Management feature, or if customers would use a manual charge depleting (CD)/CS switch (depletion/sustaining). The reviewer concluded that requiring the customer to input geo-fenced areas into his/her vehicle seemed overly complicated for the average consumer.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer said that the technical accomplishments to date were impressive and well organized; a well-managed project.

Reviewer 2:

This reviewer stated that the project described technical accomplishments well; resulting in a Ford C-Max product.

Reviewer 3:

The reviewer observed a detailed and well-organized discussion of seven major accomplishments. The reviewer continued that there was a nice summary of results of different accomplishments and value to the program. The reviewer added a few comments: the results of demonstration fleet were very valuable for understanding/interpreting results. Information on how the vehicles were driven was expected to be useful for improved optimization of future systems; the Cloud connectivity progress was very impressive. Ford appears (within this reviewer's acknowledged range of knowledge) to be leading in this area, at least from a more open data perspective; Open XC is very exciting with an almost unlimited potential of third-party designers to develop optimization applications and ultimately better educate the customer on drive style opportunities to potentially achieve dramatic improvements in FE; path forecasting and trip profiling are potentially very powerful for improved FE and to perhaps help calm those with range anxiety; and that the Cell level modeling through the cloud was an interesting approach.

Reviewer 4:

This reviewer said that all milestones and reporting requirements appeared to have been met.

Reviewer 5:

This reviewer observed that 21 demonstration vehicles were fielded under this effort and that data were accumulated from 800,000 miles of usage. The Ford C-Max and Fusion PHEVs in production today leveraged technologies developed under this program. Summary reports from the demonstration have been made available to the public.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer said that there was good cross-functional collaboration in this project, and emphasized the nice work of Ford and DOE.

Reviewer 2:

The reviewer commented that there was nice outreach; and that partnering seemed okay. The reviewer wondered if there would be other opportunities for more collaboration and commented that the summary slide listed many partners but the collaboration slide only showed a few.

Reviewer 3:

The reviewer observed that the collaborations with EPRI and INL appeared to be well coordinated and the reports on the INL website provided useful insight into the project results.

Reviewer 4:

This reviewer said that numerous project partners have involvement in this project. Lawrence Technological University has a chassis dynamometer laboratory built to evaluate the Ford Escape Hybrid. The reviewer asked if Ford was also leveraging this laboratory.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the planned work looked appropriate with the last element of migrating PHEV to production. The reviewer added that this was a pretty lofty goal but that it was good to see that in the DOE program objectives. Again, the reviewer emphasized that this was very good work.

Reviewer 2:

This reviewer stated that it was excellent that these technologies would translate from mule to production type technologies.

Reviewer 3:

This reviewer opined that there was a nice finalization with two product support Fusion and C-Max.

Reviewer 4:

This reviewer observed that further evaluation of two production C-MAX Energi PHEVs was underway by DOE. Results from this effort have been shared publically.

Reviewer 5:

This reviewer indicated that the future work plans were not very extensive and appeared to basically consist of continuing to collect data. The reviewer commented that the Future Work slide showed that the Escape PHEV development will inform the 2013 Fusion Energi and C-MAX Energi models for year-end 2013, but that these vehicles had already been introduced to the market, so it was unclear what was meant. It was also unclear where the two production C-MAX Energi PHEVs would be tested, and in what manner, by the DOE, and what INL would do with the resultant data.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said that the PHEV vehicles developed under this effort have demonstrated significant reductions in fuel consumption when compared to their conventional counterparts. Ford has a successful fleet of hybrid electric offerings, and this program has helped further develop some of the key building blocks.

Reviewer 2:

This reviewer exclaimed absolutely, 100%.

Reviewer 3:

The reviewer stated that PHEV development definitely promoted the DOE goal of petroleum displacement.

Reviewer 4:

This reviewer said that yes, DOE funding has helped launch this work and will ultimately enable high-FE vehicles to the market.

Reviewer 5:

The reviewer said that products to support technology growth were needed.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the funding for this project was relatively modest and that the successful outcomes meant that the amount of funding was appropriate and that Ford appeared to have used DOE funds wisely.

Reviewer 2:

The reviewer said that the project was on track. A lack of resources was not apparent from the presented material.

Reviewer 3:

This reviewer said that the project appeared to have the appropriate balance of resources from both the government and industry.

Idaho National Laboratory Testing of Advanced Technology Vehicles: Jim Francfort (Idaho National Laboratory) - vss021

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer indicated that this was a well-designed test. The reviewer explained that it was a difficult job to do and very important work that has to be done. The reviewer continued to say that high temperature work was important to understand. The reviewer observed a large number of participants in the test. The research plan was excellent and the reviewer noted a talented PI.

Reviewer 2:

This reviewer stated that this work appeared to be comprehensive and very useful. The primary additional information the reviewer was looking for were the lessons learned for how to improve vehicle performance and advance the technology. It seemed INL was heading in that direction but had not completed that work yet. Also, the reviewer observed that the presenter noted a lack of confidence in understanding the lifecycle performance of EV batteries under normal driving conditions. The reviewer suggested that if this was true, that the INL study ought to identify specific areas of concern and suggest specific pathways to resolve the concerns.

Reviewer 3:

This reviewer pointed out that there was good data collection activity. However, the reviewer noted that limited sample sizes could limit the strength of some conclusions.

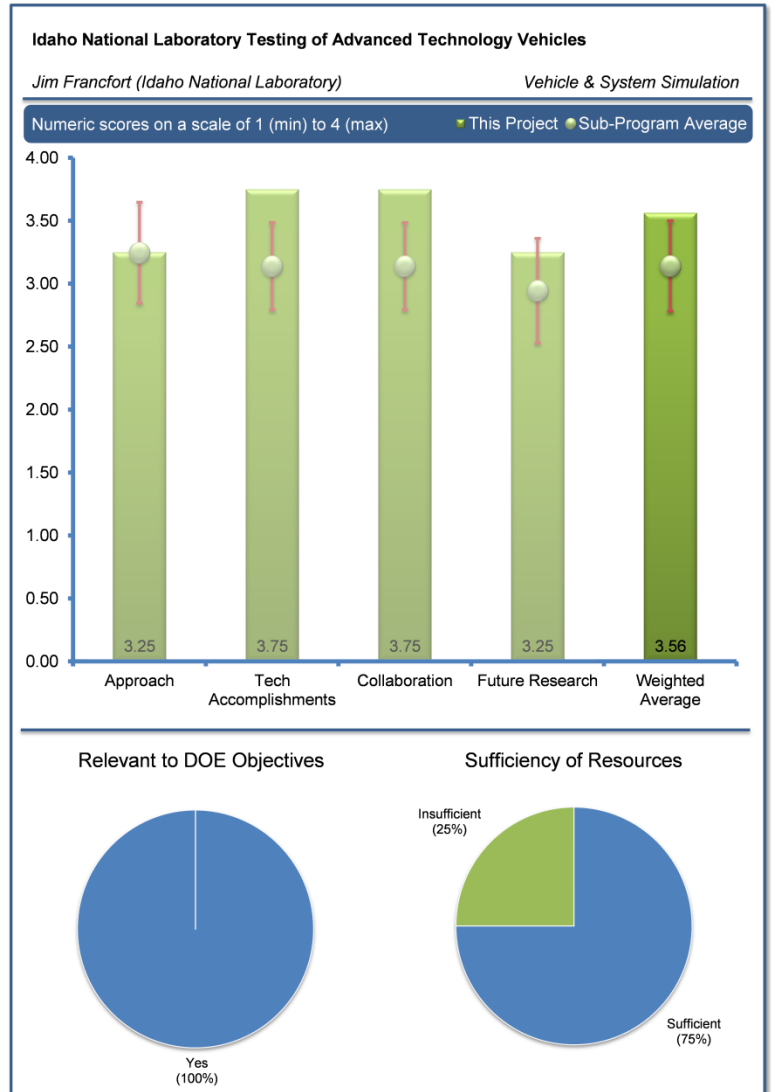
Reviewer 4:

This reviewer noted that the project efforts to address cost barriers were not well delineated or assessed. However, the reviewer observed that the project appeared to be well-organized to gather the large amount of advanced technology vehicles available in the market.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer observed that the project was important work to understand. The reviewer added there were great partnerships in the research plan; over 11,000 vehicles and therefore, a large sample size. DOE needs to collect and evaluate the data so that impacts of



smart grid. The reviewer concluded this was very important data on charging times and can change people's behavior with regard to charging.

Reviewer 2:

The reviewer commented that the overall information was useful.

Reviewer 3:

This reviewer said that the technical accomplishments of gathering mileage and monthly status reporting was evident; however, it was not clear how these accomplishments related to the three barriers of cost, infrastructure and constant advances in technology. The reviewer stated that it seemed the sample size needed some rationalization.

Reviewer 4:

This reviewer pointed out that there was no more comprehensive dataset for this type of information.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that the collaboration across DOE laboratories and partnership development was quite extensive and noteworthy.

Reviewer 2:

This reviewer commented that the project leveraged other labs and facilities very well.

Reviewer 3:

This reviewer observed that the project was collaborating with electrical utilities – 46 utilities and working with small businesses and car manufacturers.

Reviewer 4:

The reviewer indicated that there has been solid progress on collaborating with other federal agencies since the last AMR, which was appreciated. The reviewer suggested that the next step ought to be including relevant EV performance data in a useable format for GSA's AutoChoice system. AutoChoice is the Web tool that federal agencies use to purchase/lease vehicles from GSA. The reviewer commented that having data readily available on that system would be a great service for federal fleet managers to better align available EVs with their requirements.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer stated that understanding federal fleets was important and well planned. The reviewer observed that the group used 50% cost sharing.

Reviewer 2:

This reviewer said that the presenter noted that part of the future work would be identifying lessons learned from the broad dataset. That information is essential for moving these technologies forward and accelerating adoption of these vehicles.

Reviewer 3:

This reviewer observed that there were no significant barriers to address.

Reviewer 4:

This reviewer indicated that a more targeted effort in bringing this voluminous data stream down to a digestible level across this vehicle class is warranted. The reviewer added that stating that continuation of objectives reinforces no change other than collecting more extensive data.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer stated that electric vehicles were here to stay and added that more data was needed regarding wireless charging in the future. The reviewer observed that fire testing was excellent and noted that the group was thinking ahead. The reviewer cautioned that how to handle fires in batteries must be understood.

Reviewer 2:

This reviewer said that the data produced by this project were key for understanding EV performance in a variety of environments. Nobody else was collecting this broad a dataset – at least not for use by the public.

Reviewer 3:

This reviewer said that it appeared the project has relevance in providing specific electric drive vehicle performance and petroleum displacement. However, the reviewer suggested that the data should be summarized in a fashion to show how these classes of vehicles were meeting or not meeting expectations of DOE, OEMs and consumers.

Reviewer 4:

This reviewer said that yes the research was useful in looking at the useful life of technologies.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer said that the project exceeded the milestones and noted an excellent presentation. This is important data if there is going to be a smart grid. The reviewer identified a need to better understand the batteries in cars and added that the EV market was getting larger and is here to stay. The reviewer concluded that impacts must be understood.

Reviewer 2:

This reviewer said that sufficient resources were applied in meeting stated objectives.

Reviewer 3:

The reviewer said that the presenter did not suggest any additional need for funds related to this project.

Advanced Vehicle Testing & Evaluation: Tom Garetson (ECotality North America) - vss029

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer indicated that the reports being generated by this program [posted on the Advanced Vehicle Testing Activity (AVTA) website] were very informative and that the presentations were very factual. However, it was hard to discern what the real benefits of these advanced technology vehicles were. If the reviewer were a consumer looking to buy one such vehicle, the reviewer would have liked to know what the manufacturer claimed regarding the product, and what was actually being seen. Some of the Level 1 and Level 2 testing efforts at ANL could perhaps help address this issue. The reviewer continued to say that it was also quite possible that the various channels of (raw) data collected may be very useful to OEMs and other organizations. The reviewer could see that this would be a logistical nightmare and would require significant resources, but perhaps some thought should be given as to how more detailed data sets could be made available to the public in the future.

Reviewer 2:

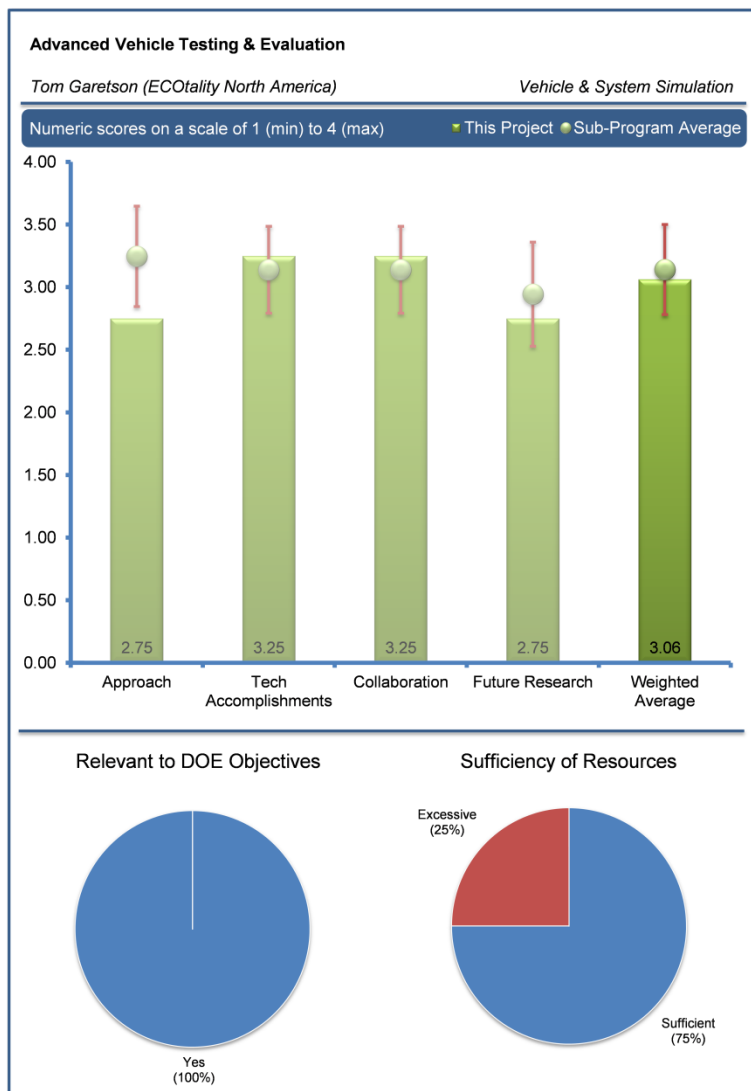
The reviewer said that the discussion questions identified logical extensions and next steps involving developing degradation factors and being used to not just develop simulation inputs but rather compare simulation outputs to real world behavior. The reviewer added that incorporating these next steps would improve the usefulness of the data even further. Additionally, the reviewer suggested that the work needed to include benchmarking of conventional and used vehicles for comparison/analysis to current fleet parameters.

Reviewer 3:

This reviewer commented that very needed data from real world situations should be attained with some direct regard to more variable control that fleets could easily provide. The reviewer did not understand the big picture in terms of numbers and data points.

Reviewer 4:

This reviewer asserted that a fixed route and on-road should not be viewed as a substitution to lab comparisons.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer observed good progress and several reports. The reviewer directed the reader to please see other comments regarding other potential uses for the raw data that were collected from the fleets.

Reviewer 2:

The reviewer said that the information generated was useful. The reviewer could not find Road Load information in the fact sheets or online.

Reviewer 3:

This reviewer thought that perhaps this was limited due to the early stage of the program.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer said that the project was leveraging laboratories and other DOE partners well.

Reviewer 2:

This reviewer said there was good cooperation with both ANL and INL but suggested perhaps more cooperation with OEMs to understand better what else the vehicles should be tested for.

Reviewer 3:

This reviewer noted the collaboration and coordination between INL and ANL; recording and dynamometer.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer asked since the DOE goal was petroleum displacement, if there should be some focus on the highest volume vehicles that were sold in the United States that incorporated advanced technologies, but not necessarily hybrids or plug in hybrids. It would seem that verifying whether some of these technologies [such as adjustable grille shutters, active warm up, improvements to internal combustion (IC) engines, etc.] actually delivered the promised benefits would also help the DOE's stated goal, and also have the added benefit of providing the U.S. Environmental Protection Agency (EPA) input on their rulemaking.

Reviewer 2:

This reviewer could not understand the specific controls of the study with the 150 vehicles left to test along the way.

Reviewer 3:

This reviewer said that there were no barriers to overcome.

Reviewer 4:

The reviewer stated that the linkage between future work based on the results of existing project scope was not clear. Medium/ heavy duty vehicle data is sorely needed and should be increased as a priority. The reviewer added that current vehicle park data is needed as a point of reference for any analysis of this data to be very useful.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer stated that most other DOE funded projects focused on specific drive cycles. This project involved real world driving, and could inform the average consumer, DOE and other government organizations, and OEMs, the real world benefits of these advanced technology vehicles.

Reviewer 2:

This reviewer stated that providing data into the public domain on advanced technologies was very supportive of DOE goals.

Reviewer 3:

This reviewer was optimistic that something was learned that the OEMs did not already know.

Reviewer 4:

This reviewer stated that this project generated understanding for life cycle effectiveness of some technologies.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that the vehicle throughput and quantity looked to be enough. The reviewer added that the project could cut to two vehicles from four per program on some, if the fleet needed to be more diverse.

Reviewer 2:

This reviewer said sorry that this was the only program the reviewer rated this way, but the reviewer did not see \$26 million of work here. The reviewer indicated knowing that the DOE guys were very diligent with fund management, but the reviewer could not see this through the presentation.

Advanced Technology Vehicle Lab Benchmarking - Level 1: Henning Lohse-Busch (Argonne National Laboratory) - vss030

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer said that the task was sharply focused on benchmarking advanced technology vehicles of specific current interest due to unique technical characteristics. This benchmarking helps establish the state-of-the-art automotive technology baseline for powertrain systems and components from an unbiased, neutral perspective. The reviewer added that well-honed testing and evaluative procedures have been developed over the years. This is a well-defined, effective, and efficient task which has evolved into a very mature effort. Given this, it is not likely to require any revolutionary changes, but the project should continue to look for evolutionary improvements wherever possible in such areas as continued cost reduction for testing, and incremental advances/synergies in test procedure development and data dissemination.

Reviewer 2:

This reviewer believed that the move to baseline the conventional technology was good.

Reviewer 3:

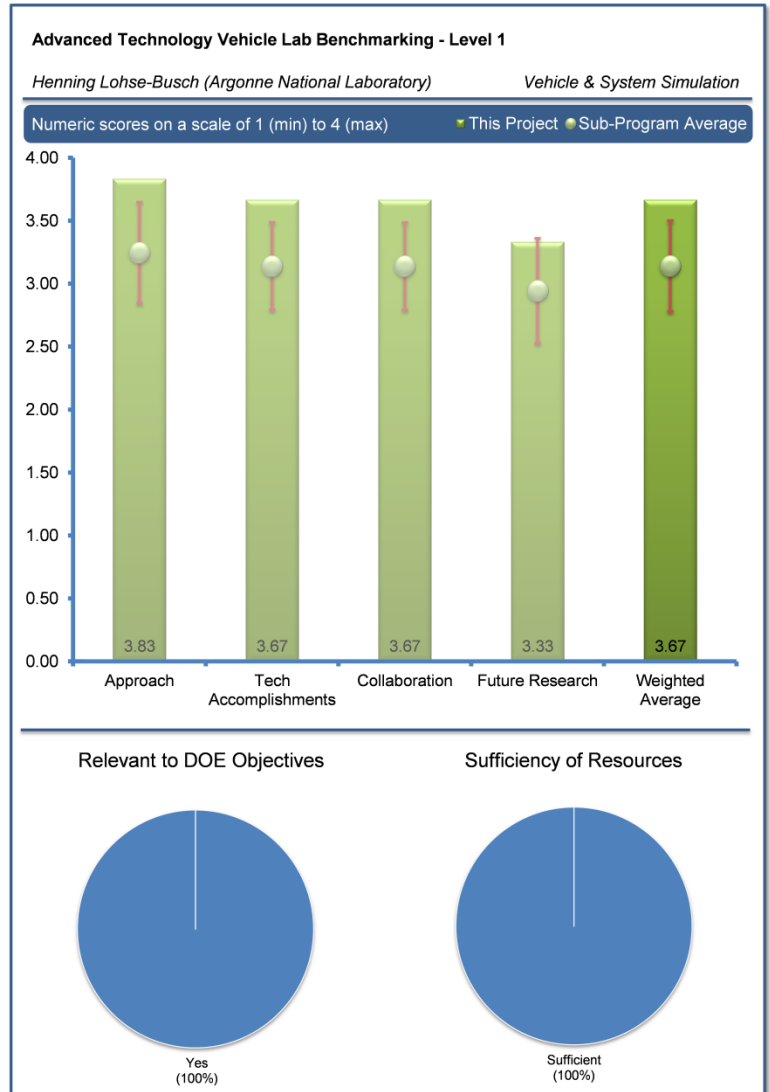
This reviewer indicated that the quality of testing provided an industry benchmark.

Reviewer 4:

This reviewer stated that it was difficult to critique greater detail in this method. The reviewer viewed this as greatly sufficient, in depth and breadth of scope.

Reviewer 5:

This reviewer said that the previous year's comments appeared to have pointed out that more real world cycles should be included. A related comment that the reviewer made was regarding the use of certain extreme cycles. The reviewer said that OEMs use certain extreme cycles for sizing their heat exchangers and other components, and the size of these components have a significant impact on overall drivetrain efficiency. It would be worth investigating some of these extreme cycles to understand the rationale behind component sizing. It would also provide valuable information to buyers in deciding what are their trade-offs when they buy these advanced technology vehicles.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer stated that Level 1 testing, by its very nature, was somewhat limited in scope; the reviewer has had a chance to look at some of the data that is being generated, and believed that the Argonne team was doing an excellent job.

Reviewer 2:

This reviewer stated that the controller area network (CAN) measurements for Level 1 were excellent.

Reviewer 3:

This reviewer observed that FY 2013 saw a considerable bump up in funding to \$1.3 million from \$600,000 in FY 2012. Ten different test vehicles are being evaluated in FY 2013, as well as four additional studies on conventional vehicle efficiency, ambient temperature effects, vehicle mass, and battery resistance. Overall, the reviewer noted that a significant level of productivity had been achieved including completion of most of the studies. The results from the studies in FY 2013 so far did not show any really surprising results and appear to confirm what would largely be expected intuitively.

Reviewer 4:

This reviewer said that the test method development has kept base with technology advances. The reviewer added that support for standards development is critical to developing comprehensive standards.

Reviewer 5:

This reviewer stated that mass study is redundant to studies done by private entities and asked why this was redone.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer stated that this task was well coordinated both internally and externally. Data developed by the advanced technology vehicle lab benchmarking was well coordinated with internal ANL modeling efforts, the SAE codes and standards activities, on-road vehicle testing and evaluation activities with INL, advanced vehicle technology competitions, domestic automakers via U.S. Council for Automotive Research (USCAR), other National Laboratories and DOE. The reviewer observed that coordination also took place with a number of international organizations in Europe and the Far East. The downloadable dynamometer database (D3) serves as a good information dissemination mechanism for all interested parties including non-primary ones. If not already being done, the reviewer suggested that it may be good to poll some of the information users to see if D3 and other informal dissemination mechanisms are continuing to best meet their needs.

Reviewer 2:

This reviewer stated that vehicle partners had been able to provide Level 1 test vehicles in a timely manner. The reviewer added that the D3 was a great assist to the industry.

Reviewer 3:

The reviewer said that sharing of properties between the labs was the correct approach and good for collaboration.

Reviewer 4:

The reviewer stated that there appears to have been an increased effort to work with the domestic OEMs over the last year, and that this was indeed very welcome. Cooperation with the other National Laboratories also appeared to be very strong. The reviewer has had a chance to interact with more than one National Laboratory, and indicated that it does indeed appear that there was significant conversation going on between the various laboratories regarding these testing efforts.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that increasing focus on thermal testing is a positive, since it is a benefit that can be achieved even in vehicles with conventional powertrains, and potentially have a significant impact on corporate average fuel economy (CAFE).

Reviewer 2:

The reviewer opined that the proposed future work was logical given the especially negative impacts of climate control on full battery electric vehicles. Additionally, the capability of being able to handle fuel cell vehicles was a plus as well as benchmarking of natural gas vehicles, which were likely to see more attention given the current and projected cost advantages of natural gas. The reviewer added that it may be advantageous to give some thought to other potential future testing activities which may not have been considered before.

Reviewer 3:

This reviewer stated that testing of Advanced Vehicle Testing and Evaluation (AVTE) vehicles will provide a broad base of data across several vehicle technologies.

Reviewer 4:

This reviewer said to continue to review the new technologies.

Reviewer 5:

This reviewer stated that many issues associated with drive-ability and reliability of technologies are what slow the adoption of advanced technologies. The future scope of work should incorporate drive-ability and reliability assessments to go with the efficiency potential in real world usage.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer stated that the project measures advances in FE and supports the standards for FE rating.

Reviewer 2:

The reviewer commented that this project directly supported DOE objectives of petroleum displacement through benchmarking of advanced technology vehicles, continual advancement of the baseline, and broad dissemination of information for maximum benefit. The overall effect is to help accelerate the progression of advanced petroleum and emission savings technologies into the nation's vehicular fleet.

Reviewer 3:

This reviewer said yes because the project focused on energy efficiency. The reviewer added that the project could be further improved by incorporating elements preventing technology adoption such as cost, reliability, and drive-ability.

Reviewer 4:

The reviewer said that the project provides extensive data to the consumers and other interested parties on a large range of advanced vehicles. The reviewer added that it verifies the claimed fuel consumption numbers by the manufacturers. The hope is that all of these (good) data will encourage more consumers to buy these advanced technology vehicles, and that it will encourage the various OEMs to continue to improve their lineup of advanced technology vehicles.

Reviewer 5:

The reviewer said that it was good to develop the understanding of fuel reduction technologies to learn to apply them appropriately, and to not double count technologies that address the same loss.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer indicated that the Advanced Powertrain Research Facility is a key resource that appears to be fully adequate to provide industry benchmark data.

Reviewer 2:

This reviewer stated that since this was Level 1 testing, and it does not involve the purchase of the vehicles and extensive intrusive instrumentation, that the funding appeared to be adequate for the number of vehicles being tested.

Reviewer 3:

This reviewer stated that the resources for this task were adequate. Specific activities for Level 1 testing and special studies have been costed out over the years. Nonetheless, as previously mentioned, it is important to continually emphasize incremental improvements in project technical and cost efficiencies.

Reviewer 4:

The reviewer commented that the throughput seemed sufficient for the type of information provided by the activity.

Advanced Technology Vehicle Lab Benchmarking - Level 2 (in-depth): Eric Risk (Argonne National Laboratory) - vss031

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that there was excellent dataset generation. As the number of vehicles that can be exhaustively tested is limited by time and resources, a more rigorous (collaborative and documented) approach to vehicle selection could make results useful to a wider audience.

Reviewer 2:

This reviewer commented that this appeared to be a thorough evaluation process that would be able to generate high quality comparable data.

Reviewer 3:

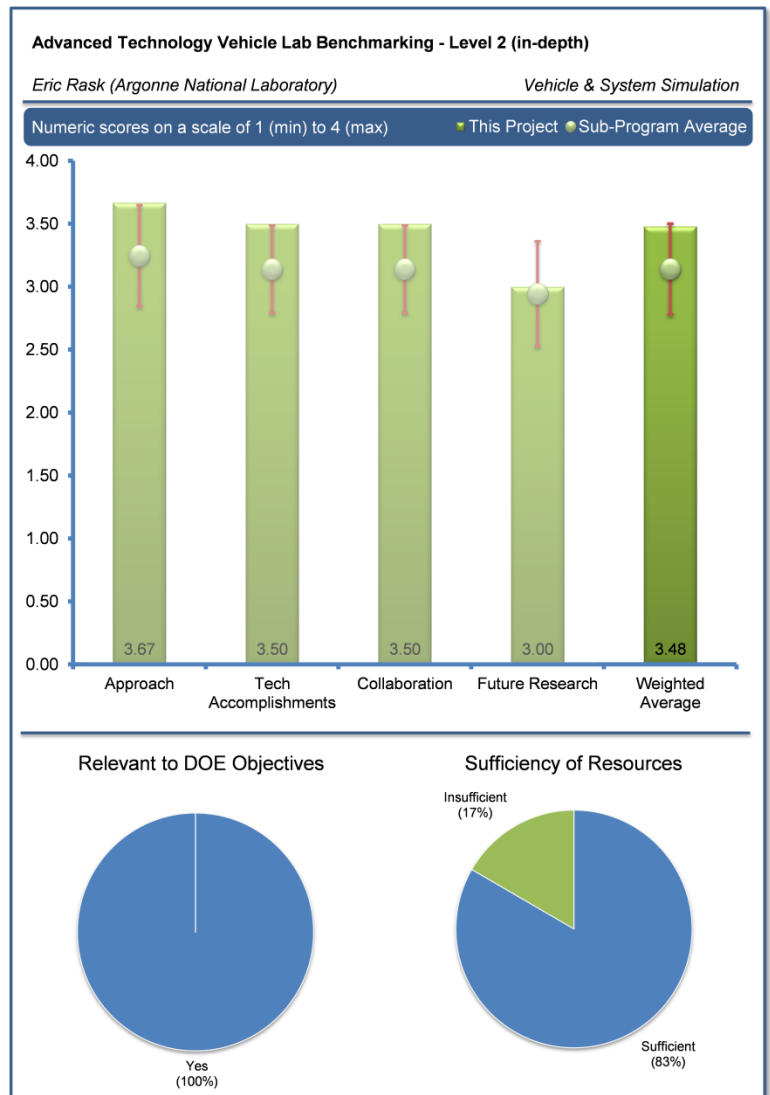
This reviewer said that the task was sharply focused on deep dive benchmarking of advanced technology vehicles of specific current interest due to unique technical characteristics. This benchmarking helped establish the state-of-the-art automotive technology baseline for powertrain systems and components from an unbiased, neutral perspective. The reviewer stated that well-honed testing and evaluative procedures have been developed over the years. This is a well-defined task which has evolved over the years into a mature effort. Given this, it is not likely to require any revolutionary changes, but should continue to look for evolutionary improvements wherever possible in such areas as continued cost reduction of testing (be it through streamlined testing processes or labor cost reductions), and incremental advances/synergies in test procedure development and data dissemination. The reviewer added that the Peugeot 3008 Hybrid4 was a good choice as a result of its unique diesel-hybrid configuration, four different user operating modes, and emphasis upon content reduction and associated cost savings. Diesel hybrid configurations have not been well studied nor understood to this point. The reviewer did have a question of interest though, and asked why the provided road loads and ANL estimated rolling and aerodynamic loss calculations were used as opposed to actual results from cost down testing through field testing with INL.

Reviewer 4:

This reviewer said it looked like the team had done great work in learning how to collect the signals needed to Level 2 benchmarking. The reviewer added that obtaining the correct signals accurately seemed to be the main barrier for this activity.

Reviewer 5:

This reviewer believed that overall, the Level 2 benchmarking generated very useful data for both modeling (Autonomie) and as inputs to other DOE funded projects in other National Laboratories. However, the reviewer said that since the primary purpose of these projects was petroleum displacement, and a significant number of vehicles that are sold in the domestic market are SUVs and



trucks, the reviewer wondered whether some of these should undergo Level 2 testing as well. Granted that they do not offer many of the advanced technology features that passenger cars are equipped with, but many of the newer trucks and SUVs do have advanced engines, transmissions, and other fuel saving features such as adjustable grille shutters, active warm-up and so on. The OEMs get credit for incorporating these features in the vehicles, and one would think that is it well worth funding projects where ANL looks at these vehicles and evaluates the true benefits of some of these features. Besides providing valuable input to EPA, it would also allow the consumer to evaluate these different technologies, and their true benefit. In the longer term, to truly achieve petroleum displacement, these technologies have to offer the consumer tangible benefits (significantly) in excess of the premium that would have to be paid for these features.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer stated that excellent progress had been made, from the standpoint of available resources (manpower and testing facilities).

Reviewer 2:

This reviewer said that there was an excellent level of information.

Reviewer 3:

The reviewer indicated that benchmarking to date was a significant resource.

Reviewer 4:

The reviewer stated that the task this year has demonstrated several technical accomplishments including normal mode versus U.S. cycle testing, understanding of basic vehicle operation, and evaluation of user selectable modes. It was ascertained that despite the vehicle's unique configuration, its operation was pretty typical. Of particular interest was the study of regenerative braking across several vehicles, which was not well-studied or understood. Additionally, it was also noted that emissions could be a significant barrier (especially in stop/start conditions) for diesel- hybrid vehicles. The reviewer commented that the presentation did not provide an indication of the overall spending to this point nor project completion to date for the year. The reviewer had a question of interest and said that it was understood that the vehicle had four operating modes, but asked if it was necessary to test the vehicle over so many drive cycles and if so why. The reviewer continued to ask if an assessment or approach of some kind had ever been considered to determine statistically really how many (and what type) of drive cycles were needed to adequately characterize a vehicle.

Reviewer 5:

The reviewer reiterated that this appeared to be a thorough evaluation process that would be able to generate high quality comparable data.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer stated that there appeared to be very good cooperation between the various National Laboratories. More recently, the reviewer believed that there had been a stronger effort to involve all the domestic OEMs, and that was definitely a welcome step. The reviewer wondered if there was any scope for increasing this cooperation even further, for instance by sharing some of the components with some of the USCAR benchmarking teams after the Level 2 testing has been completed. The USCAR benchmarking teams may be interested in evaluating the component efficiencies of some of these components, and may perhaps be willing to share some of the information in return.

Reviewer 2:

The reviewer observed that the interactions and sharing of information within the ANL's sub teams was good, as well as leveraging INL and ORNL for other data collection.

Reviewer 3:

The reviewer said that this task appeared fairly well coordinated both internally and externally. Deep dive data developed by the advanced technology vehicle lab benchmarking Level 2 testing appeared to be coordinated with internal ANL modeling efforts, SAE's codes and standards activities, on-road vehicle testing and evaluation activities with INL, domestic automakers via USCAR, other National Laboratories, and DOE. The reviewer added that if it was not already being done, that it may be good to periodically poll the information end-users to see if the data provided and dissemination mechanisms were continuing to best meet their needs.

Reviewer 4:

This reviewer stated that the support for other ANL activities appeared excellent. However, the reviewer said that the use of data by OEMs was not apparent from the presentation.

Reviewer 5:

The reviewer said that the project had engaged many if not all the major collaborators.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer observed that in FY 2014, the thrust of Level 2 benchmarking was the Ford Focus battery electric vehicle (BEV). The reviewer added that it seemed like a good selection although not much was provided supporting this choice and what exactly was to be looked for. It would be beneficial to provide more supporting information.

Reviewer 2:

This reviewer stated that it was hard to determine, as analysis of data was not included in the report. The reviewer added that future work should certainly include analysis of implications.

Reviewer 3:

This reviewer said that the proposed future research included Level 2 testing of the Peugeot 3008 Hybrid. While this had several of the characteristics that ANL looked for in a potential candidate for Level 2 testing, the reviewer feared that this configuration was overkill. There is a premium for diesel, and a premium for the hybrid, and this may limit its real potential for petroleum displacement. The reviewer noted that purely from an advanced technology point of view, perhaps it was acceptable. The reviewer said that a comment similar to the one made for Level 1 testing applied as well. The focus of the testing (specifically the drive cycles), appears to be geared towards FE. However, more severe drive cycles that are used to size components (heat exchangers, viscosity of axle lubricant, and etc.) have an indirect impact on the fuel consumption by influencing the overall propulsion efficiency. Including some of these cycles in the testing repertoire may be very beneficial in understanding the trade-offs that different OEMs have to go through.

Reviewer 4:

The reviewer stated that testing of a BEV next probably would not generate significant new data on drive train interactions.

Reviewer 5:

This reviewer commented that benchmarking an electric vehicle for the next year seemed like a step back from the more elaborate powertrains that had been Level 2 benchmarked in the past.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer stated that this project directly supported DOE objectives of petroleum displacement through benchmarking of advanced technology vehicles, continual advancement of the baseline, and broad dissemination of information for maximum benefit. The overall effect is to help accelerate the progression of advanced petroleum and emission savings technologies into the nation's vehicular fleet.

Reviewer 2:

The reviewer stated that the study of the Peugeot hybrid was very important.

Reviewer 3:

This reviewer said that the project provided data for product maturity.

Reviewer 4:

This reviewer said that understanding the technology's capability to be applied elsewhere was useful to understanding petroleum displacement.

Reviewer 5:

This reviewer said yes.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that this project team should be given a larger share of the AVTE vehicle testing budget, and seriously thinks a greater database would be had.

Reviewer 2:

This reviewer believed for the most part, that the resources are sufficient. The OEMs would always like to see results from these tests sooner rather than later, but whether achieving it is worth a significant increase in resources is debatable.

Reviewer 3:

This reviewer commented that good throughput for the resources allowed.

Reviewer 4:

The resources for this task are adequate. As mentioned above though, it is important to continually emphasize incremental improvements in project technical and cost efficiencies.

Electric Drive and Advanced Battery and Components Testbed (EDAB): Barney Carlson (Idaho National Laboratory) - vss033

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer commented that it appeared that there was a sound protocol for evaluating the battery used in the testbed system from the presentation. However, the unusually rapid degradation of the battery called for laboratory testing of the battery. The reviewer suggested that if the manufacturer will not provide useful data, this group ought to conduct pertinent tests independently. This was especially important, because this was the first battery to be evaluated in the testbed system. The reviewer was concerned that if there was not complete confidence for this first effort that conclusions from future testing would be suspect.

Reviewer 2:

The reviewer commented that there was a very good implementation of the system to match a target vehicle (the Nissan LEAF). The reviewer added that the strategy of evaluation with optimized controls seemed sound. However, the reviewer was just worried that this approach would not give good technology comparisons due to the variability of use in a field setting. The reviewer stated that this was okay as a reference point for where battery technology might be in some absolute sense under the variable field conditions, but pointed out that when more than one technology starts running, people will want to compare the results and it seemed like that would be hard. For example, the project might need to repeat a given technology evaluation at a different time of year.

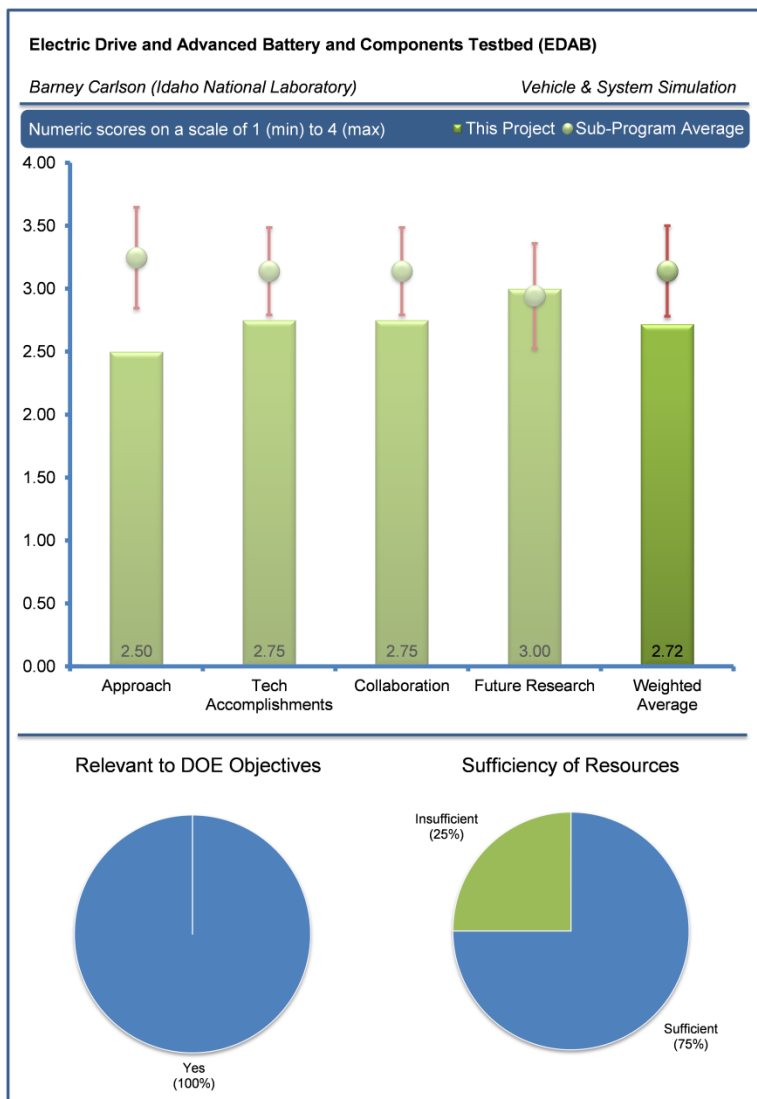
Reviewer 3:

This reviewer stated that this project had made fantastic strides to get this project functioning the way that it did. The barrier to get the vehicle to drive must have been difficult to overcome. However, the reviewer was just not convinced that the barriers needed to be overcome and that a similar level of information could be achieved on the bench.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer said that the system is in place and working, and that the development progress seemed good.



Reviewer 2:

The reviewer indicated that this was interesting work. Since the Electric Energy Storage Tech team appeared to endorse this work to help prove out the DOE battery technology projects then these were good technical accomplishments. The reviewer added that progress was excellent in that a lot of data on the battery had been collected.

Reviewer 3:

The reviewer observed that from last year to this year, there had been substantive progress. The reviewer's primary concern was with the validation of results.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer noted that it seemed like good coordination with the listed partners like ORNL and AVL North America to get the system going. There is a note in the collaboration section that results would be provided to others for modeling and energy storage system (ESS) development, but the reviewer did not see any of those partners listed. The reviewer asked if there was a clear path to delivery and if there were specific recipients for modeling especially.

Reviewer 2:

The reviewer said that having the Electric Energy Storage Tech Team select the battery and vehicle type for this activity was the correct approach.

Reviewer 3:

This reviewer said that there did not appear to be any particularly strong effort for collaboration, but that this study did not necessarily require such effort at this point.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that the PHEV selection for the next battery to be reviewed seemed to be the correct choice.

Reviewer 2:

The reviewer stated that the future battery testing would be helpful, but noted that again it would be very useful to have a validation of the initial results through some form of laboratory evaluation.

Reviewer 3:

This reviewer said that the project was in the testing phase now so the future research was just about selecting next pack to test. The reviewer did not get a feel for the process used to select the next pack to test.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said that this was a very worthwhile effort to conduct field evaluations of new battery technologies.

Reviewer 2:

This reviewer said that the effort contributed to the evaluation of battery projects that were also funded by DOE.

Reviewer 3:

The reviewer stated that it would be a small piece of a large puzzle in how new technology battery packs perform in the real world, but again the reviewer worried how comparative single tests with real world variability would be.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer thought that while the presenter did specifically note areas where additional funds would be necessary, that the project could use some additional funding to support validation of the initial testing results.

Reviewer 2:

This reviewer said that there was excellent data throughput for the resources allowed.

Reviewer 3:

The reviewer saw resources dropping from FY 2012 to FY 2013, which seemed reasonable with the change from system development to just testing packs.

Codes and Standards to Support Vehicle Electrification: Ted Bohn (Argonne National Laboratory) - vss053

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer said that the approach for standards development was pretty much cut and dried through the SAE and International Organization for Standardization (ISO) type processes. The approach of chairing some of the committees, using direct participation and bench testing to understand the technical problems was outstanding. This approach helped validate some of the situations and gave DOE a firsthand perspective in some of the problems versus taking an ivory tower type approach. Also looking at certain technologies (sub metering and vehicle de-powering) to fill in some of the gaps showed leadership and moves the industry forward.

Reviewer 2:

This reviewer said that considering the timeframe, the approach was adequate and very well executed.

Reviewer 3:

The reviewer stated that the project demonstrated a clear understanding of how this approach (i.e., committee leadership) best met objective for developing standards.

Reviewer 4:

This reviewer said that the standards were critical for wide-scale adoption. The reviewer added that it was a cost-effective use of research dollars. The reviewer concluded that proof of concepts for feeding and validation.

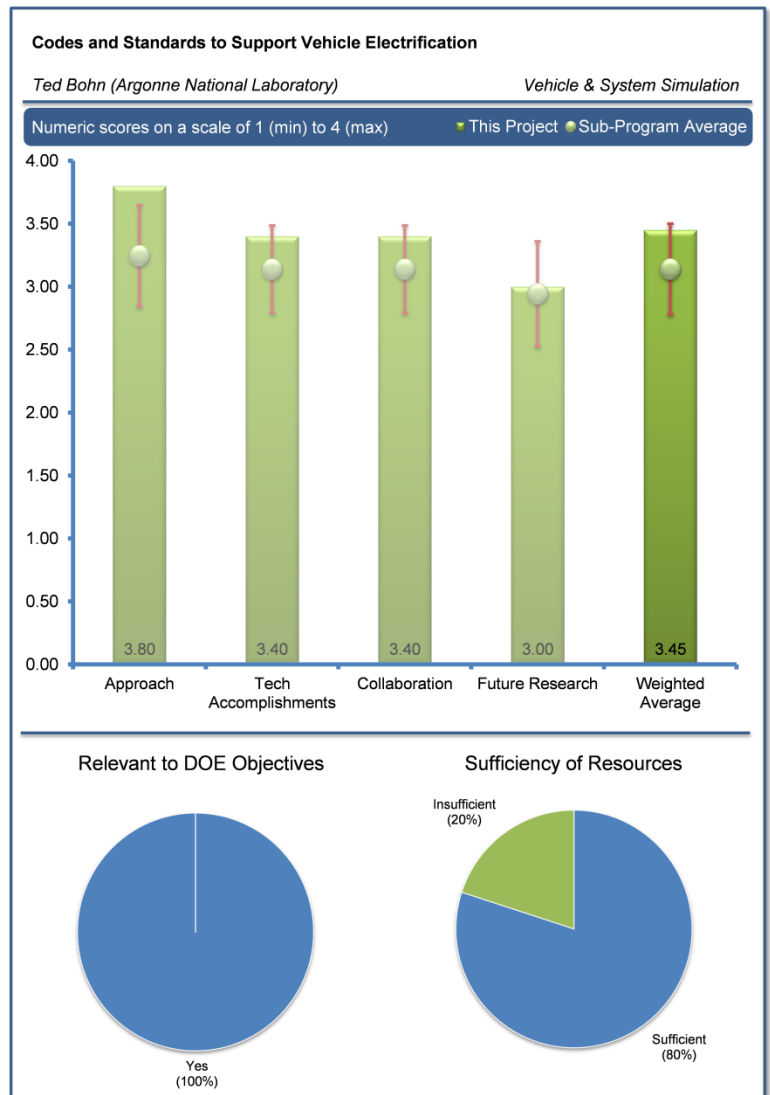
Reviewer 5:

The reviewer said that the approach of developing standards based on what was possible may divert industry efforts into areas that were not relevant to vehicle and infrastructure deployment. The reviewer added that some consideration of what was needed should be included.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the variety of areas covered was very impressive.



Reviewer 2:

This reviewer said that getting the direct current (DC) combo connector standard adopted and having hardware starting to head toward industry was good. However, as has been well known, having a U.S. standard in this area prior to 2010 could have saved the industry significant issues. It should be recognized that no single organization has total control over this issue. The reviewer added that queuing up the interoperability standards as the next priority is also good.

Reviewer 3:

The reviewer stated that it was good to see the Gantt chart since it implied a managed project.

Reviewer 4:

This reviewer stated that progress was generally slow with standard definition and development, and that those engaged were no exception.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer noted that an excellent industry team was developed to support the wide-ranging technical work underway.

Reviewer 2:

This reviewer stated that there was clear coordination with all parties. The nature of this activity is to collaborate, and although the PI clearly has an in-depth knowledge of the subject, he demonstrated through the presentation the involvement of others in defining the standards.

Reviewer 3:

The reviewer commented by the nature of the work.

Reviewer 4:

This reviewer said that the overall collaboration on the organization supporting the SAE committees and supporting research was good. If a wider range of utilities could be brought into the picture it would improve the overall effort. The reviewer added that trying to reach consensus across the wide range of competing business interest is difficult and was noted as a barrier in the 2012 presentation. The next major barrier in this area will probably revolve around the National Institute of Standards and Technology (NIST) sub-metering area. It was implied in the oral presentation that DOE was supporting the NIST standards development. The reviewer suggested that an additional chart on that effort would have been beneficial if DOE was supporting that standard development. If not, DOE should consider supporting that effort. NIST did not show up on the collaboration list. If DOE feels that it has enabling technology in this area, it should be working with NIST for adoption of that technology. This was not discussed similar to other standards development that was SAE based.

Reviewer 5:

This reviewer said that more international collaboration was required (the reviewer assumed this was restricted by travel limitations).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer observed that all of this work is focused on the future standards, and this was clearly shown in the presentation which included standards that would follow the existing work (e.g., 2953 for DC charging)

Reviewer 2:

This reviewer said that the focus on wireless charging is not supported by the current market. The sub-metering focus was well placed for grid integration, but is as much a regulatory issue as it is a technical one. The reviewer pointed out that some regulatory interface may be necessary to guide standards development.

Reviewer 3:

The reviewer opined that the plans to prioritize interoperability type standards and support of NIST sub-metering should be given priority over other elements that were identified such as V2G or wireless power transfer (WPT). The reviewer explained that the standards around the interoperability and sub-metering would be necessary for all concepts going forward and surety in these areas would help support the nascent business models that will be necessary to support industry after EVSE deployment grants are slowly phased out.

Reviewer 4:

This reviewer indicated that dynamic wireless charging needed to be addressed. This requires collaboration with Institute of Electrical and Electronics Engineers (IEEE) Standards Association (SA) electric vehicle wireless power transfer (EVWPT) activities.

Reviewer 5:

This reviewer stated that ongoing work was needed during market and technology growth.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer said that standards development was the backbone to achieving deployment at scale for PEVs with associated EVSE and surety to the consumers that they can access charging. The codes and standards are vital in supporting the overall market deployment of these vehicles which will result in petroleum displacement.

Reviewer 2:

This reviewer reasoned that because the technology being deployed that is subject to the standards being developed were clearly relevant to DOE petroleum reduction objectives, the project itself was relevant.

Reviewer 3:

This reviewer stated that standards were critical for wide-scale adoption.

Reviewer 4:

This reviewer indicated that the interoperability and grid interaction issues were significant to successful vehicle deployment. Combining hardware and software presentations next year would be more effective in conveying relevance.

Reviewer 5:

The reviewer said that the suggested standards contributed to developing an EV infrastructure that provides to the consumer and alternative to gasoline powered vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer said that it appeared that the resources were approximately at one full time equivalent employee. This appeared adequate to cover the SAE committee activities, but as previously noted, it did not show much evidence of supporting the NIST standards on sub-metering. Given that caveat, if the current funding level is also covering NIST then the resources would have been considered sufficient. If the NIST activity is not being covered then additional resources would be needed to cover that important area, especially if DOE is developing enabling technology in that area.

Reviewer 2:

This reviewer commented that the PI and his colleagues at ANL were clearly a sufficient resource for this project.

Reviewer 3:

This reviewer assumed that the resources were primarily driven by salaries and travel.

SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer: Dale Oehlerking (Navistar) - vss064

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the approach was a good straightforward analytical engineering approach but that there appeared to have been little progress beyond the analytical phase.

Reviewer 2:

This reviewer said that due to issues associated with Navistar dealing with their production engine exhaust gas recirculation EGR system (transferring to urea SCR), the project has been put on hold for one year. The approach and potential are very good; however, the business environment has complicated completion of the project.

Reviewer 3:

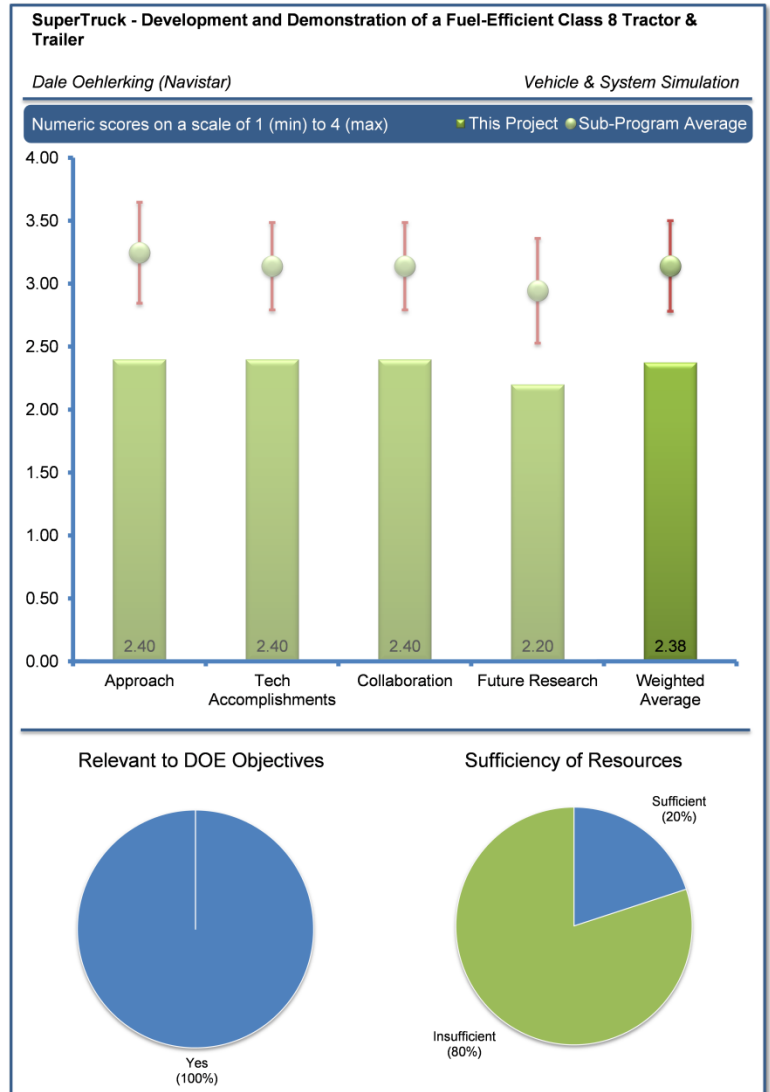
Overall, the reviewer commented that the approach was good. The aerodynamic improvement approach looked innovative. However, the reviewer was not sure how much help could be obtained from hybrid system for a highway operation. The reviewer observed that no waste heat recovery, such as Rankine cycle, would make the program hard to meet the program goal.

Reviewer 4:

The reviewer said that given that the project was put on hold nearly a year ago, and that good progress was made up to that point. The reviewer was disappointed that the presenter had only been involved with the project a short time and had limited visibility into the technical details and needed assistance from colleagues to answer questions.

Reviewer 5:

This reviewer said that unfortunately this project has been put on hold resulting in a delay of over a year, which might cause some of the work to lag behind or overlap with other SuperTruck projects. The reviewer then recommended that efforts be made to look at results of other SuperTruck projects before proceeding.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said that given the work stoppage, the progress was good and commented that the Hybrid and Aero work were well executed. The reviewer added that the smart cruise control should be validated in real world conditions (or modeled accordingly) to quantify actual improvements.

Reviewer 2:

This reviewer indicated that the project was on a one-year hiatus due to the business environment and lack of resources within Navistar for completion. The reviewer added that the approach seemed sound, but that progress was limited due to internal resource.

Reviewer 3:

This reviewer was impressed with the forward windshield/driver and rear engine analysis and said that this was provocative. The reviewer was disappointed in the hold on the project, but appreciated that Navistar was very honest in their reasons.

Reviewer 4:

This reviewer observed there was not so much progress since the last annual report due to the program on hold.

Reviewer 5:

This reviewer noted that the rate of progress has been slow and that little actual hardware seemed to have been built and tested.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer stated there were good collaborations with Meritor and Lawrence Livermore National Laboratory (LLNL).

Reviewer 2:

This reviewer stated that the collaboration could be good if work was permitted to proceed; but until or unless that occurs, there was little real collaboration.

Reviewer 3:

This reviewer stated that the appropriate collaborators were on board, however, that the progress following the hiatus would better to determine proper collaboration.

Reviewer 4:

This reviewer commented that it would be helpful if the contractor could be more specific about how the partners helped the program. Perhaps, an acknowledgement with partner logo for those slides would be helpful.

Reviewer 5:

This reviewer stated that the turmoil at Navistar had likely affected their relationships with partners. This will probably have an effect on this project, now and when the team restarts next year.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer stated that although the project was on hold, that the project proposal appeared sound. The reviewer added that completion was an issue until the Navistar business environment improves.

Reviewer 2:

This reviewer thought that Navistar had good ideas to move forward with later on and certainly hoped that project finish its total scope.

Reviewer 3:

This reviewer stated that the future plan was good, but identified that the entire program was on hold, which would make the program progress way behind their competitors.

Reviewer 4:

This reviewer said that unless work resumed, there was no future for this project.

Reviewer 5:

This reviewer observed no future research proposed due to the work stoppage.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said that the improvement of freight efficiency supported the overall DOE objectives of petroleum displacement.

Reviewer 2:

The reviewer stated that the goals were in line with petroleum displacement.

Reviewer 3:

This reviewer said that this project could indeed support the overall DOE objective of petroleum displacement if it were allowed to proceed.

Reviewer 4:

The reviewer commented that if successful, the project could result in a commercial product that improves freight efficiency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer commented that currently, Navistar has to re-allocate its resources to production projects. Once this environment improves, resources can be re-applied to project.

Reviewer 2:

This reviewer said that since the work has stopped, it was obvious that resource availability was the issue.

Reviewer 3:

The reviewer said the project was on hold due to resource issues.

Reviewer 4:

The reviewer was not sure how Navistar was able to support this program with their 58% cost-sharing due to their current financial situation. However, this was not caused by DOE. Rather, this was due to Navistar management.

Reviewer 5:

The reviewer observed sufficient resources given the agreement to put the project on hold.

Vehicle Mass and Fuel Efficiency Impact Testing: Jim Francfort (Idaho National Laboratory) - vss074

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the research plan was well thought-out. Good research methods were used in collecting data.

Reviewer 2:

The reviewer commented that this appears to have been a reasonably well-constructed study, and that future efforts appeared to be relatively minor tweaks to the initial effort.

Reviewer 3:

This reviewer said that the technical approach was sound. Adjusting for ride height was good attention to detail but this was not really new stuff with a lot of new barriers. The biggest barrier is the variability of coast down testing. Vehicle coast down testing can have high variability, so many tests are needed. It sounds like there was adequate attention to detail to obtain good repeatable results. Fourteen were done but the reviewer would have liked to see the statistical significance of that number of tests. The reviewer thought that including error bars on Slide 10 showed the variability. Within those error bars it was hard to say that the weight changes had a different impact in the LEAF and Fusion Hybrid. The reviewer added that an omission is any analysis or modeling to suggest what the answer should be based on knowledge of the vehicles. It seems like there should have been a better connection to use this data for model validation and improvement and also to use modeling to get expected results.

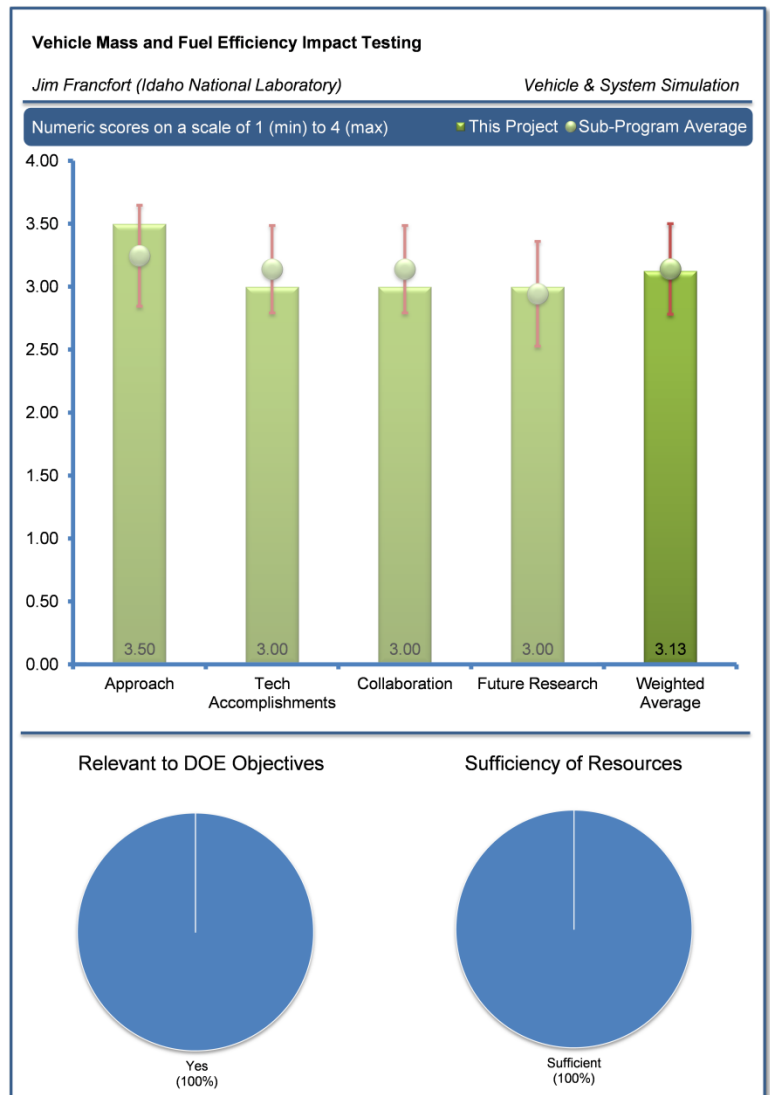
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer said yes, that the data gave some surprising results. This data will help validate DOE models. Therefore, future data collection may not be needed. This will reduce cost. The reviewer added that this was important work.

Reviewer 2:

This reviewer observed that the study accomplished what it set out to do, but the reviewer was not sure that the results were particularly meaningful. In fact, the data suggested this study was more relevant for internal combustion vehicles than EVs. In the future, it would be helpful for INL to more clearly articulate how the data produced by this study could be used to advance EV technologies.



Reviewer 3:

This reviewer thought the why could have been shown better. The reviewer asked if it made sense that the vehicle mass had less impact on highway driving. The reviewer continued by asking what the analysis of the breakdown of loads, like aero versus rolling resistance and weight related was.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer observed significant work from all partners.

Reviewer 2:

This reviewer commented that there were good collaborators.

Reviewer 3:

This reviewer indicated that this study did not necessarily require strong collaborations, but that it might be useful to coordinate activities with other entities or projects to better relate the results to future actionable activities.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer commented that there has always been a tradeoff between safety and weight. This work will help designers and other researchers make better choices. Other reviewers were concerned about tire pressure remaining the same. The reviewer indicated that looking at low friction tires for future work would be helpful.

Reviewer 2:

The reviewer stated that this work was complete. The reviewer just thought this kind of work should be done with a goal in mind of looking a little deeper than just reporting results, so more modeling should be involved.

Reviewer 3:

This reviewer stated that the proposed future research appeared to be relatively minor tweaks to the existing effort, but that it was unclear that those tweaks would cause any significant changes to the underlying trends of the original data. The reviewer was not sure about supporting funding for the future work without a much clearer description of how any of the results could be used to further advance EV technologies.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer said that weight and FE were important for DOE. This work validates DOE simulation models.

Reviewer 2:

This reviewer said that the project showed how lighter-weight vehicles could get better fuel consumption.

Reviewer 3:

The reviewer stated that at a minimum, the study could serve as validation for the current design of EVs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer said that resources appeared to be adequate.

Reviewer 2:

The reviewer observed that the study was funded sufficiently to produce verifiable data, but that the presenters did not suggest any additional funds were essential to further advance this study.

Reviewer 3:

This reviewer stated that resources seemed reasonable.

CoolCab Test and Evaluation and CoolCalc HVAC Tool Development: Jason Lustbader (National Renewable Energy Laboratory) - vss075

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

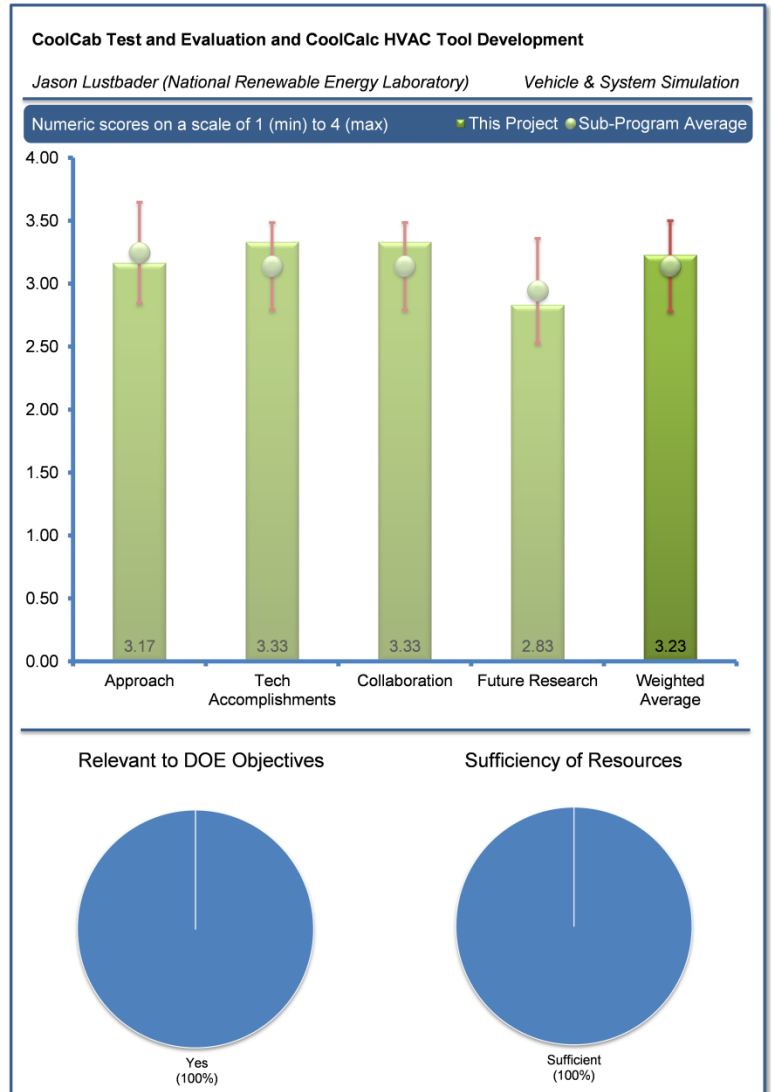
This reviewer stated that heating energy requirements were not addressed. The data reported for cooling situations was good, but this may not translate to the heating side. For example, a white paint job is good for cooling, but not for heating. This aspect really needed to be addressed to make sure that the results/conclusions were valid whether the vehicle is operated in a hot or cold zone. The reviewer added that the testing processes/setup seemed to be adequate for the scope of research. The reviewer said that it was important to try and relate design changes to the cost of the change, and FE benefit. Adoption of new technologies by the industry will be driven primarily by cost.

Reviewer 2:

The reviewer commented that the overall approach was good; however, the reviewer would have preferred to have seen the technologies picked after the benchmark data produced an energy audit that identified the largest opportunities. The reviewer added that it was possible that prior work provided insight into the technologies; however, these insights were not identified in the presentation.

Reviewer 3:

The reviewer commented that there was a lot of material in the slides related to the effort to develop and deploy the CoolCalc tool. The approach to the overarching goal, however, may be a bit lost in this detail. If the goal were simply to develop the analytical tool, it would be a different matter. The reviewer added that it was not clear how the project would first split the dictionary to determine if the majority of opportunity for 30% reduction was on the heating or the cooling side. If it was an 80% heating issue and 80% effort (for example only) was focused on cooling efficiencies, then this would be a very ineffective approach. A couple years into the effort it seemed there would have been some insights into this fundamental question. The reviewer also questioned surveys as a research tool in this case and are admittedly uncertain, especially segmenting down to specific relevance to thermal loads. A shift to some data loggers would be advisable.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed good progress with accomplishments. The simulation was almost complete, and it seemed that lots of technical insight would be gained from it. Some very valuable data had been generated/presented regarding cooling loads. The reviewer continued to say that a good grasp of actual idle times was critical to the accuracy of simulation results. The reviewer suspected that most fleets have this information, and would be much more willing to share than OEMs. Lastly, the reviewer concluded that the experiments seem really well controlled, and data appears to be valid.

Reviewer 2:

This reviewer thought that the technical accomplishments were many and commended the PI for that. The reviewer had questioned the approach to the stated goal but this was not to detract from the substantial effort and results even if not efficiently targeted to the stated objective.

Reviewer 3:

This reviewer stated that the technical progress and progress toward goals appeared consistent with the plan; however, the reviewer's only concern was not being sure that the project helped if the systems were already adopted. The reviewer was under the impression that systems were already fielded to address anti-idling laws, and commented that the presentation did not lay out the current market landscape cleanly. It was not clear to this reviewer if the technologies under consideration were not yet adopted widely and if this was an enabler to support more beneficial technologies.

Reviewer 4:

The reviewer indicated that the progress is to plan.

The reviewer added that more disclosure on the effects of other variables would be helpful as those become available.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer acknowledged that there were many involved parties, especially from the industry, which showed excellent collaboration.

Reviewer 2:

This reviewer commented that the collaboration was very good, almost outstanding. It was not clear exactly how much the partners were really involved, other than with the hardware supply. The reviewer suggested that the project try to demonstrate how the data might be used in the design processes. It may be good to report on their feedback on the project.

Reviewer 3:

The reviewer observed that the project had good working relationships with several OEMs. The reviewer added knowing that the project planned to bring fleets in and suggested that sooner rather than later would be helpful to get fleet viewpoints, even before the tools and techniques are completely polished.

Reviewer 4:

The reviewer indicated that the collaborators had skin in the game, thus there was a reasonable path to market should the technology be viable.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the results of other proposed insulations and cab materials will provide good design guidance to the OEMs. The reviewer added that very specific payback information on proposed solutions will help guide fleets to purchase these solutions.

Reviewer 2:

The reviewer indicated that the planned work appeared to be good, but that the lack of focus on cold work, where heating was needed, was a major drawback.

Reviewer 3:

The reviewer said that the proposed future research seemed reasonable, but it did not appear to leverage other transportation segments that could benefit from lower HVAC cabin loads [light-duty (LD) BEV/PHEV markets]. With SC03 testing with A/C on, the reviewer believed others were interested in lower HVAC cabin loads. The reviewer noted that one of the technologies that was not considered (or mentioned) is the control of the fresh air/blend door to reduce thermal loading.

Reviewer 4:

This reviewer stated that there was not enough plan specifics here for a multi-year, multi-phase project. The reviewer reported that FY 2014 boiled down to the following: bring together knowledge...; and improve capabilities.... The reviewer opined that these were very broad and insufficient to effectively achieve the objective without more specifics. The reviewer noted that perhaps these existed but just did not come through well in the presentation.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said that the project was absolutely relevant and that much fuel is used for idling.

Reviewer 2:

This reviewer said that idle fuel consumption reduction was a major issue that consumed massive amounts of fuel. Additionally, there were economic drivers for fleets to adopt the lessons learned from this project, so it was likely to have a benefit on fuel consumption.

Reviewer 3:

This reviewer observed that this project targeted the reduction of fuel consumption during idling periods of trucks. The findings are also relevant for electrified trucks and will help to reduce the required amount of energy for heating and cooling.

Reviewer 4:

The reviewer indicated that the topic was relevant though it could be questioned if the subject matter should not be simply left to competitive OEM development. It was not clear to the reviewer that the tool was worth the investment in its impact to the real product development efforts at the OEMs.

Reviewer 5:

This reviewer stated that the core technology under consideration appeared consistent with petroleum displacement, but that the path to adoption was simplified into the following: if the three-year pay back is met, of course everyone would adopt the technology. In the past, anti-idling discussions were about meeting anti-idling laws, but anti-idling laws were not really mentioned as a driver. The reviewer's concern was that a three-year pay back may not be enough to drive the technology, thus leading to reduced petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that resources were adequate. The data that the project was able to generate now seemed to be sufficient to draw the conclusions required at the end of the project.

Reviewer 2:

This reviewer thought that the resources were sufficient. Per other comments in the approach, etc. it could be argued that the resources could be allocated in a different way and perhaps lead to greater returns toward the objective.

Development and Demonstration of a Fuel-Efficient Class 8 Highway Vehicle: David Koeberlein (Volvo) - vss081

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the work had technically sound systems approach to goals. The reviewer added that the project used sufficient tools to achieve the task, and was confident to hit target.

Reviewer 2:

This reviewer very much appreciated Volvo's approach on this project. The reviewer commented that it was methodical, technical, good use of resources, etc. The project is taking the opportunity to integrate into a complete system. Volvo very much understands that this is a completely new tractor trailer and old school analysis/thinking no longer applies (e.g., how engines work with significantly better aero).

Reviewer 3:

This reviewer commented that this was a well-constructed project plan and a good approach to identify and evaluate the most promising technologies which could achieve the goal.

Reviewer 4:

The reviewer observed that the approach was a straightforward engineering approach whereby candidate technologies were evaluated for possible use to overcome barriers to achieving the project objectives. System simulation studies were done for both the baseline truck followed by the improved truck with various technologies included.

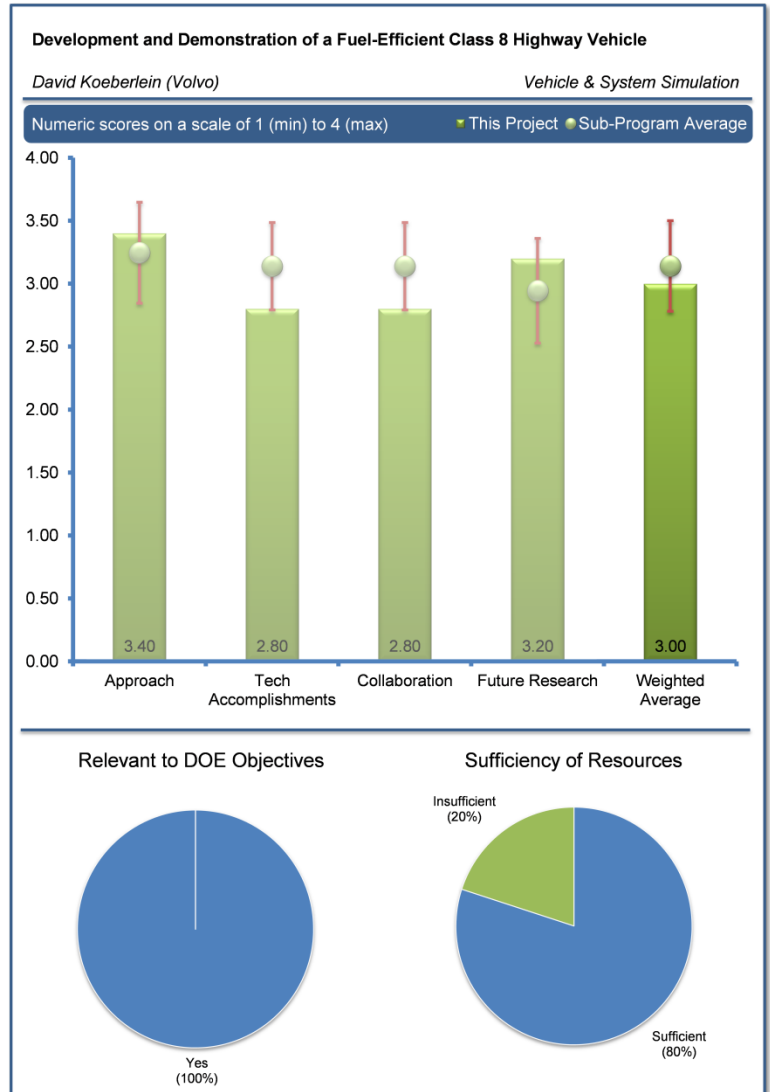
Reviewer 5:

This reviewer observed that the work included all necessary means to achieve the program goals. The reviewer was not sure why a pick-up truck on Slide 5 was used, which was not appropriate because this was a heavy duty truck program.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer observed that the progress toward overcoming fuel efficiency barriers in the engine powertrain via right-sizing the engine appeared to be good.



Reviewer 2:

This reviewer observed that the brake thermal improvements were ahead of schedule, showing a 48% brake thermal efficiency. Vehicle aero improvements had been implemented on trailer. The design to reduce the weight on cab system was complete (concept complete, 7,800 lbs. reduction in modeling completed).

Reviewer 3:

This reviewer indicated that this was a bit difficult because the project started so much later, but given that the project was starting to build their test mule, it seemed great progress was being achieved.

Reviewer 4:

The reviewer indicated that the progress was impressive considering that the program started late, but most of the slides were still about the road maps; not too much to be quantified.

Reviewer 5:

The reviewer said that right sizing the engine could result in a very specific design and it was unclear if this engine could perform as well in a different application or if all the changes were not implemented in the truck design. Comments on hybrid commercial feasibility were well throughout.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer stated that there were sufficient partners when compared to other projects.

Reviewer 2:

The reviewer stated there was a good balance of collaborators with institutes, testing, manufacturers, and etc.

Reviewer 3:

The reviewer observed that collaboration seemed solid with the suppliers.

Reviewer 4:

This reviewer said that the project should have a fleet/customer involved more.

Reviewer 5:

This reviewer stated that aerodynamic improvements would require a great deal of collaboration between the prime contractor and the trailer manufacturers. This collaboration appeared to need some additional work to enable the system - tractor and trailer to meet the performance objectives.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that the project was outlined and in progress, and that appropriate tools and analysis were guiding the decisions (with a focus towards production).

Reviewer 2:

This reviewer stated that the project demonstrated a well thought-out plan for the next few years.

Reviewer 3:

This reviewer said that on-road testing and validation of final demonstrator should show good results.

Reviewer 4:

The reviewer stated that the plans for future work should lead to improvements but did need better focus on overcoming barriers.

Reviewer 5:

This reviewer commented that the future research needed to be more specific on the technologies.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer opined that this work, if successful, would support the overall DOE objective of reducing petroleum.

Reviewer 2:

This reviewer commented that results, in production, could greatly impact consumption for freight transportation.

Reviewer 3:

This reviewer said that if successful, this project could result in a commercial product that improves freight efficiency.

Reviewer 4:

The reviewer indicated that improvement of the freight efficiency was always in the line of DOE objectives of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer stated that resources for the project were quite substantial and appeared to be sufficient to meet the stated milestones, but perhaps not in such a timely manner.

Reviewer 2:

This reviewer indicated that at the present, most of the presentation slides were only on road maps, and was not so sure how the contractor could achieve the goal with much less funding compared to their competitors.

Improving Vehicle Fuel Efficiency Through Tire Design, Materials, and Reduced Weight: Timothy Donley (Cooper Tire) - vss083

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer commented there was an excellent approach and excellent use of go/no go steps. The reviewer liked the number of tests performed already.

Reviewer 2:

This reviewer observed that the project identified six novel technologies that could favorably impact fuel efficiency through weight and/or rolling resistance savings, rather than focusing on just one. The reviewer also observed separate milestones and go/no-go gates for each of the six technology approaches. The reviewer commented that the fuel savings and weight reduction goals were more aggressive than some other projects in the DOE portfolio.

Reviewer 3:

This reviewer commented that exploring several technologies in one project was an ambitious approach, which could benefit the project outcome. However, it seemed that the project approach was working in the sense of 50/50 chance on the development of the six technologies. So a decision needs to be made on whether or not to drop the non-working technologies at this time.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

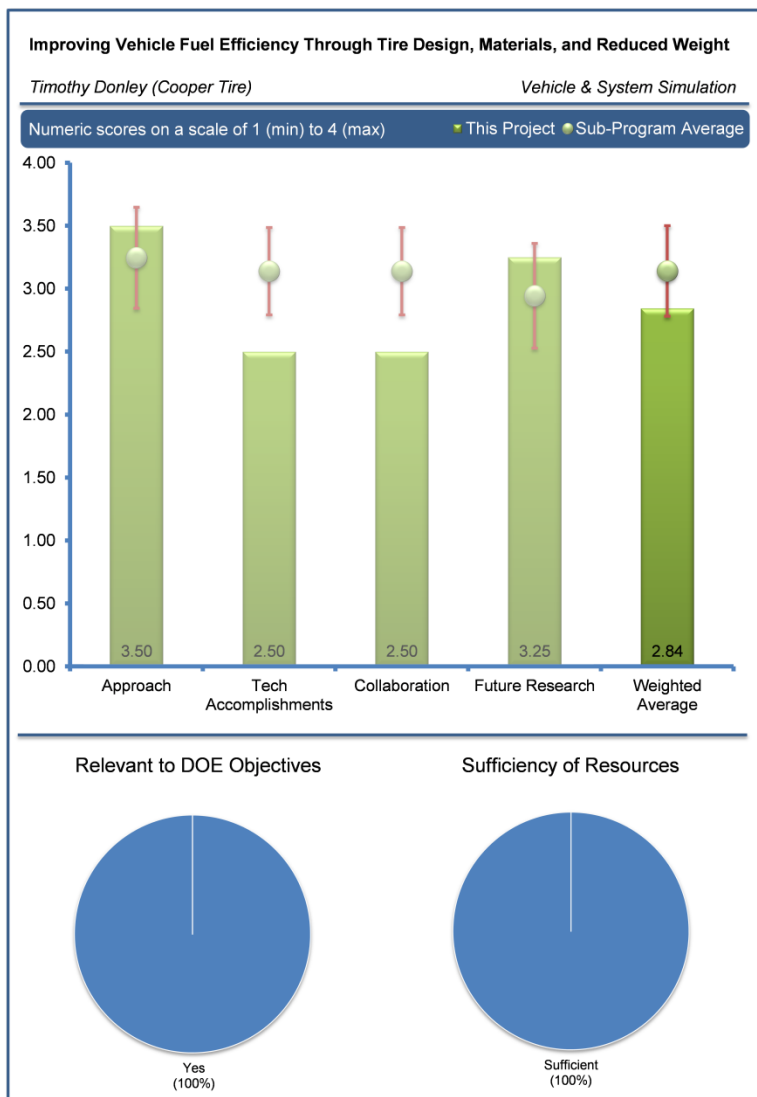
This reviewer noted that the project had performed a number of tests already and had made excellent progress.

Reviewer 2:

This reviewer stated that there was good progress on all six technical approaches. The reviewer added that testing to date suggested Cooper was on track to meet goals of 20% weight reduction and 3% fuel savings.

Reviewer 3:

The reviewer commented that the project was achieving progress with the working technologies and could achieve the required goal of the DOE's objective, in spite of no positive results for some technologies.



Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer stated there was good progress with the collaboration with NREL.

Reviewer 2:

This reviewer observed that there was a dynamic adjustment based on actual needs. NREL was developing a lightweight tire model, but Cooper has its own modeling capability now and will explore whether it is possible to transition the NREL contract to focus on testing fuel efficiency. The reviewer added that wear testing was done externally; and that all other testing is currently being done within Cooper.

Reviewer 3:

The reviewer observed that the collaboration with the only partner, NREL, ended, and that there was no further indication that more collaboration would happen in the current or future work. However, the project could benefit from collaboration in the area of material development, consumer feedback, and other areas.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer observed excellent go/no go decision points coming up. The reviewer added that there was good use of decision making for cost feasibility.

Reviewer 2:

This reviewer commented that the proposed future research is generally very good. In one of the technical approaches (i.e., Approach 5), Cooper plans to try making tires with shallower treads but with better rubber compounding to result in the same tire life. The reviewer asked why not have a very long-life tire with (near-) standard tread depth instead. That approach would likely be safer in water/snow, and there would be fewer tires to make/transport/landfill/recycle overall.

Reviewer 3:

This reviewer said that the project had clear decision points for each technology. However, it seemed that the decision points were not followed in the development of some of these technologies and planning for future work.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer indicated that rolling resistance reduction and weight savings in tires could modestly reduce fuel consumption on a per-vehicle basis, but this can be multiplied across the entire vehicle fleet for a significant overall benefit.

Reviewer 2:

This reviewer commented that this project was well designed for cost savings by reducing gas mileage.

Reviewer 3:

The reviewer indicated that the project seemed on track for achieving the DOE objectives of petroleum displacement with the technologies that were showing positive results.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer observed good progress and no indication of resource constraints.

Reviewer 2:

This reviewer said that it seemed there were sufficient resources to achieve the goal of the project.

A Materials Approach to Fuel-Efficient Tires: Peter Votruba-Drzal (PPG) - vss084

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

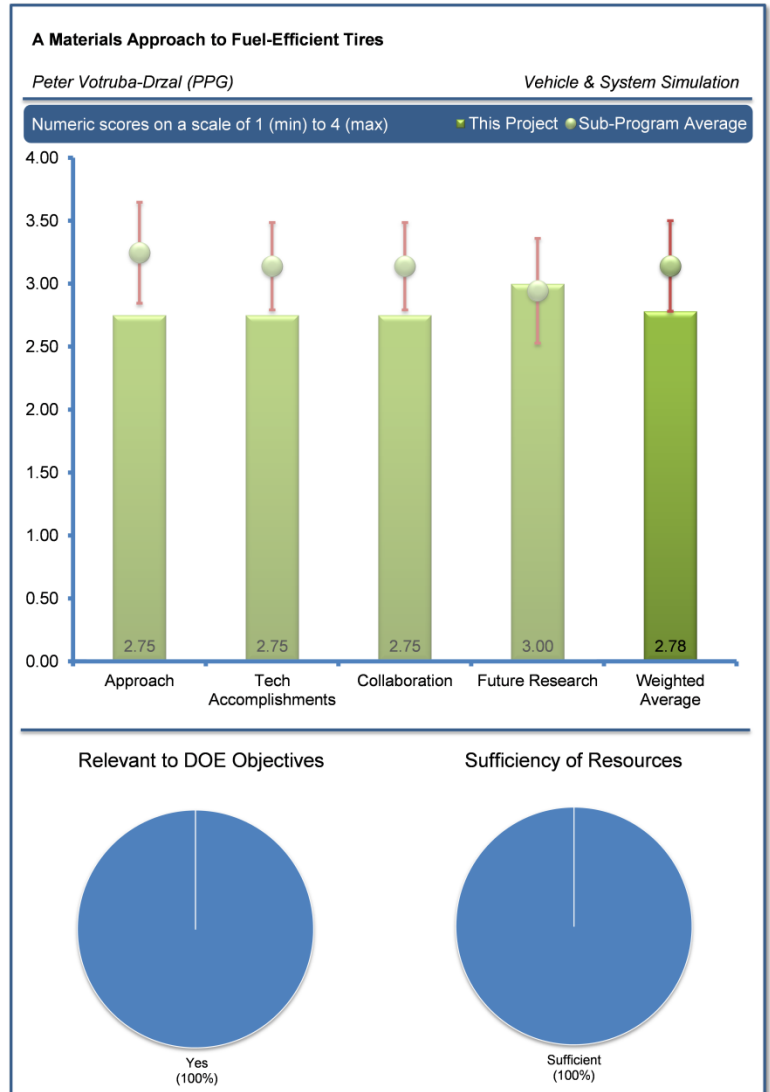
The reviewer liked that the project had a go/no go milestone coming up. It will be an important step.

Reviewer 2:

This reviewer commented that the approach of developing tire materials to improve its fuel efficiency by using innovative fillers and barrier coating technologies was the most feasible method for achieving good results while maintaining other tire performance parameters. However, the approach needed to elaborate more on how the project would address the manufacturability issues especially with the inner liner coating material. In addition, there was no discussion on the cost of these technologies, especially filler materials, and how it would be solved.

Reviewer 3:

This reviewer observed the refinements of traditional technologies. The reviewer noted that the milestones looked reasonable. The reviewer added that the Programmatic Approach slide was not helpful.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said that the project achieved its milestones, had excellent milestones set, and had achieved their goals to this point. The reviewer added that the project was doing a good job on focusing on keeping costs reasonable for consumers.

Reviewer 2:

The reviewer said that filler material work showed progress on developing compounds that have improved properties for meeting the rolling resistance performance requirements; however, the cost will be the main factor for commercialization of these materials. Also, the coating material has showed good results in terms of barrier performance however, manufacturing issues will be the key factor for any good outcome of the project.

Reviewer 3:

This reviewer identified that the project was about 5% behind on barrier work, but that corrective action was underway. The reviewer observed that the project had prototyped and tested numerous materials. The reviewer added that the progress appeared substantial; as

of March 15, there were 115 functionalization experiments, 181 rubber compounds mixed, 1,755 tests on rubber compounds, and 8 pilot-plants scaled-up. Lastly, the reviewer commented that it appeared that the current barrier coating was not stable at vulcanization temperature.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer observed that the collaboration with Goodyear continued and that the project apparently added collaboration with North Dakota State University Center for nanoscale science and engineering in 2013.

Reviewer 2:

This reviewer stated that there was good collaboration with Goodyear and that it was an important one to achieve goals.

Reviewer 3:

The reviewer said that the collaboration with a major tire manufacturer and a research institute were well coordinated.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the project had a clear future plan, especially the milestone for building a tire using the down selected filler materials, and also for mentioning maintaining alignment with tire manufacturers for coating material, which can resolve manufacturability issues.

Reviewer 2:

This reviewer could have benefitted from more detail in the presentation but indicated that what was reported looked reasonable.

Reviewer 3:

The reviewer noted important steps were coming in the future. This reviewer added the presentation could have detailed the go/no go step better.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said that the change in silica would allow for better gas savings.

Reviewer 2:

This reviewer stated that the project supported DOE's objectives.

Reviewer 3:

This reviewer commented that reducing tire rolling resistance would save a modest amount of energy per vehicle, but could be rapidly deployed across the entire new and legacy vehicle fleet. Those legacy vehicles that are driven the most (consuming the most fuel) will be able to access this fuel-saving technology soonest.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the project has sufficient resources.

Reviewer 2:

This reviewer stated that the resources appeared to be appropriate. The project is mostly on-track (a minor delay, with a corrective plan in place) and PPG has not indicated a need for additional resources.

Reviewer 3:

The reviewer observed good partners and coordination.

System for Automatically Maintaining Pressure in a Commercial Truck Tire: Robert Benedict (Goodyear) - vss085

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the approach had clear steps and milestones. It also covered several aspects of project concerns, for example, not altering the tire significantly, maintain current manufacturing process, and addressing retreading issues.

Reviewer 2:

The reviewer liked that the project has surveyed to see interest in buying these tires.

Reviewer 3:

This reviewer stated that the peristaltic pump molds into the tire sidewall near the bead. The regulator in the tire opens to allow air to enter the pump tube when the tire pressure is under the set value. All system components are built into the tire; this compatible with existing standard fleet wheels and tire-pressure monitoring system (TPMS). The system lasts the life of the tire, including retreading. The reviewer concluded that the project would test in diverse vehicle fleets.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

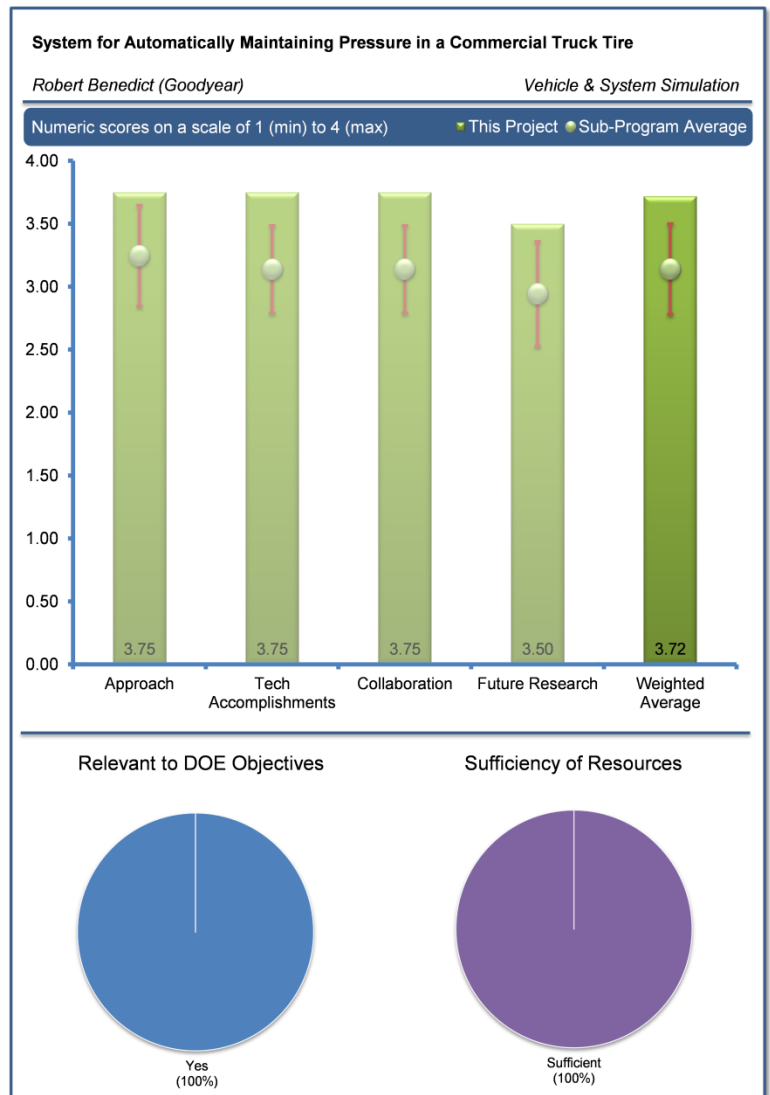
This reviewer noted excellent progress. Much of the 2013 presentation was completely different from the 2012 presentation. The reviewer observed that there were molded prototypes anticipated in summer 2013. Target specifications have been met to date.

Reviewer 2:

This reviewer liked that the project considered the cost implications and that the project was trying to accomplish the objectives in a cost-effective manner for consumers.

Reviewer 3:

The reviewer observed that the project had overcome some barriers with possible successful approaches, for example, designing redundant check valves to prevent leaks, and replaceable filters. However, the reviewer opined that more emphasis on tire durability and reliability is needed, as well cost.



Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer said that there were good indicators of collaboration with components manufacturers, fabrication facilities, and consultants.

Reviewer 2:

This reviewer observed that the project was collaborating with fleets, vendors, and suppliers. The reviewer commented that roles were appropriate and defined. The reviewer noted vendor/supplier contracts were completed with Sam Landers (former Goodyear R&D fellow), AMB (tire production fixtures), Logan (tire production fixtures), and Eaton (air management components).

Reviewer 3:

The reviewer said that the project team knew what it was good at and knew where help was needed. The reviewer noted a good collaboration with Eaton.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer noted that there was well-defined, appropriate, and apparently complete plans for tire prototyping, performance and durability testing, fleet trials, and design refinement.

Reviewer 2:

The reviewer indicated that the project had excellent and realistic milestones set. The timelines were reasonable to achieve objectives.

Reviewer 3:

The reviewer observed that the future plan had accounted for design refinement, evaluation of prototype tire performance, and the durability of the tire. However, further planning for mitigating durability issues may improve the chance of having a working final product. In addition, the project could have a future plan to evaluate the effect of this device on the TPMS or similar technologies.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer indicated that while Goodyear was (appropriately) starting with HD truck tires, this technology was ultimately applicable to every on-road vehicle. The per-vehicle FE savings would be modest; however, the benefits could be realized by every vehicle; new and legacy after a short phase-in (and the vehicles that drive the most would be ready for new tires the soonest).

Reviewer 2:

The reviewer stated that the project would support DOE objectives by automatically maintaining proper tire inflation pressure and reducing fuel consumption of under inflated tires.

Reviewer 3:

The reviewer said that yes the project allowed for savings in fuel by changing tires.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer did not think that the project has the resources to accomplish the objectives.

Reviewer 2:

The reviewer commented that resources appeared to be adequate. The reviewer added that Goodyear has made excellent progress, and offers no indications that resources are insufficient. Goodyear is approximately halfway through the three-year project. The reviewer noted funding as \$1.5 million DOE, \$2.57 million match.

Reviewer 3:

This reviewer stated that the project had sufficient funding

Next Generation Environmentally Friendly Driving Feedback Systems Research and Development: Matthew Barth (University of California at Riverside) - vss086

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer said that the project team approach appeared consistent with the original proposal.

Reviewer 2:

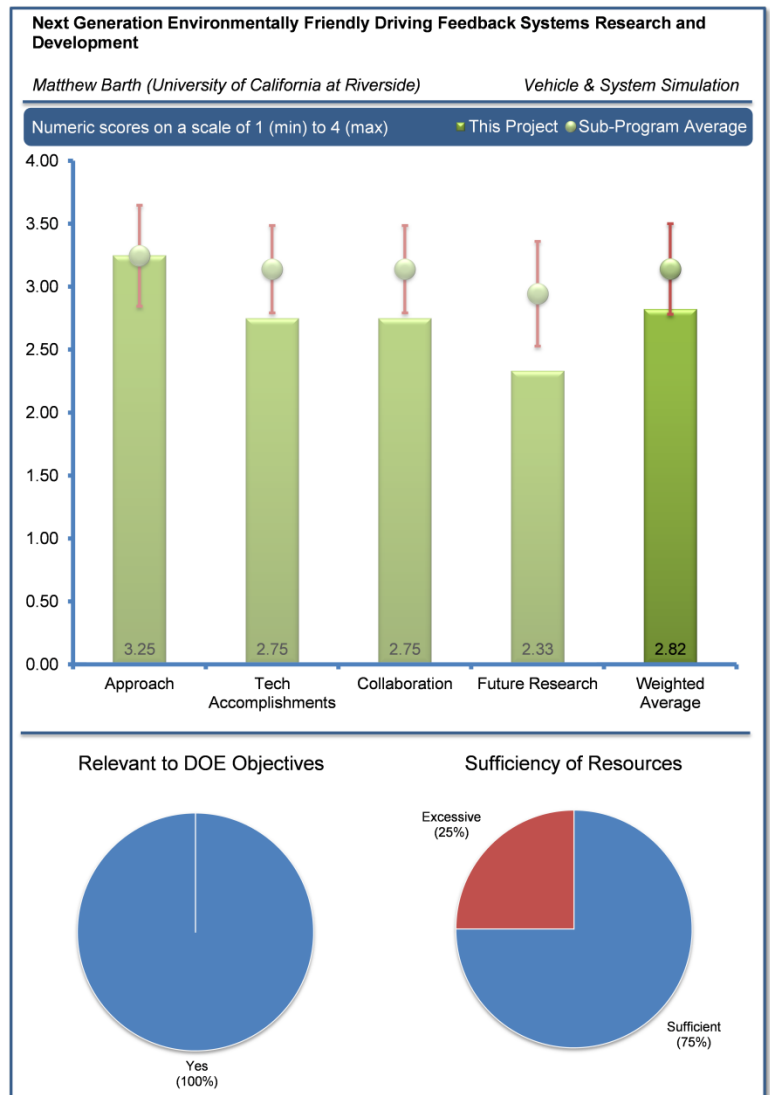
This reviewer said that the multi-pronged approach addressed many opportunities for reducing fuel consumption. The project is well designed and feasible, but it was not clear how closely it is integrated with any other projects. The phased approach to the project is logical.

Reviewer 3:

This reviewer said that it was not clear until later that this project applied only to light-duty vehicles. It was confusing because the inclusion of Riverside Transit Agency implied the inclusion of Class 8 heavy-duty vehicles operating on fixed routes. The reviewer commented that the approach needs a lot of work for both consumer drivers and fleet drivers. It was not clear to the reviewer how many consumer drivers would be involved, how they would be selected, and what controls would be established. While controls could be established for fleet drivers because the drivers operate from and return on a daily basis to a centralized base, there were several deficiencies. Most important, it was also unclear to the reviewer if individual drivers in a fleet were being tracked. Without tracking individual drivers, there could be no accountability and no incentivization. The incentive for the consumer drivers is clear – reducing fuel consumption saves money. However, as far as the fleet driver is concerned, the driver has no incentive to improve FE because the driver is not paying for the cost of fuel. The presenter did not discuss any incentives for the fleet driver to improve FE. The reviewer asked what happened when the fleet driver was not being observed by the project investigators. The reviewer continued to say that for incentivization to take place for fleet drivers, there has to be supervisor intervention. The supervisor needs to monitor periodically (e.g., weekly) fuel consumption for each individual fleet driver and provide rewards for improvement as well as discipline for lack of improvement.

Other observations were provided by the reviewer as follows:

The reviewer suggested setting the commercial fleet average fuel consumption reduction goal at 5-10%, citing a 2010 National Academy of Sciences report that states that improvements with driver can result in as much as 17% fuel savings.



The reviewer also noted the need to calibrate fuel consumption measurements and referenced a West Virginia University study that indicates on-board diagnostics (i.e., J1939) fuel consumption measurements can be off by 10%. The reviewer questioned the 2% improvement shown by the project when the inaccuracy is 10%. Thus, 2% improvement is in the noise level.

The reviewer recommended including go/no-go decision points between phases so that if the appropriate progress is not made, the successive phase is not engaged until the preceding phase is satisfactorily accomplished.

The reviewer suggested taking advantage of the recommended practices and displays made by the U.S. DOT Intelligent Transportation Systems Joint Program Office (ITS JPO) on Human Machine Interfaces that apply to drivers. The reviewer stated that the ITS JPO has been working on prioritizing the types of warning, alerts, and displays of information to the driver so that the driver is neither overwhelmed nor confused and makes the appropriate decision to act safely.

The reviewer stated that the project did not seem to control variables such as miles driven, route, duty cycle, terrain, routing, climate, traffic conditions, and weight of load carried, and noted that the last variable has a tremendous effect on fuel consumption (because the National Academy of Sciences has recommended a measure of FE based on weight-specific or weight-normalized fuel consumption per mile). Unlike passenger cars, FE of light-duty vans can vary with load carried. As such, the reviewer recommended that the project show that either the weight of the load does not matter or that the vehicle load is weighed.

According to the reviewer, there did not appear to be measures in place to prevent distracted driving. A smartphone was used for the driver to receive information, but no safety countermeasure feature was in place to prevent the driver from texting or otherwise using the smartphone to dial or transmit.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that there was a long list of technical accomplishments so far and said great work.

Reviewer 2:

This reviewer said that the presenter seemed to have a very good understanding of the project and the work remaining. Accomplishments and progress appeared consistent with the original schedule. The project appeared to be on track for completion. Proper consideration of safety issues appeared to be important to the project team.

Reviewer 3:

This reviewer said that the results were shown for only two drivers, which should have been stated up front and not withheld until the question was asked about sample size. The reviewer added that unless there was a good, sound technical approach, technical accomplishments can be meaningless.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer said that there was a good explanation of collaborative roles.

Reviewer 2:

This reviewer stated that the project lacked collaboration with experts on fuel consumption measurement, statisticians (who address design experiments, determine sample sizes of statistical significance, and conduct retrospective cohort analysis and power analysis), human factors experts (who specialize in driver display information and driver-car interactions), fleet operations managers (who review driving performance on a periodic basis and provide driver intervention when necessary), and actual fleet drivers (who can provide insight and feedback on acceptance of new technologies and incentivization strategies. The reviewer stated that there was too much focus on data collection and not enough focus on establishing the accuracy and appropriateness of the data.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the explanation of future plans was adequate but that it was not clear if any alternative development pathways were considered for research project.

Reviewer 2:

This reviewer stated that the project sorely needed to have developed a good, solid research plan, and then have had that research plan rigorously peer reviewed before having proceeded.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said that the purpose of this study was to reduce petroleum fuel consumption.

Reviewer 2:

The reviewer said that the high cost of paratransit service combined with legal mandates to provide it make this project relevant to reducing the public cost of human services transportation. The reviewer added that the team appeared to be doing a good job of it, and seemed sincere about the project's potential to make a difference. As with its sister project at Eaton, with increasing amount of research into driverless vehicles, the reviewer questioned the long-term potential for continuing research into driver assistance strategies for saving fuel. However, the reviewer thought that in the interim it would still continue to be an important issue for public and private fleet managers concerned with fuel costs. The reviewer thought that the modest level of research is appropriate.

Reviewer 3:

This reviewer commented that a National Academy of Sciences report issued in 2010 showed that the driver could contribute as much as 17% savings in FE through proper training and certification although strategies such as driver feedback was not considered. If driver feedback were considered, the savings would be even higher.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that it was not clear why this project should be 30% more costly than the project that was covered in the immediately preceding presentation. The reviewer added that without a cost breakdown, it was difficult to say.

Look-Ahead Driver Feedback and Powertrain Management: Rajeev Verma (Eaton Corporation) - vss087

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the work approach appeared consistent with the original proposal.

Reviewer 2:

The reviewer said that the project developed a combination of advisory feedback to drivers and powertrain control to minimize fuel usage. It was not clear from the presentation how these two strategies would interact. The technical approach to the project is sound. Human-to-machine Interface (HMI) testing in a simulator followed by testing systems in real trucks is a strength of this project.

Reviewer 3:

The reviewer provided several comments on the project's approach to performing the work. The reviewer suggested setting the commercial fleet average fuel consumption reduction goal at 5-10%, citing a 2010 National Academy of Sciences report that states that improvements with driver can result in as much as 17% fuel savings.

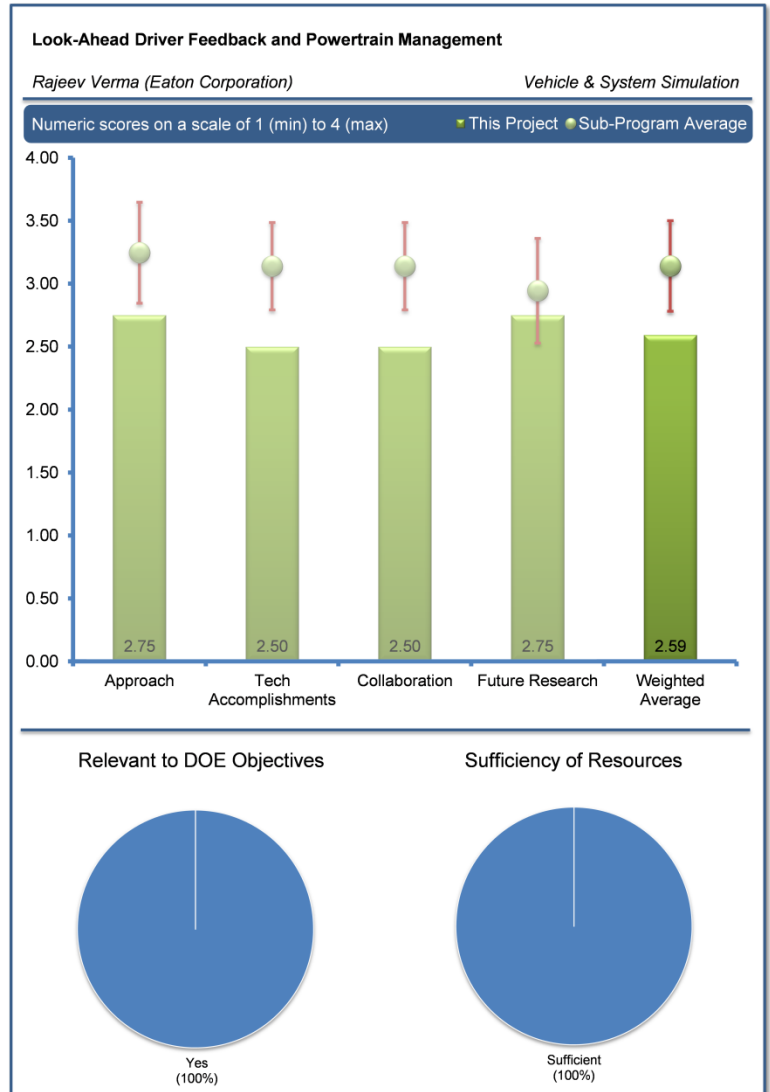
The reviewer also noted the need to calibrate fuel consumption measurement and referenced a West Virginia University study that indicates on-board diagnostics (i.e., J1939) fuel consumption measurements can be off by 10%. The reviewer asked how the project could show an improvement of 2% when the inaccuracy was 10%. The reviewer asserted that it is in the noise level.

The reviewer recommended including go/no-go decision points between phases so that if the appropriate progress is not made, the successive phase is not engaged until the preceding phase is satisfactorily accomplished.

The reviewer suggested taking advantage of the recommended practices and displays made by the DOT ITS JPO on Human Machine Interfaces. The ITS JPO has been working on prioritizing the types of warning, alerts, and displays of information to the driver so that the driver is neither overwhelmed nor confused and makes the appropriate decision to act safely.

The reviewer recommended establishing a baseline with a control group to make a valid comparison of before-and-after results, rather than using the 600,000 miles of naturalistic driving data for comparison.

The reviewer stated that the project did not seem to control variables, such as route, duty cycle, terrain, routing, climate, traffic conditions, weight of freight carried, and type of driver, and noted that the last two variables have a tremendous effect on fuel



consumption (the National Academy of Sciences had recommended a measure of FE based on weight-specific or weight normalized fuel consumption per mile). Unlike passenger cars, FE of trucks varies vastly with load carried. The reviewer added that FE of trucks also varies vastly depending on whether the tractor is a day cab or sleeper cab. Day cabs make a lot of pick-up and deliveries while sleeper cabs make a lot of long-haul, overnight trips. The FE of sleeper cabs is vastly different from that of day cabs.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said that the project seemed to be on track with the schedule and key milestones accomplished.

Reviewer 2:

This reviewer observed that progress appeared consistent with the original schedule. The project team appeared focused and on track for completion.

Reviewer 3:

The reviewer stated that without a good, valid, and rigorous technical approach, the technical accomplishments can be meaningless.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that there appeared to be excellent collaboration between partners with work shared between organizations.

Reviewer 2:

This reviewer observed that there was no collaboration with the experts who measured/calibrated fuel consumption, statisticians who design experiments (such as the set-up of retrospective cohorts, control of variables, power analysis, sample sizes for statistical significance), fleet managers who supervise trucking operations, and human factors engineers/psychologists (experienced in human machine interface). The investigators did not familiarize themselves with the 2010 National Academy of Sciences study or use anybody with expertise related to that study. The reviewer commented that the investigators also did not engage or propose to engage with actual truck drivers to establish/determine acceptability of any of the proposed displays and interventions with their driving behavior and control of the truck.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the project management seemed good. Plans for future work were logical and seemed do-able.

Reviewer 2:

The reviewer said that the project needed to have developed a good, solid research plan, and then have that research plan rigorously peer reviewed before having proceeded. Also, V2V was not relevant at this point; it should be omitted for the time being. The inclusion of radar such as for lane departure warning or forward collision warning systems is definitely out of scope. Radar sensors are already studied under the Integrated Vehicle-Based Safety Systems study paid for by the DOT ITS JPO and integration of safety systems with systems to provide FE feedback to the driver should be considered a separate project for the future with separate funding. The reviewer stated that there is already too much work in the FE area alone to accomplish here without trying to integrate collision avoidance at the same time and confusing the issues.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer observed that the stated goal of the system in development was to reduce fleet fuel consumption by at least 2%.

Reviewer 2:

The reviewer questioned the long-term potential for continuing research into driver assistance strategies for saving fuel with the increasing amount of research into driverless vehicles. However, the reviewer thought that in the interim it would still continue to be an important issue for fleet managers concerned with fuel costs. The reviewer thought that the modest level of research was appropriate.

Reviewer 3:

This reviewer referenced that a National Academy of Sciences report issued in 2010 showed that the driver can contribute as much as 17% savings in FE through proper training and certification although strategies such as driver feedback were not considered. If driver feedback were considered, the savings would be even higher.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Advanced HD Engine Systems and Emissions Control Modeling and Analysis: Zhiming Gao (Oak Ridge National Laboratory) - vss089

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the approach integrating a HD engine powertrain system and emission after treatment control modeling together was very noteworthy and needed to optimize freight efficiency of the entire vehicle. Currently, individual component optimization modeling has been accomplished by individual component suppliers but an integrated vehicle based model has not been taken on in the past. Lastly, the reviewer commented that using and expanding integrated Autonomie models would benefit the industry to understand system level interactions and dependencies.

Reviewer 2:

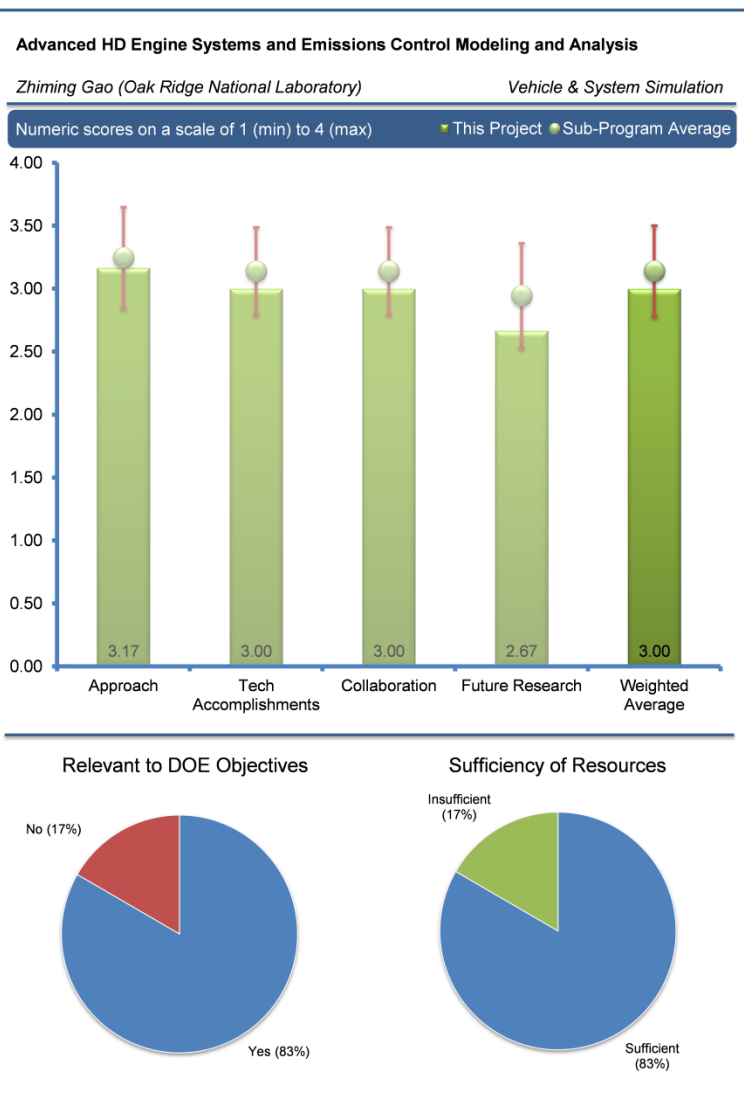
The reviewer said that as an ongoing project to advance the knowledge base of MD/HD hybridization, the approach was appropriate and was building the foundation for future work with the linking of component models. The reviewer suggested that perhaps a description of how the sequence of modeling elements would be chosen would be helpful. The reviewer asked if to date this may have been driven by elements involved in the Cooperative Research and Development Agreement (CRADA).

Reviewer 3:

The reviewer indicated that the approach appeared sound, but that the project was working with old (2010) engine calibrations. It was not clear if industry-significant results would come from this project. The process that the project team was developing to analyze this problem was very good though. It may be up to an OEM in the future to use the process to gain useful technical insight. The reviewer added that it was not clear how realistic of an engine control strategy that the project was using. If the project was only using steady-state maps to make FE predictions, then the project team may be missing many real economy and emissions impacts of transient conditions. FE benefit should be weighed against emissions reduction potential. If emissions could be reduced, then maybe further FE gains could be made by re-calibration of the engine. This is not addressed in the current work, but probably needed significant OEM involvement to achieve.

Reviewer 4:

It was not clear to the reviewer that the overall model including hybrid powertrain and emissions system was correlated with physical data for more than the example case study shown on Slide 10. The reviewer said that if that was the only example then more work should be done with other routes. The engine maps looked to take much time and effort. The reviewer asked if Southwest Research



Institute (SWRI) checked to see if this information already existed for the engines. The reviewer continued to ask if it was checked and did not exist, if other engines could have been used. The reviewer commented that SWRI was not inexpensive, but is probably less costly than doing the map.

Reviewer 5:

This reviewer stated that it was not clear if the models were public domain or internal project use only. If the models are public domain, then the ability to use with software other than Autonomie is of interest. If the models are internal project use only due to confidential partner information, then the real value of the project is the insight the model produces, but that was not a part of the project focus. Normally when a tool is developed, it starts from the need (i.e., need something to help do X) and the tool requirements are established such that the end goal is met. The project did not really focus on the end goal, rather than just developed some tools. As a result, the tool that is developed may not provide the required functionality. The reviewer added that the opportunity to link FE and emissions in a single optimization effort was very powerful, and if the tool does not help link these for the broader community, then it is leaving something on the table. The reviewer said that the PI's mindset was his task to develop a tool, and not to explore some interesting space using a tool, which is leaving something on the table.

Reviewer 6:

The reviewer said that considering the shift towards natural gas powered HD trucks, the question was whether compressed natural gas/liquefied natural gas (CNG/LNG)-hybrids needed to be considered for future power train configurations.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the progress seemed very good. The overall accomplishments may strongly depend on details of the control strategy and drive-ability issues. However, the reviewer commented that the model the project is building is a very useful tool.

Reviewer 2:

The reviewer commented that there were significant results of model construction and simulations with observations.

Reviewer 3:

The reviewer commented that the technical accomplishments and progress seemed reasonable relative to the project plan and project goals.

Reviewer 4:

This reviewer said that the maps were generated and at least one example case study was done.

Reviewer 5:

The reviewer commented that Autonomie modeling development and modeling calibration seemed to have taken longer than expected. Further simulation work scheduled for FY 2013 seemed further drawn out. Most fuel consumption simulation observations (Accomplishment 3) published across the chosen five different drive cycles were not news. The reviewer remarked that the value of this integrated model was better shown in Accomplishment 4, where the tailpipe emissions were predicted. Yet the alternative hybrid drivetrains, waste heat recovery and control strategy variations were even further out in the 2014 timeframe when those answers were needed earlier to support other freight efficiency system projects such as SuperTruck.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer commented that the collaboration and coordination involving Meritor's CRADA, Cross-Cut Lean Exhaust Emissions Reduction Simulations (CLEERS) and a multitude of ORNL-related activities was a fine example for other projects to follow. The reviewer added that some explanation of how this is accomplished would be a benefit.

Reviewer 2:

The reviewer commented that the collaboration appeared appropriate for the activity. The reviewer thought that the summary addressed previous reviewer concerns of the collaborations not being sufficiently highlighted (or in question). The reviewer typically wonders why EPA was either not involved or not explicitly listed as a collaborator in these types of projects.

Reviewer 3:

This reviewer asked why SWRI was not involved for the engine maps. The reviewer commented that Arvin was a good partner when their work was moving forward, but that the models should be used for more than one vehicle even if Arvin continued to be part of the project.

Reviewer 4:

This reviewer commented that it would greatly improve the project to have collaborations with the engine controls and calibration groups of an OEM. It would help add realism to the results. There is plenty of sound technical expertise on the modeling side, but some practical issues should be addressed with OEM insight.

Reviewer 5:

The reviewer noticed that the item that was missing in the collaboration list is OEM adopters of the tool. It appeared that the adopters were other DOE and ORNL researchers, but influencing the OEMs in how they operate is the key to promoting change. Plus, the development of the tool needs end-user feedback to insure the tool meets needs. The reviewer commented that this project was technically very interesting and could have significant impact, but it appeared to be a technology push rather than a market pull, and market pull is so key for adoption of the tool into best practice.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that this work could be very valuable for decreasing emissions test costs of hybrid systems - maybe even being used in lieu of the test for a relatively small amount of vehicles sold for some hybrid systems. The reviewer asked if there was a possibility of using it for that. The emission system development and test costs are part of the barrier to introducing new hybrids systems commercially.

Reviewer 2:

The reviewer thought that the proposed future research was good, but suggested that the influence of drive cycle/driver behavior should be considered in the final results.

Reviewer 3:

The reviewer said that the proposed future research was down the right path but that the timeline was not.

Reviewer 4:

This reviewer had not seen a mention regarding MD (versus HD) in the future work, even though MD was listed as in scope with the objectives of the project.

Reviewer 5:

The reviewer referenced a previous comment that natural gas powered engines needed to be considered in the future. Due to performance issues, hybridization might have to be considered. The reviewer added that CNG/LNG hybrids should be considered in future research.

Reviewer 6:

The reviewer said that the proposed future work appeared to be focused on other architectures, rather than getting insights into the public domain using the tool. The reviewer would much rather have had one solid data point (i.e., one architecture) rather than a blur

on seven different architectures. The reviewer would have preferred to open the eyes of the world on one architecture (parallel, the most common) and validate the approach of optimizing with emissions considerations as a good idea before the tool is developed to include more less-common architectures.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said that the project was very relevant to support industry decisions on what technologies needed to support the greenhouse gas regulations other than the greenhouse gas emissions model (GEM model) currently offered.

Reviewer 2:

The reviewer stated that the project was highly relevant to DOE objectives to advance state-of-the-art in system simulation for efficiency gains and emission reductions.

Reviewer 3:

The reviewer stated that there was a strong trade-off between FE and regulated emissions. A better understanding of this area is greatly needed, especially on the system level (which this project addresses).

Reviewer 4:

The reviewer said that this project could decrease the cost of emissions systems development and test for hybrid vehicles.

Reviewer 5:

The reviewer said that a substantial fuel efficiency improvement is addressed via hybrids powertrains. The question is of course how quickly this market will develop for HD vehicles.

Reviewer 6:

The reviewer said that this was a tough question because the tool helps bring emissions over drive cycles into the simulation world to the same level as current FE. Currently, emissions standards are over a standard drive cycle with a variety of pass-fail criteria. If the emissions pass/fail criteria were to change, then the tool could be very useful to evaluate FE and emissions together. As it is currently, they are separate.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that it appeared more resources were needed to improve timeline.

Reviewer 2:

The reviewer stated that more funding might allow more hybrid systems to be modeled and correlated with real world cycle data.

Reviewer 3:

The reviewer indicated the resources were sufficient. There was plenty of computing power available.

Reviewer 4:

The reviewer indicated that there were sufficient resources for an ongoing activity, and appeared to be part of a baseline budget.

HEV, PHEV, EV Test Standard Development and Validation: Mike Duoba (Argonne National Laboratory) - vss094

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that there was an outstanding approach even if SAE standards development was pretty cut and dried. Somewhere up front in the oral presentation there was a general statement made about the benefits to industry of standards. The reviewer thought that this would be even more important to overstate. In these types of technologies, nothing is comparably real until it is in a specification or tested to a standard. The reviewer would like to commend ANL for chairing some of these development committees. The reviewer acknowledged that it takes a lot of time and dedication and patience in leading these groups and getting to a standard. That was why the reviewer gave it an outstanding rating.

Reviewer 2:

The reviewer indicated that there was a high return on a \$150,000 investment. The reviewer added that the SAE/ISO committee leadership/membership provided data to the efforts.

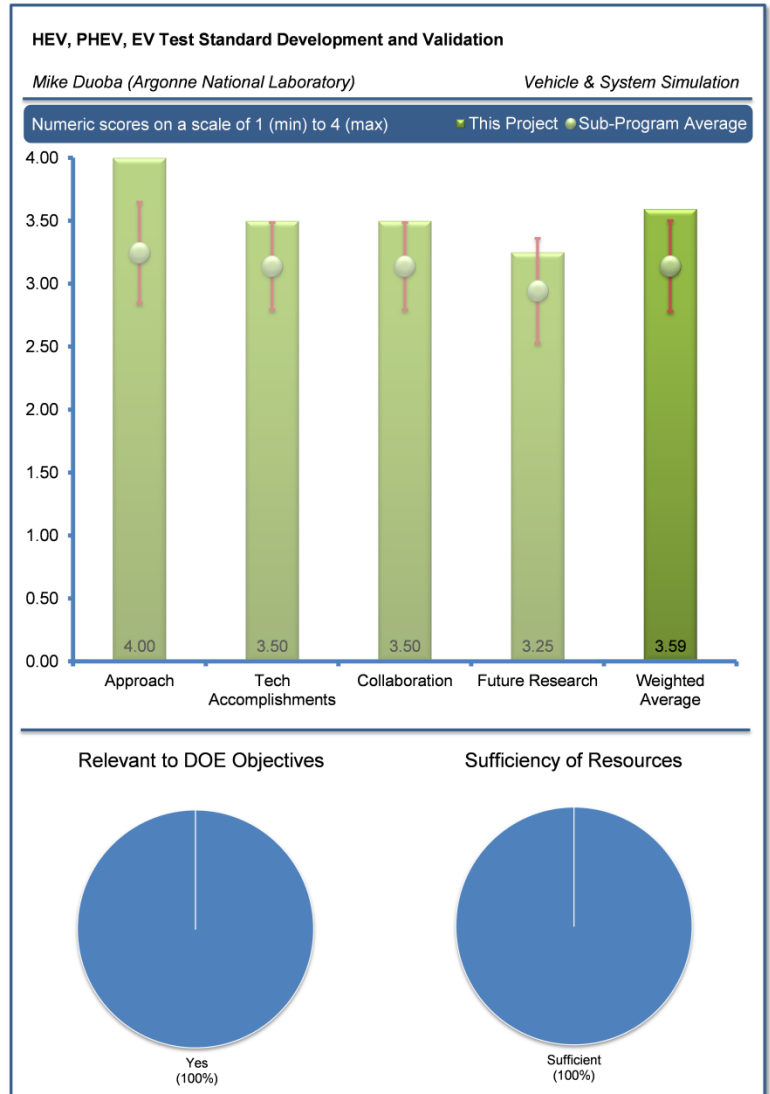
Reviewer 3:

The reviewer stated that the leadership on standard development and testing to support standards clearly addressed the industry needs in this area.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer said that it appeared that all the hard work that started a while ago was starting to pay off, with a lot of the important standards coming online in 2012. The reviewer continued that there were lots of good accomplishment charts showing the test results provided by the new standards development. It is always good to see some data after spending a lot of time reaching a standard. Further charts also showed some of the variables and differences that could occur given the different test conditions. This showed a depth of understanding what the issues are. There was a comment in the oral presentation that real world driving was much more complex than coming up with a simple single number for vehicle energy comparison. The reviewer liked Chart 10, which showed the comparative aspects of the PHEV/extended range electric vehicle (EREV) making it to the market.



Reviewer 2:

The reviewer observed two SAE standards updated and/or developed that addressed vehicle technological developments in recent years. The reviewer added that work on the newest vehicles and evaluating their applicability to existing standards also demonstrated technical progress.

Reviewer 3:

This reviewer noted that J1634 was balloted, that there was field validation of J1634 and J1711 with revisions, and that the approach and contribution depended on the market and technology standard.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer said that it appeared that all the right players were involved, although the EPA was not listed as a collaborator.

Reviewer 2:

The reviewer indicated that the industry collaboration was clear and a necessary part of standards evaluation and development, and were identified as such in the presentation.

Reviewer 3:

The reviewer commented that collaboration and coordination with other institutions were by nature of the activity, domestic and international.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer liked the plans for the next standard on power trains. The reviewer recognized the variability of the specmanship and claims. There is potentially a safety aspect for consideration in this standard development and that would be available vehicle acceleration when a PHEV has a fully depleted battery. Having adequate acceleration capability is an important safety criteria that not all PHEV designs (especially by non-OEM's) take into consideration. To provide a vision of this issue, the reviewer suggested thinking about merging onto the freeway and having a Class 8 truck barreling down the slow lane at you and considering whether one would have enough acceleration capability under all battery state of charge (SOC) conditions to make it or if one would have to swerve out of the way. The reviewer asked if this could be worked into the standard such as listing the available PHEV horsepower at minimal SOC.

Reviewer 2:

The reviewer commented that there was a clear vision on future evaluation, refinement and analysis of existing standards discussed. New standards were also identified and presented as future work.

Reviewer 3:

The reviewer stated that the project was continuing to improve information to customers and the public.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer stated that standards development to help create the PEV industry was certainly needed to accelerate the market and give consumers confidence in buying these vehicles. The reviewer noted that that would lead to petroleum displacement.

Reviewer 2:

This reviewer commented that standards were critical to treat automakers in a balanced way and to provide good information to the public.

Reviewer 3:

This reviewer stated that FE measurement was a clear part of the standards work in this project. Better standards for performance testing helps to measure progress and success in meeting petroleum displacement objectives.

Reviewer 4:

This reviewer stated that developing test standards for EV and PHEV contributed to determining the correct energy consumption calculation and measurement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

Given the number of standards reaching the industry in the last few years, it appears that this has sufficient resources.

Reviewer 2:

This reviewer said that ANL clearly identified having sufficient resources to complete this project and its ongoing nature.

Reviewer 3:

This reviewer stated that there was a high return on the investment.

Grid Connectivity R&D: Ted Bohn (Argonne National Laboratory) - vss095

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that the leadership and participation in interoperability and new technology evaluation and demonstrations clearly supported the project's stated objective to support transitional and transformational technologies associated with grid connected vehicle charging.

Reviewer 2:

The reviewer said that this was a messy technology segment. The reviewer commented that the technology and potential markets are developing and changing at a fast pace. A lot of stakeholders are trying to shape the market and there is a lot of diversity. Given that the approach is that the DOE is trying to stay out of the business fray, and more or less providing common technology solutions that would benefit all parties in key areas, is a good approach. This will be especially important in the sub-metering on a chip project because the electricity meter is essentially the cash register for electricity and all the stakeholders will be angling to take control of that technology. The reviewer remarked that also given all the permutations of vehicles, EVSE, communication nuances, basic functionality, control strategies, and communication pathways, this will be an ongoing growing area, that probably could use some more funding to dive into more of these issues as they begin to appear. According to the reviewer, this was probably the difference between good and outstanding. If more resources were available for testing a lot more of the hardware and communication software permutations and finding more agnostic technical solutions, that would move this toward outstanding.

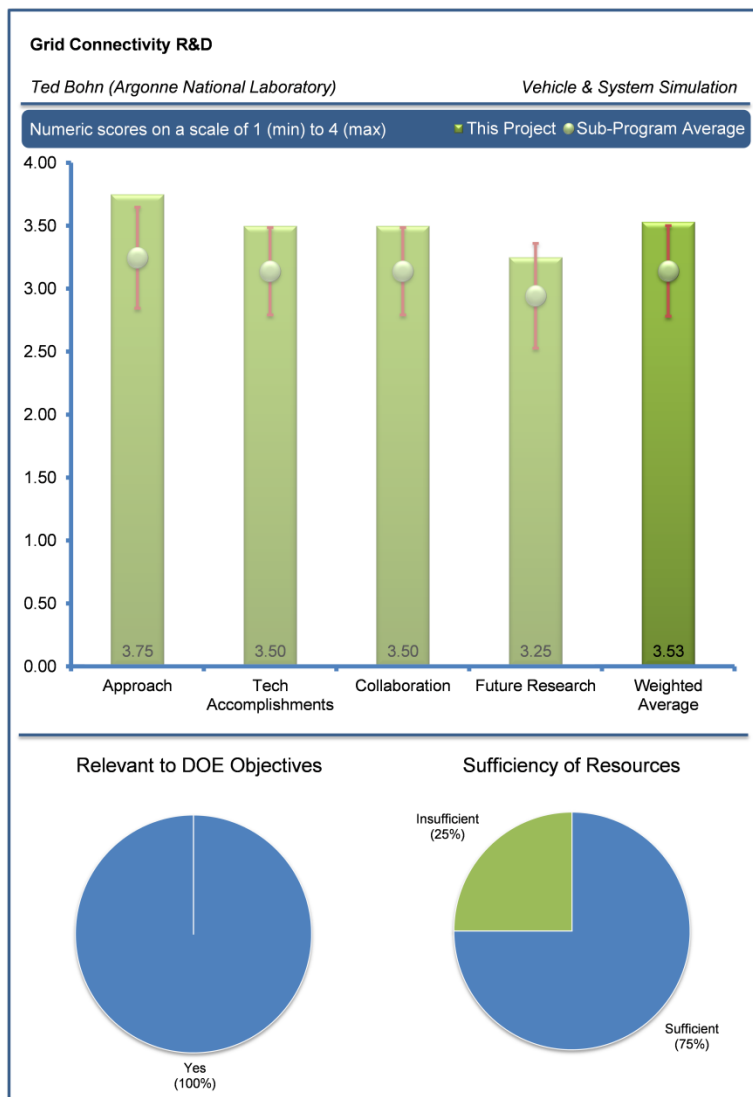
Reviewer 3:

The reviewer said that hardware development for electrification and grid interaction provides data for standards making, proof of concepts, and disseminates information. The reviewer stated that a barrier was the interoperability of EV to grid. The reviewer commented to find and fill technology gaps. Lastly, the reviewer stated it was very important to provide data to the providers and the consumers.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed that the project identified technical accomplishments that clearly supported understanding for the traditional and transformational technologies.



Reviewer 2:

This reviewer stated that there was good progress, given that so much was changing in this area and that keeping up with all the changes was difficult. Getting hardware and testing protocols is important. The reviewer thought that the recent release of Smart Energy Profile (SEP) 2.0 would help in this matter. To some degree the reviewer thinks that the delay in SEP 2.0 getting to the market, created a technology vacuum that all the other networks and controls schemes took advantage of. Once again, concentrating on agnostic technology, universal communication standards and not propriety solutions will be important. Once more standards exist, making progress will help organize activity and support progress. Regarding milestones, and smart grid related charging, in the oral presentation there was mention that subscription services are starting to appear like a likely business model. The reviewer thinks it might be too early to presuppose this. There is somewhat of a backlash from PEV drivers about having to belong to each individual subscription service to get coverage and some folks are suggesting a simple credit card reader for a default payment system is necessary, to get around subscription services. This could simplify and change the market place to some different technical solutions. The reviewer liked the accomplishments and technical depth that was provided on wireless charging in the oral presentation. Often, the technology vendors have little knowledge of these bigger picture issues that were discussed, such as EMF/EMI compatibility with vehicle back up sensors, medical equipment and other ancillary technologies. A lot of work and testing in this area will be required.

Reviewer 3:

The reviewer stated that it was difficult to judge whether the standards development was in time to help the market.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer observed that collaborations were listed, but not as clearly identified in the work, but certainly existed with charging standards organizations, product suppliers and internally with team approach to proof of concept work.

Reviewer 2:

The reviewer suggested getting more utility involvement in this space. The reviewer asked if the project has tried engaging EPRI. The reviewer pointed out that EPRI was listed on one chart and have also been working with the OEM's for years. Utilities are a diverse bunch (over 3,000 in the United States) and getting input from just a handful can be limiting. The reviewer commented that EPRI tries to strike the best balance of getting as much of the utility world on one page. The reviewer was a little cautious on putting a lot of emphasis on the California Public Utilities Commission (CPUC) sub-metering protocols. There was not much thought given to the consumer protection aspects of metering when the project team made a decision to go in that direction. The reviewer believes that the project may have to revisit some of that in the future or it will be overtaking by the ongoing NIST effort.

Reviewer 3:

The reviewer commented that the collaboration and coordination with other institutions was by the nature of the work.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that all work in this project was looking to future needs and standards. The reviewer added that the work is clearly path-dependent and is the nature of research.

Reviewer 2:

This reviewer stated that there was a wide landscape for this area going forward. The reviewer liked the general direction everything was headed but said that a lot more testing will be necessary and it will probably take a lot more funding. The reviewer commented on environmental testing. The reviewer said that a lot of the DC fast charging hardware is only UL listed to work in ambient environments up to 104°F. The reviewer said that that was not going to cut it for a wide market deployment. So things like additional environment testing of hardware will be needed and likewise for wireless charging. The reviewer asked what the reliability of that

equipment was going to be after repeated cycles at temperatures as high as 160°F, just above the pavement. The reviewer also asked what the EMF signature under different thermal conditions would be.

The reviewer stated that the \$100 sub-meter chip was a great goal from a utility value chain, but believed that a lot of the EVSE folks want stuff in the \$10 range. The reviewer commented that just like having an agnostic metering chip under development, the reviewer thinks that an agnostic communication board-insert slot could also be of value to the industry. The reviewer thought that was discussed last year. Just like the EVSE companies have worked on proprietary communication protocols, so have the AMI systems companies. It is problematic for the industry. The reviewer said that hopefully SEP 2.0 will help.

As previously discussed, the reviewer thought that incorporating SEP 2.0 will be an important step going forward and testing some of the aspects of that improved communication protocol.

The reviewer commented on Slide 11 regarding Demand Response (DR) Test Cases. The reviewer suggested considering a test case where the project ratchets the DR level from 100% Level 2 down to a simple Level 1. The reviewer believes the only other test cases were either to 0 or 50%. The reviewer added that the charging level has a greater grid impact than the time of day, and charging at Level 1 is probably 80% as good as optimized smart charging based on some ongoing utility analyses.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer stated that the technologies involved with this project supported the DOE's objectives for petroleum displacement, and so this project does also.

Reviewer 2:

The reviewer said that a lot of these technologies were enabling in making PEV charging ubiquitous, easy and reliable. This would further help to accelerate the PEV market to support petroleum displacement.

Reviewer 3:

This reviewer commented that future research was critical for mass adoption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer commented that there was no indication that the ANL team was not able to support industry needs in these areas.

Reviewer 2:

This reviewer said that it appeared that the funding in this area had been all over the map. Upwards of \$950,000 back in 2010, then down to \$300,000 in 2012, now back up to \$650,000 in 2013. The reviewer thinks having some more consistent funding would be beneficial. The reviewer also thinks that more activity would benefit the industry; the reviewer liked the approach of being independent and agnostic. Since the PEV market is growing and the technology is changing, additional resources would be good.

INL Efficiency and Security Testing of EVSE and DC Fast Chargers: Jim Francfort (Idaho National Laboratory) - vss096

Reviewer Sample Size

A total of two reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer recounted data collection for DC fast charging and wireless - battery impact, system efficiency, and cyber security.

Reviewer 2:

This reviewer observed that there was a variety of projects identified in this presentation. The reviewer added that the approach was to provide testing and qualification of existing systems and confirm compliance with requirements.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said that much of the accomplishments for these projects would take place in the future, so technical accomplishments were not as relevant yet. The reviewer added that test set-ups and procedures were identified and read of upcoming evaluations.

Reviewer 2:

This reviewer stated it was difficult to judge progress against planned deliverables.

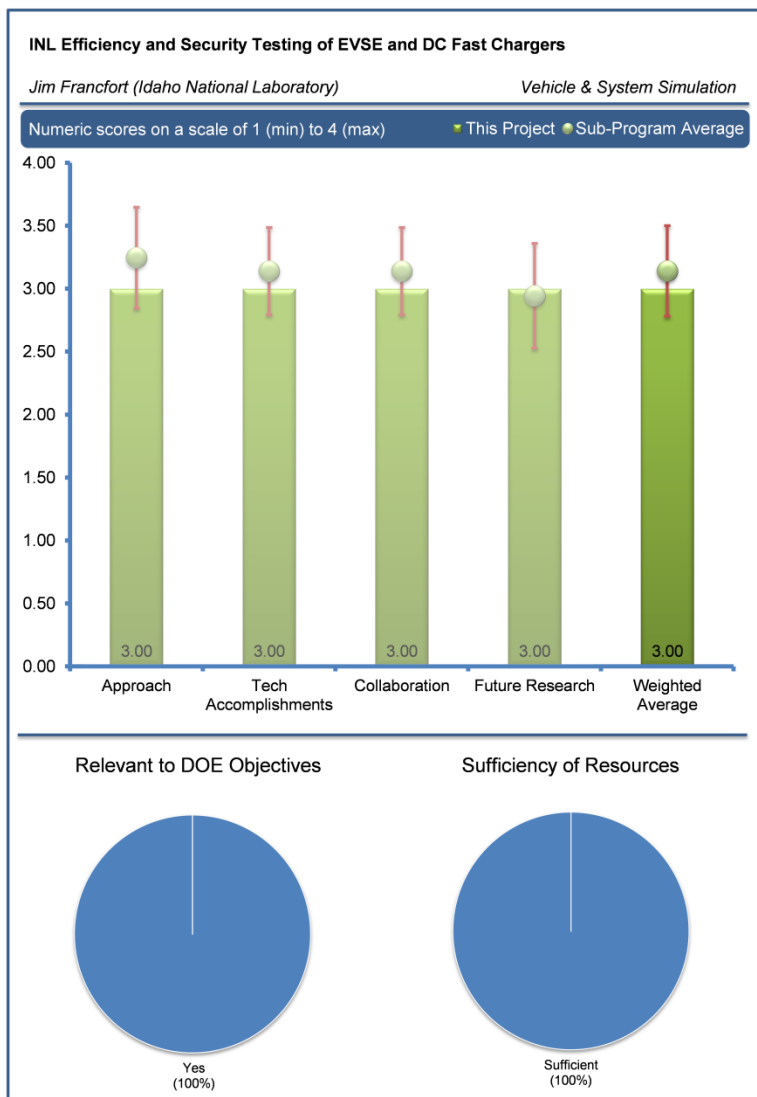
Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer stated that the project clearly demonstrated collaboration in all areas including agreements and broad participation for needed partners.

Reviewer 2:

The reviewer said that collaboration and coordination with other institutions was unclear from the presentation. The reviewer recounted the discussion that OEMs were asking for interoperation between EVs and charging systems (EVSE).



Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that future work was identified for most of the projects as time dependent on others for the evaluations. INL appeared to be ready for evaluations and not the cause for any delays.

Reviewer 2:

The reviewer stated that the proposed future research was difficult to judge from the presentation.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer commented that the technologies being evaluated were clearly in support of petroleum displacement. Benchmarking and compliance evaluations clearly supported this objective.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that the project was clearly utilizing resources wisely to meet milestones and objectives where INL has influence. No milestone requirements appeared to be missed due to the INL resources applied.

Reviewer 2:

The reviewer commented that there were unspecified efforts to reduce testing (possibly capital) costs.

Electric Drive Vehicle Climate Control Load Reduction: John Rugh (National Renewable Energy Laboratory) - vss097

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that barriers were properly identified and that the approach was appropriate.

Reviewer 2:

The reviewer stated that there was a good combination of simulation and testing to develop understanding for HVAC energy.

Reviewer 3:

This reviewer would have liked to see defog (dehumidification) and defrost (removal of ice) included in this study, as both consume energy, especially with defrost. The total glass area (minimal defined viewing area) needs to be kept clear of ice and this is an energy challenge especially with EVs and PHEVs.

Reviewer 4:

The reviewer commented that the baseline needs to be better characterized, especially for extreme environments such as Phoenix, Arizona or Fairbanks, Alaska.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

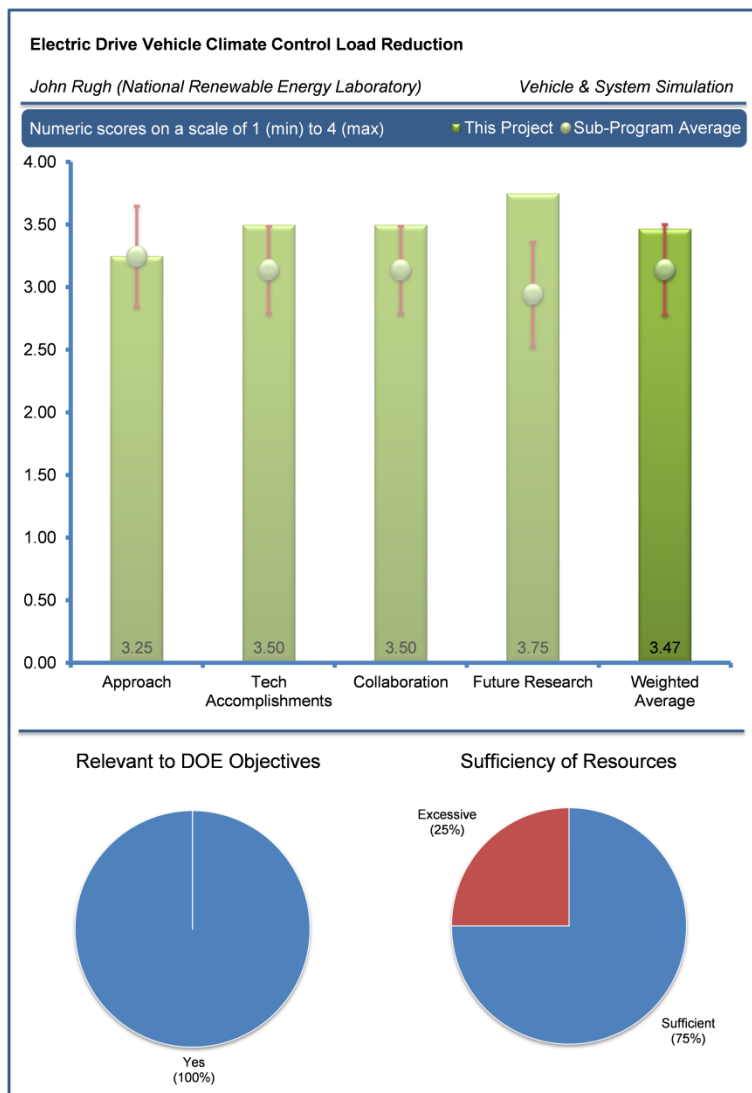
The reviewer stated that the project appeared well executed and is following the defined plan.

Reviewer 2:

The reviewer commented that the project is early on and that the goals and control factors to measure for fuel consumption reduction are good.

Reviewer 3:

This reviewer commented that the use of good simulation models represented a solid step forward. The proper use of these data, however, would be a real challenge.



Reviewer 4:

The reviewer commented that the work done to date was excellent, but \$1.7 million seemed to be a lot of money for what has been accomplished so far. The reviewer added that the project has not even completed the baseline testing.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted an impressive list of partners who were providing important inputs, plus that were leveraging existing DOE research.

Reviewer 2:

This reviewer commented that there was a good use of industry partners, including both suppliers and OEMs.

Reviewer 3:

The reviewer commented that it was good that the supply base to the components used to insulate or diffuse energy were involved.

Reviewer 4:

This reviewer indicated that collaboration with an OEM vehicle manufacturer (Ford) was absolutely necessary for real world results.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the plan was excellent and addressed the primary issues.

Reviewer 2:

The reviewer stated that the proposed future work clearly builds upon past progress and the use of models represents a solid engineering approach.

Reviewer 3:

This reviewer stated that logical next steps were well-defined.

Reviewer 4:

The reviewer commented that the mission of increasing electric range while operating the HVAC by 10% appears that it will be understood with the proposed activities.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that any capability to further electrify the fleet of vehicles strongly supports the DOE objective of petroleum displacement.

Reviewer 2:

The reviewer asserted that this project does support the DOE objectives.

Reviewer 3:

The reviewer said that it will support DOE objectives where petroleum is used to generate electricity.

Reviewer 4:

The reviewer noted that climate control was a significant barrier to adoption of EVs. In addition, the reviewer stated that improvements identified by this program may also help reduce climate control fuel consumption and GHG emissions in conventional vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that resources appeared adequate to achieve the stated milestones on a reasonable time schedule.

Reviewer 2:

The reviewer commented that the resources appeared sufficient.

Reviewer 3:

The reviewer commented that the amounts spent to date (\$1.7 million) appeared to be far too much for the relatively limited results seen so far.

Advanced Transmission Impact on Fuel Displacement: Namdoo Kim (Argonne National Laboratory) - vss098

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the approach, in the absence of data from OEM vehicle manufacturers, was excellent. It may be a bit more difficult to validate the model outputs without active collaborative input from these OEMs.

Reviewer 2:

The reviewer observed that the approach seemed appropriate. This project appeared to be merely an update to Autonomie to keep it relevant and on track with current technology trends.

Reviewer 3:

Use of the Advanced Powertrain Research Facility (APRF) for data collection to build the plant models is the correct choice.

Reviewer 4:

The reviewer commented that there was a wide range of baseline vehicles, although the data gathered was minimal. The reviewer said that the project was inferring many of the parameters analytically. The reviewer suggested that it may have helped improve modeling if more detailed data had been gathered (although this would have required a larger budget). The reviewer noted a wide range of test cycles. The reviewer added there was good integration with Autonomie. Lastly, the reviewer said it was not entirely clear how shifting points would be optimized for future transmissions, especially for hybrids with electric motors.

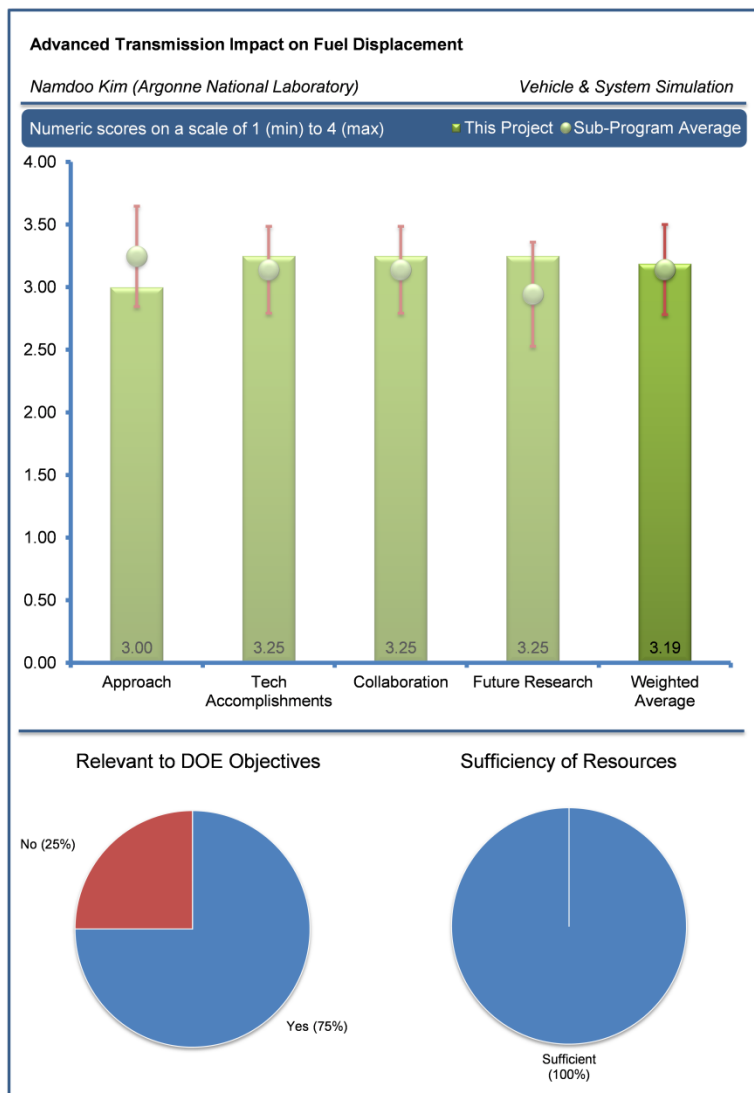
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the progress toward overcoming the barrier of lack of OEM transmission performance (gears) was admirable and will help establish credibility of the DOE vehicle R&D activities, especially that of hybrid technologies.

Reviewer 2:

The reviewer commented that the project was progressing well. The reviewer added that lots of testing was completed and procedures developed to assess shift points.



Reviewer 3:

The reviewer observed that the accomplishments are as per the plan and appear to be of high quality.

Reviewer 4:

The reviewer said that keeping DOE's fuel consumption evaluation tools up to date was a necessity.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated that the collaboration was appropriate for the project (not a lot of coordination is required).

Reviewer 2:

The reviewer observed that the collaboration and coordination with the OEMs in these kinds of activities were particularly difficult as transmission design was one of the most proprietary areas of vehicle manufacturer's technologies.

Reviewer 3:

The reviewer said that it was unclear how much collaboration was actually occurring on this program. While there was obvious collaboration within ANL, the extent of OEM manufacturer or Tier 1 supplier involvement is not spelled out in the presentation material.

Reviewer 4:

The reviewer asked the team to continue to try to work directly with OEM's when possible.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer affirmed that all technologies proposed to be updated in the model were appropriate to research.

Reviewer 2:

The reviewer said that this was a relatively small, sharply focused program.

Reviewer 3:

The reviewer stated that the proposed future research was clearly based upon past progress to overcome the barrier of proprietary knowledge base of the OEM vehicle manufacturers.

Reviewer 4:

The reviewer observed that the proposed future work included validation of various transmission technologies and that extending the coverage into medium- and heavy-duty would be a significant step forward.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that transmissions are very important to future conventional vehicle efficiency. This is especially important for integrating transmissions with hybrid systems.

Reviewer 2:

The reviewer stated that the improvement model allowed better accuracy to displacement projections.

Reviewer 3:

The reviewer commented that without these kinds of models (Autonomie), DOE would have no means of evaluating the benefits of the research. It is often stated (by certain critics) that DOE's R&D has not produced any benefits. These models as well as more in depth analysis (retrospectives) demonstrate the benefits (cost/benefit analyses) of the VTO research.

Reviewer 4:

The reviewer was unclear why DOE was funding the development of Autonomie.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated there was not a lot of money for a very important upgrade.

Reviewer 2:

The reviewer said that this was a good single year project with a start and end date, good purpose, and good to see reach a conclusion. The reviewer added that follow-up on the medium and heavy-duty seemed like a good use of the resource continuing on from here.

Reviewer 3:

The reviewer said that the resources for this effort were sufficient for the project to achieve the stated milestones in a timely fashion.

Reviewer 4:

The reviewer indicated that resources seemed sufficient.

Government Performance and Results Act (GPRA): Jake Ward (DOE) - vss099

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that there was a good approach with clear objectives, and exclaimed that success needed to be measured somehow.

Reviewer 2:

The reviewer commented that the approach was very good. The reviewer said that assessing how VTO's projects accelerate technology introduction, compared to what would have occurred without VTO, was extremely subjective. The approach taken handles these subjective factors as well as possible.

Reviewer 3:

The reviewer said that it was understood that the Government Performance and Results Act (GPRA) analyses was required but that there must be a means to simplify the presentation of the impacts of the VTO R&D. The reviewer asked if there was a way to extract some of the benefits of technologies from the GPRA analysis and present them separately from all of the other technologies.

Reviewer 4:

The reviewer commented that the question this is trying to answer was difficult to answer with a high degree of fidelity. The reviewer noted that the appropriate DOE partners are pulled for data, so continue to increase the accuracy and fidelity as best as is possible.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

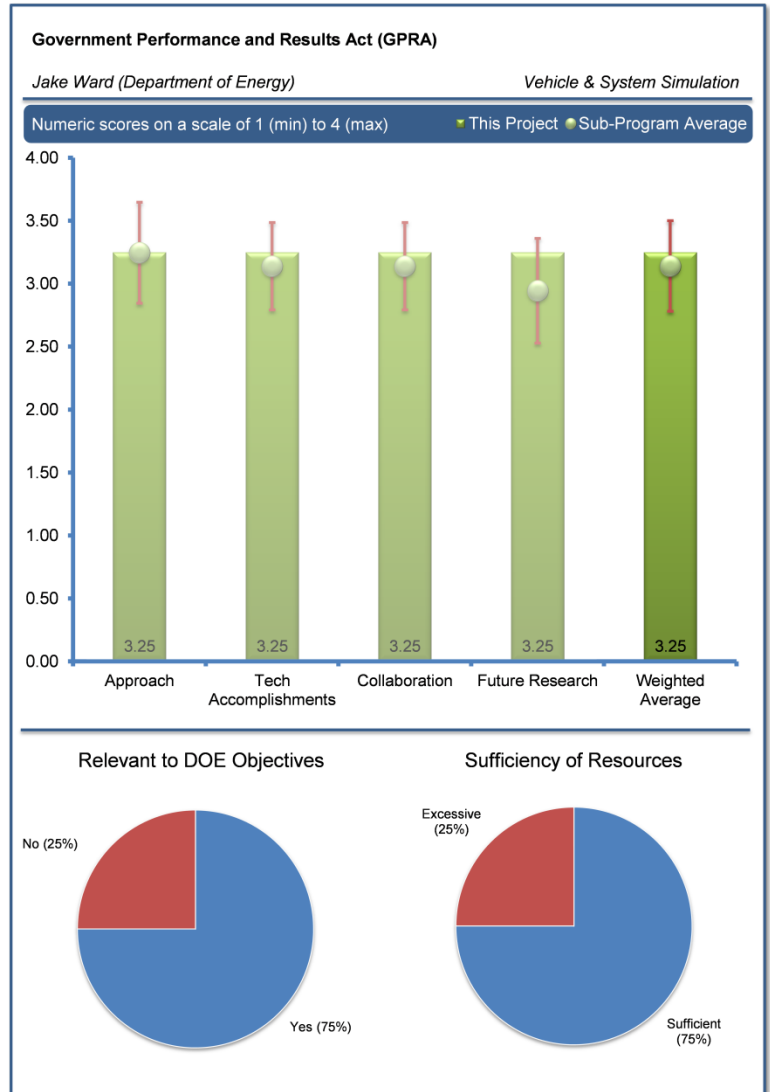
The reviewer noted that the projections of technologies, market, and fuel out to 2050 would have a high percentage chance for being inaccurate, but that as a review of the DOE project portfolio, this appeared to be a good effort.

Reviewer 2:

The reviewer exclaimed that the project does what it states it will do.

Reviewer 3:

The reviewer said that since the GPRA analysis was required by law, progress toward that objective was essentially a given.



Reviewer 4:

The reviewer questioned the validity of the market penetration data presented. The reviewer stated that the vehicle modeling and simulation part of the work was very useful and important, but estimating the market penetration with and without VTO's programs was not possible. Forecasting technology penetration in general is extremely difficult and assessing differences in penetration is often subjective.

The example presented on Slide 7 illustrates the problem. DOE estimates that light-duty vehicle (LDV) efficiency would be about 50 mpg in 2050 without VTO and about 85 with VTO. However, 85 mpg in 2050 could also be achieved simply by continuing to increase CAFE standards, even if VTO did nothing. Another example is fuel cell penetration, which will be largely determined by building hydrogen infrastructure just ahead of vehicle sales. The reviewer pointed out that work to improve the vehicle will have relatively little impact on fuel cell penetration (it might on fuel cell cost). The reviewer acknowledged that managers want to see these numbers to help support program activity, but that does not change the fact that there was no real way to know how the programs will affect future market penetration.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer commented that there was a good use of Autonomie, good leveraging of other DOE departments, and good pull of data from many sources to create estimates.

Reviewer 2:

The reviewer stated that this was entirely a coordination project. The reviewer stated that it does not advance any technology on its own.

Reviewer 3:

The reviewer stated that the data was used by a large number of activities in many partnerships/initiatives.

Reviewer 4:

The reviewer commented that GPRA is essentially an internal DOE required activity, so the collaboration outside of DOE really would not make sense. However, the reviewer commented that including in the GPRA process a linkage to more in-depth retrospective analyses would make the GPRA results seem more real to outside stakeholders (e.g., Congress).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the proposal was to make the tool better, which is the appropriate mission of future research for this project.

Reviewer 2:

The reviewer commented to continue the GPRA with the caveat discussed previously.

Reviewer 3:

The reviewer suggested that future research needs to continue as outlined.

Reviewer 4:

The reviewer stated that the proper steps were being taken to use the analyses. The reviewer stated it is just GIGO.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the whole purpose of the DOE GPRA for VTO R&D was to reduce petroleum consumption.

Reviewer 2:

The reviewer asked how else the success of VTO could be measured.

Reviewer 3:

The reviewer said that the results were almost entirely subjective and had little value; especially if DOE wants to use the results to help plan their future projects.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that resources appeared sufficient.

Reviewer 2:

The reviewer said that this seemed like the appropriate level of funding compared to the entire DOE project list for this type of activity.

Reviewer 3:

The reviewer commented that the resources for GPRA appeared adequate but should be increased by about 15% to accommodate retrospective analysis to capture the benefits of DOE VTO R&D for specific technologies.

Reviewer 4:

The reviewer noted that the value of this work was greater to DOE internally rather than externally.

Thermal Electric Generation Study with GM - Phase 2: Ram Vijayagopal (Argonne National Laboratory) - vss100

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this was a very challenging topic and one that would in time yield very good results.

Reviewer 2:

The reviewer said that the thermoelectric generation (TEG) evaluation sounded excellent, but it was still not clear to if the model was properly translating TEG output to the overall efficiency of the vehicle.

Reviewer 3:

The reviewer stated that the approach contributed to overcoming some barriers but that it was unclear what these barriers were.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that material science was where most of the breakthroughs were going to happen in this arena.

Reviewer 2:

The reviewer reiterated again, that the TEG evaluation looked to be excellent, but that it was not clear about calculation of fuel savings.

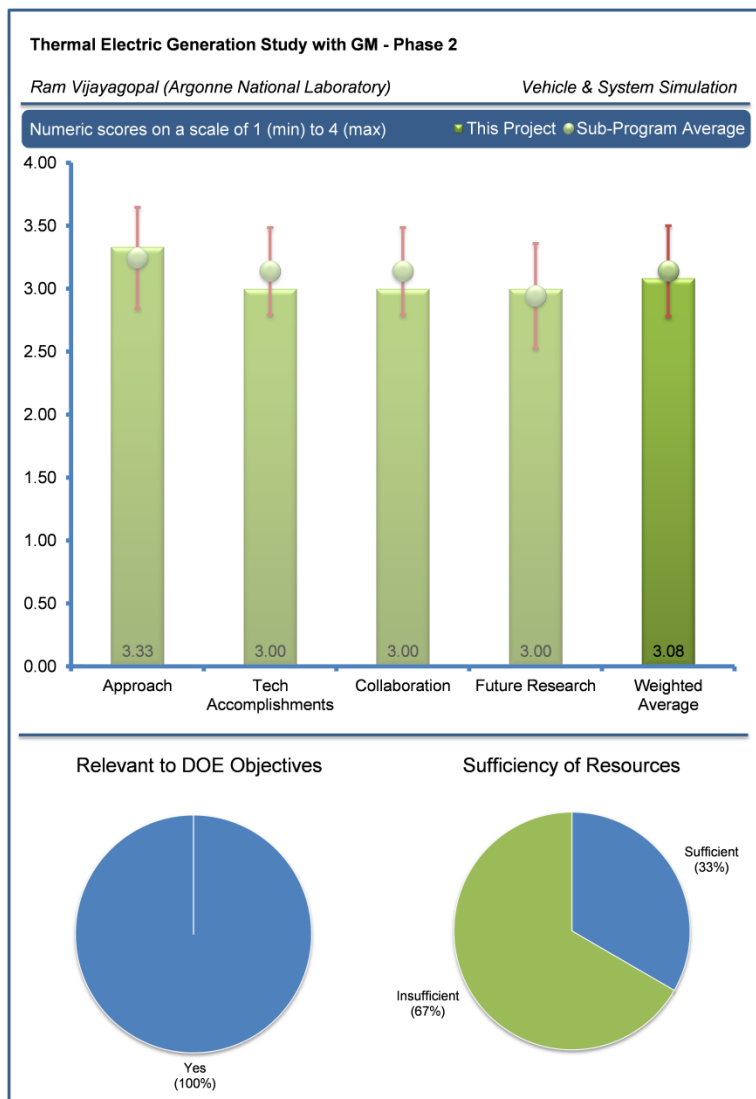
Reviewer 3:

The reviewer said that the rate of progress has been slow and it was not even clear why this project was necessary.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that this was a small project that does not require much coordination. The reviewer added that obtaining TEG modeling data from GM was key to the whole program.



Reviewer 2:

This reviewer would like to see more collaboration, especially with the OEMs.

Reviewer 3:

The reviewer observed that collaboration was said to be with GM, yet the hand of GM did not seem much in evidence.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer noted that future plans focused on better assessing ways to recover energy from TEGs, which was properly focused.

Reviewer 2:

The reviewer stated that this technology must be pushed forward.

Reviewer 3:

The reviewer indicated that the proposed future research needed better focus to overcome barriers, whatever they might be.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that this was very relevant and asked why waste all that energy as heat.

Reviewer 2:

The reviewer commented that energy recovery was a potentially large improvement to hybrid efficiency and deserved more work.

Reviewer 3:

The reviewer said that if this project contributed to the use of thermoelectric devices to improve vehicle FE, then this project would support the overall DOE objective to displace petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that aside from the lack of more OEM participation, the resources looked adequate.

Reviewer 2:

The reviewer hoped that this was just one of a number of projects that DOE had on TEGs. The reviewer added that not only was this an important area of research, but that it is also an area that is not well advanced and in which DOE work can make a difference.

Reviewer 3:

The reviewer observed that funding for this project was so small as to be almost non-existent and therefore, it does not appear capable that this project would be able to achieve the stated milestones in a timely fashion.

Wireless Charging: Allan Lewis (Hyundai) - vss102

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this project is a system development that is intended to create a salable design for a wireless charging system by the end of 2015. The reviewer noted that the approach is not fully explained as the company claims it is pursuing intellectual property (IP) filings and therefore offered limited information regarding the product and/or approach. The reviewer commented that it is distinctly different from VSS103 which is designed to explore the limits of wireless charging in the area of flow rate.

Reviewer 2:

The reviewer stated that the general objectives are appropriate but the plan of attack is somewhat generic. This reviewer believed that technical hurdles and means to overcome them were not outlined. The reviewer remarked that the reader is left with the impression that technical barriers may not exist and that this is primarily an application development problem.

Reviewer 3:

The reviewer specified that this appears to be in the planning stage. The reviewer noted that the relevant standards and organizations were identified. The reviewer observed that barriers were described on a technical level, but not a practical one. For example, the reviewer asked why these degrees of alignment tolerances were necessary when many cars could now parallel park themselves.

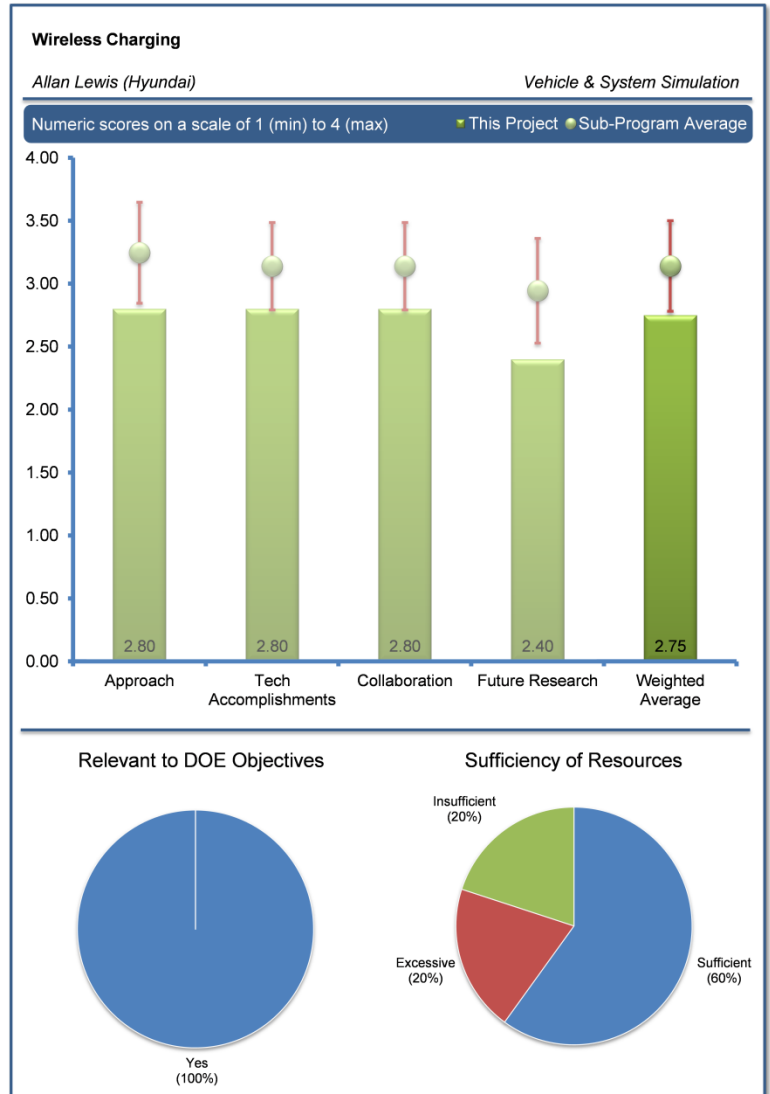
Reviewer 4:

The reviewer pointed out that the presenter provided very high level generalities and very little technical details. The reviewer noted that it was hard to see if the approach was appropriate or whether it produced significant progress. Perhaps, the expectations were not very high to begin with, but according to the reviewer it was very hard to tell.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer remarked that the project started late last year so progress was limited. The reviewer observed that the modeling showed promise of meeting some performance objectives.



Reviewer 2:

This reviewer thought that technical barriers were identified and a framework was described, but there was no mention of technical advantage over other approaches that are being pursued. Perhaps it is too early to tell.

Reviewer 3:

The reviewer stated that because there is a near term salable product objective it seemed that the approach is intended to limit risk and take a next generation product to market. The 6.6 kilowatt-hours (kWh) is a sizable gain from the 3.3 kWh units in commercial use today but is a conservative gain when compared to the work of VSS103. The reviewer remarked that the entire schedule also seemed to be very slow. A greater use of modeling and quick builds, to gain hardware earlier, would be a great addition.

Reviewer 4:

This reviewer stated that the team has made very little technical progress in the first year compared to the other teams that have been working on the project for the last year.

Reviewer 5:

The reviewer noticed that no quantitative data was presented to show technical progress towards the go/no-go criteria, which was quantitative [i.e., wireless power transfer of at least 6.6 kW with at least 85% efficiency with at least a 20 centimeter (cm) gap]. In addition, the presenter excused himself from presenting data on the results of misalignment on wireless power transfer on the basis of intellectual property.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer indicated that project division of labor seems well defined between Hyundai and Mojo Mobility. Also, the reviewer said coordination and participation with SAE J2954 committee was good.

Reviewer 2:

This reviewer stated that the partnerships identified appear to be appropriate for the time being. This reviewer added that the anticipated list, upon fruitful results, should be expanded, such as the DOT.

Reviewer 3:

This reviewer observed that only one collaborator was listed (i.e., Mojo mobility). The reviewer expected other collaborators that should be included on a project like this, such as suppliers, to the automotive industry, of rectifiers, AC/DC converters, electronic controllers, and dedicated short-range communications (DSRC).

Reviewer 4:

This reviewer stated that collaboration is somewhat limited. This reviewer noticed that only a potential charger manufacturer, who is a sub-contractor, seems to be providing serious input. This reviewer has not seen significant collaboration with DOE labs or other industrial entities.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said it is good but aimed at a low risk implementation.

Reviewer 2:

This reviewer stated that future research forecasts are understandably limited to the maturity of the project; however, some vision would be refreshing considering the dynamic nature of the topic.

Reviewer 3:

This reviewer thought that the steps were appropriate to meet the project objectives. Also, the reviewer observed that it appears that a lot of work remains to be done in FY 2013.

Reviewer 4:

This reviewer listed the following Proposed Future Work tasks, which the reviewer thought were meaningless and needed details: first generation system test and corrections; second generation wireless power transfer prototypes; and second generation system test and corrections.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer observed that electrification of a significant portion of the passenger vehicle population would be a great benefit to not only the DOE, but also the Federal Highway Administration (FHWA), EPA, and areas striving to meet attainment status under the clean energy act.

Reviewer 2:

This reviewer stated that this could create a greater rate of EV adoption.

Reviewer 3:

The reviewer indicated that this project helps commercialization of high-power wireless charging for PEVs. The reviewer added that this will help to improve market acceptance PEVs due to better usability.

Reviewer 4:

This reviewer noticed that all wireless power transfer projects meet DOE objectives of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer said compared to the VSS103, it seems this project intends to accomplish more (more vehicles, higher performance) with less funding.

Reviewer 2:

This reviewer said quite.

Reviewer 3:

This reviewer thought at first glance, the schedule just seems to be so long. Also, the reviewer said it looks like this project is intended to fit the Funding Opportunity Announcement's (FOA's) time limits. The reviewer added that there was not enough information given to really understand the phases and tasks in any detail, but it looks like this has been done to protect some IP that is in the process of registration.

Reviewer 4:

This reviewer said this project was priced at \$6 million. The reviewer thought that without a cost breakdown, it is hard to understand why so much money is being spent on this project.

Wireless Charging: John Miller (Oak Ridge National Laboratory) - vss103

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer indicated that there was a detailed research plan and targets. The reviewer also added that the project team had a clear understanding and appreciation of technical issues, including safety.

Reviewer 2:

This reviewer stated that unlike the other wireless project, this one is designed to push the envelope on the capability of wireless charging. In addition, the reviewer noted that while it may be extremely aggressive to target a 19 kW transfer rate, the commercial value of establishing the parameters and challenges of reaching that level are worthwhile. The reviewer strongly encouraged the project to go higher.

Reviewer 3:

This reviewer said that the team has made a lot of progress in the first year of the project and that the technical accomplishments of the project were substantial.

Reviewer 4:

This reviewer stated that the principal investigator has done excellent work in identifying the parameters that have a significant effect on wireless power transfer (e.g., gap, current, and voltage) and performing a good parametric analysis (e.g., frequency versus power). However, the principle investigator's approach could be improved by depicting in quantitative terms where the contributions (or losses) in efficiency from each of the major components (on the grid side as well as on the vehicle side) are and whether they add up to achieve the target goal of 85% efficiency.

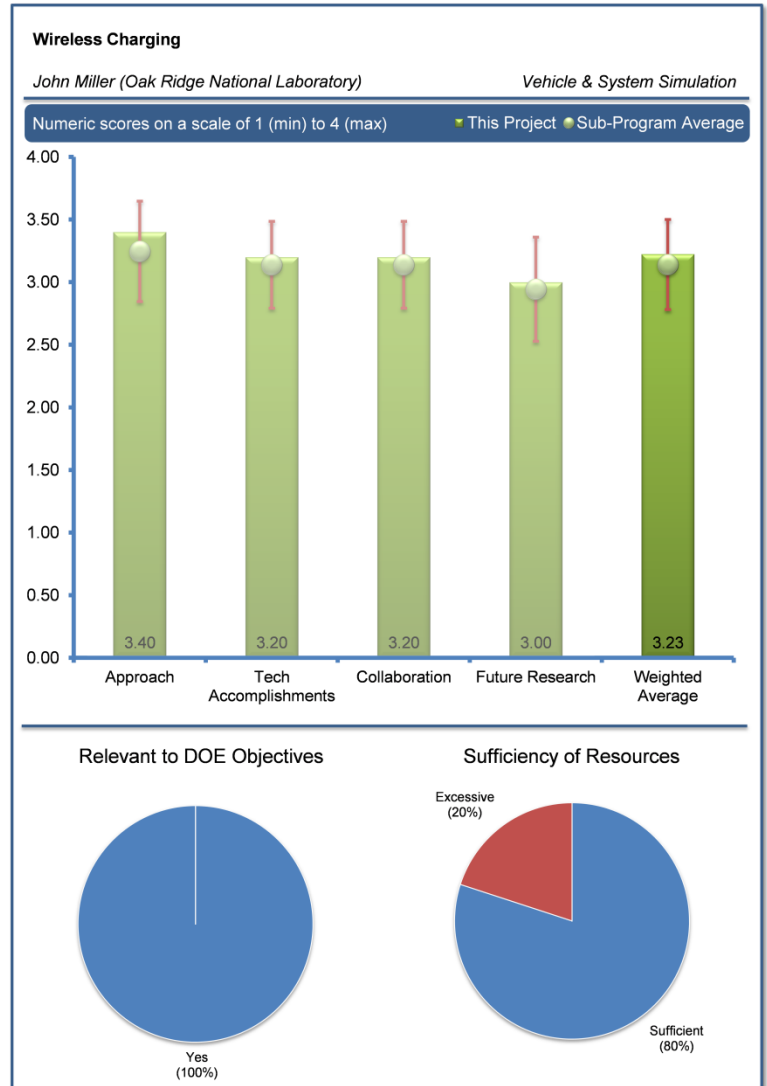
Reviewer 5:

This reviewer noticed that the project is well within the bounds of the scope. The reviewer indicated that the milestones have been established; however, go/no-go decisions do not include options for the no-go condition. Also, the reviewer noted that coil durability was not identified as a barrier.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer observed that the accomplishments to date are outstanding. This reviewer stated that the project gives us a superior understanding of the quantitative effects or relationship of current and frequency, power and frequency, misalignment and (primary or



secondary) power, tilt and efficiency, tilt and power, tilt and coupling coefficient, and dynamic frequency versus gap changes. This reviewer said that this understanding led to development of a new theory of wireless power transfer operation and control (e.g., tuning the input control achieves efficient power delivery). The reviewer noticed that the project even included potential conducting materials such as aluminum foil wrapper debris that may intervene between the charging pad and the vehicle.

Reviewer 2:

This reviewer stated that the accomplishments indicate excellent progress and point to eventual success; given 7 kW charging is already demonstrated in this project. The reviewer indicated that the theoretical accomplishments are noteworthy. Also, the reviewer thought that the testing seems thorough so far.

Reviewer 3:

The reviewer remarked that the program seems to be on track as designed. In addition, the reviewer said that it is in the first year of a multiyear endeavor so should be evaluated more critically next year.

Reviewer 4:

This reviewer stated that the approach described the following investigations, all of which are highly important and not covered in other projects to this detail: alignment starts to decline when x and y misalignment reaches 10%; tilt did not affect efficiency; ferrite plates 4 mm thick; only project offering manufacturing details; coil resistance increases exponentially with frequency; frequency needs adjustment with Z; investigation of radio frequency communication.

The reviewer then went on to comment on the presentation. According to the reviewer, there are those in the audience who may not work with differential equations on a daily basis, but remember enough to understand the physical significance if the presenter would walk them through the terms. Otherwise, the equations are useless in the time allowable for the presentation and should probably not be presented unless requested. It can be a distraction otherwise. The reviewer commented that if presented patiently, the equations can be more information than any text and even more so if accompanied by a graphic. This reviewer also added that the implications of coil spacing and geometry on continuous charging may not be realized in the laboratory environment for a number of factors, such as geometric space and speed. Also, the reviewer said the lab is not considering interference or losses associated with placement in pavements.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer stated that ORNL seems to be doing most of the work at this stage of the project. The reviewer noted that the project team was keeping SAE J2954 updated on progress. The reviewer added that the collaboration seems to be primarily in the deployment phase.

Reviewer 2:

This reviewer said all the essential partners were present (i.e., electric/electronics equipment packaging, test vehicles, vehicle testing, communications technology, vehicle integration, utility power grid, and high-speed power rectifier). The reviewer suggested that possible ancillary partners or experts who should be added are those who specialize in human safety with respect to magnetic and electric non-ionizing radiation.

Reviewer 3:

This reviewer stated that broad collaborations to define and solve technical challenges were presented.

Reviewer 4:

This reviewer indicated that the project team needs to include the DOT.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer indicated that the project team had a well-planned approach with roles and responsibilities of partners identified. The reviewer also stated that the project team needs to include the DOT.

Reviewer 2:

This reviewer indicated that with many challenges identified, the technical work plan is designed to progress along those critical paths.

Reviewer 3:

This reviewer indicated that the future steps focused on demonstrating a particular wireless charging implementation in a production vehicle. The reviewer said that one barrier not directly addressed is uncertainty in product offerings regarding control method, but the project findings appear geared to help clear up some of the uncertainties.

Reviewer 4:

This reviewer commented that a shortcoming of the research or possibly the presentation, was the failure to identify the barriers to, or showing the technical progress in achieving, the wireless power transfer efficiency of 85% at 10 kW. The reviewer remarked that it was not clear from the slide on future work, that there are either no barriers or feasibility; it just describes prototype factor correctors, DSRC, a demonstration of prototype, and SAE J2954.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer indicated that electrification of vehicles not only support the DOE, but also DOT and EPA objectives.

Reviewer 2:

This reviewer said that this project is an enabler for improved usability of Electric Vehicles (EVs), which will help commercialization prospects of the technology and improve market acceptance of EVs.

Reviewer 3:

This reviewer said that this project could enable higher adoption rates of battery EVs.

Reviewer 4:

This reviewer said all wireless power transfer projects support DOE objectives of petroleum displacement by facilitating the deployment of electric vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said resources appear to be sufficient for this project.

Reviewer 2:

This reviewer stated that no specific resource challenges were presented.

Reviewer 3:

This reviewer stated that the timeline is optimistic, especially if infrastructure (pavement) integration is considered, which is not.

Reviewer 4:

This reviewer indicated that without a breakdown of the expenditures, it is difficult to see how \$11.3 million is justified.

Dynamic Wireless Power Transfer Feasibility: Perry Jones (Oak Ridge National Laboratory) - vss104

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer said the project is well designed. Also, the reviewer stated that an inherent difficulty of this project is projecting cost and benefits of Direct Wireless Power Transfer (DWPT) given market uncertainties. The reviewer added that the approach assumes existing DWPT technology is adequate, which is unclear.

Reviewer 2:

This reviewer noticed that the approach is appropriate for this short term program.

Reviewer 3:

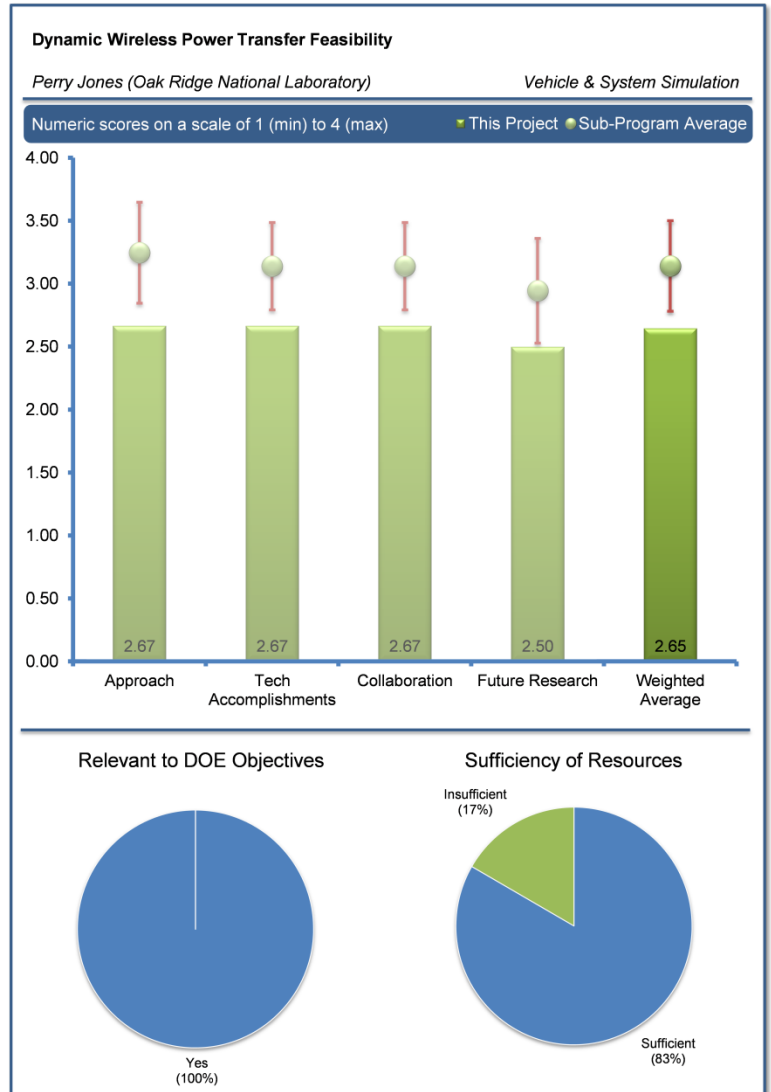
This reviewer indicated that the barriers were stated up front in broad terms along with corresponding objectives. The reviewer added that being that this is such a new exploratory topic a high level approach is appropriate. The reviewer warned that care should be taken in the communication of the results of this study that clearly indicate the maturity level. The reviewer stated to avoid giving the impression to the public that this is coming soon, as there are many obstacles to be overcome even with stationary WPT. This reviewer added that emphasis should be placed on the vertical gap factor when comparing with stationary WPT requirements as opposed to DWPT which may be embedded below the pavement surface. The reviewer said the project team made a good use of existing data sources from ANL and INL.

Reviewer 4:

This reviewer stated that the approach is a good first start; however, the approach misses an important step related to "quasi-dynamic" charging which comes after static charging. The reviewer thought that this should be considered as a "bridging technology" to the dynamic charging. In addition, the reviewer stated the approach seems to be developed in a vacuum (except National Laboratory input) without industry input. The reviewer thought that the dynamic charging needs to be joined with the static, and quasi-dynamic also through joint discussions with the industry and standardization efforts.

Reviewer 5:

This reviewer said that the goal of the project is very relevant to the investment that DOE is making into wireless charging research; however, it is unclear what the outcomes of the project are so far. The reviewer added that the physical implementation and maintenance issues are critical for successful deployment, and the team seems to be looking at these issues to a degree, but no insight into the issues was given in the presented work.



Reviewer 6:

This reviewer thought the approach to this effort is not the best. The reviewer said that the results of the literature survey to date were not presented. The reviewer added it is hard to identify what needs to be done in the future without understanding what has been done in the past. The past is important to finding a future direction. In addition, the reviewer commented this project did not elucidate the baseline application for dynamic wireless power transfer very well. The reviewer did not get a good understanding of what specific scenarios, what types and classes of vehicles, what vehicle platforms, and for what vehicle duty cycles, dynamic wireless power transfer is best suited for. Instead the reviewer heard that we should just pursue it because it is a good idea for the future.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer indicated that there was a set up good partners for collaboration and data sharing, such as the J2954 effort for static wireless charging. The reviewer added that early performance and evaluation metrics, as well as scenarios of interest are a good logical start. The reviewer also said evaluation of the impact of DWPT on grid is crucial, as well as clearly conveying the assumptions that need to be made. The reviewer added that the example of differences in funding between United States and Korea Advanced Institute of Science and Technology (KAIST) in Korea is a very good place to start. The reviewer added that fundamental differences in the power transfer technology in terms of configuration and operations should be brought forward for that particular scenario of interest (SOI). When identifying and evaluating SOI (i.e., dedicated lanes, changes in construction, etc.) consider additional data sources, such as the National Household Travel Survey (NHTS) available through the FWHA: <http://nhts.ornl.gov/introduction.shtml>.

Reviewer 2:

This reviewer observed that there was good progress towards goal of assessment of DWPT from the performance side (vehicle power requirements, proposed routes, etc.) and that there was less clarity around cost/benefits.

Reviewer 3:

This reviewer stated the project is achieving the originally defined objectives.

Reviewer 4:

This reviewer was not sure what accomplishments have been made to date.

Reviewer 5:

This reviewer indicated that this project was premature in two aspects: first, it was too early to provide any results; and second, not until the feasibility and understanding of stationary wireless power transfer is demonstrated, should there be a start on dynamic wireless power transfer.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer thought that the collaboration effort is quite strong so far and stated that it is expected that as the project moves forward, some additional outreach to utilities and perhaps state highway agencies with pavement testing facilities may be needed.

Reviewer 2:

This reviewer observed that collaboration and coordination is integrated with others where appropriate.

Reviewer 3:

The reviewer indicated that this project requires use of many resources from other laboratories and the DOT. The reviewer added that the results have been obtained by working closely with these groups.

Reviewer 4:

This reviewer would recommend discussing directly with KAIST/Conductix-Waempfler/SAE and others. The reviewer observed good collaboration between National Laboratories.

Reviewer 5:

This reviewer said that international or foreign partners should have been included as collaborators or coordinators.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer stated that the project is 40% complete and that the remaining tasks are clear with respect to objective.

Reviewer 2:

This reviewer observed that this was a short program and that the only future work is completion of current tasks.

Reviewer 3:

This reviewer stated there was no slide on future work.

Reviewer 4:

This reviewer indicated that the project team did not list any proposed future research.

Reviewer 5:

This reviewer said that if possible a progress update should be provided to the DOT in the effort to develop a collaborative roadmap for future joint research needs. The reviewer added that a paper for submission to the Transportation Research Board (TRB) annual meeting should also be considered.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer noticed that although this is a high-level feasibility study, the petroleum displacement potential for scenarios of interest are included to shed light on where the most impact may be realized.

Reviewer 2:

This reviewer indicated that DWPT would be one major means to overcoming EV range anxiety. This reviewer added that this study is needed to begin practicality assessing this approach in terms of its impact on transportation infrastructure.

Reviewer 3:

This reviewer indicated that it is relevant to define implementation strategies for DWPT, evaluate potential costs, barriers and benefits of various scenarios.

Reviewer 4:

This reviewer stated that this project defines the technical agenda items for wireless charging that would increase EV adoption.

Reviewer 5:

This reviewer said that all wireless power transfer projects support the DOE objective of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that the resources seem sufficient for a one-year study without experimental requirements.

Reviewer 2:

This reviewer stated that the resources were proper for a short program.

Reviewer 3:

This reviewer said none.

Reviewer 4:

This reviewer was not sure how realistic strategies for DWPT can be created without some analytical tools or cooperative projects with the U.S. DOT on electrified roadways, etc.

Reviewer 5:

This reviewer noted that the current resources appear sufficient to perform the high-level evaluation identified in the objectives. This reviewer added that a follow up on funding should be considered for future research needs identified as a result of this effort to prevent any loss in momentum.

Analysis of In-Motion Power Transfer for Multiple Vehicle Applications: Jeff Gonder (National Renewable Energy Laboratory) - vss105

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the project had well detailed methodology given the limits of available information.

Reviewer 2:

This reviewer said the project team had a good approach.

Reviewer 3:

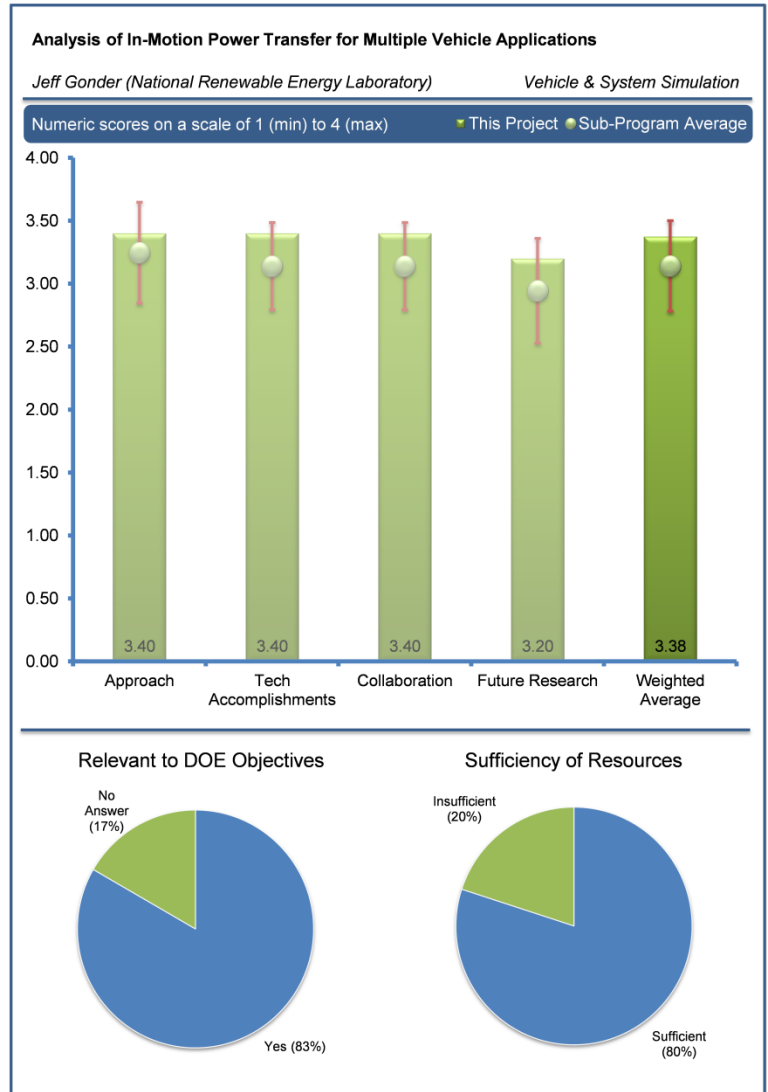
This reviewer pointed out that this project is exploratory in that it is attempting to understand an aspect of EV adoption that has not been well understood in the past. The reviewer asked just how much charging infrastructure is really needed to gain broad adoption of EVs. Also, the reviewer said that the approach is very well conceived.

Reviewer 4:

The reviewer listed the following: address barriers; 50% complete; risk aversion; cost; infrastructure; will quantify petroleum consumption and greenhouse gases (GHG); coordination with Oak Ridge and other partners; spacing, efficiency, and alignment; grid load and Vehicle-to-Infrastructure (V2I) communications; NREL has a transportation secure data center with GPS data on driving type and location/ road overlap; good data set example for Atlanta; market analysis; grid load analysis shows potential problem; future work; Class 8 roadway impacts; 5% or roads equipped with WPT could double EV penetration; Annual Energy Outlook (AEO); DOT Federal Motor Carrier Safety Administration (FMCSA). The reviewer added that the project team needs be made aware of the NHTS Traffic user survey database.

Reviewer 5:

This reviewer thought that the approach was very good. The reviewer stated that the approach establishes a baseline with real-world data on vehicle usage and market factors from which to start. The reviewer added that the approach uses consumer choice models for passenger cars on preferences to make forecasts; however, it is weak on making forecasts for commercial vehicles, especially Class 8 trucks and buses. In fact, the reviewer said the project looked at only hybridization, only Class 8 benefit potential without taking into account the future market for hybrid Class 8 trucks and buses as well as for battery electric and plug-in battery electric Class 8 trucks and buses. Also, the reviewer noted that the project did not take into account the changes in the future brought about with the DOE SuperTruck program with the development hybridization for long haul, over-the-road trucks.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer indicated that the project is only about 50% completed, and that there are already significant, noteworthy accomplishments. The reviewer then listed the accomplishments: first, the summary of travel distribution across the road infrastructure showing that relatively little infrastructure can cover a large amount of travel for charging; second, the infrastructure placement showing opportunities for low-range and slow recharge improving consumer preference for battery electric vehicles; third, a model enhanced for infrastructure rollout facilitating a rollout impact analysis to determine best approach and its impact on market adoption; fourth, initial estimates of reduced petroleum use and GHG emissions showing potential impact on achieving DOE goals; fifth, initial estimates of loads on the electric utility grids implying load shifting away from the peak may be needed; and sixth, the validation of the Class 8 truck model and duty cycle considerations.

Reviewer 2:

This reviewer stated that there was good technical progress.

Reviewer 3:

This reviewer said that the draft results indicate clear progress toward meeting objectives. The reviewer appreciated the detailed presentation of accomplishments. The reviewer then stated the project team should check impact of EVs on GHG, or state assumption that EV energy source is 100% renewable.

Reviewer 4:

This reviewer stated that some of the early information is quite enlightening and should, if used properly, contribute to understanding the real infrastructure needs of an EV fleet for the U.S.

Reviewer 5:

The reviewer stated that this is an important project that looks at the effects of WPT charging on the fleet efficiency and makeup. The reviewer added that the work builds on the substantial database that NREL has available, which makes them uniquely positioned to do this work.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer observed that the project team was utilizing inputs and background work of many collaborators and integrating it very well.

Reviewer 2:

This reviewer indicated that there was a lot of data from other partners but most of the work was done by NREL.

Reviewer 3:

This reviewer noticed that all topical aspects of dynamic wireless power transfer appeared to be covered in the collaboration: consumer preference modeling, dynamometer test data, Class 8 trucks duty cycles, and passenger car GPS profiles.

Reviewer 4:

This reviewer noted that there were good collaborations and stakeholders. This reviewer would expand on stakeholders to include U.S. DOT efforts on electrified roadways and survey teams such as J2954.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that this is a short term project and it can hopefully help define a path for other projects that will define a rational EV infrastructure system.

Reviewer 2:

This reviewer stated that the role that commercial vehicles can play in in-motion wireless power transfer should not be underestimated because of their current high consumption of fossil fuel that could be displaced by adoption of electric and hybrid-electric technologies. This reviewer would have liked to see the inclusion of forecasts for increasing deployment of electric and hybrid-electric Class 7 and 8 trucks and buses (transit and motor coaches).

Reviewer 3:

This reviewer thought that the next logical step is to refine the conclusions, given the levels of uncertainty involved. The reviewer indicated that it was not clear how well the cost impact on infrastructure can be developed with high reliability given chicken-and-egg nature of making DWPT practical.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer indicated that two slides addressed this question and answered it very well. The reviewer then listed the answers: increased electric energy available, battery electric vehicle enabler, and opportunity to improve electrification cost-effectiveness.

Reviewer 2:

This reviewer stated that this project helps address questions of viability and GHG impact of dynamic wireless power transfer, which would be a significant enabler to EV adoption.

Reviewer 3:

The reviewer said that understanding the real infrastructure need and therefore investment levels can and should offer the opportunity to increase EV adoption rates.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer would suggest supporting this project.

Reviewer 2:

This reviewer thought that the resources appear sufficient given progress to date.

Reviewer 3:

This reviewer indicated that the resources are appropriate for the tasks described.

Autonomous Intelligent Plug-in Electric Vehicles (PEVs): Andreas Malikopoulos (Oak Ridge National Laboratory) - vss107

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer remarked that the approach was good and that more insight from OEMs should be considered. The reviewer added that complex control and optimization strategies can be a difficult to sell to most companies, where there is not a lot of control expertise. Also, the reviewer stated that drivability and customer acceptance of control strategies requires more focus. The reviewer noticed there is risk that the results of this study will not have a significant influence on hybrid powertrain (PT) design without it.

Reviewer 2:

This reviewer noted that the project is integrated well with Arvin on the DOE projects. This reviewer added that hybrids need to have customer payback to be accepted by the customer and OEMs. The reviewer said that by saving more fuel than traditional control schemes, this work will help hybrid acceptance.

Reviewer 3:

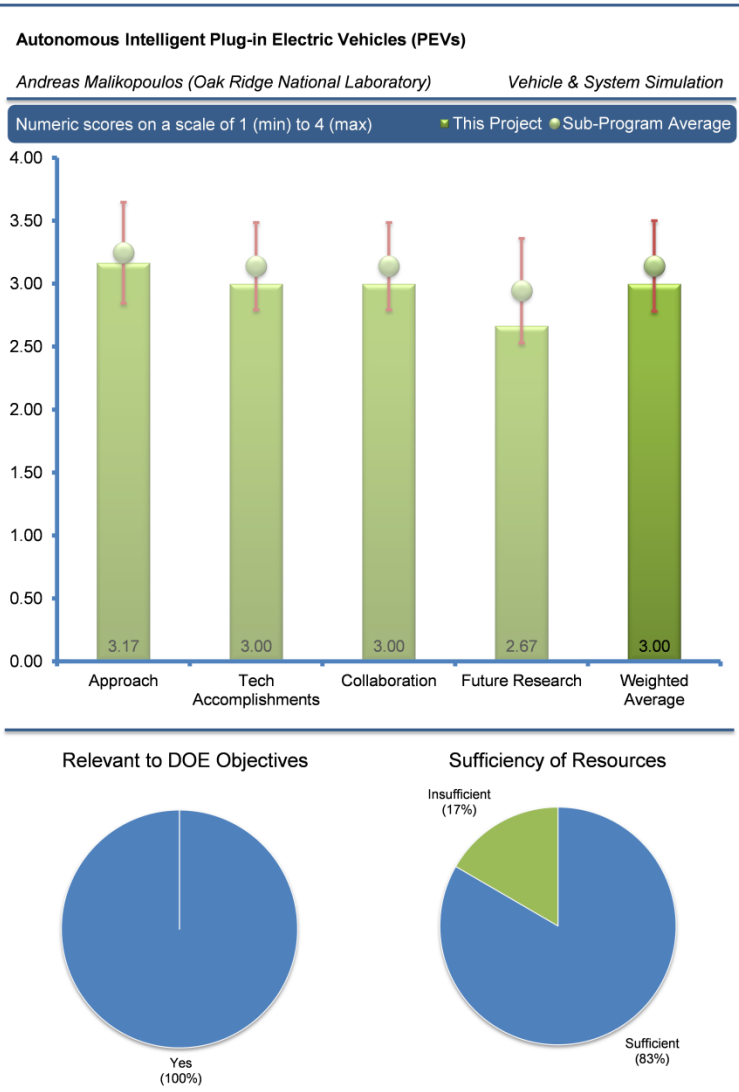
This reviewer pointed out that the approach looks solid for the type of advanced controls work at which this project is aimed. Additionally, the reviewer remarked that it is understood that the research has started with simulation and will advance to a real application when an OEM is identified with collaborative interest.

Reviewer 4:

This reviewer thought that the overall the presentation was very clear; however, the reviewer felt that there could have been more emphasis on explaining how the project addressed the technical barriers and other barriers that were mentioned briefly (cost, constant advances in technology).

Reviewer 5:

This reviewer commented that the primary issue the reviewer had with the approach is it was not grounded by benchmarking a state of the art hybrid controller in simulation and then comparing an alternative controller to it. The reviewer could not tell if the new controller strategy was five years behind or five years ahead. Plus, the reviewer thought the controller claimed approximately 6% better FE, but questions indicated that basic hybrid features such as electrical launch, engine stop start, regeneration, electrical assist, shifting of engine operating points, shifting of Electric Motor (EM) operating points, and battery temperatures were not considered. As these were not considered, the reviewer then inquired about what the new controller was better than by approximately 6%.



Additionally, this reviewer observed that it appears that the architecture was picked due to OEM hardware availability, which at some point will be important, but for now, getting all of the strategies into the algorithm and creditably demonstrating the value of the algorithm would appear to be a higher priority (hardware constraints may be limiting this goal). The reviewer would have picked the most common architecture that offered the full range of control strategy options for the first studies, even if it was not available yet.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer stated that the accomplishments reflect both improved system performance with stochastic control versus baseline (of greater than 5%) as well as the intended equivalent performance to offline dynamic programming, thus achieving key objectives.

Reviewer 2:

This reviewer stated that significant progress on optimization of hybrid electric vehicles (HEV) was demonstrated through five technical accomplishments.

Reviewer 3:

This reviewer stated that the models appear to be running and producing results; this is an important tool for the design of future powertrain systems.

Reviewer 4:

This reviewer noted that more correlation with other working hybrid systems will prove the controls work in more situations than just one or two.

Reviewer 5:

This reviewer observed that the project appears to be moving forward, meeting goals, but a key question is to what level does the control strategy in this project need to be at to declare success and either achieve OEM adoption or justify a follow on program. Additionally, the reviewer said that there seems to be many control strategies not yet incorporated, and for adoption, the strategy needs to be more encompassing. The reviewer went on to say that the third goal of developing an online self-sustainability algorithm for an HEV electrical path is a very tough goal, and is missing a key phrase: viable and comprehensive leveraging the full range of strategies for improved FE.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer indicated that an industry partner is working with the results/process developed here and that is very encouraging. The reviewer went on to say that the other collaborations provide much of the data required for the project.

Reviewer 2:

This reviewer indicated that the project team is close collaborations with Meritor, CLEERS, and Centers at ORNL.

Reviewer 3:

This reviewer pointed out that the control algorithm appears to have been developed too much in isolation, and broadening the collaboration could help improve the algorithm, in addition to begin to socialize the community to concepts. The reviewer added that one OEM on the project has a single architecture and thus there may be a limited number of strategies that can be utilized. As a result, the reviewer thought the focus may be limited and may not capture many other strategies. The reviewer noticed that if there was an advisory board helping the project, then it would help get that community input into the project. The reviewer stated that the advisory board would help generate interest on the project and help achieve adoption.

Reviewer 4:

The reviewer stated that this is a difficult topic to establish broad collaborations early on. The reviewer commented the fact that Meritor started down the path is a plus even if there were later decisions to shift their priorities and participation. The reviewer thought that the other collaborative groups/initiatives are also very relevant. The reviewer would anticipate a successful quest in finding an OEM partner to further the work and advance to a real application test.

Reviewer 5:

This reviewer said that the project just needs more demonstration partners especially now that Arvin has pulled out.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer observed that the presentation concluded with a clear statement of logical next steps. The reviewer added that the project seemed to be well managed.

Reviewer 2:

This reviewer remarked that the comparison of this algorithm with others is an important next step. The reviewer observed that an OEM collaborator will greatly help this project, so this is a good future goal. The reviewer felt that one should have been identified by this point of the project though. The reviewer thought that having an OEM collaborator is critical for the results of this project to have a path to commercialization.

Reviewer 3:

The reviewer pointed out that it would be good to try the controls out in a mass produced passenger vehicle, if possible, as is noted in the proposed future work; hopefully there are some ongoing discussions to do that.

Reviewer 4:

This reviewer would like to see a little more into the future of what will be done once an OEM is identified for implementation. The reviewer asked what would be proposed to engage that OEM to follow on in FY 2014. The reviewer acknowledged that this specific project ends in September 2013, and would like to know the vision or proposal for continuing into 2014.

Reviewer 5:

This reviewer observed that one of the proposed future work recommendations is to look at other architectures, but the reviewer would prefer to see all of the control strategies into the logic and understand how the control algorithm performs when it has all the strategies available. The reviewer is amazed to see future work as compare to existing literature as the reviewer would have thought that would have been the first step in understanding where the new algorithm fits and provides opportunities where other algorithm cannot.

The reviewer went on to say that the market pull on the algorithm will be through its Finite Element (FE) benefit relative to a mature baseline, so the reviewer thinks the focus needs to be on getting creditable and robust benefit. The reviewer stated that two of the proposed future work items focus on publishing rather than developing a robust case for market pull for a technology that should have appeal if it can be validated.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said advanced control and related improvement in emissions and efficiency is highly relevant.

Reviewer 2:

This reviewer stated that the project supports DOE objective of petroleum displacement by optimizing power management control in HEVs. The reviewer added that this project will reduce petroleum fuel consumption.

Reviewer 3:

This reviewer observed that this project supports the development and understanding of advanced vehicle powertrains that are aimed at significantly reducing fuel consumption from the transportation sector.

Reviewer 4:

This reviewer stated that this project saves fuel in hybrid vehicles.

Reviewer 5:

This reviewer noticed that the control strategy could have benefit in reducing petroleum, but it is hard to qualify as the presentation is missing the data to establish creditably.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer pointed out that this is a big subject with significant upside potential. The reviewer added that software updates are low cost relative to the FE savings. Additionally, the reviewer commented that to be effective and convince folks in this complex subject, \$200,000 per year is not enough money to develop a robust and creditable case in a timely fashion.

Reviewer 2:

This reviewer observed that resources do not seem to be in question to closeout project by September 2013 as planned for this round of funding.

Reviewer 3:

This reviewer indicated that computing power seems to be sufficient, but experimental results would greatly add to the outcome of this project. This reviewer does not believe this is in the original scope though.

Reviewer 4:

This reviewer stated that it should be checked that sufficient resources exist to try the controls out in several vehicles and check the fuel savings from using the controls.

Reviewer 5:

This reviewer said no insights on sufficiency of resources were provided in the presentation.

Heavy Duty Powertrain System Optimization and Emissions Test Procedure Development: Paul Chambon (Oak Ridge National Laboratory) - vss108

Reviewer Sample Size

A total of two reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that development of valid test procedures requires hardware in the loop experimentation. The reviewer added that this project is applying the correct approach.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer observed that the project has constructed a capable hardware in the loop test harness and is exercising the test harness to produce project milestones.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer indicated that the project has strong collaboration between DOE, EPA, and prominent members of the heavy-duty (HD) truck powertrain industry.

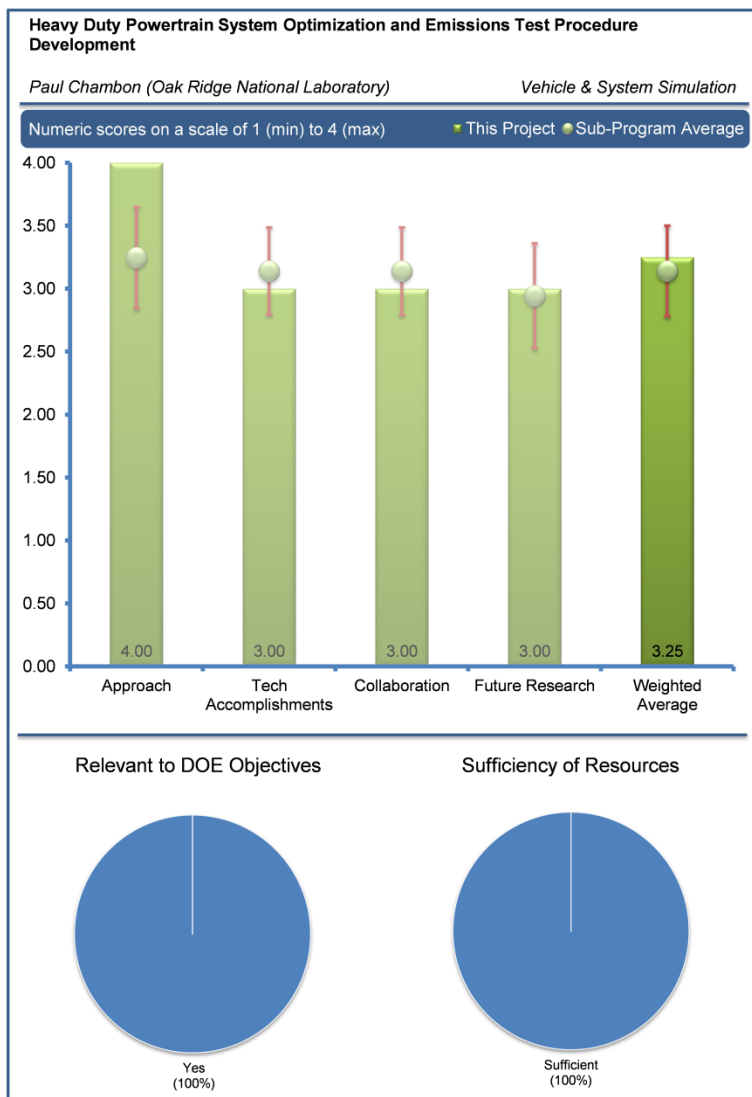
Reviewer 2:

This reviewer stated that the collaboration and coordination efforts are currently adequate but the reviewer believed other component and truck OEM system partners need to be participants. The reviewer stated that the ORNL laboratory program needs better advertisement amongst industry, maybe this should be an added objective and would reduce cost barrier.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that the project is focused on providing useful information to the EPA.



Reviewer 2:

This reviewer requests that more project detail for hardware in the loop variations be considered for this lab besides Meritor's DMHP, Eaton's Ultrashift, other OEM engines, other Advanced Hybrid Drives (AHD), and other conventional advanced transmissions that will proceed AHD's to the market.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer stated that this project should have been started prior to EPA GHG regulations being implemented. Hence, the scheduled results will come too late to offer value for truck OEMs' product implementation processes. This reviewer said that this dynamometer lab unfortunately will be in effect after 2014 calendar year (CY) JOB1 dates and will be marginally beneficial for 2017 GHG regulations. The reviewer added that the EPA GHG work should take highest priority, which will benefit DOE objective of petroleum displacement.

Reviewer 2:

This reviewer pointed out that DOE and EPA programs need to complement each other to effect practical solutions to petroleum displacement. This reviewer added that the emissions produced by new HD vehicle technologies must be quantified properly for the true costs and benefits of those technologies to be fully understood.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that this presentation does not state that resources are any issue; however, it was mentioned that bringing controls systems online was an issue.

PHEV Advanced Series Genset Development/Demonstration Activity: Paul Chambon (Oak Ridge National Laboratory) - vss109

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer thought the approach to the work was practical and reasonable. The reviewer thought this was a worthwhile project that will give some interesting results.

This reviewer stated that every project has practical constraints in terms of scope, but in this case the reviewer thought there were a couple additional considerations the reviewer wished were covered. In particular, the reviewer would like a more detailed exploration and definition of engine requirements for the genset. The reviewer said that this could include both exploration of the system architecture and the engine operating strategy. For example, the reviewer asked if the engine load were allowed to vary, would this impact the battery requirements. Also, the reviewer asked how different sized gensets may impact overall system performance and cost.

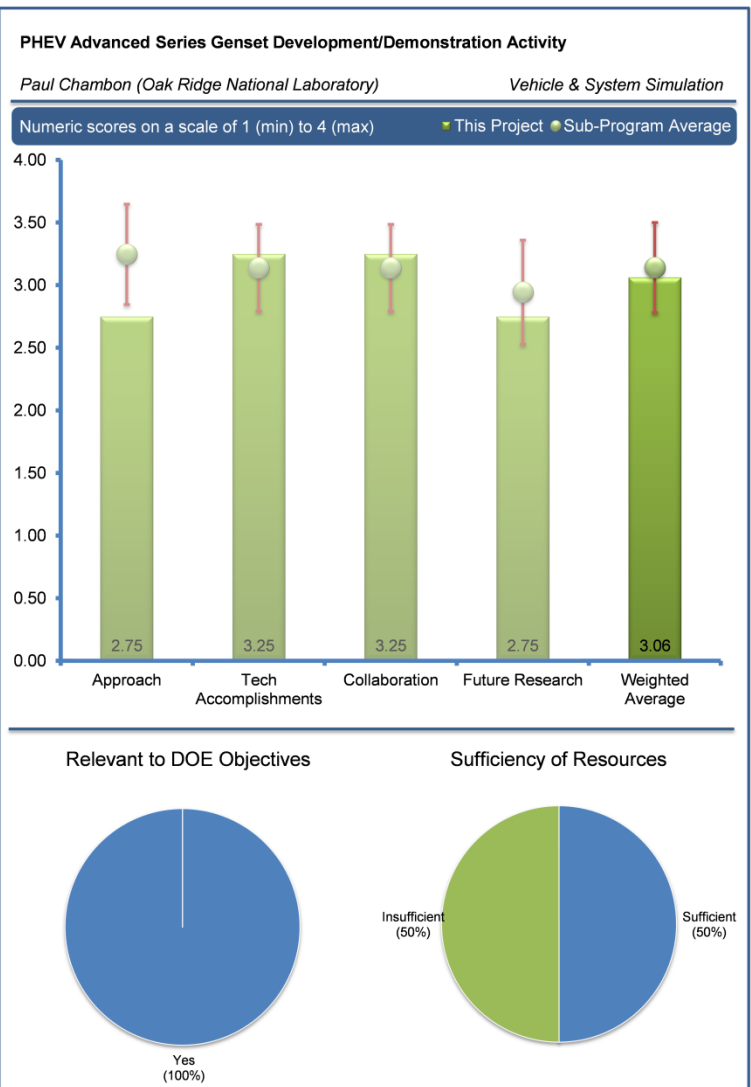
The reviewer added that the requirements for engine operation for this system are significantly different as compared to a traditional powertrain; significantly different engine requirements could lead to significantly different engine design. The reviewer therefore remarked that the definition of those engine requirements, and consideration of how the requirements might impact design, would be very interesting. This reviewer went on to say this might take the form of some trade-offs at the system level (expanding on the battery cost versus genset size) of cost or performance versus engine requirements, which might then lead to some different options for engine design. In other words, a single speed genset which allows load to vary might have lower battery usage than a single speed, single load genset. However, the single speed, single load genset might present more opportunities to optimize the air handling system (the reviewer does not know if that is true, it is just an example to try and illustrate the point).

Reviewer 2:

This reviewer observed that there were mismatched performance specifications between the engine and electric machine (which was not designed as a system) that might delay the project. The reviewer added that although this mismatch is not an outright barrier, it is clearly an issue that should have an alternative path for project success.

Reviewer 3:

This reviewer said that the hardware portion of the project does not go as far as it might in developing an optimal range extender unit. The reviewer added that demonstrating a compromised design does not advance the state of the art or provide the best performance.



The reviewer indicated that the project develops a range extender but this is already being done by many suppliers and even OEMs, so the benefit of ORNL doing one too is not so clear-cut.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer indicated the project is making good progress.

Reviewer 2:

This reviewer pointed out that it was good that Autonomie model and simulation study are well under way with results. The reviewer was concerned that hardware in the loop will take longer to evaluate and yet contract paperwork for engine technology is not completed.

Reviewer 3:

This reviewer stated that the simulation portion of the project could be improved by exploring the control strategy fully. This reviewer added that the hardware partners were selected based on available offerings, which leads to a compromised design.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer said that the project team did an excellent job in getting everything aligned, given the project constraints.

Reviewer 2:

This reviewer noticed that the collaboration strategy seems like a reasonable mix of industry and National Laboratory partners. The reviewer thought that additional partners with expertise in engine design might bring some additional perspective (existing partners are good, but sometimes some additional input brings new ideas).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that the proposed work stream is good. The reviewer commented that it would be worthwhile to find a partner to simulate an optimal motor design to go with the MAHLE engine performance characteristics.

Reviewer 2:

This reviewer remarked that the next steps of demonstrating the system capabilities in hardware should help validate the initial modeling results.

Reviewer 3:

This reviewer said that the program is hard coded with a single powertrain and single induction machine. The reviewer thought it would be beneficial to incorporate a broader supplier/partnership opportunity to truly have the opportunity for future research and collaboration.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer indicated that yes, this project does support the goal of reducing petroleum consumption. The reviewer added that the use of a genset in a PHEV can dramatically reduce product cost, increasing likelihood of adoption of the technology (which could

displace traditional IC engine powertrain technology). Additionally, the reviewer said that the use of a genset in a PHEV may result in lower carbon dioxide (CO₂) emissions as compared to an EV, depending on the source of electricity used for charging.

Reviewer 2:

This reviewer commented that this project helps promote electrified vehicles, and strategy to overcome the range anxiety of EVs.

Reviewer 3:

This reviewer stated that the goal of increasing the range of electric vehicles can include the use of range extension IC engines that provide generator power. The reviewer added that highly efficient range extenders are needed to increase the market share of electric vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer thought that the project resources seem reasonable to meet the stated project goals. The reviewer said it would be nice to have additional resources to expand the scope slightly to allow further consideration of system trade-offs versus engine requirements, and engine design options that result from those requirements.

Reviewer 2:

This reviewer stated that since the idea is to demo a range-extender power unit, the best case would be to make it as optimal as possible. The reviewer added that funding to make the best hardware demo possible would seem to be required.

Reviewer 3:

This reviewer noted that the amount of resources is only sufficient for scratching the surface when it comes to developing highly efficient range extenders. The reviewer added that R&D programs need to start somewhere and this project will help the DOE R&D laboratories to increase the knowledge base to support future development.

Battery Energy Availability and Consumption during Vehicle Charging across Ambient Temperatures and Battery Temperature (conditioning): Eric Rask (Argonne National Laboratory) - vss110

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer thought this was a really good piece of work.

Reviewer 2:

This reviewer stated that the project seeks to answer questions for what appears to be third order technical barriers.

Reviewer 3:

This reviewer stated that the work is useful, but as the PI indicated, getting decent measurements can be tricky. The reviewer added that for best data results, the project team would need to measure operation of the cooling system inputs (fans, pumps, etc.).

Reviewer 4:

This reviewer said that a good mix of PHEV and BEV was used in the evaluation. This mix had a range of operating styles, charger capabilities and thermal management capabilities. The reviewer went on to say that the testing approach and strategy took into account several important factors such as ambient recharge temperature, vehicle soak times, and battery usage prior to charging and vehicle HVAC settings.

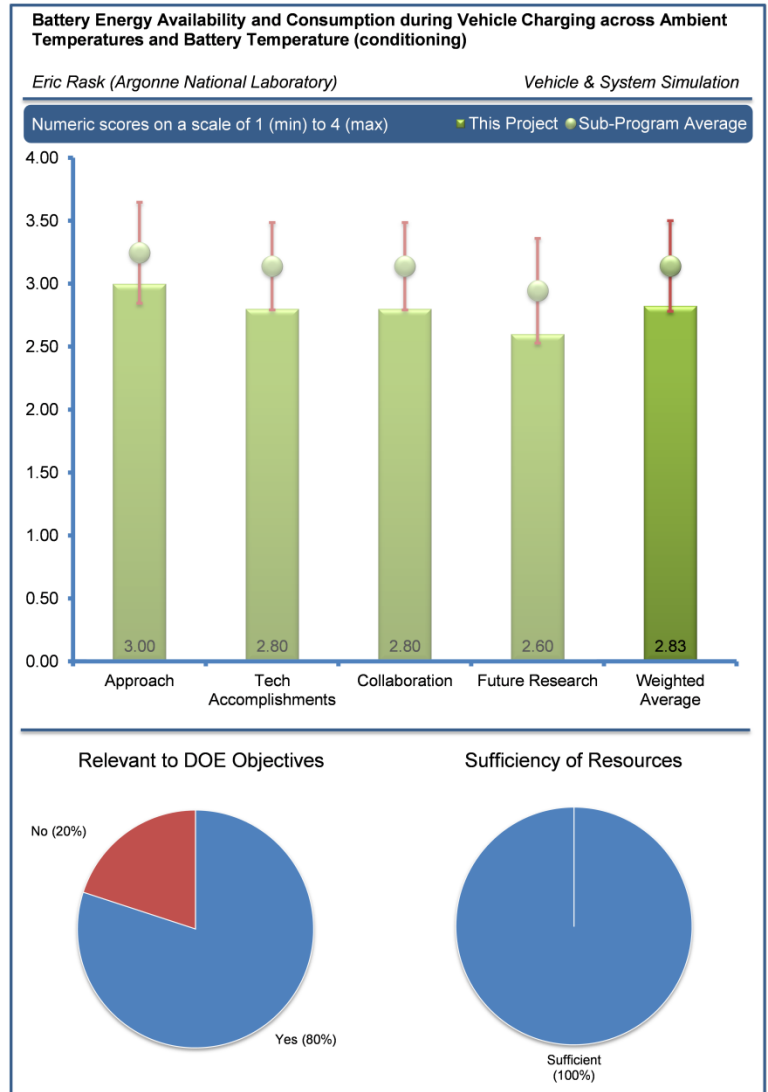
Reviewer 5:

This reviewer observed that the presentation did not state a clear concise objective. The reviewer discovered bits and pieces of objectives throughout presentation, embedded within title, relevance and summary sections.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer pointed out that most of the testing on the four vehicles is complete. The reviewer added that the testing yielded several important results which include: the Chevrolet Volt showed two cooling operations when plugged-in under hot conditions; the Volt also showed intermittent stand-by heating when plugged-in; other vehicles showed reduced battery power during low temperature testing, which may mean more thermal management during recharge is necessary.



Reviewer 2:

This reviewer stated that the project has managed to capture quite a bit of data, and made good progress toward stated goals.

Reviewer 3:

This reviewer thought that the testing program is on track and looks to be heading for completion in the desired time frame.

Reviewer 4:

This reviewer stated that the barriers were addressed.

Reviewer 5:

This reviewer stated that the project team performed the tests, but the barriers overcome are missing.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer indicated that the collaboration approach seems reasonable. The reviewer commented that inclusion of battery manufacturers in the project, as partners, may have helped provide some additional insights.

Reviewer 2:

This reviewer observed that most of the work is done by ANL and that there is good data sharing.

Reviewer 3:

This reviewer stated that in addition to the four vehicles being evaluated, groups such as National Laboratories, SAE International and U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability (U.S. DRIVE) are involved in shared data and analysis and the development of test procedures.

Reviewer 4:

This reviewer said that these are production vehicles and that the project does have the support of vehicle OEMs. Also, the reviewer asked if the thermal management issues of battery energy availability and consumption findings are a surprise to the OEMs.

Reviewer 5:

This reviewer commented that the degree of coordination with other organizations is unclear.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer stated that the focus on BEVs is a good next step.

Reviewer 2:

This reviewer remarked that a good next step would be to consider how this work might be incorporated into new test procedures for vehicles.

Reviewer 3:

This reviewer noted that it appears future work will only include in-depth benchmarking of the Ford Focus BEV.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer observed that this project improves the understanding of electrified vehicle behavior so that DOE can make proper technology assessments.

Reviewer 2:

This reviewer noticed that thermal management of the battery during recharge can have a major impact; therefore this project supports the overall DOE objective of petroleum displacement.

Reviewer 3:

The reviewer stated that this project highlights the need for a comprehensive evaluation of system performance. The reviewer added that if battery thermal state is not considered in evaluation of FE, the results could be misleading.

Reviewer 4:

The reviewer commented that this appears to be a third order issue. The reviewer added that information regarding battery cooling and heating during motion would be more useful.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that the resources appear to be sufficient. In fact, the reviewer said it seemed that for the funding available there is a lot of work and results being reported.

Reviewer 2:

This reviewer noted that the resources are adequate, the handicap being that it is difficult to take some types of measurements.

Fuel Consumption Benefits from Low Temperature Combustion (LTC) of Gasoline CI Technology using EIL: Neeraj Shidore (Argonne National Laboratory) - vss111

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the approach of leveraging existing expertise in vehicle system simulation and low-temperature combustion (LTC) research at ANL is a good use of federal funds. The reviewer added that the approach of evaluating a variety of fuels, engines technologies and drive cycles in the project's design of experiments will provide useful results.

Reviewer 2:

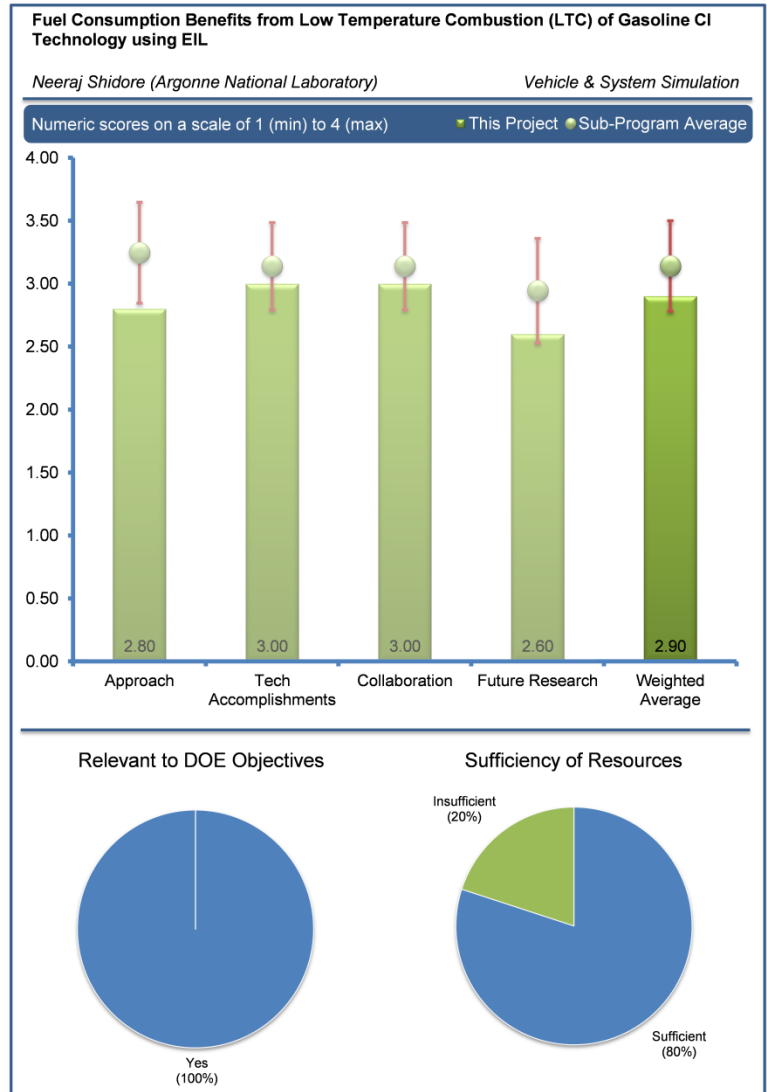
This reviewer said that the project seems like good work to complete. The reviewer noted that transient control of LTC modes is an issue. The reviewer liked to see the comparison of simulation and test. The reviewer liked to see the simulation used before going to test. The reviewer added that the use of engine in the loop (EIL) is a good approach for repeatable fuel consumption measurements on a transient cycle. The reviewer did not note any reference to include some noise factors like driver behavior or shifting pattern. The reviewer said that would be nice to see. The reviewer went on to say that extrapolation of the LTC points for the engine map is a little questionable. The reviewer asked if that is needed how will the real cycle run if it needs to get to those other operating points.

Reviewer 3:

The reviewer noted that the barrier identified is developing robust control of LTC over different operating points, but this project seems to be trying to identify FE improvements of LTC through Hardware in the Loop (HIL) testing. This reviewer went on to say that what is actually being done is very useful, but it is not clear that it will directly help the technical barrier at this point.

Reviewer 4:

This reviewer said that this seems like a reasonable approach. The reviewer understand the need to limit the scope of the work, but the reviewer does wonder if the selection of Urban Dynamometer Driving Schedule (UDDS) and Highway Fuel Economy Driving Schedule (HWFET) as the test cycles will really test capabilities of the technology. The reviewer added these cycles are quite lightly loaded and it is likely it will not require the engine to operate at high torques. Also, the reviewer stated the evaluation of LTC at high torque and high transient conditions seems like it should be an objective of the work.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said good progress.

Reviewer 2:

This reviewer said the development of models and test cell approach is good.

Reviewer 3:

This reviewer indicated that the process developed to generate an engine map to compare LTC to Spark Ignition Direct Injection (SIDI) and Port Fuel Injection (PFI) by simulation will be able to be used for future projects. This reviewer added that significant improvements in FE were shown during the simulation of LTC with PFI and SIDI.

Reviewer 4:

This reviewer stated that simulations have been performed to demonstrate the benefit of LTC combustion. The reviewer noted that it appears that this group is simulating that the LTC engine will operate in that mode throughout the operating range. The reviewer then asked is this a practical assumption. The reviewer also asked will this really be a mode-switching engine.

Additionally, the reviewer remarked that FE results from simulation are given, but the LTC case has very different gear ratios than the other two. One would expect very different FE results from this. The reviewer noted that the investigators should run the same simulation for all combustion modes with the same ratios to compare apples-to-apples, or justify why this was done.

The reviewer went on to say that it would be good to plot and compare where each engine operated over the drive-cycles. Maybe a scatter plot of every few seconds on the Torque/Rotations per Minute (RPM) plot would help. The reviewer observed that this type of experimental setup can be complex, but can provide a significant amount of data in a short time once working. The reviewer added that the timeline could still be met. The reviewer thought that it was not clear how the group plans to run or control the LTC engine during transients. This should be clarified.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer said that a strong group has been assembled. The reviewer has no concerns.

Reviewer 2:

This reviewer observed that the project team has a good mix of industry and National Laboratory partners. The more industry participation is the better it is for this project.

Reviewer 3:

This reviewer stated that collaboration and coordination exists between several National Laboratories, OEMs and U.S.DRIVE to share test plans, data and analysis.

Reviewer 4:

This reviewer indicated that all the work has been done at ANL, but giving credit that for the LTC work there is collaboration with more partners. This reviewer commented that using an Autonomie vehicle model in a manner that has been done before is not really that much collaboration. The reviewer said that it is commercially available.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that the plan looks good, and also to compare the baseline and LTC.

Reviewer 2:

This reviewer noted that potential follow-up activities to evaluate the impact of hybridization on FE gains due to low temperature combustion gasoline comparing SIDI and PFI will be a good addition to the project.

Reviewer 3:

This reviewer stated that this project will generate very useful data, but it does not seem to be addressing the control of LTC issues stated as a barrier.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer stated yes, this project focuses on testing and understanding the FE benefits of advanced engine concepts.

Reviewer 2:

This reviewer said that the LTC is a promising technology for lowering fuel consumption but transient controls is a barrier. The reviewer added that this project is focused on that issue.

Reviewer 3:

The reviewer pointed out that the low temperature combustion research is being conducted to improve efficiency of engines which will help to displace petroleum. The reviewer stated that the objective of this project is to evaluate FE impact of low temperature combustion technology using engine-in-the loop will help meet the DOE objectives.

Reviewer 4:

This reviewer commented that the LTC could be an effective technology to reduce fuel consumption as compared to traditional spark ignition (SI) gasoline engines. This reviewer stated that the fuel efficiency seems to be comparable to diesel. The reviewer added that some additional considerations going forward might be how the cost of this technology compares to alternatives that have similar efficiency, identifying the fuel sensitivity to this form of combustion, and whether it can be successful with commercially available fuels.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that as always additional resources could help expand the scope. The reviewer said in particular some additional funds could expand the program to include consideration of alternative cycles (higher load and transients) and a range of fuels.

Reviewer 2:

This reviewer indicated that for the amount of work to be performed the funding is sufficient.

Reviewer 3:

This reviewer described resources as okay.

Reviewer 4:

This reviewer said the hardware, software, and technical expertise are sufficient.

Nanofluids for Cooling Power Electronics for HEV: Dileep Singh (Argonne National Laboratory) - vss112

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that this is an outstanding project. The reviewer added that the DOE discovered nanofluids back with Dr. Steve Choi in 1995; this group is building on this earlier work.

Reviewer 2:

This reviewer said the plan is highly organized with multi-year glide path.

Reviewer 3:

This reviewer observed that the project actions seem to be very well aligned with stated technical barriers. The reviewer added that the only barrier that does not seem to be addressed at this point is industrial acceptance of the technology. The reviewer thought that the final cost of the coolant and results will address that.

Reviewer 4:

This reviewer stated that there was no clear answer presented regarding the degree to which there is a need for larger heat transfer coefficient fluid for converter. The reviewer stated no value was established. The reviewer stated that cost analysis seems to be the last item to be studied. The reviewer observed no effort planned to establish value versus non-fluidic technologies; or to understand value of liquid cooling in general. The reviewer stated that it appears that long-term particle suspension stability studies under aggressive conditions not planned. Additionally, the reviewer pointed out that no investigation on impact of particle deposits on tube walls impacts fouling factors in hex tubes. The reviewer stated that manufacturability and scalability were not addressed. The reviewer went on to say that industry acceptance of a new working fluid; particularly one that may be in a combined cooling loop, would have a difficult time being adopted without broad acceptance, commercial development, fully scalable and sustainable formulation, and the ability to ensure long-term costs.

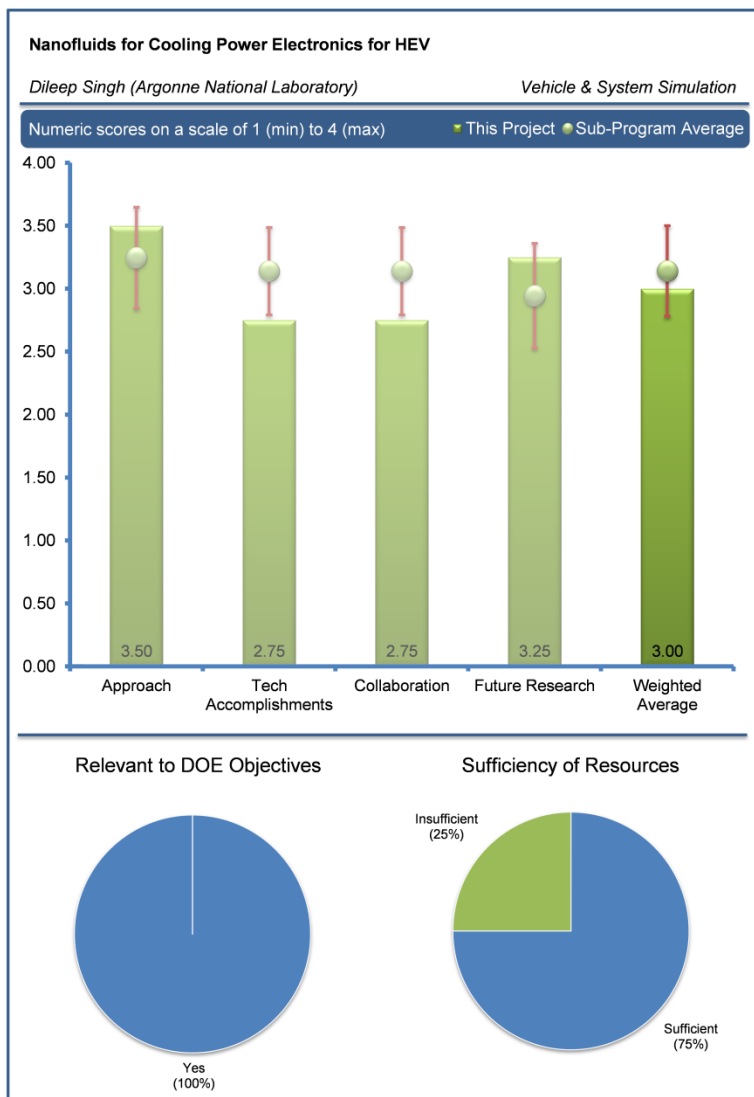
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer thought that this was a well-planned research plan, the PI is an expert in this field, and the project had an excellent team.

Reviewer 2:

This reviewer observed that there was confirmed viability with relatively low-cost material (graphite-based nano-particles)



Reviewer 3:

This reviewer noted that there was outstanding progress on technical barriers. Some of the barriers rely on industry partners (demonstration in HEV, and industrial acceptance), but it is not clear how these are being addressed at the moment.

Reviewer 4:

This reviewer said that the project addresses the use of nanofluids to cool power electronics. The reviewer observed that no specific requirements from industry were cited; only non-industry sources were cited for requirements. The reviewer added that engineering issues for implementing these fluids and managing long-term usage issues were not addressed. The reviewer stated that the heat transfer experiments were not completed in the current phase of project, but planned for final phase of project. The reviewer asked does the key-life test for the converter enable assessment under rigorous conditions. No interaction with module manufacturers or OEMs. This reviewer noted that it was not clear how project addresses secondary objective in heavy vehicle cooling. Additionally, the reviewer commented that the nanofluid engineering approach was not clear.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer said that the project team was partnering with suppliers and manufacturers.

Reviewer 2:

This reviewer said that it appears that project partners such as Valvoline and Dynalene are appropriate for the test plan and stage of development.

Reviewer 3:

This reviewer said there appears to be some collaboration, but it was not discussed in the presentation.

Reviewer 4:

This reviewer stated that collaborations appear to not be well coordinated, other than sharing some laboratory facilities. The reviewer said that the project does not appear to be closely tied with any industry or cross-cutting teams to help establish or evaluate benefits and value of high temperature coolants. The reviewer stated that the project would benefit from involvement with OEMs or suppliers who help to guide the requirement necessary for assessment and commercialization of the technology.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer stated that the project needs long time stability, corrosion. The reviewer commented that the PI knows this and has a plan.

Reviewer 2:

This reviewer stated that the project team has a firm multi-step plan in place for what is next in the development. The reviewer added that it is critical to get to the cost and efficiency assessments to move the project along and progress toward commercialization.

Reviewer 3:

This reviewer said more industry collaboration is needed to help address the technical barriers.

Reviewer 4:

This reviewer indicated that the decision points for future efforts were not clearly laid out. The reviewer stated that key milestones were not established (either technical or business); development pathways not fully planned. The reviewer added that there are no clear plans to address key barriers to entry into marketplace: value equation, establishment of technical need, requirements from industry, etc.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer noticed that this project is highly relevant to keep bringing system costs down through simplification and greater effectiveness of cooling

Reviewer 2:

The reviewer indicated that this project could help powering electronics cheaper, more reliable, and lighter. The reviewer added that all of these issues are barriers to HEVs making further penetration in the marketplace.

Reviewer 3:

This reviewer said that increasing heat transfer in fluids will improve FE efficiency and reduce the weight of the vehicle.

Reviewer 4:

This reviewer commented that these fluids, if they meet technical and commercial requirements, may benefit transition to electrified vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer noticed that the project resources do not appear a concern to achieve the objectives in the allotted time.

Reviewer 2:

This reviewer thought that the budget is sufficient for the amount of effort expended in this project.

Reviewer 3:

The reviewer observed that this technology could also improve heat transfer in refrigerants, thereby reducing FE.

Reviewer 4:

The reviewer stated that facilities to produce the coolants seem to be sufficient. The reviewer added that the testing of the coolants in-vehicle seems to be lacking currently, but may be outside of the original project scope.

DC Fast Charge Impacts on Battery Life: James Francfort (Idaho National Laboratory) - vss113

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated the key points of the approach as follows: data is being shared with other labs; combining track and lab testing; there are four vehicles; only 30,000 miles is used; this is low mileage. The reviewer stated that the research plan includes looking at contact temperature in environmental chambers. The reviewer added that this is a well thought out research plan.

Reviewer 2:

This reviewer remarked that the controls on the test activity and the understanding of the baseline performance are very well designed. The reviewer added that to understand the differences, the specific drive cycle and charge controls are very well designed.

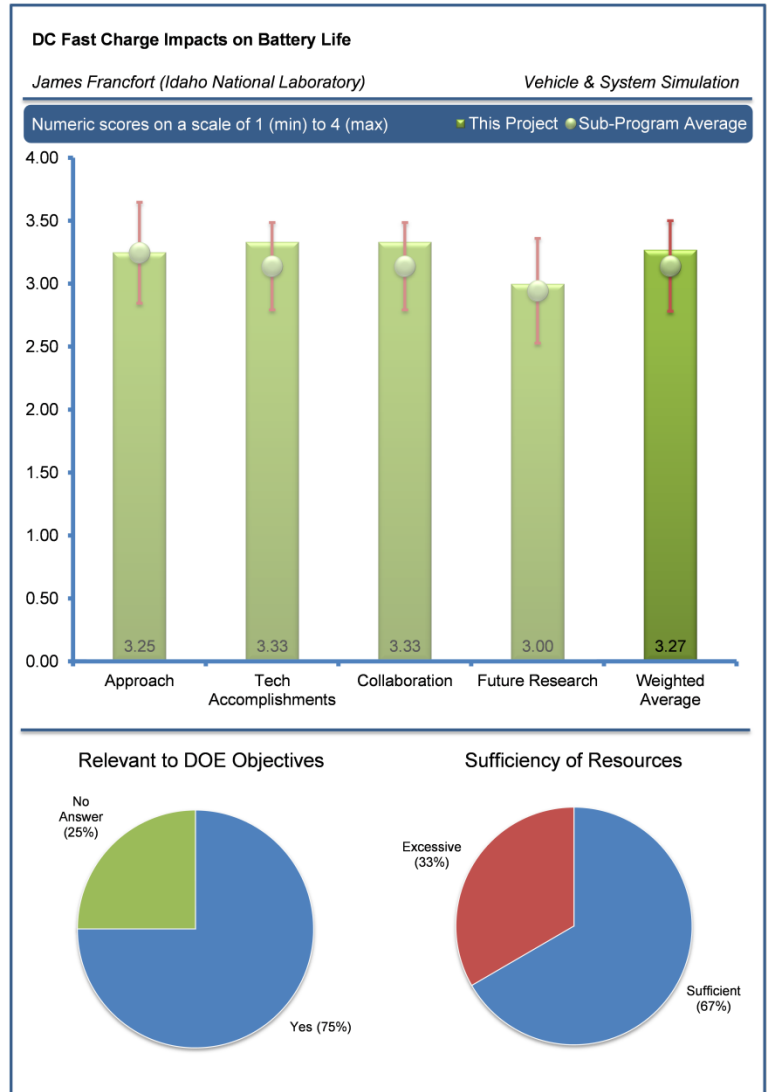
Reviewer 3:

This reviewer listed the barriers addressed as follows: cost risk aversion; on-road mileage accumulation and testing using 4 vehicles; pack testing every 10,000 miles; end of test lab and track performance testing at 30,000 miles. The reviewer then asked for what reason are the packs tested every 10,000 miles. The reviewer detailed various parts of the experiment, specifically the project is using 2012 Nissan LEAFs; the project team track constant speed and acceleration; 2 cycles per day about 220 miles per vehicle; Nissan recommends one fast charge/day; in the lab there is a constant current discharge; dedicated drivers and routes, cars run simultaneously, two cars DC fast-charge and two at Level 2 only.

The reviewer listed various data logging characteristics of the experiment: 1 Hertz (Hz) data logging on cars, electronic and manual, power levels and energy throughput, as well as ambient temperature and internal; cycle accumulation based on road vehicle testing from onboard data collections; after first 10,000 miles, there was no significant effect in constant current discharge test; 30,000 test data not yet available. The reviewer detailed the various companies' roles in the experiment: ECotality is road testing vehicles; INL cycling/testing two lab vehicle pack; Round Robin testing of two packs at each lab. The reviewer added that the batteries were tested at constant moderate temperature in lab.

Reviewer 4:

This reviewer said that given the objectives, the approach seems reasonable; however, the reviewer asked whether running four vehicles for 30,000 miles of a single chemistry with a single Battery Management System (BMS) is going to conclude much about the fundamental effects of fast charging. Also, the reviewer asked would the research be better served to have more varieties of packs under more controlled conditions with key parameters identified by battery chemists. The reviewer added that the road approach is



expensive, less controlled and thus sample limited. In addition, the reviewer asked is 30,000 miles a sufficient exposure in the lifecycle of a pack to draw conclusions. The reviewer does not know the answer to this question and defers to the battery experts to make that call.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said that the project is on schedule and completion of the tasks to plan is excellent. The reviewer added that this is a simple set of tasks to perform but to consistently perform them day to day is not trivial.

Reviewer 2:

The reviewer stated that the progress seems to match the objectives and approach well.

Reviewer 3:

This reviewer thought that the sample size may be too small because the project team is only comparing only four vehicles.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer indicated that collaboration and coordination with other institutions is sufficient and appropriate for test objectives. This reviewer said that questions on the methodology (and what can be concluded) may require more core scientific interactions with battery expert groups; this is not clear.

Reviewer 2:

This reviewer observed that this project has a narrow set of collaborators and added that the project is coordinated with the partners that are necessary.

Reviewer 3:

The reviewer stated that the project team is exceeding the manufacturer's suggestions with two fast charges per day. The reviewer was not sure if DOE should be doing this because Nissan should be paying for this data. The reviewer added that the benefit to this data was not clear.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer commented that the proposed future research was to simply continue what has been designed and to get the lab version of the testing fully operational.

Reviewer 2:

This reviewer noted that only 30,000 miles may be too low to get meaningful data.

Reviewer 3:

This reviewer indicated that there were very broad statements on what will be accomplished and what will lead into the next phases. The reviewer added that the project team needs more substance here tied to a staged methodology.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said yes, this project can help to increase EV adoption.

Reviewer 2:

This reviewer stated that knowing more about fast charging is important to know if EVs are to be used. The reviewer observed that battery technology is changing and improving. The reviewer added that this project may be measuring something that is always changing.

Reviewer 3:

This reviewer remarked that it is relevant to understand potentials for fast charging and effects on batteries; charge times are a key barrier to widespread adoption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that there was no indication of a mismatch of resources to the plan.

Reviewer 2:

This reviewer stated the project is well designed and has well trained resources.

Reviewer 3:

This reviewer was not sure DOE should be paying for this data. The reviewer added that this is very limited data, only 1 location and only 30,000 miles.

Fast Charge Technology Adoption Challenges: Anthony Markel (National Renewable Energy Laboratory) - vss114

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer noted important information to get. The reviewer added that the infrastructure will need to be improved if EVs are to take off.

Reviewer 2:

This reviewer indicated that this was a very difficult modeling topic conceptually and the PI has done a good job with an approach in absence of a real-world baseline (using a sampling of from Electric Avenue). The reviewer added that some more could have been said about the potential explanation of the time shift for on-demand charging. For example, the sample is skewed to yyyy population with specific behaviors given today's EV product offerings (versus the general population).

Reviewer 3:

The reviewer observed that the barriers were addressed, but not thought through in the sense that there was no mention made about the opportunity for renewable energy or the idea that hydrogen production may overcome electrification.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

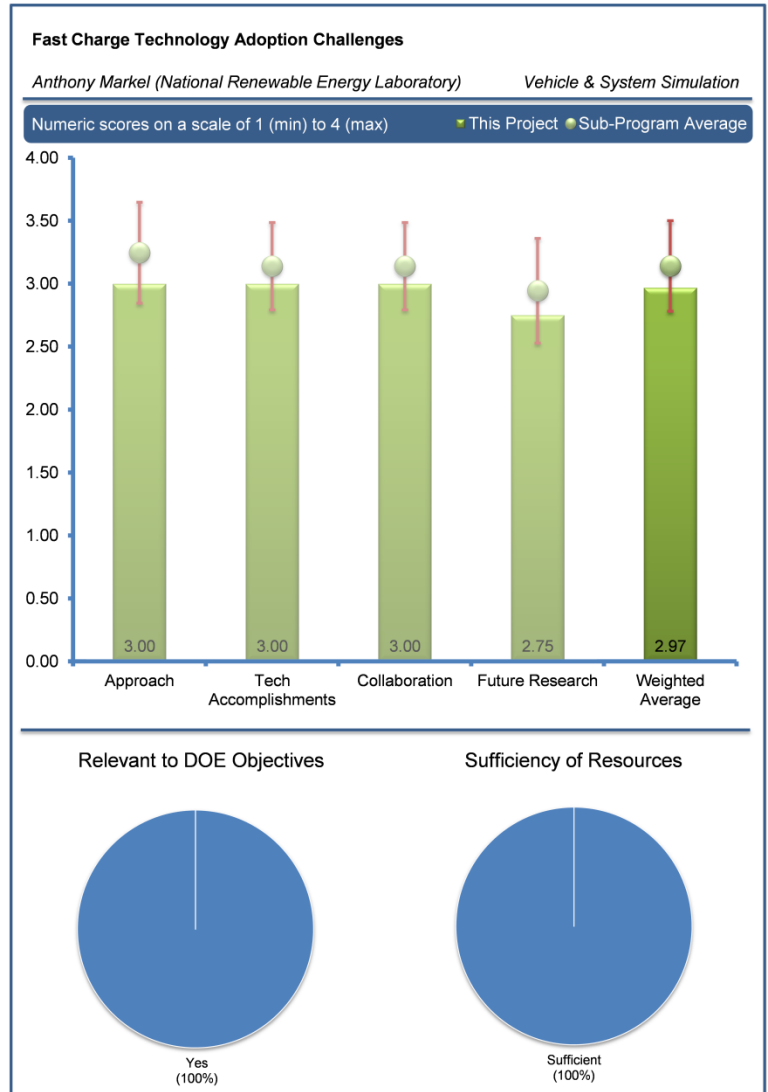
This reviewer stated that the project team pulled in a lot of data in year one.

Reviewer 2:

This reviewer noticed that the model was constructed and first results were achieved. The reviewer added that explanations for model outcomes were commented on with the next steps understood.

Reviewer 3:

This reviewer thought that there was no consideration or explanation for why the project team is using such a small car when most folks are driving full-size Chevrolet pickup trucks.



Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer observed that varied collaborations are appropriate and in place. Also, this reviewer stated that there was a good cross section including private industry. Additionally, the reviewer suggested that the project team may want to consider a gasoline retailer or oil company that has retail network planning expertise for approximations or modeling approaches.

Reviewer 2:

This reviewer said there were four collaborators on this project. This reviewer stated that the project cost is \$220,000, that the contractors are not cost sharing, and that more utilities should be involved.

Reviewer 3:

This reviewer indicated that some explanation should have been provided as to how the project team decided on the partnerships.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer stated that electrical utilities need this data.

Reviewer 2:

This reviewer pointed out that it seems an element of future work should include direct consumer behaviors and influences rather than purely macro assumptions (at least the impression of this reviewer). The reviewer then asked how the sample drivers would stack up against the assumptions of their behavior, for example, the forgetfulness factor seems high at 10%.

Reviewer 3:

This reviewer observed that there was no indication that the team was working with the fuel cell group to meet their shared energy storage needs.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer stated that renewables are a worthy goal for fast track.

Reviewer 2:

This reviewer stated that fast charge network modeling tools will be very relevant as the industry matures and BEVs become more commonplace in geographic pockets.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer noticed that it appears the project team has just enough resources to provide the resources required; however, their funding will be an inadequate number of resources to support the vehicle's potential.

Reviewer 2:

This reviewer indicated that this is a low cost project, \$220,000, that the project is an important modeling goal and that the project team needs ROI on the fast charger.

Reviewer 3:

This reviewer remarked that resources do not appear to be a constraint, or surplus, for the stated scope.

Zero Emission Heavy Duty Drayage Truck Demonstration: Brian Choe (SCAQMD) - vss115

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the project approach and scope of developing four types of zero emission drayage truck technologies, testing and collecting data, both in the lab on a chassis dynamometer and in the field for two years, and analyzing the cost and performance data, will provide for an outstanding set of information to evaluate this technology.

Reviewer 2:

This reviewer stated that the project is impressive, and that it appears to be an excellent application of the electric vehicle technology to achieve both fuel savings and emission reductions.

Reviewer 3:

This reviewer indicated that the overall approach seems reasonable with three different types of battery electric drayage vehicles and one type of hybrid/fuel cell drayage vehicle being developed (over one year periods), dyno tested, and undergoing demonstration for two years. The reviewer commented that data on vehicle operations as well as maintenance will be collected and forwarded to NREL for analysis. The reviewer added that the total operations and maintenance (O&M) cost of drayage operation and different charger technologies (on board charger and DC-DC fast charger with 500kWh energy storage) will be assessed. The reviewer then asked why it was decided for Balqon to produce three vehicles, Transpower four vehicles, US Hybrid two vehicles, and Vision four vehicles as opposed to all of the vendors producing say two vehicles each. Additionally, the reviewer asked has an upfront modeling/duty cycle/cost analysis been conducted to help define technology and cost parameters for the project from the beginning.

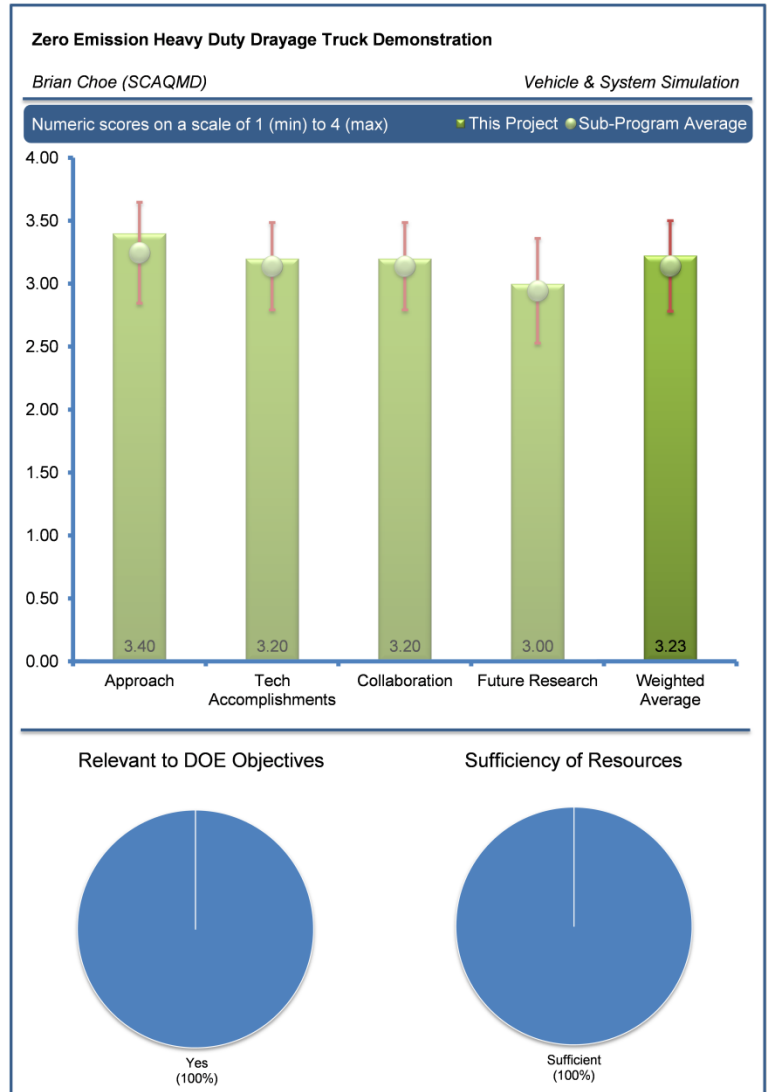
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said that since this project recently started it is understandable there are few technical accomplishments reported so far. The reviewer added that the plans for the types of technologies to be evaluated and subsequent data collection will be very good.

Reviewer 2:

This reviewer noted that this project is a new start (kick-off October 2012) and there are no technical accomplishments to report, only contractual ones.



Reviewer 3:

This reviewer thought that the project was a bit slow on getting things in place. The reviewer observed that there are no subcontracts in place, and that the technical work is pending.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer said that there was good coordination with four vehicle types proposed. Also, the reviewer stated that there was good variability with the designs to see what actually works and guarantee at least a couple vehicles are placed in service.

Reviewer 2:

This reviewer stated that the collaboration and coordination of this project with other entities seems logical and well defined. The reviewer also said four vehicle manufacturers, two fleet/demo partners, UC Riverside, and NREL round out the project team. The reviewer noted that these are appropriate entities and cover all the required project elements.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer noted that the project team had an appropriate match for future work given the current state of the project, which will likely change as work commences.

Reviewer 2:

This reviewer stated that the project team may need to address the potential for reliability problems with the vehicles and what the alternative options are to complete the project in full.

Reviewer 3:

This reviewer pointed out that the majority of this project will be occurring in the future, including completing vehicle integration, testing the vehicles in the laboratory, getting the vehicles into the field and evaluating them for a two year period. The reviewer added that this project should provide an excellent set of data to evaluate the different technologies.

Reviewer 4:

This reviewer thought that the proposed future work activities are logical, but superficially defined. Also, the reviewer stated that it is essential to keep a focus on the overall durability of the systems and total cost of ownership for the different applications. The reviewer suggested that the project team clarify what defines overall project success as soon as possible.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said absolutely. The reviewer added that even though it is a niche application it is in line with the objectives of DOE and EPA for applying energy efficient vehicles. The reviewer said the project was very good.

Reviewer 2:

This reviewer said heavy-duty truck zero emission vehicles for drayage operations have the potential to mitigate stubborn air quality issues in highly populated urban areas and reduce consumption of petroleum in the transportation sector. The reviewer added that these applications are potentially suitable for application of electric drive technologies as they are centralized operations, with dedicated and often limited range requirements, and the vehicles frequently operate in creep mode.

Reviewer 3:

This reviewer stated that using battery and fuel cell technology to displace old diesel trucks in drayage service will reduce the petroleum used and help meet the DOE objective of petroleum displacement.

Reviewer 4:

This reviewer said direct displacement of petroleum one for one.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that the resources are sufficient for the projects that are identified.

Reviewer 2:

The reviewer observed that this project is 55% cost shared, resources are adequate, although it seems possible to achieve the desired project proof-of-concept and understanding with fewer overall vehicles.

Zero Emission Cargo Transport - Houston #1: Christine Smith (Houston-Galveston Area Council) - vss116

Reviewer Sample Size

A total of four reviewers evaluated this project.

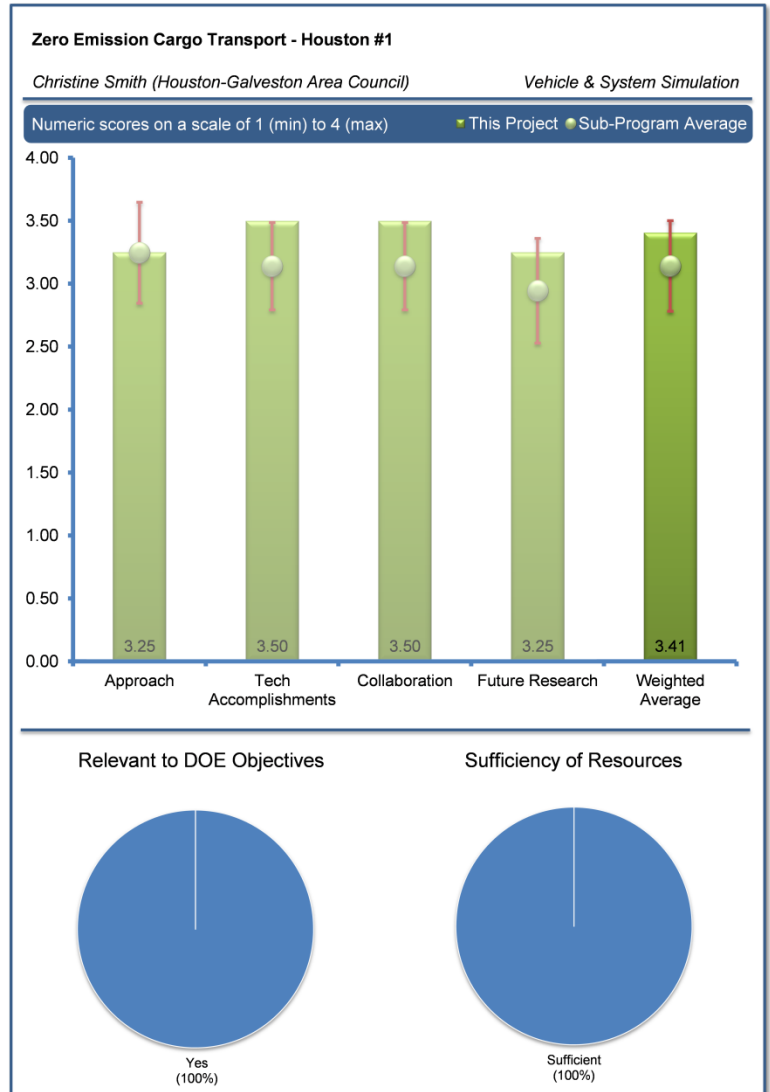
Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer indicated that the approach to deploy 30 electric delivery trucks to be used in the Houston non-attainment area and collect data to demonstrate a 50% improvement in freight hauling efficiency is very good. The reviewer reported use by several nationally known companies such as UPS, Coca Cola, Fed Ex, and Frito-Lay. This reviewer added that using such well known organizations will help to promote the use of electric vehicles.

Reviewer 2:

This reviewer thought that the use of an all-electric vehicle for delivery applications is new and should be encouraged with the DOE support; however, there is very little detail on the program because of the late launch of the program. The reviewer stated that the project should be more specific on what kind of electric vehicles are used and added that the project is too vague.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer noted that because this project recently started, there are not many technical accomplishments that were reported; however, many of the milestones to be completed later this year, including the ordering of vehicles and charging equipment, and the plan to have the first vehicles delivered, are all on schedule. The reviewer added that vehicle procurement and charging station installation has been initiated.

Reviewer 2:

This reviewer indicated that there has not been much progress reported due to the very recent launch of the program.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer said that five fleets will be involved in the program, which is excellent.

Reviewer 2:

This reviewer pointed out that there is an outstanding group of national and local companies that are going to be the operators of these vehicles during the data collection phase of the project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that the future plan seems good

Reviewer 2:

This reviewer noted that because this project recently started, future work in FY 2013 will include getting the vehicle procured and on the road to start operational service. The reviewer said the planned future work in FY 2014 will be an important phase of the project since data will continue to be collected and that is when benefit analysis will be performed to show expected reductions in petroleum use, GHG emissions and criteria pollutants.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer indicated that this project definitely supports the DOE objective of displacing petroleum used.

Reviewer 2:

This reviewer pointed out that if the huge cost is not an issue, the program is relevant to the DOE overall objectives.

Reviewer 3:

This reviewer said direct one for one displacement of petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer thought that the resources should be sufficient to complete the work planned.

Reviewer 2:

This reviewer stated that it is not clear how much each electric vehicles costs, so it is hard to quantify the resource.

Zero Emission Cargo Transport - Houston #2: Christine Smith (Houston-Galveston Area Council) - vss117

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the approach of introducing 20 hydrogen fuel cell electric hybrid drayage trucks into service is excellent. The reviewer added that this project will help reduce diesel fuel use, criteria pollutant emissions and greenhouse gas emissions.

Reviewer 2:

This reviewer pointed out that the concept of the program is new and should be encouraged by the DOE support. However, to the minimum, the contractor should describe what kind of the technologies would be used, it is so vague.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said no technical milestones have been completed, but the timeline of milestones is to be completed over the next several years appears to be very manageable.

Reviewer 2:

This reviewer observed that no actual progress has been made due to the program's recent launch.

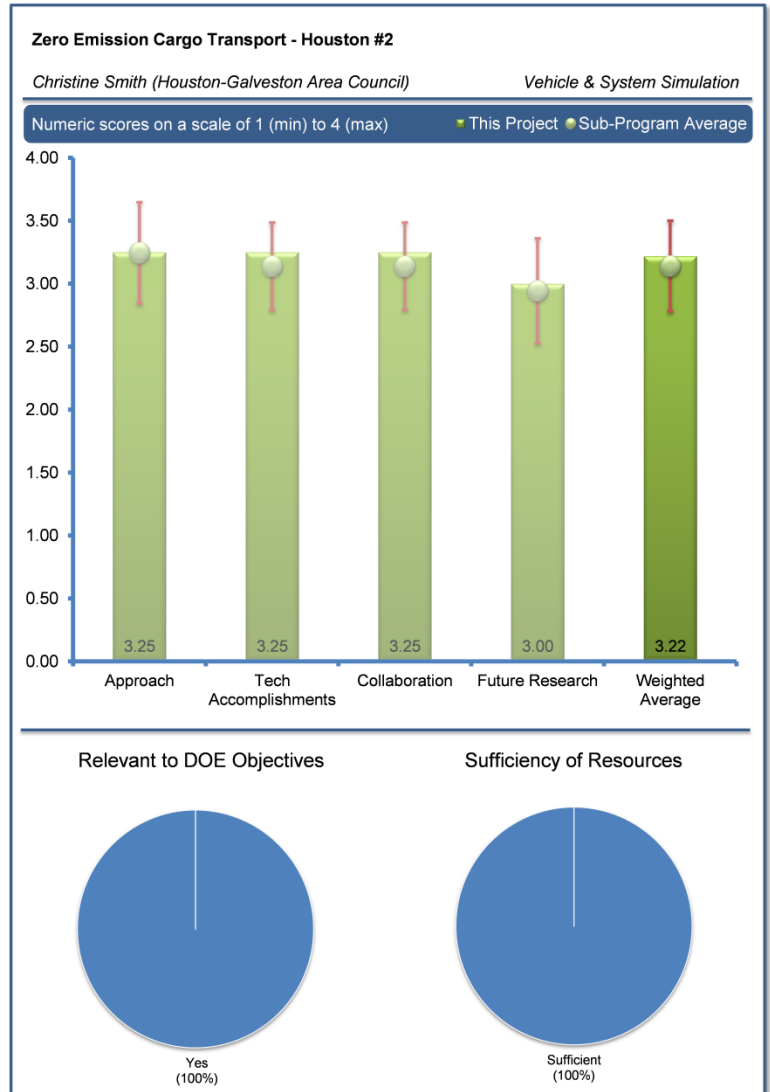
Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer stated that it is good the project is partnering with Wal-Mart stores since they are known all over the country and could create more public interest in the effort. In addition, Wal-Mart may want to expand this effort to other stores after seeing the results of using this technology.

Reviewer 2:

This reviewer indicated that the use of Wal-Mart is a solid starting point.



Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked that since this project recently started nearly all of the milestones are still to be accomplished, including the ordering assembly and delivery of the vehicles and initiating data collection.

Reviewer 2:

The reviewer stated that the future work plan seems to be doable, but the reviewer was unsure if the vehicle and technology will be available on time.

Reviewer 3:

This reviewer noted that the project team needs to discuss contingency plans if the vehicles do not function well (poor reliability and/or poor performance). The reviewer then asked how the project team will handle this.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said yes, the project supports the DOE objective of petroleum displacement. In fact, the reviewer indicated that the plan is to reduce petroleum consumption by over 1.1 million gallons of diesel fuel over the lifetime of the vehicles.

Reviewer 2:

This reviewer stated direct petroleum displacement one for one.

Reviewer 3:

This reviewer said the cost is a big deal. The reviewer added that this project should have significant impacts on improvement of the freight efficiency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that resources are sufficient to complete the planned work.

EV Roadmap V2.0: Fred Wagner (Energetics, Inc.) - vss118

Reviewer Sample Size

A total of two reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer thought that the approach of the American National Standards Institute (ANSI) roadmap seemed ok, and the project team has identified some barriers.

Reviewer 2:

This reviewer stated that the project has clearly addressed safety and interoperability barriers; however it was unclear whether performance and cost barriers received an equality of attention or focus.

Reviewer 3:

The reviewer indicated that the project identified barriers in wide ranging areas, both for the United States and internationally.

Reviewer 4:

This reviewer said that although the scope of the work was simply identification of gaps, the reviewer wanted to see some effort made to evaluate the effectiveness of standards as written. The reviewer would suggest adding a feedback step, where the results of the study are sent back to all of the organizations contacted or mentioned. The reviewer stated that this may already be included.

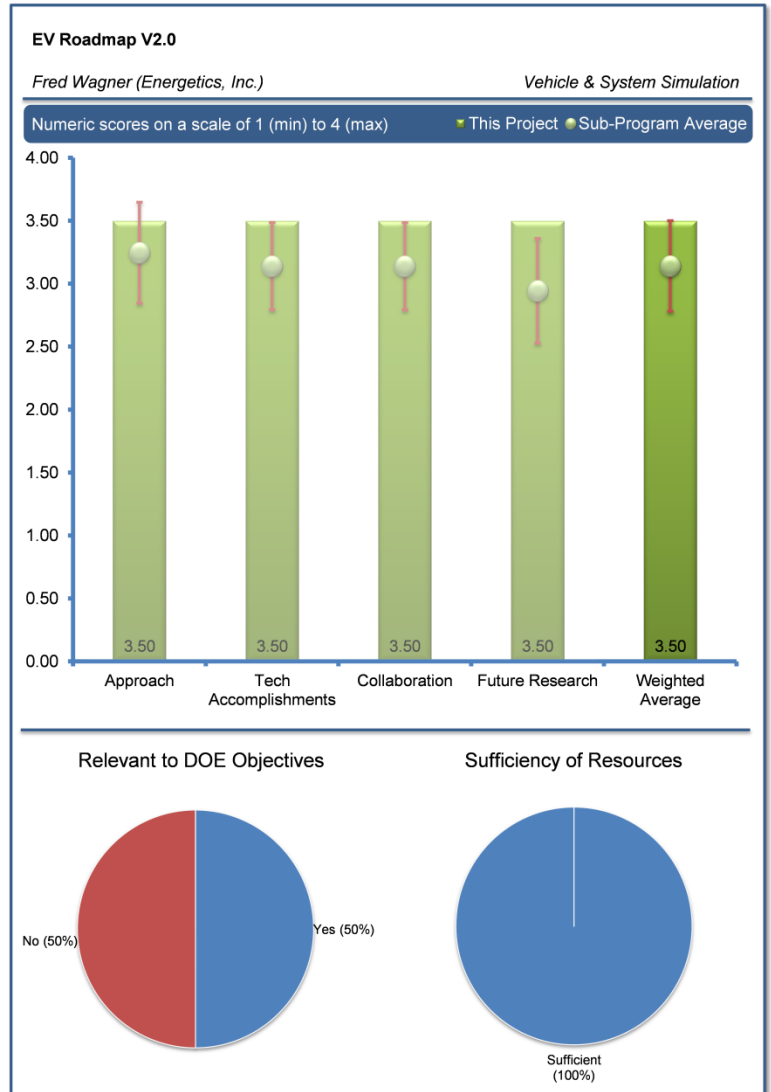
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer noticed that with the project nearing completion, the single underlying accomplishment for this project is that the ANSI Electric Vehicles Standards Panel (EVSP) roadmap and EVSP Standards compendium both in their version 2.0 and these are well organized, acronyms defined, and written in readable English for broader than just the technical community to utilize. The reviewer added that a secondary accomplishment of establishing a fair assessment of gap status, priorities, timelines and Standard Data Objective (SDO) responsibility, is encouraging.

Reviewer 2:

This reviewer stated that there really are not barriers to this project; the point of this project is to identify gaps and provide suggestions on how others can address these gaps.



Reviewer 3:

This reviewer pointed out that just about all of the organizations/standards have been identified and tabulated. The reviewer added that it would be useful for the project team to include a short summary that identified the key areas to address, in addition to the generic list with time-ranking.

Reviewer 4:

This reviewer indicated that it was hard to gauge technical accomplishments with the presentation as it is. The reviewer observed many claims without real examples of what gaps were outlined; however, after reviewing the actual 170-page report from ANSI, it was apparent that it is indeed a comprehensive report.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer said that the project demonstrates collaboration at the highest level with over 100 private and public sector organizations involved.

Reviewer 2:

This reviewer stated that there is a very wide variety of organizations involved in this effort.

Reviewer 3:

This reviewer commented that the collaboration and coordination with other institutions is tricky because there are so many organizations the project needed to identify and coordinate with. The reviewer added that one organization that the project team seems to have missed is the UN Electric Vehicles and the Environment group, which is addressing the issues associated with EV standards internationally.

Reviewer 4:

This reviewer pointed out that this effort (with reference to the ANSI report) has a good cross-section of industry and institutions, although not all OEMs were contacted (e.g., German OEMs). The reviewer suggested having them on the invitation list as the other OEMs, including Japanese OEMs, were involved.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that the proposed future research seems like a solid list of topics though the reviewer stressed that there should be two specific points that need more focus: wireless communications for EVs; and wireless charging. The reviewer also suggested some tie into the standardization for Fuel Cell Vehicle standardization and the global technical regulations especially regarding EV Crash (and SAE J1766).

Reviewer 2:

This reviewer thought that the only future plan is to track the issues as they develop. The reviewer assumed that dissemination of results is also included.

Reviewer 3:

This reviewer described the proposed future work in FY 2013 and FY 2014 as only being in a discussion stage, which was somewhat disappointing. This reviewer also observed signs of limited direction. The reviewer added that the alignment with Europeans to harmonize standards is noteworthy and needed in a global economy to make EV's take a firm market acceptance. However, as this DOE co-funded project is closed out, the reviewer asked if ANSI carries the continuation of driving the standardization roadmap and EVSP Compendium forward. Also, the reviewer asked what funding will sustain these accomplishments.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said that yes, this is a topic that supports coordination for codes and standards (C/S) for PHEV, EVs, and outlines topics needed to accelerate the standardization.

Reviewer 2:

This reviewer indicated that the development and dissemination of EV standards and codes promotes the expansion of the EV market and the DOE objective of petroleum displacement.

Reviewer 3:

This reviewer emphasized that EVs will not make it into the market place if there are regulatory barriers or incompatibility issues that make life difficult for owners.

Reviewer 4:

This reviewer indicated that battery-electric vehicles will never be more than a niche market unless recharge time can be brought down to about five minutes. This reviewer stated that mainstream customers will not accept long recharge times. Also, the reviewer indicated that the DOE needs to refocus its battery efforts on high-power batteries that can be rapidly recharged, not high energy batteries.

The reviewer added that until batteries that can be rapidly recharged are developed, the standardization efforts in this project will only support reduction of a tiny amount of petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer stated that this was a pretty small project, and thought that the project team did quite well with its limited resources.

Reviewer 2:

This reviewer thought that this project has demonstrated over the two and a half year period that sufficient resources were in play to yield the published accomplishments and roadmap promotions both in the United States and the international venues.

Reviewer 3:

The reviewer would not add further resources to this effort, as the document is published.

Fleet DNA: Kevin Walkowicz (National Renewable Energy Laboratory) - vss119

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the approach contributes to overcoming some barriers and is generally effective, but could be improved.

Reviewer 2:

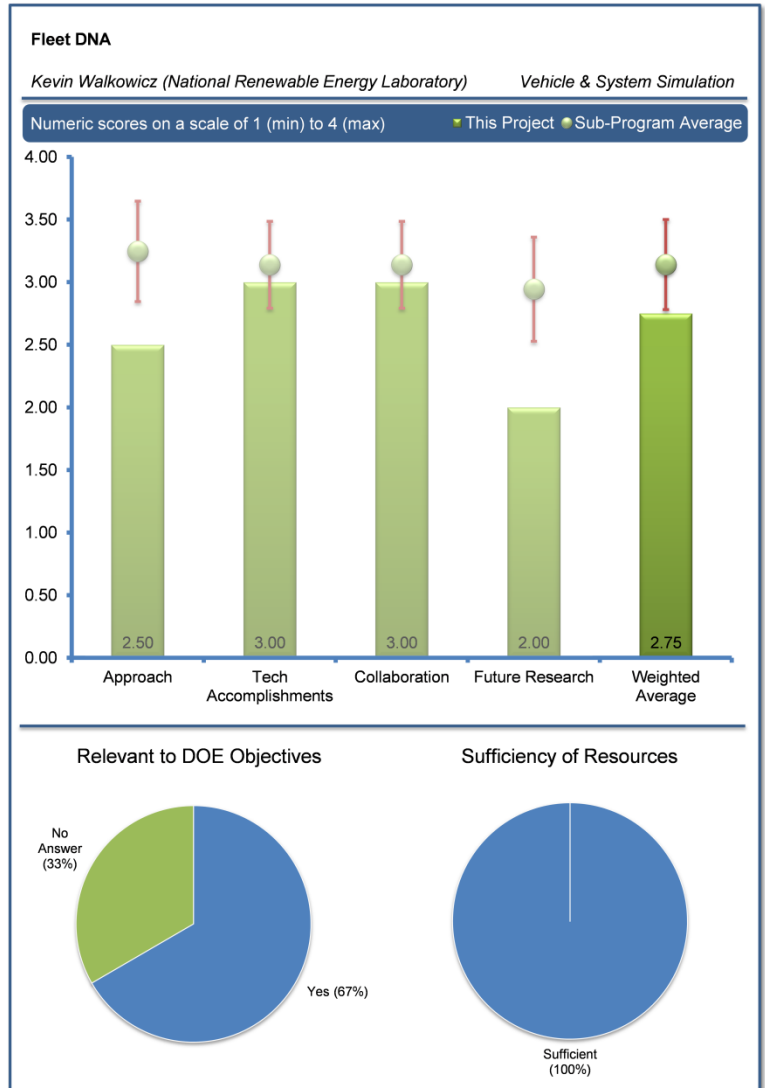
This reviewer stated that the cost and risk aversion barriers were clearly addressed by examples; however, no specific explanation of how the Computation Models, Design and Simulation barriers were addressed. The reviewer added that a few examples would be beneficial of either internal DOE or partners' use in these areas.

Reviewer 3:

This reviewer pointed out that in the area of data selection and collection, DOE VTO goals, priorities, and technology focus areas should be used to help guide fleet selection. Just as a single example, the reviewer said that hybrids are an area with significant funding from the DOE. Also, the reviewer indicated that data collection could highlight applications that could be good candidates for hybrid technology. The reviewer added that with that data, the OEMs can design hybrid systems and calculate fuel savings from hybrid systems. The reviewer stated that this information can be used in business cases to get more hybrid systems into production and encourage fleets to adopt those systems. The reviewer went on to say that more niche applications like bucket trucks are needed to help hybrid technology cross the chasm. The data from this project could help identify those niches. The reviewer stated that there are likely other areas besides hybrid technology. Controller Area Network (CAN) sensor data is relatively easy to obtain. The reviewer commented that although it is more expensive, more work could be done on getting energy usage and torque for components that are not on CAN but can have a significant effect on FE.

Reviewer 4:

This reviewer said that there appears to be no protocol for data dissemination or security in this plan. This reviewer added that protocol for data security, redundancy, and dissemination should be documented and made prominent.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer stated that organizing how this large amount of the vehicle data is processed and stored was quite an undertaking that achieved demonstrated results in development of the master and web databases along with data collection and reporting.

Reviewer 2:

This reviewer noted that the technical accomplishments with establishing the data center, reporting, and some analysis seemed to be good.

Reviewer 3:

This reviewer thought that technical accomplishment appears to be in line with the plan. The reviewer added that the database work provides a good way to analyze the data. The reviewer was not sure how many more fleets/trucks are planned for data collection.

Reviewer 4:

This reviewer said there was no mention for a vision about the dataset in terms of modern social media. Also, the reviewer asked if it was safe to assume the format is Extensible Markup Language (XML).

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer noticed that the appropriate public institutions have been involved and the fleets will grow this year. Also, this reviewer said that hopefully, other DOE projects will use the data. The reviewer advised that continuing efforts should be made to reach out to PI's of appropriate projects that might be able to use the data.

Reviewer 2:

This reviewer observed that geographic regions are well represented to gain insight on climatic effects.

Reviewer 3:

This reviewer indicated that it appears that this is a good collaboration between organizations in California and throughout the United States, with perhaps a need to contact some of the HD manufacturers directly.

Reviewer 4:

This reviewer noted the collaboration with ORNL and preliminary industry/government/OEM partners were noted, but cautioned that this database will solely have isolated consumers if collaboration and coordination is not expanded upon. The reviewer recommended seeking input, comments, and discussions from actual vehicle OEM consumers now. The reviewer reported that additional fleet and OEM partners are planned sometime in the future.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer commented that the proposed future work is broader than just accumulating more data and expanding the partnership network. Again, having a broader OEM audience interacting and using the database should be an objective. The reviewer added that this would authenticate and justify the effort versus just primarily being an internal DOE lab use.

Reviewer 2:

This reviewer said that effort should continue to be made to match the needs of other DOE projects for data and to standardize ways to get needed data that is not on the CAN bus.

Reviewer 3:

This reviewer noted that the future work seems okay, but the reviewer suggested having some specific data mining goals defined from the DOE to be evaluated for presentations. The reviewer added that FE versus duty cycle and other factors, etc., should be able to be summarized. Also, the reviewer thought that it would be interesting to partner with some of the institutes in California working on intelligent highways to determine if any data synergies on data gathering with advanced MD/HD vehicles can be found (e.g., platooning, etc.).

Reviewer 4:

This reviewer stated that there was no mention of collaboration with renewable energy entities.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer stated that, in the universe of medium- and HD vehicle development to improve fuel consumption, this project is very relevant.

Reviewer 2:

This reviewer said yes, it is important to monitor the medium- and HD projects and use the data to assist in future developments.

Reviewer 3:

This reviewer indicated that vehicle electrifications promote electricity as an easily identified production source that is more easily managed than distributed source emissions such as the millions of ICEs.

Reviewer 4:

The reviewer said that this data will provide the information for business cases for fuel saving technologies and should help generate new ideas and projects to save fuel.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer thought that a resource check should be done to see if the needed people are available to take data on the desired number of fleets.

Reviewer 2:

This reviewer indicated that no matter how data is drilled down, somebody will want something different or visualized differently. The reviewer went on to say that having the public data report with multiple vocations is a step in the right direction, but having access to the public database for personalized data analysis would be ideal. Additionally, the reviewer said that desktop database analytical tools are becoming more available and widespread that would allow this database more general use.

AC Model Development: Jason Lustbader (National Renewable Energy Laboratory) - vss120

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

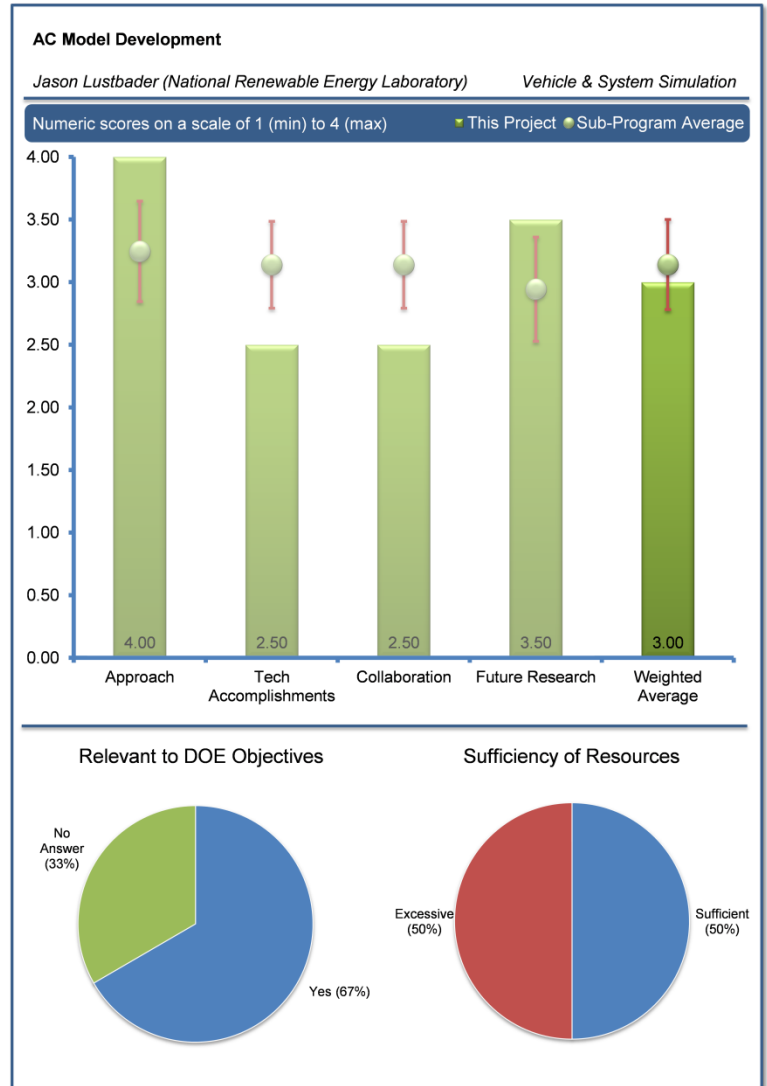
This reviewer stated that this was an outstanding project with appropriate objectives and goals appearing to match the resources available. The reviewer thought this project was a very interesting topic.

Reviewer 2:

This reviewer indicated that the project team's approach covers all bases. The reviewer observed that the project team is developing both a detailed model of air conditioning efficiency for use by component suppliers and a simplified model for use by vehicle manufacturers. The reviewer stated that the air conditioning model will be integrated with Autonomie.

Reviewer 3:

This reviewer observed that two of the three barriers were technically addressed, while the third (i.e., constant advances in technology) had limited scope.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer indicated that there appears to have been substantial progress on the elements of the model and the project has maintained substantial flexibility to apply to similar applications.

Reviewer 2:

This reviewer stated that this project is mostly complete and appears to have completely met objectives.

Reviewer 3:

The reviewer reported that technical accomplishments with component modeling and validation, system validation, Autonomie integration, and drive cycle simulation were achieved.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer stated that there was good collaboration on both component technology support and application.

Reviewer 2:

This reviewer remarked that collaboration with stated partnerships was definitely achieved; however, the reviewer recommended broader collaborative effort with other vehicle and HVAC OEMs because Autonomie use is growing.

Reviewer 3:

This reviewer stated that more thought could be made towards how to use the model. For example, the reviewer asked how the model results compare to the new air conditioning test procedure (AC17) recently adopted by EPA and the National Highway Traffic Safety Administration (NHTSA) for CAFE/CO₂ standards.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer stated that the proposed future research was a good match with objectives, and that there were achievable tasks within work scope.

Reviewer 2:

This reviewer thought that the proposed future work for FY 2013 is adequate. The reviewer added that another area of increased focus for FY 2013 is to address specific advanced HVAC technologies. Another recommendation the reviewer had was to consider proposed alternative HVAC operating strategies and their impact to Fuel Used Rate.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer explained that because HVAC has become commonplace, this project has DOE relevance to improve fuel consumption in all vehicle classes and especially EVs and hybrids.

Reviewer 2:

This reviewer pointed out that air conditioning is only 5% of light-duty petroleum displacement, but the proportion is growing and evaluating air conditioning efficiency is very difficult.

The reviewer added that to really be effective, the modeling should be incorporated into the air conditioning efficiency credits granted by NHTSA and EPA for their CAFE/CO₂ standards. The reviewer stated that this would apply to heavy-duty as well as light-duty vehicles.

Reviewer 3:

This reviewer remarked that developing an open model for user/industry use is an excellent project in a technical area that has substantial energy impact, but has received little attention relative to vehicle propulsion.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer indicated that the resources appear to be sufficiently managed and applied for yielding the technical accomplishments.

Reviewer 2:

This reviewer said that this is a really nice program, but \$900,000 is a lot of money.

APEEM Components Analysis and Evaluation: Paul Chambon (Oak Ridge National Laboratory) - vss121

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer suggested that investigators may want to develop a consistent set of system level requirements as inputs to the component level Electric Motor Technology R&D team. The reviewer added that the results shown have usefulness but the results need to be refined further to increase the utility of the requirements information.

Reviewer 2:

This reviewer stated that the program goals are modest, so it is not difficult to fully address all of the technical barriers.

Reviewer 3:

This reviewer stated that the overall approach of trying to co-develop a modeling, simulation, and HIL test program that will be used to evaluate DOE project outputs is quite a lofty goal. The reviewer found the depth of the individual project elements lacking or very optimistic given the funding level and time associated with the project. The reviewer relayed previous experience emanating from three government labs and two industry labs proposing very similar objectives and all have taken multiple years and tens of millions of dollars. The reviewer indicated that this project would serve well as an introductory program for ORNL to understand the issues of each area (modeling, simulation, and lab testing) to be followed by a more thorough proposal for a real evaluation project. The reviewer added that the DOE should be prepared for a large capital project followed by a long-term support cost for labor and infrastructure.

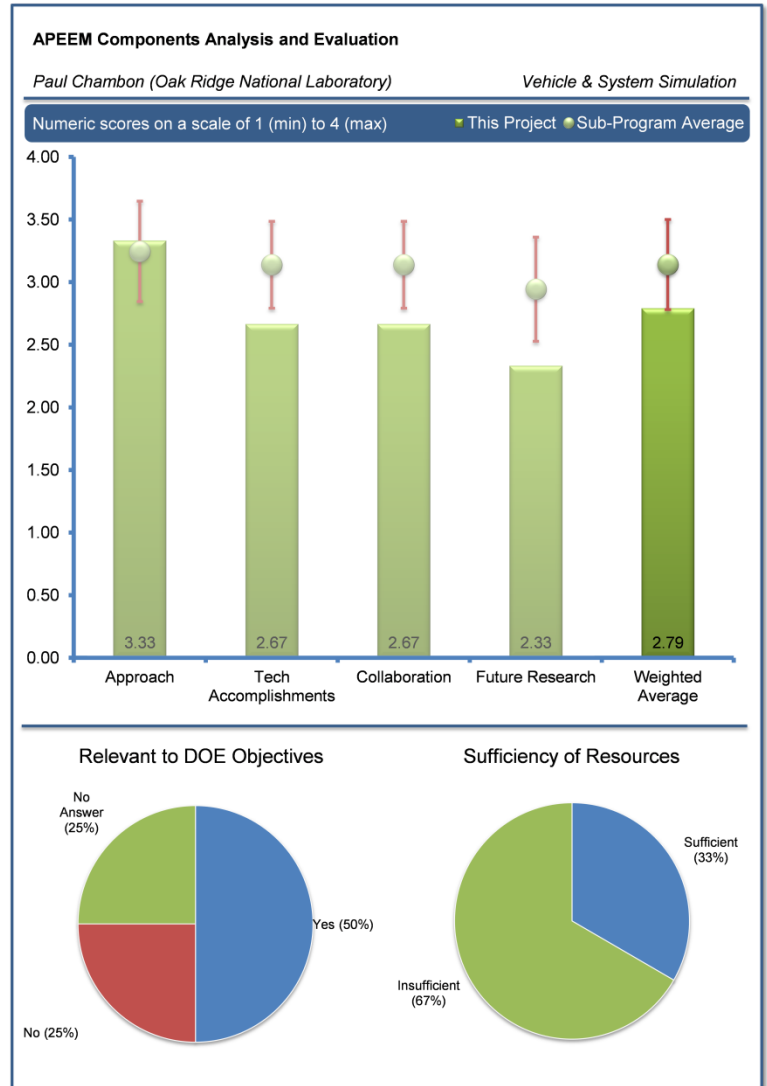
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the objectives are modest, so it is not difficult to fully overcome barriers.

Reviewer 2:

This reviewer stated that the program objectives do not match the project capabilities. The project will not be able to properly evaluate the technologies with the little effort, time, and funding assigned to the task.



Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer pointed out that the project has strong collaboration between DOE's systems level vehicle R&D and component level R&D programs.

Reviewer 2:

This reviewer said that little collaboration is needed to meet the objectives of benchmarking current technologies and enhancing the prototype evaluation capabilities of the DOE Advanced Power Electronics and Electric Machines Program (APEEM).

Reviewer 3:

This reviewer observed that collaboration is limited to accessing previously developed battery models.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer remarked that the project team has adopted an approach for future work that will perform laboratory based component characterization. The reviewer said that the connection between future component characterization work and impacting market barriers should be clarified.

Reviewer 2:

This reviewer noticed that the primary barrier is simply that test equipment does not currently exist. The reviewer added that the project is spending much of the funding simply to install a new high-speed, transient dynamometer and use it to do transient benchmarking.

Reviewer 3:

This reviewer said that the future research was very much of an overrepresentation of the project capabilities.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer observed that the development of more efficient electric vehicle systems and electric motor components will help to decrease petroleum use in the U.S. transportation sector. The reviewer added that this project supports the overall goal by providing more complete system requirements to component technology developers.

Reviewer 2:

This reviewer noted that motor and power electronics efficiency is already very high and only modest improvements can be made; however, as hybrids become widespread in the future, even modest efficiency improvements will have a measurable impact on petroleum consumption. Also, the reviewer indicated motor and power electronics have been relatively neglected, so this is an area where this research can make an impact.

Reviewer 3:

This reviewer noted that the project is a learning exercise for ORNL in electric power system modeling, simulation, and HIL testing.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer referenced previous comments that the project is way under scoped for the overall objective of evaluating the output of other DOE research projects.

Reviewer 2:

The reviewer stated that this project would likely produce a bigger and timelier impact if it were allotted a bigger budget.

Reviewer 3:

This reviewer commented that \$500,000 would be excessive just to do benchmarking, but some of the funds are being used to improve the DOE's test facilities, which will have benefits in the future.

Vehicle to Grid Communications Field Testing: Richard Pratt (Pacific Northwest National Laboratory) - vss122

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated the project team had an excellent approach and were very tuned in to what the industry needs for grid communication evaluations.

Reviewer 2:

This reviewer remarked that participating with the SAE in working groups and document development is a very good approach to developing useful codes and standards. The reviewer stated that the project continues to address the barriers of the lack of codes and standards for communication between PHEV and the grid. The reviewer added that the project is in communication and collaboration with ANL to make sure that there is not a duplication of effort on codes and standard development.

Reviewer 3:

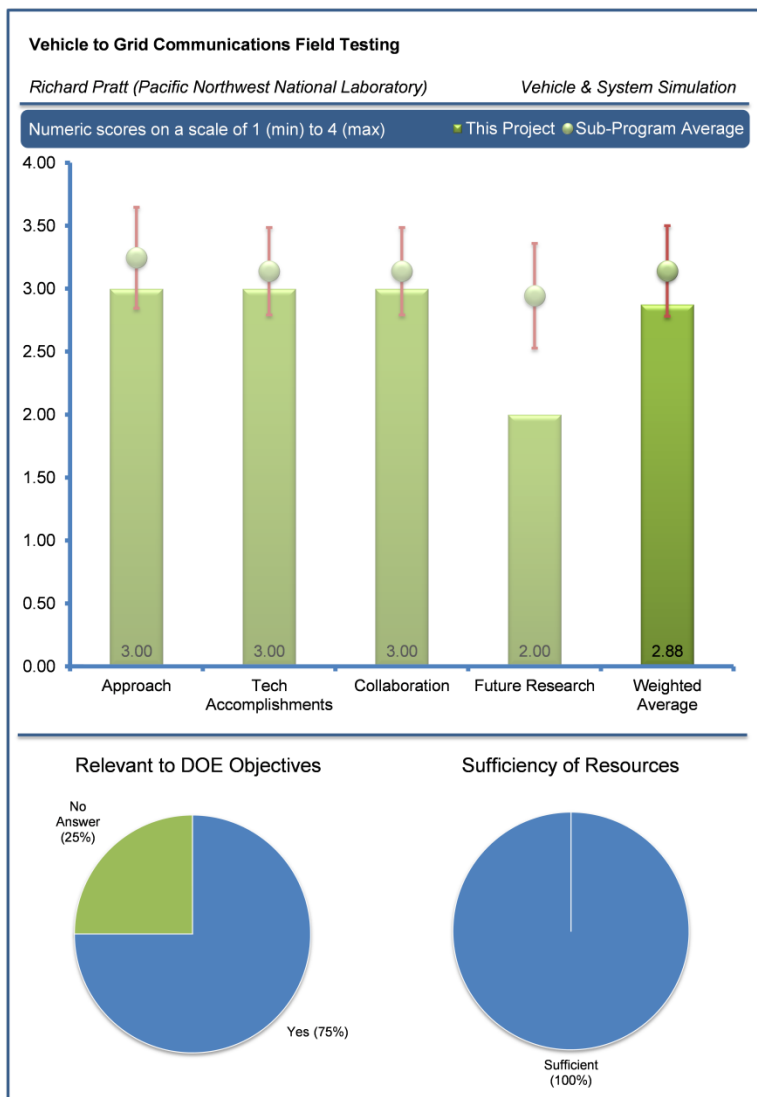
This reviewer commented that the approach will benefit from defining technical interaction products (e.g., operational requirements, use cases) based on technical interactions with utilities and academic partners involved in the Northwest Smart Grid Project. The reviewer said these requirements may help to increase the impact of the work as an input to codes and standards organizations.

Reviewer 4:

The reviewer recommended that some sort of gap analysis should be used to identify where codes and standards are lacking and to present a similar ANSI vehicle standards Roadmap format assessment (e.g., VSS118). The reviewer added that the project does appear to put a limited set of grid communication hardware for development, testing and interoperability assessments.

Reviewer 5:

This reviewer thought that there is not enough focus on how the data formats are being considered. The reviewer added that though this may be technical, it is a crucial aspect to meeting project objectives.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer stated that good progress has been made since the 2012 review. The reviewer observed that the project team reviewed and completed the development of several SAE standards. The reviewer added that progress has been made during 2013 on field testing including development of an Electronically Stored Information (ESI) interface and implementing open standard based communication. The reviewer indicated that the project team was leveraging other activities at PNNL, such as the PNNL laboratory homes project, which allows for good use of government funds.

Reviewer 2:

This reviewer observed that the project appears to be on track and with a well-founded interaction with appropriate standards committees.

Reviewer 3:

The reviewer noted that the presenter indicated that tangible progress has been made for establishing a working prototype to investigate key concepts.

Reviewer 4:

This reviewer thought that the project had very good support of the SAE Hybrid communications committee regarding technical accomplishments.

Reviewer 5:

This reviewer indicated that the project had multiple location sites, and a variety of vehicles, vendors, and utilities involved with field testing, that put a real world spin on project outcome. The reviewer added that the standards and codes gap analysis needs improved clarity of status similar to ANSI roadmap on electrical vehicle Standards.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer stated the project team had an excellent approach and was very tuned in to what the industry needs for grid communication evaluations.

Reviewer 2:

This reviewer stated that the investigator has a potentially rich collaboration and coordination context for performing the research. The reviewer added that the investigator should work to increase the level of interaction and feedback from the Northwest smart grid project partners. The reviewer indicated that the increased level of interaction has the potential to increase the impact of this project.

Reviewer 3:

This reviewer said that it is important that the project continues to coordinate with the SAE and the Smart Grid Interoperability Panel to ensure the standards developed are useful to industry.

Reviewer 4:

This reviewer stated that the establishment of significant industry partnership is not yet demonstrated.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer pointed out that the future work addresses current hardware/software limitations.

Reviewer 2:

This reviewer thought that the continuation of SAE standard development is an important aspect of this project. The reviewer added that the utility and vehicle OEM field testing that will be accomplished in the future is an important activity.

Reviewer 3:

This reviewer commented that the project team had a good approach, however, it is very important that SAE J2836/6 is also evaluated for wireless communications to grid as it appears none where in this presentation, even though it is a published document.

Reviewer 4:

This reviewer indicated that the project documentation did not reflect specific decision points, although one could assume that their contributions to the standards committee work will inform decisions on the appropriate technical approaches for the Standard.

Reviewer 5:

This reviewer observed that there was no proposed future work given.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer noted that the project provides technical investigations regarding communications between grid connected electric vehicles and electric vehicle supply equipment. This reviewer added that electric vehicles can displace or reduce petroleum use by allowing vehicles to use energy supplied by the electrical grid (instead of petroleum).

Reviewer 2:

This reviewer stated that the project supports the DOE objectives by addressing codes and standards to require and enable widespread adoption of electric-drive transportation technologies.

Reviewer 3:

This reviewer observed that electrification will offset petroleum only to the extent that it is used in light weight transportation.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer noted that funding should be increased and also to cover published documents such as SAE J2836/6 also for wireless power transfer communications with the grid.

Reviewer 2:

This reviewer thought that resources appear to be sufficient to complete the project.

Reviewer 3:

This reviewer thinks that the resources are sufficient to the extent the project team details the next path for research.

Acronyms and Abbreviations

Acronym	Definition
A	Ampere
AC	Alternating Current
A/C	Air-Conditioning
AEV	All Electric Vehicle
AHD	Advanced Hybrid Drives
AMI	Advanced Metering Infrastructure
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
APEEM	Advanced Power Electronics and Electric Machines Program
ARPA-E	Advanced Research Projects Agency - Energy
APRF	Advanced Powertrain Research Facility (ANL)
APU	Auxiliary Power Unit
ARRA	American Recovery and Reinvestment Act
AT-PZEV	Advanced Technology Partial Zero Emissions Vehicle
AVTA	Advanced Vehicle Testing Activity
AVTE	Advanced Vehicle Testing and Evaluation
BEV	Battery Electric Vehicle
BTE	Brake Thermal Efficiency
CAN	Controller Area Network
CAFE	Corporate Average Fuel Economy
CD	Charge Depleting
CEC	California Energy Commission
CFD	Computational Fluid Dynamics
CLEERS	Cross-Cut Lean Exhaust Emission Reduction Simulation
CNG	Compressed Natural Gas
CO₂	Carbon Dioxide
CPUC	California Public Utilities Commission
CRADA	Cooperative Research and Development Agreement
CS	Charge Sustaining
C/S	Codes and Standards
CSS	Cascade Sierra Solutions
CY	Calendar Year
D3	Downloadable Dynamometer Database
DC	Direct Current
DCFC	Direct Current Fast Chargers
DFT	Department of Transport

Acronym	Definition
DOE	Department of Energy
DOT	Department of Transportation
DR	Demand Response
DSRC	Dedicated Short-Range Communications
EIL	Engines in the Loop
EGR	Exhaust Gas Recirculation
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EREV	Extended Range Electric Vehicle
ESI	Electronically Stored Information
ESS	Energy Storage Systems
EV	Electric Vehicle
EVSE	Electric Vehicle Supplemental (Supply) Equipment
EVSP	Electric Vehicles Standards Panel
EVWPT	Electric Vehicle Wireless Power Transfer
FAT	Fleet Analysis Tool
FE	Finite Element
FE	Fuel Economy
FF	Flex Fuel
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMVSS	Federal Motor Vehicle Safety Standards
FOA	Funding Opportunity Announcement
FY	Fiscal Year
FOA	Funding Opportunity Announcement
GEM	Greenhouse Gas Emissions Model
GEN 2	Generation 2
GIS	Geographic Information System
GM	General Motors Corporation
GSA	General Services Administration
GPRA	Government Performance and Results Act
GPS	Global Positioning System
GHG	Greenhouse Gas
GWh	Gigawatt hours
HAN	Home Area Network
HD	Heavy-Duty
HEV	Hybrid Electric Vehicle
HIL	Hardware in the Loop
HMI	Human-to-Machine Interface
HVAC	Heating Ventilating and Air Conditioning
HWFET	Highway Fuel Economy Driving Schedule

Acronym	Definition
IC	Internal Combustion
ICE	Internal Combustion Engine
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transportation Systems
INL	Idaho National Laboratory
IP	Intellectual Property
IPO	Initial Public Offering
ISO	International Organization for Standardization
ITS JPO	Intelligent Transportation Systems Joint Program Office
KASIT	Korea Advanced Institute of Science and Technology
kW	Kilowatt
kWh	Kilowatt Hour
Li-ion	Lithium Ion
LD	Light-Duty
LLNL	Lawrence Livermore National Laboratory
LNG	Liquid Natural Gas
LTC	Low-Temperature Combustion
MWh	Megawatt-hour
MEDC	Michigan Economic Development Corporation
MD	Medium-Duty
MDU	Multiple-Dwelling Unit
NASA	National Aeronautics and Space Administration
NC	North Carolina
NHTS	National Household Travel Survey
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory
OEM	Original Equipment Manufacturer
O&M	Operations and Maintenance
ORNL	Oak Ridge National Laboratory
PEEM	Power Electronics and Electric Machines
PEV	Plug-in Electric Vehicle
PFI	Port Fuel Injection
PHEV	Plug-In Hybrid Electric Vehicle
PI	Principal Investigator
PLC	Programmable Logic Controller
PNNL	Pacific Northwest National Laboratory
PPG	Pittsburgh Plate Glass Company
R&D	Research and Development
ROI	Return on Investment

Acronym	Definition
RPM	Rotations per Minute
SA	Standards Association
SAE	Society of Automotive Engineers
SDG&E	San Diego Gas and Electric
SEP	Smart Energy Profile
SI	Spark Ignition
SIDI	Spark Ignition Direct Injection
SOC	State Of Charge
SOI	Scenario of Interest
SOFC	Solid Oxide Fuel Cell
SWRI	Southwest Research Institute
TARDEC	U.S. Army Tank Automotive Research, Development, and Engineering Center
TEG	Thermoelectric Generation
TMS	Thermal Management System
TPMS	Tire-Pressure Monitoring System
TRB	Transportation Research Board
TRU	Trailer Refrigeration Unit
TSB	Technology Standard Board
TSE	Truck Stop Electrification
UC	University of California
UDDS	Urban Dynamometer Driving Schedule
UK	United Kingdom
UL	Underwriters Laboratories
USCAR	United States Council for Automotive Research
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle efficiency and Energy sustainability
V2G	Vehicle-to-Grid
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VTO	Vehicle Technologies Office
WHR	Waste Heat Recovery
WPT	Wireless Power Transfer
XML	Extensible Markup Language

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2. Energy Storage Technologies

Improving the batteries for electric drive vehicles, including hybrid electric (HEV) and plug-in electric (PEV) vehicles, is key to improving vehicles' economic, social, and environmental sustainability. In fact, transitioning to a light-duty fleet of HEVs and PEVs could reduce U.S. foreign oil dependence by 30-60% and greenhouse gas emissions by 30-45%, depending on the exact mix of technologies.

While a number of electric drive vehicles are available on the market, further improvements in batteries could make them more affordable and convenient to consumers. In addition to light-duty vehicles, some heavy-duty manufacturers are also pursuing hybridization of medium and heavy-duty vehicles to improve fuel economy and reduce idling.

The Vehicle Technologies Office (VTO) focuses on reducing the cost, volume, and weight of batteries, while simultaneously improving the vehicle batteries' performance (power, energy, and durability) and ability to tolerate abuse conditions. Reaching the Office's goals in these areas and commercializing advanced energy storage technologies will allow more people to purchase and use electric drive vehicles. It will also help the Department of Energy (DOE) meet the *EV Everywhere* Grand Challenge goal of making the United States become the first nation in the world to produce PEVs that are as affordable for the average American family as today's gasoline-powered vehicles within the next 10 years.

The VTO pursues three major areas of research in batteries:

- **Exploratory Battery Materials Research:** Addresses fundamental issues of materials and electrochemical interactions associated with lithium and beyond-lithium batteries. This research attempts to develop new and promising materials, use advanced material models to predict the modes in which batteries fail, and employ scientific diagnostic tools and techniques to gain insight into why materials and systems fail. Building on these findings, it works to develop ways to mitigate those failures.
- **Applied Battery Research:** Focuses on optimizing next generation, high-energy lithium ion cells that incorporate new battery materials. The activity emphasizes identifying, diagnosing, and mitigating issues that negatively impact the performance and life of cells using advanced materials.
- **Advanced Battery Development, System Analysis, and Testing:** Focuses on the development of robust battery cells and modules to significantly reduce battery cost, increase life, and improve performance. This research aims to ensure these systems meet specific goals for particular vehicle applications.

This research builds upon decades of work that the DOE has conducted in batteries and energy storage. Research supported by the VTO led to today's modern nickel metal hydride batteries, which nearly all first generation HEVs used. Similarly, the Office's research also helped develop the lithium-ion (Li-ion) battery technology used in the Chevrolet Volt, the first commercially available (PHEV). This technology is now being used in a variety of hybrid and PEVs coming on the market now and in the next few years, including the Ford Focus electric vehicle (EV), and Chevrolet Spark EV.

The major goals of the Batteries and Energy Storage subprogram are by 2022 to:

- Reduce the production cost of an EV battery to a quarter of its current cost
- Halve the size of an EV battery
- Halve the weight of an EV battery

Achieving these goals would result in:

- Lowering battery cost from \$500/kWh to \$125/kWh
- Increasing density from 100 Wh/kg to 250 Wh/kg, 200 Wh/l to 400 Wh/l, and 400 W/kg to 2000 W/kg

In August 2009, DOE announced the selection of 26 projects (totaling \$1.5 billion) for expanding U.S. manufacturing capacity for advanced batteries and advanced battery components. These American Reinvestment and Recovery Act (ARRA)-funded projects support establishing a significant domestic capacity for batteries that will, in turn, help commercialize advanced electric drive vehicles. Twenty of those ARRA projects focus on developing manufacturing capacity for advanced batteries and battery components (including the production of lithium-ion cells and polymers), production of polymer separators and other components, and battery recycling. The six remaining projects focus on the creation of new battery facilities, or the upgrading of existing facilities, to enable researchers to test batteries, improve battery safety, and increase the throughput of specialized thermal testing.

Subprogram Feedback

DOE welcomed optional feedback on the overall technical subprogram areas presented during the 2013 AMR. Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area who volunteered to provide subprogram overview comments responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1: Was the subprogram area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Question 3: Does the subprogram area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Office's needs?

Question 4: Other Comments.

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc., as reviewer responses were optional.

Subprogram Overview Comments: David Howell (U.S. Department of Energy) – es000

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer noted an excellent overview of the DOE program directed at EV battery systems.

Reviewer 2:

The reviewer felt that the presentation covered the technical areas very well and provided measurable metrics toward the deliverables. It appeared that the DOE energy storage program was engaged very well with key industrial partners that were responsible for powertrain electrification. The focus areas clearly covered all key components, from battery materials to systems (packs and modules), including thermal management and performance modeling.

Reviewer 3:

The reviewer remarked that the overall battery program was well presented and clearly explained. The issues were highlighted and each sub-program's goals were laid out. The VTO's focus and status were clearly shown. This reviewer further noted that it was complementary to DOE Basic Energy Sciences (BES) and very realistic as to accomplishments and challenges.

Reviewer 4:

The reviewer stated yes and yes.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?**Reviewer 1:**

The reviewer acknowledged that the cost target of \$300 by 2015 seemed feasible and the cost roadmap seemed to sync very well with the progress in the technical roadmap. This reviewer added that the technical gap charts were clearly identified and a clear timeline was presented to identify the barriers.

Reviewer 2:

The reviewer stated yes, and that the portfolio was well balanced.

Reviewer 3:

The reviewer observed that the program addressed the major issues and proposed solutions that were viable. The challenge was to produce new battery systems with high performance and low cost. The program included a stretch in identifying new high performance systems and was beginning to address the manufacturing cost issues leading to a competitive EV.

Reviewer 4:

The reviewer said it was well presented, with a high level of emphasis on materials cost reduction. This reviewer added that there seemed to be a gap in novel coating processes for electrode manufacturing. Much of the overall cell cost could be addressed through new higher-throughput coating processes for Li-ion and other technologies.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?**Reviewer 1:**

The reviewer would rank this sub-program very highly given a number of successes in the past year, both in terms of reducing the cost of battery cathode materials (with BASF) and developing a new synthesis method for addressing issues related to high-voltage cathodes.

Reviewer 2:

The reviewer asserted that the programs were focused to meet the identified needs.

Reviewer 3:

The reviewer simply said yes.

Reviewer 4:

The reviewer expressed that the VTO roadmap was well organized as explained by the presenter, and that this discussion was helpful over what was available online.

Question 4: Other Comments

Reviewer 1:

The reviewer explained that the program should be able to benefit from process and production advancements. This reviewer suggested considering how other industries had evolved and trying to accelerate the evolution of battery manufacturing in the United States. This reviewer emphatically noted operational excellence.

Reviewer 2:

The reviewer indicated that the Computer-Aided Engineering of Batteries (CAEBAT) program rightfully bridged the gap between different key areas of battery technology and had made good progress over the past year. This reviewer added that more efforts should be directed toward experimental validation.

Reviewer 3:

The reviewer highlighted that the lack of a U.S.-based Li-ion battery business was a drawback in developing new technology. Today, explained this reviewer, essentially all of the advanced systems were taken to China for implementation and cell production. This resulted in the loss of control of the technology on a worldwide basis.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (*on a scale of 1 to 4*). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
PEV and HEV Battery Cost Assessment	Brian Barnett (TIAX LLC)	2-9	2.86	2.29	2.29	2.67	2.48
† A High-Performance PHEV Battery Pack	Mohamed Alamgir (LG Chem, Michigan)	2-13	3.33	2.67	2.67	3.00	2.88
† JCI PHEV System Development-USABC	Avie Judes (Johnson Controls-Saft)	2-15	3.67	3.33	3.33	2.67	3.33
† Validation of Electrode Materials and Cell Chemistries	Wenquan Lu (Argonne National Laboratory)	2-17	3.33	3.33	3.33	3.00	3.29
Fabricate PHEV Cells for Testing & Diagnostics	Andrew Jansen (Argonne National Laboratory)	2-20	3.20	3.40	3.40	3.00	3.30
† Mitigating Performance Degradation of High-Energy Lithium-Ion Cells	Daniel Abraham (Argonne National Laboratory)	2-24	3.33	3.00	3.00	3.33	3.13
Novel Cathode Materials and Processing Methods	Michael Thackeray (Argonne National Laboratory)	2-27	3.80	4.00	4.00	3.20	3.85
High Capacity, High-voltage Cathode Materials for Lithium-ion Batteries	Arumugam Manthiram (University of Texas at Austin)	2-30	3.40	3.60	3.60	3.20	3.50
Design of High Performance, High Energy Cathode Materials	Marca Doeff (Lawrence Berkeley National Laboratory)	2-34	2.80	3.20	3.20	3.00	3.08
Development of High Energy Cathode Materials	Jason Zhang (Pacific Northwest National Laboratory)	2-38	3.00	3.40	3.40	3.00	3.25
Inexpensive, Nonfluorinated (or Partially Fluorinated) Anions for Lithium Salts and Ionic Liquids for Lithium Battery Electrolytes	Wesley Henderson (North Carolina State University)	2-41	3.50	3.25	3.25	3.25	3.31
Nanoscale Heterostructures and Thermoplastic Resin Binders: Novel Lithium-Ion Anodes	Prashant Kumta (University of Pittsburgh)	2-44	2.75	3.00	3.00	2.75	2.91
Metal-Based, High-Capacity Lithium-Ion Anodes	Stanley Whittingham (Binghamton University-SUNY)	2-47	3.50	3.50	3.50	3.25	3.47
Electrolytes - Advanced Electrolyte and Electrolyte Additives	Khalil Amine (Argonne National Laboratory)	2-50	3.50	3.25	3.25	3.25	3.31
Development of Electrolytes for Lithium-ion Batteries	Brett Lucht (University of Rhode Island)	2-53	3.33	4.00	4.00	3.00	3.71
Bifunctional Electrolytes for Lithium-ion Batteries	Daniel Scherson (Case Western Reserve University)	2-56	3.25	3.75	3.75	3.00	3.53
Novel and Optimized Materials Phases for High Energy Density Batteries	Jordi Cabana (Lawrence Berkeley National Laboratory)	2-59	3.40	3.20	3.20	3.00	3.23
Interfacial Processes - Advanced Diagnostics	Robert Kostecki (Lawrence Berkeley National Laboratory)	2-62	3.75	3.50	3.50	3.50	3.56
Development of Polymer Electrolytes for Advanced Lithium Batteries	Nilash Balsara (Lawrence Berkeley National Laboratory)	2-64	3.50	3.25	3.25	3.50	3.34

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Interfacial and Bulk Properties and Stability	John Kerr (Lawrence Berkeley National Laboratory)	2-67	3.25	3.75	3.75	3.00	3.53
In-Situ Electron Microscopy of Electrical Energy Storage Materials	Ray Unocic (Oak Ridge National Laboratory)	2-70	3.60	3.20	3.20	3.20	3.30
Sulfone Liquids and Sulfate/Triflate Solids for High Voltage Electrolytes	Austen Angell (Arizona State University)	2-72	3.25	3.25	3.25	3.00	3.22
Carbon/Sulfur Nanocomposites and Additives for High-Energy Lithium Sulfur Batteries	Chengdu Liang (Oak Ridge National Laboratory)	2-74	3.20	2.80	2.80	3.00	2.93
Studies on High Voltage Lithium Rich MNC Composite Cathodes	Jagjit Nanda (Oak Ridge National Laboratory)	2-77	2.60	3.00	3.00	2.40	2.83
Progress of Computer-Aided Engineering of Batteries (CAEBAT)	Ahmad Pesaran (National Renewable Energy Laboratory)	2-80	3.57	3.71	3.71	3.29	3.63
† Development of High Energy Density Lithium-Sulfur Cells	Donghai Wang (Pennsylvania State University)	2-84	3.17	3.33	3.33	2.67	3.21
† Silicon Nanostructure-based Technology for Next Generation Energy Storage	Ionel Stefan (Amprius)	2-88	3.17	3.33	3.33	2.50	3.19
† Development of Large Format Lithium Ion Cells with Higher Energy Density	Erin O'Driscoll (Dow Kokam)	2-92	3.50	3.17	3.17	3.00	3.23
† Modular Process Equipment for Low Cost Manufacturing of High Capacity Prismatic Li-Ion Cell Alloy Anodes	Sergey Lopatin (Applied Materials)	2-96	3.33	3.83	3.83	2.83	3.58
† High-Voltage Solid Polymer Batteries for Electric Drive Vehicles	Hany Eitouni (Seeo)	2-100	2.67	2.67	2.67	2.67	2.67
† Innovative Cell Materials and Designs for 300 Mile Range EVs	Yimin Zhu (Nanosys)	2-104	3.33	3.50	3.50	3.50	3.46
† High Energy Novel Cathode / Alloy Automotive Cell	Jehwon Choi (3M)	2-107	3.50	3.33	3.33	3.33	3.38
† Utilization of UV or EB Curing Technology to Significantly Reduce Costs and VOCs in the Manufacture of Lithium-Ion Battery Electrodes	Gary Voelker (Miltec UV International)	2-111	4.00	4.00	4.00	4.00	4.00
† Significant Cost Improvement of Li-Ion Cells Through Non-NMP Electrode Coating, Direct Separator Coating, and Fast Formation Technologies	YK Son (Johnson Controls)	2-113	3.33	3.33	3.33	3.00	3.29
† Dry Process Electrode Fabrication	Mike Wixom (Navitas Systems)	2-115	3.00	2.67	2.67	2.33	2.71
† Stand-Alone Battery Thermal Management System	Brad Brodie (DENSO International America)	2-117	4.00	4.00	4.00	3.50	3.94
† Innovative Manufacturing and Materials for Low-Cost Lithium-Ion Batteries	Steve Carlson (Optodot Corporation)	2-119	4.00	4.00	4.00	3.50	3.94
† LEES Battery Development	Kimberly McGrath (Maxwell)	2-121	3.00	3.33	3.33	3.33	3.25
† Lithium Source For High Performance Li-ion Cells	Keith Kepler (Farasis)	2-123	2.67	2.67	2.67	2.33	2.63
† Implantation, Activation, Characterization and Prevention/Mitigation of Internal Short Circuits in Lithium-Ion Cells	Suresh Sriramulu (TIAX)	2-125	2.83	1.40	1.40	2.25	1.86

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Novel Anodes Materials	Jack Vaughney (Argonne National Laboratory)	2-129	3.33	3.67	3.67	3.33	3.54
Development of Si-based High Capacity Anodes	Ji-Guang (Jason) Zhang (Pacific Northwest National Laboratory)	2-131	3.50	3.00	3.00	3.25	3.16
Atomic Layer Deposition for Stabilization of Amorphous Silicon Anodes	Chunmei Ban (National Renewable Energy Laboratory)	2-134	3.50	3.50	3.50	3.25	3.47
New Layered Nanolaminates for Use in Lithium Battery Anodes	Yury Gogotsi (Drexel University)	2-137	2.00	3.00	3.00	2.00	2.63
Synthesis and Characterization of Structured Si-Carbon Nanocomposite Anodes and Functional Polymer Binders	Donghai Wang (Pennsylvania State University)	2-140	3.50	3.25	3.25	3.50	3.34
Wiring up Silicon Nanoparticles for High Performance Lithium-Ion Battery Anodes	Yi Cui (Stanford University)	2-142	3.75	3.25	3.25	2.75	3.31
Synthesis and Characterization of Silicon Clathrates for Anode Applications in Lithium-Ion Batteries	Kwai Chan (SwRI)	2-145	2.00	2.75	2.75	2.25	2.50
Addressing the Voltage Fade Issue with Lithium-Manganese-Rich Oxide Cathode Materials	Anthony Burrell (Argonne National Laboratory)	2-148	3.67	3.83	3.83	3.50	3.75
† Development of Industrially Viable Battery Electrode Coatings	Robert Tenent (National Renewable Energy Laboratory)	2-152	2.60	2.80	2.80	2.60	2.73
† Overcoming Processing Cost Barriers of High-Performance Lithium-Ion Battery Electrodes	David Wood (Oak Ridge National Laboratory)	2-155	2.80	3.40	3.40	2.80	3.18
† Roll-to-Roll Electrode Processing and Materials NDE for Advanced Lithium Secondary Batteries	David Wood (Oak Ridge National Laboratory)	2-158	3.20	3.20	3.20	2.80	3.15
† Process Development and Scale-up of Advanced Cathode Materials	Greg Krumbick (Argonne National Laboratory)	2-162	3.00	2.40	2.40	3.00	2.63
Process Development and Scale up of Advanced Electrolyte Materials	Greg Krumbick (Argonne National Laboratory)	2-165	3.50	2.75	2.75	2.75	2.94
Analysis of Electric Vehicle Battery Performance Targets	Jeremy Neubauer (National Renewable Energy Laboratory)	2-167	3.86	3.57	3.57	2.71	3.54
Promises and Challenges of Lithium- and Manganese-Rich Transition-Metal Layered-Oxide Cathodes	Kevin Gallagher (Argonne National Laboratory)	2-170	2.83	2.83	2.83	2.83	2.83
Composite Electrolytes to Stabilize Metallic Lium Anodes	Nancy Dudney (Oak Ridge National Laboratory)	2-174	3.75	3.75	3.75	3.50	3.72
In situ Solvothermal Synthesis of Novel High Capacity Cathodes	Patrick Looney (HRL Laboratories LLC/Brookhaven National Laboratory)	2-177	2.60	3.00	3.00	2.80	2.88
Lithium-Bearing Mixed Polyanion (LBMP) Glasses as Cathode Materials	Andrew Kercher (Lawrence Berkley National Laboratory)	2-180	2.40	2.60	2.60	2.40	2.53
† Cell Fabrication Facility: Current Research Activities in Electrode and Cell Prototyping	Bryant Polzin (Argonne National Laboratory)	2-183	3.20	3.00	3.00	2.80	3.03
† Linking Electrochemical Performance with Microstructural Evolution in Lithium Battery	Dean Miller (Argonne National Laboratory)	2-186	3.67	3.00	3.00	3.00	3.17

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
† Solid State NMR Studies and Local Structure of Voltage Fade Materials	John Vaughey (Argonne National Laboratory)	2-189	3.67	3.00	3.00	3.33	3.21
† Electrochemical Characterization of Voltage Fade in LMR-NMC cells	Daniel Abraham (Argonne National Laboratory)	2-192	3.33	3.33	3.33	2.67	3.25
† Examining Hysteresis in Lithium- and Manganese-Rich Composite Cathode Materials	Kevin Gallagher (Argonne National Laboratory)	2-195	3.25	3.00	3.00	3.00	3.06
† Arresting VF: Theory-Guided Synthetic Approaches to Cathodes	Christopher Johnson (Argonne National Laboratory)	2-198	3.50	3.00	3.00	3.50	3.19
† Impact of Surface Coatings on LMR-NMC Materials: Evaluation and Downselect	Ali Abouimrane (Argonne National Laboratory)	2-201	2.75	3.25	3.25	2.50	3.03
† Thermodynamic Investigations of Lithium- and Manganese-Rich Transition Metal Oxides	Wenquan Lu (Argonne National Laboratory)	2-204	3.50	2.75	2.75	3.25	3.00
† First-Principles Models of the Atomic Order and Properties of LMR-NMC Materials	Roy Benedek (Argonne National Laboratory)	2-207	3.50	2.50	2.50	3.50	2.88
† Addressing Voltage Fade: Synthesis and Characterization of Lithium- and Manganese-Rich Electrode Structures	Michael Thackeray (Argonne National Laboratory)	2-210	3.75	3.25	3.25	3.50	3.41
† Phase Relations and Voltage Fade Response in LMR-NMC Materials	Ira Bloom (Argonne National Laboratory)	2-213	4.00	3.25	3.25	3.00	3.41
† Impact of ALD Coating on Li/Mn-rich Cathode Materials	Shriram Santhanagopalan (National Renewable Energy Laboratory)	2-216	3.00	3.60	3.60	3.00	3.38
Overall Average			3.27	3.21	3.21	3.00	3.20

† denotes poster presentations

PEV and HEV Battery Cost Assessment: Brian Barnett (TIAX LLC) - es001

Reviewer Sample Size

A total of 7 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the approach to updating the existing PHEV cost model projections was very sound. The reviewer emphasized that some improvements in the presentation of the overall results were noted that may be a result of the approach. The reviewer outlined that the following comments reflect what those improvements could be: the addition of information such as the change in production yield because of the increase in the number of large format cells being produced, which it was stressed may also affect the production yield; clarifying how the manufacturing equipment cost information was used or incorporated into the cost model, showing graphically the different amounts of materials needed for the 25 million cells produced and, the total actual cost for that material for the different chemistries; and that nickel manganese cobalt oxide (NMC) should have been used as the example material rather than nickel cobalt aluminum oxide (NCA) because of the earlier mention of the NMC. The reviewer was not clear on the presenter's conclusion comment that there is greater variation based on cell designs and whether that applies to cylindrical or prismatic cell designs or both.

Reviewer 2:

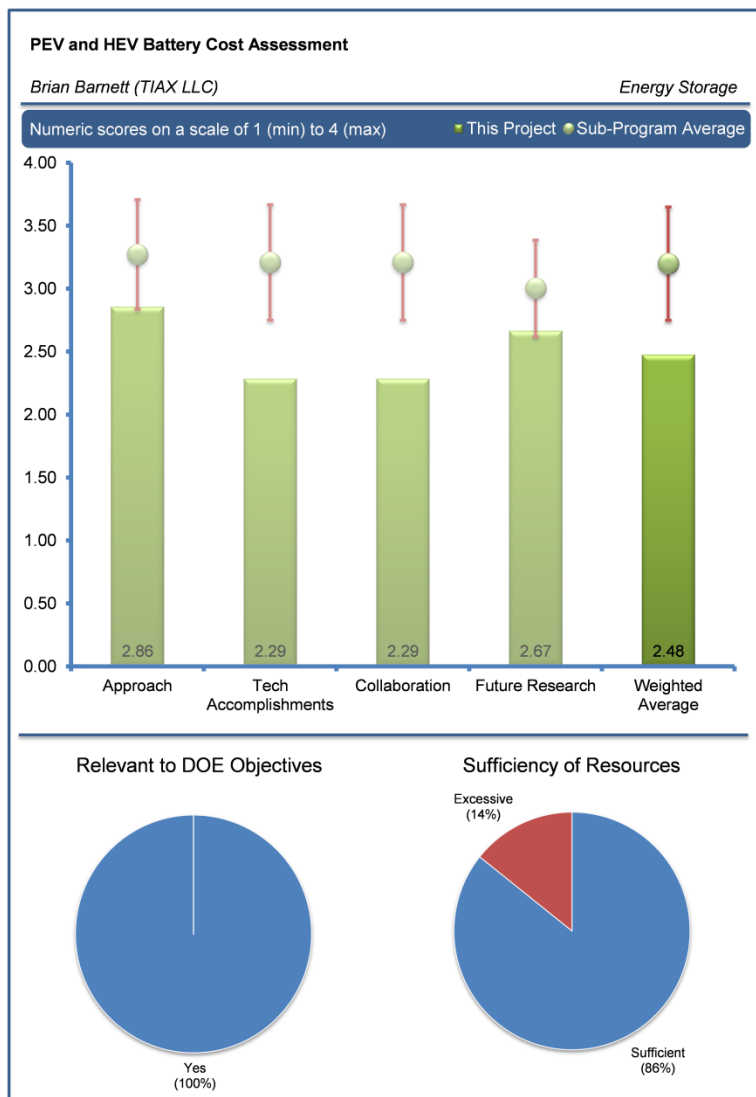
The reviewer indicated that the analysis was sound; it was narrow, however, focusing on one type of cell design.

Reviewer 3:

The reviewer asserted that the inclusion of Japan and Korea exchange rate influence effects provided good insight. The reviewer felt it would be useful to expand this relative effect consideration to also include the People's Republic of China (PRC) exchange rate influences and to go even further to look at not just the direct impact to the United States, but also the effect between Japan, Korea, and PRC.

Reviewer 4:

The reviewer pointed out that this is only a paper study without a validation of results. The sensitivity analysis is very useful in predicting the range and variation of cost estimations.



Reviewer 5:

The reviewer identified a need to state assumptions such as cell type used in modeling. Even though the difference between prismatic pouch cell and cylindrical cell was presented in 2012, the reviewer said that it was worthwhile to have a comparison slide, given the perceived labor and capital equipment cost associated with pouch cells.

Reviewer 6:

The reviewer stated that the project seems to be logically structured, but its limitation to consider only a vertically-integrated manufacturing process chain could be too much of a simplification. The reviewer also noted that there is no obvious evidence presented of how the project is integrated with other program efforts.

Reviewer 7:

The reviewer thought that the scenarios giving sensitivity analyses of different parameters (changes to loading, changes to cathode and anode chemistry, etc.) represent a sound approach and help target areas of future battery development for cost reduction. The reviewer, however, was not sure why the manufacturing layout and costs in the model are still largely based on wound/cylindrical cells. Production PHEV applications (General Motors [GM] Volt, Honda Accord PHEV, Toyota Prius Plug-in) are using stacked or folded and laminated cells, which is a very different manufacturing process with different costs and different manufacturing throughput. The reviewer was also not sure that freezing the balance of plant design is valid considering the differences in heat rejection between different cell geometries and the differences in cell size between cylindrical and stacked or folded and laminated cell geometries.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer asserted that significant progress was made in updating the PHEV Cost Model to provide better cost projections. The presentation provided enough information to show a very systematic approach to capture the most recent production and material cost information from the various stakeholders (material and cell manufacturers in particular).

Reviewer 2:

The reviewer summarized that the activity was to revise the model using recent information. This activity wholly accomplished this goal and no additional model featuring was considered.

Reviewer 3:

The reviewer reported that the DOE accepted cost model was used for the new inputs. The new input shows the sensitivity of the material and equipment cost.

Reviewer 4:

The reviewer affirmed that the presenter's conclusions on materials dominating the cost and breakdown of the materials cost were in agreement with the previous model developed by Ralph Brodd, but TIAX's conclusions were actionable and showed one path to reduce the cost per kilowatt-hour (\$/kWh).

Reviewer 5:

The reviewer criticized that the presentation does not include identified goals, nor does the project directly address any technology or cost goals. The project aims at providing an updated cost assessment, necessary for guiding further program decision-making. The reviewer explained that one of the findings feeding into the cost assessment is an increase in throughput in manufacturing operations. Together with costs, this higher throughput is used in the cost assessment. No indication is given on how increased throughput may affect the quality of the semi-product and how this, in turn, may affect costs. The reviewer added that a relevant cost factor, namely recycling, is not considered.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noticed that the presenter stated that material and cell manufacturers were consulted, but the reviewer reported that none were highlighted. The reviewer felt that it would have been good to highlight that major material and cell manufacturers from China, the United States, and/or Korea, were consulted for this information to add real value to the numbers presented.

Reviewer 2:

It appeared to the reviewer that the Principal Investigator (PI) received significant cooperation from the supply base, as well as peer review.

Reviewer 3:

The reviewer reported that it is not very clear who the collaborators are. The reviewer surmised that the material suppliers and equipment suppliers may be collaborators.

Reviewer 4:

The reviewer simply stated that the status of collaborations were unknown.

Reviewer 5:

The reviewer asserted that to achieve its goals, the project must necessarily have interacted with a number of stakeholders; however, no evidence of such interaction was presented.

Reviewer 6:

The reviewer would have liked to see better coordination between the development of Argonne National Laboratory (ANL) BatPaC Model and the TIAX Cost Model. The reviewer felt that there appeared to be considerable overlap between inputs, outputs, and targeted end users of these two models.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer reported that there was no need or plan for future research.

Reviewer 2:

The reviewer pointed out that the presenter provided no identification of topics for further research within the project; however, the last slide presented recommendations to guide further work at program level.

Reviewer 3:

The reviewer stated that no clear future plans for this project were presented.

Reviewer 4:

The reviewer said that no future work was planned at this time.

Reviewer 5:

The reviewer could not rate this element since future research was not discussed.

Reviewer 6:

The reviewer indicated that future research plans were unknown, but expected.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that the project has helped to identify that there has been significant progress in development of manufacturing processes that drive cell costs down and that DOE's involvement has played a valuable role in that progress. Consequently, the reviewer added, continued DOE involvement and initiatives will keep that progress moving at a faster rate.

Reviewer 2:

The reviewer explained that the model provides insight into those design features in cells with greatest sensitivity to input costs, and those design outputs with greatest sensitivity to design requirements. The reviewer noted that this permits the DOE to evaluate other research projects for the rationality of their claims and research objectives.

Reviewer 3:

The reviewer agreed that the project indirectly supports DOE's overall goal by providing program-level guidance for achieving this DOE objective.

Reviewer 4:

The reviewer indicated that the DOE cost goals are dependent on the reliable cost models; however, the DOE assumptions are not validated here.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that the resources seemed sufficient for the project.

Reviewer 2:

The reviewer commented that there were no issues.

Reviewer 3:

The reviewer indicated that the level of resources was unknown.

Reviewer 4:

The reviewer remarked that no information on resources was available; however, that TIAX is a capable organization for this type of study.

Reviewer 5:

The reviewer remarked that no cost was provided in the presentation.

Reviewer 6:

The reviewer expressed that it was difficult to answer the question, as no project milestones were identified.

A High-Performance PHEV Battery Pack: Mohamed Alamgir (LG Chem, Michigan) - es002

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

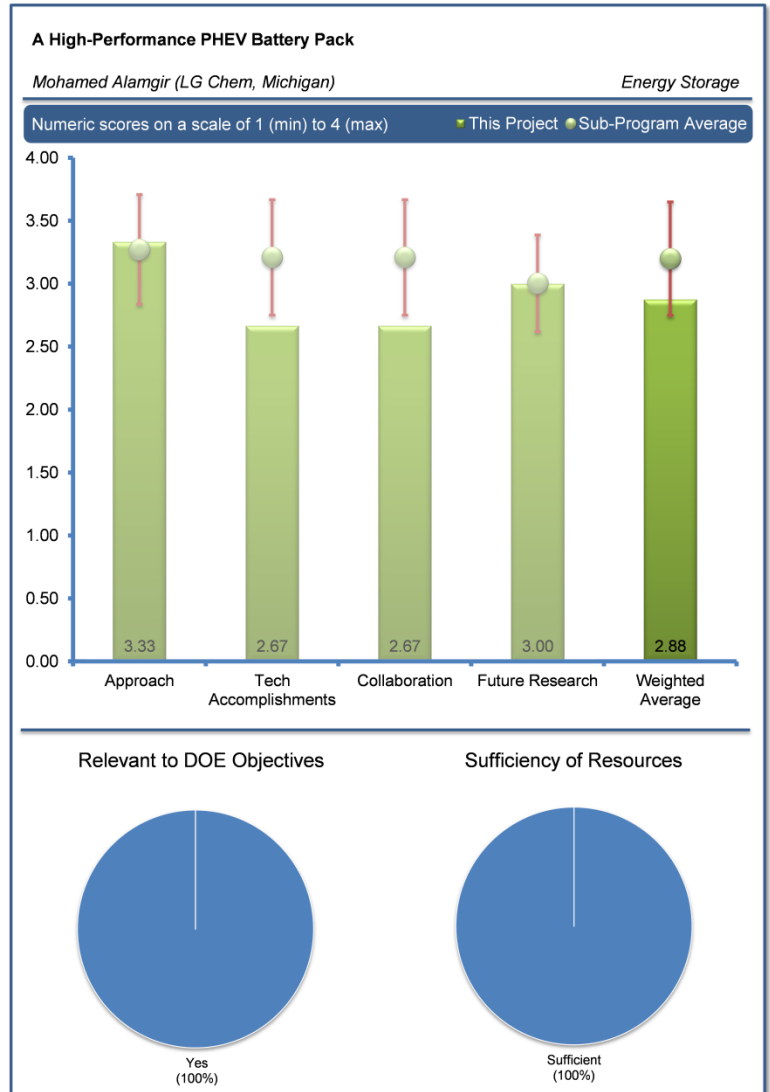
The reviewer stated that the approach is good and that the program goal is to lower the cost close to a \$3,400 target. The reviewer concluded by asking for clarification on what the current cost is.

Reviewer 2:

The reviewer explained that the project's approach addressed the need to develop a cell that was able to meet the PHEV 40- mile program performance and cost goals. The reviewer indicated that the technical barriers to achieve these goals included: specific energy and power; cycle and calendar life; and affordability. The reviewer reported that the barriers were being addressed by studying high capacity, manganese-rich cathode materials from several vendors and by developing a refrigerant-to-fin indirect cooling system.

Reviewer 3:

The reviewer highlighted that the researchers did not address the electrolyte stability with the 5V cathode.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer summarized that the future work included surface modified cathodes; however, the reviewer asked if this meant that a different coating other than the one used now would be needed. The reviewer asked what the reasons for the new electrolyte composition and additives were.

Reviewer 2:

The reviewer explained that the project is near completion and according to the Quad Chart (Slide 6), only 21% of the efforts remains to be completed in the next eight months. The reviewer mentioned that \$2 million was allocated to the project for fiscal year (FY) 2012. The reviewer stated that, with respect to the manganese cathode investigation, there appeared to be minor accomplishments made. The reviewer criticized that several of the Accomplish/Results slides were duplicative of the previous (2012) presentation; these included Slides 12, 13, 15, 17, and 18. The reviewer observed, however, that the data on Slides 10, 14, and 16 were updated. The reviewer also acknowledged that there was new work reported on an improved separator (Slide 19); but that was not mentioned in the Approach, which gave the reviewer the impression that it may have been the offspring of another project. The reviewer also pointed out that the results from the manganese cathode surface coating study (Slide 22) were new and promising. The reviewer also reported

that it was noted in the 2012 presentation that efforts would be directed to improving power and life would include investigating different electrolyte compositions; however, there were no results reported in this area. It appeared to the reviewer that much of the efforts this year were directed toward the cooling system with results reported in Slides 27 and 28.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer acknowledged the good collaboration between LG Chem and the National Laboratories (e.g., Idaho National Laboratory [INL], Sandia National Laboratories [SNL], and National Renewable Energy Laboratory [NREL]).

Reviewer 2:

The reviewer voiced that collaboration with other institutions are good. The reviewer suggested that the researchers should try to test the Envia Systems battery if possible.

Reviewer 3:

The reviewer stated that no collaboration was mentioned.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer summarized that future work includes surface modified cathodes; however the reviewer asked if this meant that a different coating other than what is used now would be needed. The reviewer asked what the reasons for the new electrolyte composition and additives were.

Reviewer 2:

The reviewer pointed out that it was noted in the presentation that future efforts in the use of new electrolyte compositions or additives would be pursued; however, there was no mention of this in the Approach slides.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer agreed that the project supports DOE objectives of petroleum displacement by seeking to develop a cell/battery that will meet the PHEV 40-mile program goals.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

JCI PHEV System Development-USABC: Avie Judes (Johnson Controls) - es005

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the approach is good. However, the reviewer indicated that the water-based binder and perform coating trials were not clearly defined.

Reviewer 2:

The reviewer summarized that the program is investigating higher energy electrode materials to meet the program energy density goals. The materials include blended cathode materials, cathodes of high nickel content in the nickel, manganese, cobalt (NMC) material. The reviewer agreed that lowering the cobalt content of NMC is expected to decrease material cost which supports another program objective. The reviewer pointed out that the program is undergoing an electrode processing and design optimization effort. The reviewer also mentioned that, although not expressed implicitly in the slides, the dry powder compounding process should result in a more affordable cell because it reduces the amount of solvents required.

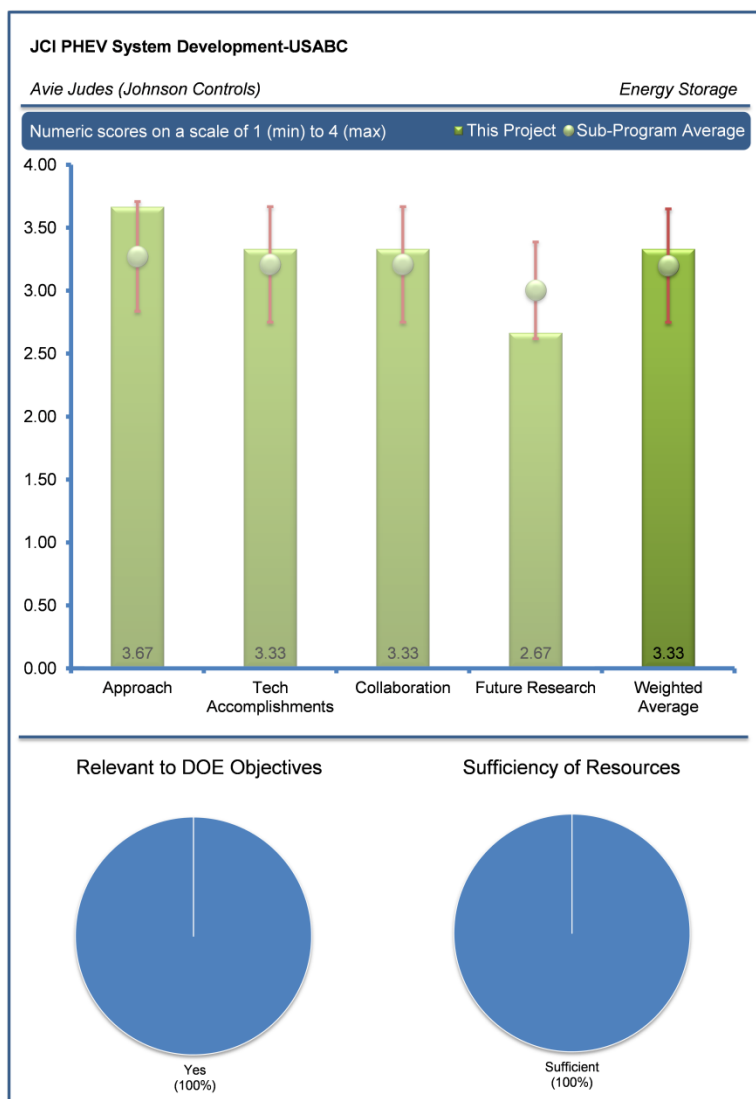
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer asked the researchers why the 11% energy density increase showed the same power as the baseline, and requested an explanation of the potential reasons for this. The reviewer also pointed out that the high Ni NMC (A) had higher specific capacity, but asked for how many cycles.

Reviewer 2:

The reviewer described that this program was initiated in April 2012 and is reported to be 45% complete; however, the presenter noted that \$1.9 million (35%) was spent out of the \$5.5 million allocated for the program total. The reviewer agreed that the program has demonstrated good technical accomplishments. The reviewer noted that cycling test data of cells under the last United States Advanced Battery Consortium (USABC) PHEV program were shown. The reviewer also felt that excellent cycle life has been demonstrated to date. Cycling of cells developed in this new program was also reported and two high content NMC cathode materials showed higher specific capacities than the baseline. The reviewer also mentioned that data were also presented on the efforts to extend the useable state-of-charge window and to optimize the electrode processing. Although no specifics were given regarding the optimization of cell connections and insulation, the reviewer mentioned that it was noted in bullet format on Slide 20.



Reviewer 3:

The reviewer stated that no details on the specific capacity (mAh/g), number of cycles, or actual storage time were provided, so it was difficult to assess the project's progress.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer felt that the collaborations were good.

Reviewer 2:

The reviewer thought that there was good collaboration with national laboratories regarding electrical and thermal testing of cells; however, the reviewer criticized that no collaboration was shown with the laboratories experienced in cathode/anode material development.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer agreed that the proposed efforts were justified and relevant to the success of the program.

Reviewer 2:

The reviewer stated that the proposed future work indicated completion of several tasks. The reviewer emphasized that it was good to put a timeline and section criteria for all.

Reviewer 3:

The reviewer commented that it was difficult to assess future work due to a lack of details on the accomplishments.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer agreed that the program's objectives are clearly in line with DOE objectives of petroleum displacement, including seeking to develop Li-ion PHEV systems for 20- and 40-mile all-electric range applications. The reviewer mentioned the following specific goals: improvement to the low temperature performance of cells; increased volumetric energy density (goal of 350 Wh/L), affordability (\$250/kWh), and safety.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer commented that no funding information was provided.

Validation of Electrode Materials and Cell Chemistries: Wenquan Lu (Argonne National Laboratory) - es028

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer confirmed that the project approach is substantially focused on the barriers. The reviewer highlighted that the aqueous binder work can have important implications on cost.

Reviewer 2:

The reviewer explained that the approach adopted here for the electrochemical assessment was quite comprehensive and is usually used for evaluating battery materials. The reviewer noted that several experimental variables had been examined e.g., type of binder, electrolyte, voltage regime, electrolyte additive, etc. The reviewer observed that even though these studies added value by themselves, it was not clear if all the material characterization presented was being coordinated/consolidated through this task (i.e., does this represent the Cell Fabrication facility), or if this was in addition to what had been done by several other individual PIs in their tasks. In any event, the reviewer thought this task/approach was justified if it looked at commercial, low-cost materials, or materials from external sources or from the ANL scale-up only. Also, the reviewer added that these studies would be justified if these assessment studies would use design parameters (such as electrode loadings, test conditions) that were consistent with the industry; for example, results with thinner electrodes (and excess electrolytes) and half-cell tests resulted in misleading conclusions.

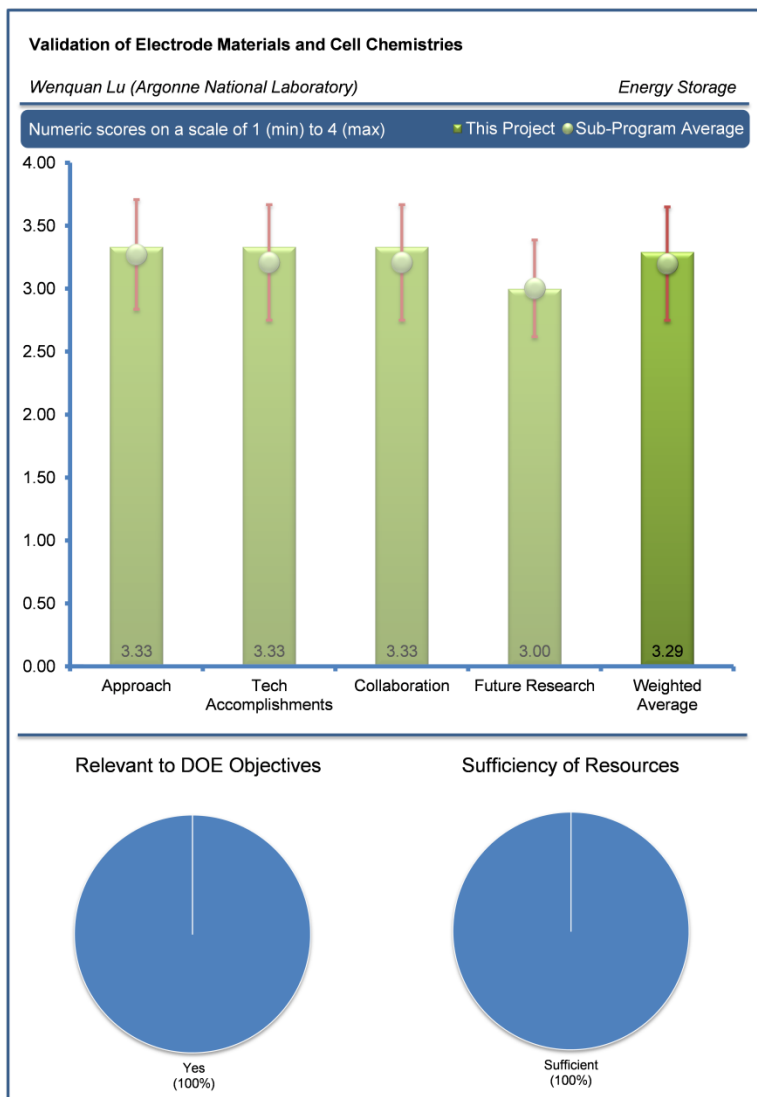
Reviewer 3:

The reviewer explained that lithium and manganese rich-NMC (LMR-NMC) and silicon are both relevant for PHEVs and hopefully EV, but the key success would be if they worked together. The reviewer felt that it would have been really outstanding if the PI would have done a systematic study to address the barriers associated with this high energy redox couple.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer agreed that the use of styrene butadiene copolymer (SBR) aqueous binders was an excellent idea. The reviewer stated that more work should be done with conventional binders so that aqueous binders can be compared with a large database.



Reviewer 2:

The reviewer acknowledged that good progress has been made in terms of understanding the behavior of LMR-NMC cathode and silicon composite anode in different electrolytes. Furthermore, the reviewer noted that several studies were successfully carried out with various high energy cathodes, silicon and carbon anodes, electrolytes, additives, etc. However, the reviewer criticized that the results were not significant. The reviewer asked whether these materials (electrolytes additives, redox shuttles) are new, or being adopted from other on-going tasks. The reviewer offered that, based on these results, for instance, reviewers cannot judge if a particular material has attained the technology maturation for it to be picked up by the industry. The reviewer also reported that some of the cycling tests on the LMR-NMC cathode were performed over a wider voltage range, while the other tests were carried out over a narrow voltage range (only to 4.55 V). Overall, the reviewer felt that the amount of progress is impressive, but stated that the relevance of these results in the context of the overall DOE Applied Battery Research program was still not quite clear.

Reviewer 3:

The reviewer described that the first part of the work relates to the voltage fade (VF) aspects of LMR-NMC, which is already being studied by a number of Argonne PIs. The reviewer criticized that this does not add too much to current understanding, or at least should be clubbed into that project. The reviewer also suggested that Si anode and aqueous binder work should be encouraged.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer pointed out that, as expected from the nature of the project, there are several contributors and collaborators to provide electrode, electrolyte and other materials.

Reviewer 2:

The reviewer reported that the list of collaborators was substantial. The reviewer thought it was interesting to see that several of them were from the industry.

Reviewer 3:

The reviewer observed that the PI had a whole laundry list of collaborators and industrial partners. The reviewer suggested that it may help to know who the critical contributors are.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer thought that the proposed future research to continue the assessment of materials coming out of the Material Engineering and Research Facility (MERF) and from other sources to build materials performance database is logical and useful. Also, the reviewer indicated that the planned studies on the lithium-excess layered-layered composite materials and Si anode were quite relevant, as these are the focus of the DOE Applied Battery Research program.

Reviewer 2:

The reviewer agreed that, as mentioned by the authors, the scale-up by the MERF should be emphasized.

Reviewer 3:

The reviewer suggested that the PI should work on full cell chemistry as much as possible trying various binder chemistry and compositions.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer agreed that yes this project is very relevant and important since a variety of samples from different companies can finally be analyzed under the same set of conditions.

Reviewer 2:

The reviewer explained that with several advanced materials of cathodes, anodes and electrolytes being developed in the DOE Applied Battery Research program, as well as elsewhere, it is essential to have their performance independently assessed against the PHEV performance targets in standard test vehicles and environment. The reviewer indicated that the objective of this project is to conduct independent screening tests using standardized test procedures to: streamline the Li-Ion electrode optimization process; enhance the understanding of these advanced materials; and select promising advanced materials and cell couples for an internal cell build and further testing. The reviewer thought this project would thus serve as a bridge between the material development and the scale-up/cell fabrication activities within the DOE Applied Battery Research program. The reviewer remarked that a successful verification will thus lead to an infusion of the high-energy materials in PHEV cells and batteries.

Reviewer 3:

The reviewer summarized that the research and development (R&D) area is related to the development of high energy density batteries.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer thought that the budget of \$550,000 looked adequate for the scope of the work.

Reviewer 2:

The reviewer simply stated that the resources were covered well.

Fabricate PHEV Cells for Testing & Diagnostics: Andrew Jansen (Argonne National Laboratory) - es030

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that a very clear, straightforward presentation on the high level objective, goals, and approaches to providing a flexible cell demonstration platform was provided. The reviewer also commented that the approach was a useful objective that appears to have been carried out. The reviewer felt that there could be some more discussion regarding the specific objectives and goals that will be generated, with the ability to produce cells from materials provided by suppliers.

Reviewer 2:

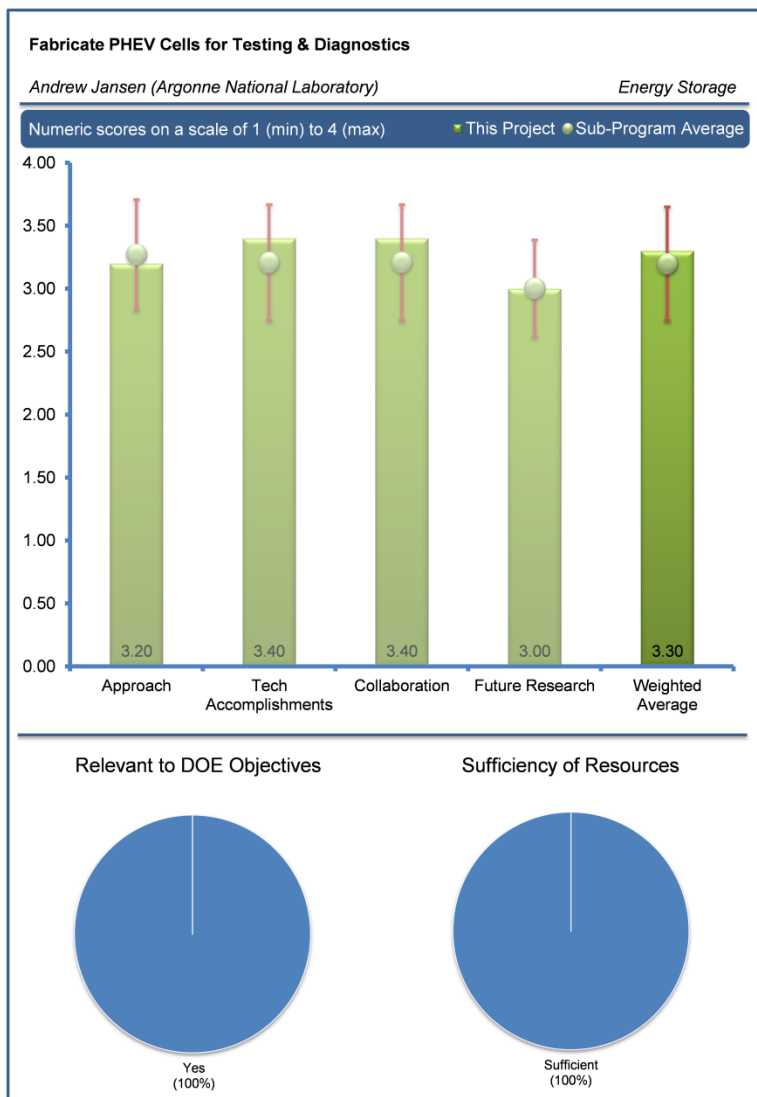
The reviewer was unclear on the real value of this project for overcoming key barriers. The reviewer acknowledged that having cell making capabilities was clearly beneficial, and could lead to acceleration of new learning, but the reviewer asked how that was different from what, for example, was offered by TIAX where a full functioning line was in place and available for use. The reviewer also expressed concerns about the reliability and know-how that is necessary to operate cell making equipment. The reviewer explained that this took many years for leading cell makers, so it was hard to imagine getting through this step faster. The reviewer suggested that, perhaps collaborating with cell makers in a more engaged way would be helpful.

Reviewer 3:

The reviewer was not clear how this project was integrated with numerous other DOE Applied Battery Research programs on LMR-NMC. The reviewer asked how materials graduated from bench to Cell Fabrication Facility evaluation, and what decisions or improvements followed from Cell Fabrication Facility results.

Reviewer 4:

Many aspects of the program show considerable progress and merit the rating on the approach; however, the reviewer had some concerns about the approach to cell building and data presentation. The reviewer was concerned about the scarcity of statistical data in presentations, and elaborated that it is a standard practice in the battery industry to include the error bars (determined from multiple cell measurements) on the data points to indicate the reliability of the conclusions drawn from the data. The reviewer highlighted that if the populations of two measurements overlap sufficiently, it is not statistically accurate to claim that one measurement is better than another. In these cases, the reviewer added that it then becomes a good practice to do a thorough statistical analysis of any comparison made under these circumstances. The reviewer acknowledged that the workers may be aware of this, and may be using the appropriate



analysis, but in the absence of any statistical data it was not obvious that this is the case to the reviewer. The reviewer also expressed that the approach used is limited by using only a few formulations of electrode materials, without any attention to the possibility that the range of formulation is far from the optimum. The reviewer again stressed that the standard practice of the industry is to vary the formulation for trial materials to observe the sensitivity of the material to the formulation. In fact, the reviewer observed that after some early trial formulations, it seems that a single formulation has been adopted. The reviewer remarked that the effect of graphite as an electrochemically active component of the positive electrode was noted, but the result on the formulation was not discussed. The reviewer warned that this can be a very serious result, since all previous formulations are based on at least equal amounts of graphite and carbon black. The reviewer pointed out that if the new formulations contain no graphite, then previous conclusions may still not be valid. Finally, the reviewer thought that it would be very useful to get some discussion and advice from the industrial partners, because it is in everyone's interest to obtain the maximum benefit from this program.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer pointed out that the technical accomplishments were dominated by getting the entire facility up and running. The reviewer agreed that this should contribute substantially to the materials program at ANL. The reviewer suggested that attention should now be directed to making the best electrodes with a reasonable effort as possible to give the best results to materials developers. The reviewer would like to see greater efficiency in processing, so that several runs per week, including formulation and processing variations, can be carried out. This would require several coating runs as well as calendaring, slitting, and cell manufacturing. The reviewer noted that the runs do not need to create large coating areas, but should be sufficient to produce statistically significant cell numbers.

Reviewer 2:

The reviewer commented that the data generated in a variety of systems was interesting and it appeared the work and progress has been good. A somewhat more comprehensive overview of what the specific testing would be, and why it would be helpful, should have been included in the presentation rather than just listing a variety of different experiments and conclusions.

Reviewer 3:

The reviewer reported that the cell fabrication lab is fully-functioning and that various projects are under way to learn from larger cells compared to coin cells. The reviewer highlighted that the fundamental question, which was not answered in the report, is how much new learning is really happening due to larger cells and the use of commercial equipment compared to what was already known from coin cell tests.

Reviewer 4:

The reviewer reported that this is a lot of progress. The reviewer, however, added that the starting point was not defined, but clearly reflects work that began prior to the October 2012 restructuring.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer felt that collaborations are good within the laboratory and with external customers, but as previously noted, thought that it would be valuable to have more input from industrial partners to improve throughput and emphasize statistical experiments as well as formulation improvements.

Reviewer 2:

The reviewer mentioned that it appears that an open and extensive collaboration plan was pursued, with good result.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer suggested that some thought should be put in to considering the larger intent of the capability. The reviewer asked whether it was available for the purpose of evaluating materials developments provided by a number of contributing companies, or if it had been developed to provide a platform for independent development (i.e., performance improvement) of specific systems. The reviewer concluded that it appeared to have elements of both, so it was just a question about the mission.

Reviewer 2:

The reviewer explained that there are plenty of research directions that will be explored. The reviewer suggested that perhaps more effort on optimizing and streamlining fabrication equipment and process would also be valuable. This approach may reduce variability and improve the quality of the data.

Reviewer 3:

The reviewer criticized that the project had a very broad scope and relatively little in terms of quantitative goals or go/no-go decisions that would narrow scope or permit higher priority directions to be accelerated. The reviewer asked for a description of what the decision making process was.

Reviewer 4:

The reviewer reported that the authors stated that there was no definitive Si anode material available, but that the 3M work in this area may be close to providing a commercial solution. The reviewer suggested attempting to work with materials from and to seek advice from 3M, as their materials become available.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer affirmed that this facility is critical to DOE programs in materials and has great relevance to determining progress in these programs. The reviewer emphasized that it will be necessary to have high reliability cells produced by the facility and to be able to substantiate the degree of improvement in experimental materials.

Reviewer 2:

The reviewer explained that a cell platform above the level of coin cell, but below the level of commercial cell, is quite useful for the evaluation of new materials and may be in limited supply. The reviewer remarked that the facility can provide solid benchmarking within a known demonstration platform, which can be quite useful. The reviewer suggested that carefully addressing the question of the type of work that will be employed on the platform is worth some more consideration.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer felt that the resources seem adequate to the challenges faced by this group.

Reviewer 2:

The reviewer commented that the project appears to be appropriately manned. The reviewer asserted that this was not an easy area, so it was thought that a good deal of progress had been made by the team.

Reviewer 3:

The reviewer indicated that it was difficult to tell from review information where the budget is in terms of CapEx and labor and alignment of spending with time line. The reviewer stated that it would be interesting to know what the limiting resource is (test

channels), and what results additional resources would produce. Overall, the reviewer felt that this seemed to be a pretty productive and well-organized team.

Mitigating Performance Degradation of High-Energy Lithium-Ion Cells: Daniel Abraham (Argonne National Laboratory) - es032

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

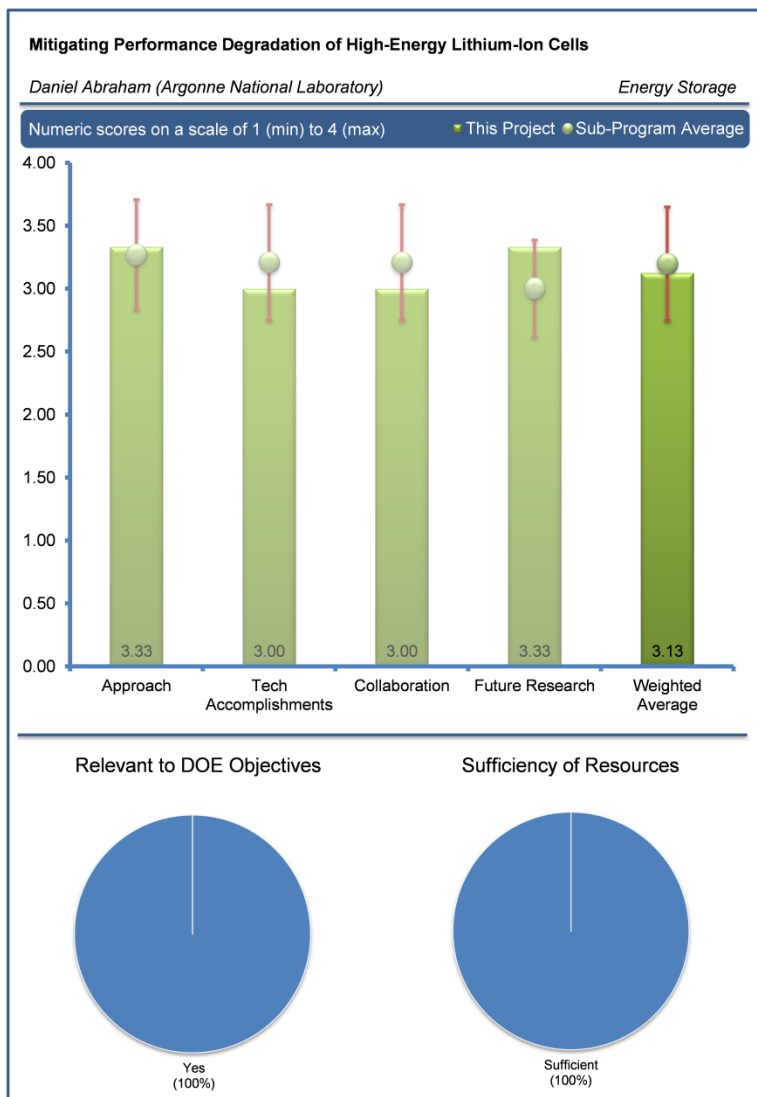
The reviewer commented that the work is nicely focused on the technical barriers. The reviewer also pointed out the very interesting information about the impedance rise on aging and the use of additives to mitigate this problem.

Reviewer 2:

The reviewer expressed that a relevant approach has been used to study the reason for capacity fade in LMR-NMC chemistry. The reviewer described that the PI has used several techniques, such as secondary ion mass spectrometry (SIMS), x-ray photoelectron spectroscopy (XPS) and electrochemical studies, to evaluate cell level performance degradation and correlate this to changes at the electrode and materials level.

Reviewer 3:

The reviewer explained that the approach is fairly standard, i.e., to make test cells (coin, pouch or half cells) with the selected electrode couples, study the interfacial properties through electrochemistry and harvest the electrodes after cycling, for various ex-situ analytical techniques. Interestingly, the reviewer observed, in addition to being a diagnostics project, that this project also examined several experimental variables such as cathode coatings, electrolyte additives, and electrode composition (conductive diluent, binder, etc.). The reviewer noted that the approach being adopted here addresses the technical barriers of Li-ion batteries, i.e., limited cycle life and performance degradation (e.g., energy loss in lithium-rich NMC cathode materials) during cycling. It is important, according to the reviewer, to understand these performance-limiting processes for designing new materials to overcome these limiting processes. The reviewer highlighted that more emphasis was placed on EIS measurements, which are not as informative on the material properties or the interfacial changes. Instead, the reviewer suggested that this project should focus more on ex-situ analysis to augment the on-going in-situ studies elsewhere to gain a better handle on the material properties and interfacial layers. As with some of the other projects, there seems to be considerable overlap with the other projects in diagnostics (e.g., at ANL's diagnostic facility and at Brookhaven National Laboratory [BNL]), which if avoided and if such diagnostics-related projected were better coordinated, would be helpful to the overall VTO.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer highlighted that the technical accomplishments were outstanding considering that the project started only a few months ago.

Reviewer 2:

The reviewer acknowledged that reasonably good progress has been accomplished in terms of understanding the performance limitations of the LMR-NMC cathode. In particular, the reviewer pointed out that it was shown that lower charge voltages are preferable to extend the cycle life and that a surface coating (alumina) would help in the capacity retention during cycling; however both these findings are known to the battery community. The reviewer emphasized that the more interesting results are with the use of electrolyte additives (LiDFOB, HFIP, etc.), which need to augment the surface studies on the harvested electrodes (apart from tacking the EIS). For example, the reviewer suggested that evaluating the effect of such an additive (or any such experimental variable) on the manganese dissolution (and presence of anode) would be useful. The reviewer agreed that the overall progress, though moderate, was oriented towards meeting the project and DOE program goals.

Reviewer 3:

The reviewer asserted that the presenter had delivered quite a bit of message. The reviewer thought it was good to see conclusive evidence that manganese, nickel, and cobalt are deposited on anode (graphite) after long-term cycling of LMR-NMC. The reviewer indicated that the other important aspect is the choice of carbon that needs to be used for high-voltage composition. The reviewer was impressed by the technical detail, rigor, and the clear conclusion. The reviewer concluded by asking whether the PI could do a careful analysis of manganese dissolution (possibly at anode) under cell abuse condition both calendar and cycle life, preferably at 55-60°C.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported that there are several useful collaborators in this effort, mainly from universities and national laboratories.

Reviewer 2:

The reviewer remarked that it seems that the team is well-coordinated. The reviewer suggested that it could be very important to also find an industrial partner.

Reviewer 3:

The reviewer acknowledged that there was a pretty good team here that was also receiving help from other national laboratory colleagues when needed for addressing/mitigating issues.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that future plans included performing similar studies with the LMR-NMC cathode materials under various experimental cognitions, with 5V manganese spinel oxide, and the silicon-carbon anodes. The reviewer reinforced that clearly the industry needed to understand a lot on these next-generation materials, in terms of their structural and interfacial stability, and that the proposed studies were quite relevant and well-aligned with these objectives.

Reviewer 2:

The reviewer reinforced that the experiments with water-based binders should be strongly encouraged because that type of work may have important implications on cost.

Reviewer 3:

The reviewer observed that the PI and team's work seemed to be heavily dependent on the ongoing DOE focus on the current Li-ion chemistry, which the reviewer surmised was probably the current mandate. The reviewer suggested, however, that the researchers should also use these tools to study other interesting chemistries such as Si and other high capacity multivalent cathodes.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer agreed that the project supports the overall DOE strategy of petroleum displacement by focusing on very practical issues such as cycle life and abuse tolerance.

Reviewer 2:

The reviewer agreed that the work directly relates to high energy density batteries for electric vehicles.

Reviewer 3:

The reviewer reported that the current and advanced Li-ion battery, especially the high energy (high voltage) cathode materials being developed for PHEVs and EVs do not quite meet the requirements in terms of calendar life and cycle life. In addition to the significant changes in the structure and microstructure of the materials, the reviewer commented that there are considerable changes at the interfaces with the electrolyte, more so with the use of high-voltage cathode and high capacity anodes (silicon-composites). It is essential to understand these changes at the system level, as a function of electrolyte composition, additives, electrode compositions, etc., which this project has been addressing. As a result, the reviewer thought this project is thus well-aligned with the goals and objective of DOE's VTO.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the budget of \$450,000 per year looks reasonable for the scope of the project.

Reviewer 2:

The reviewer stated that the resources were adequate.

Novel Cathode Materials and Processing Methods: Michael Thackeray (Argonne National Laboratory) - es049

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the approach was innovative and appeared to have good potential for optimized performance of structurally integrated electrode structures. The reviewer explained that sonochemical coatings were used to coat oxides in order to protect underlying metal oxide particles from the electrolyte. The reviewer also mentioned that first-principle modeling was planned to be used to aid the design of bulk and surface cathode structures and to understand electrochemical properties.

Reviewer 2:

The reviewer simply stated that the approach was good.

Reviewer 3:

The reviewer confirmed that the approach was sound and focused on the technical barriers. The reviewer observed that objectives are to design high capacity, high power, and low-cost cathodes for PHEVs and EVs. To accomplish this, the reviewer observed that the PI proposes to improve the composition of the manganese-based cathode, explore new processing routes for advanced electrodes, and use atomic-scale modeling to guide the identification and design of the new cathode materials.

Reviewer 4:

The reviewer observed fundamental, hypothesis-driven work to understand stabilization and structural formation in layered-layered material. The reviewer agreed that this was essential to fixing problems and felt that the researchers have made good use of theory/simulation to strengthen their understanding.

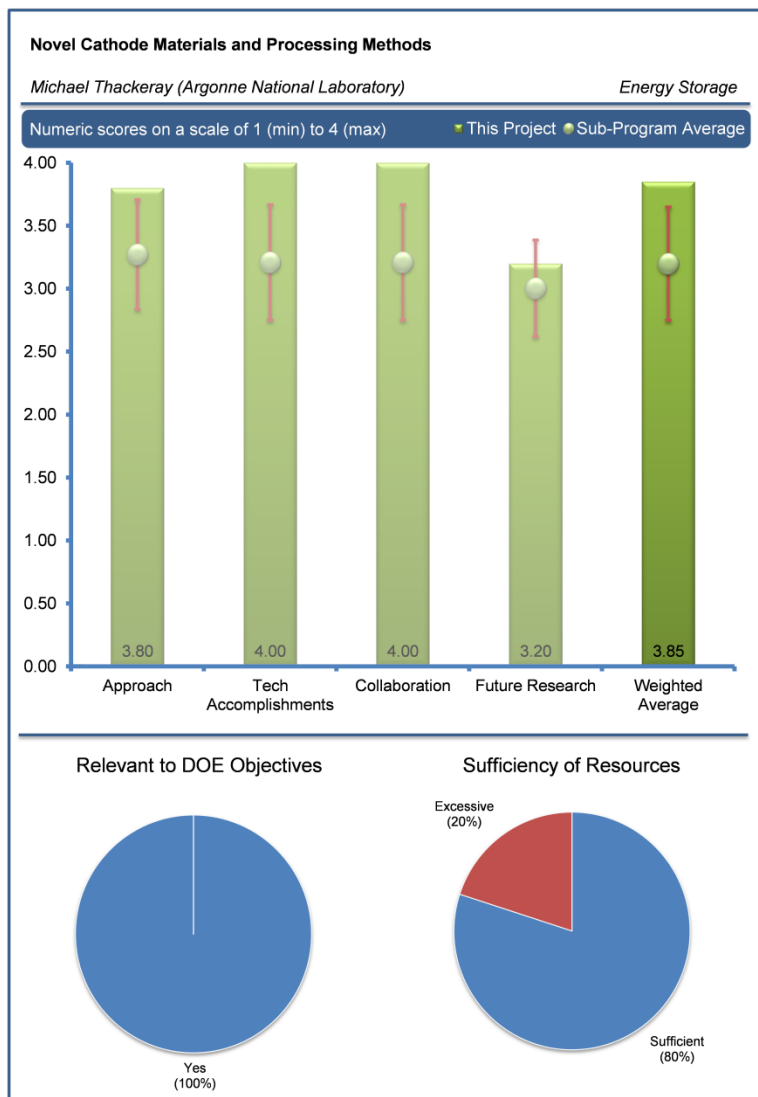
Reviewer 5:

The reviewer suggested that the 5V layered composite approach to achieve high energy should also be compared to other high-voltage cathodes such titanium (Ti)-substituted NMC.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that excellent progress was made in understanding the VF issue.



Reviewer 2:

The reviewer simply stated that the project accomplishments seemed to be good.

Reviewer 3:

The reviewer noted that the VF phenomenon for the cathode materials was studied. The reviewer explained that structural issues and the cycling limitations of layered-layered composite structures were studied with state-of-art X-ray absorption spectroscopy (XAS) and X-ray diffraction (XRD) techniques. The reviewer also described that several stabilized oxides were successfully tried to be deposited on the electrode particles and that first-principle modeling was used to simulate the manganese dissolution and coatings.

Reviewer 4:

The reviewer explained that this is the first reporting period for this effort (25% complete). The reviewer thought the PI has demonstrated excellent progress toward meeting the program goals. The reviewer highlighted that a considerable amount of effort had been made in the area of manganese cathode development and understanding the nature of degradation upon cell cycling was demonstrated. The reviewer also noted the excellent publications, patents, and presentations that resulted from this effort.

Reviewer 5:

The reviewer expressed that all milestones are ongoing, so it is difficult to measure progress. The reviewer added that, certainly, there is increased knowledge and understanding, but the researchers are not necessarily at the point of the project to demonstrate improvements from the increased knowledge.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer expressed that the research team appears to be a very strong team with both the academic and industry partners. The reviewer suggested that the involvement of battery and/or components producers will help the potential transition of the technology to be developed. It was unclear to the reviewer if the industry partners have been involved in the evaluation and characterization of the cathode fabrication process.

Reviewer 2:

The reviewer simply stated that the project was well-coordinated.

Reviewer 3:

The reviewer confirmed that excellent collaboration has occurred in this program. There is involvement with scientists and laboratories that bring good value to the effort.

Reviewer 4:

The reviewer concluded that the collaboration to better understand and solve the VF in layered-layered materials is well-coordinated and well-communicated. The reviewer explained that this project provides concepts to all researchers from which they can build their experiments.

Reviewer 5:

The reviewer noted there was excellent collaboration to solve the VF issue.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer described that the team seemed to be focused on the important issues of stabilization for both the surface and bulk structures of composite electrode materials using Li_2MnO_3 and other precursors. The reviewer also mentioned that the processing route with sonication to prepare the electrodes will be continued in the future work.

Reviewer 2:

The reviewer asserted that the proposed future work was justified and the accomplishments to date suggested that this approach would succeed. The effort was well-planned and thought out.

Reviewer 3:

The reviewer warned that, at some point, the researchers needed to set targets for improvements. But the reviewer agreed that this was good fundamental work and the learnings can be leveraged to many others.

Reviewer 4:

The reviewer suggested that efforts to stabilize both surface and bulk structures of composite electrode materials using Li_2MnO_3 and other precursors for layered oxide versus spinels should be compared to explain the possible future aspects for each of them.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer reported that development of reliable high capacity positive electrode materials with high performance was a critical element for battery advancement and is relevant to the DOE effort of reducing petroleum consumption.

Reviewer 2:

The reviewer agreed that the program's objectives were clearly in line with DOE petroleum displacement objectives, in that it sought to design high capacity, high-power, and low-cost cathodes for PHEVs and EVs.

Reviewer 3:

The reviewer explained that high energy density batteries are required to enable widespread adoption of battery electric vehicles (BEV). The reviewer explained that layered-layered cathode material is one of few options available to meet the desired targets; thus this project provides the fundamental knowledge required to solve the remaining problems for this material.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer claimed that the project resources and funding available seemed to be sufficient for the work

Reviewer 2:

The reviewer felt that the resources were sufficient to achieve the stated goals of the program.

High Capacity, High-voltage Cathode Materials for Lithium-ion Batteries: Arumugam Manthiram (University of Texas at Austin) - es051

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the approach was innovative and that an understanding of the factors controlling the electrochemical performance of the cathodes materials was established to help developing the cathodes. The reviewer felt the surface control appeared to have potential for improving electrochemical performance. It was unclear whether the electrolyte employed in the electrochemical investigation is stable to the developed cathodes and it was suggested to run more charge/discharge cycles with the experimental cell and characterize the capacity decay for polyanion cathodes.

Reviewer 2:

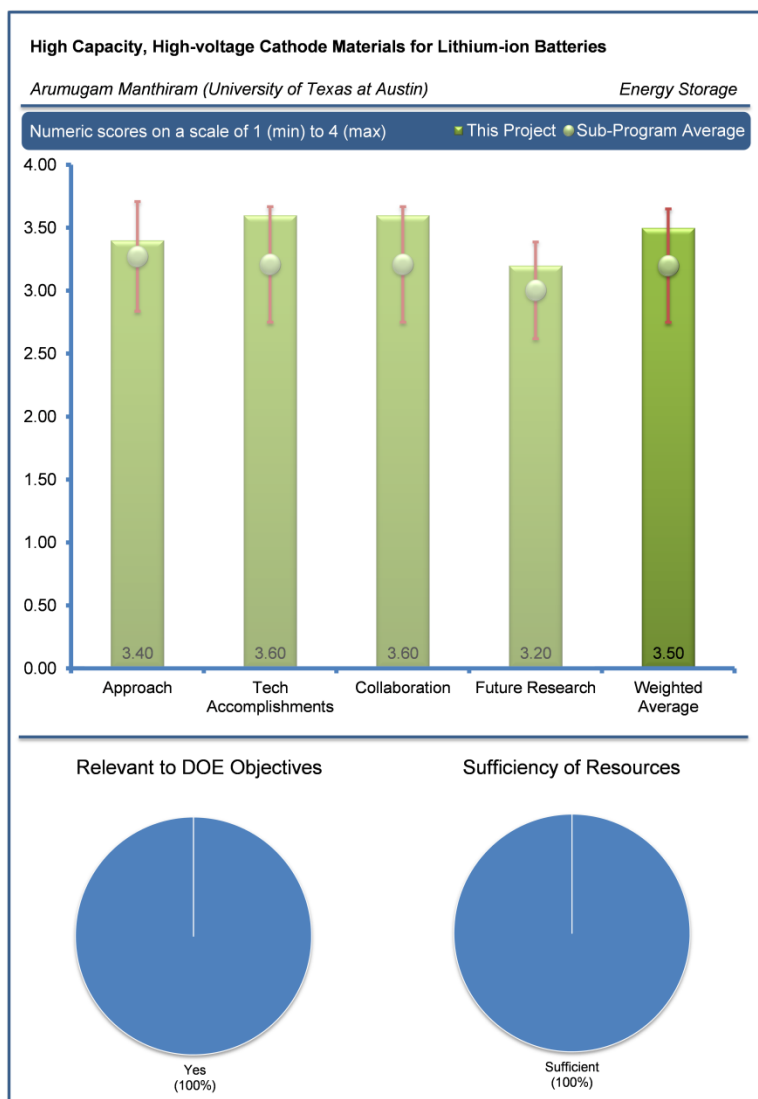
The reviewer simply stated that the approach was good.

Reviewer 3:

The reviewer explained that the program was focused on the technical barriers of cost, cycle life, and energy/power density by developing a fundamental understanding of the factors that control the electrochemical performance of high-voltage spinel and polyanion cathodes. Once this understanding is obtained, the reviewer stated that new cathode materials would be developed. The reviewer felt that this was a good approach towards meeting the need for higher energy density batteries that have good cycle life.

Reviewer 4:

The reviewer was very glad to see supported work on alternative cathode materials and acknowledged that the researchers were exploring a rich variety of materials using a richer variety of synthesis techniques. The reviewer pointed out that these were seed projects to show a proof-of-concept, each of which could then become its own research project. The reviewer suggested that the work could benefit from some calculations/predictions of theoretical energy densities to help focus (although this may not be possible). Also, the reviewer cautioned that the charge capacities for some of these materials were too low, although the discharge looked okay due to the presence of the lithium metal. It was not so clear to this reviewer that this was a kinetic effect. The reviewer asked the researchers what evidence the project team had that all of the lithium incorporated during synthesis was actually in the structure. The reviewer also asked if these materials were phase pure.



Reviewer 5:

The reviewer suggested that the polyanion cathodes that were presented might not be competitive with other high-voltage cathodes on an energy density (Wh/L) or specific energy (Wh/kg) basis, so the reviewer asked the researchers to please compare the energy density of the polyanion cathodes with the other high-voltage cathodes.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer explained that this work encompasses a large number of materials and methods of preparation and has shown good progress on evaluation of many compositions. The reviewer asked whether there is a timeline for prioritizing or ruling out some of the approaches. The reviewer affirmed that the researchers were certainly contributing to the fundamental understanding of these materials; however, this person felt that it was hard to judge the progress towards performance goals since the targets were not quantitative.

Reviewer 2:

The reviewer noted that extensive data, correlating structure, composition and performance was gathered; however it was not clear to this person if the annealing effect at 700°C versus 900°C can solely account for the cation ordering. The reviewer pointed out that manganese spinel is very prone to oxygen non-stoichiometry and noted that Tarascon showed that the oxygen stoichiometry of LiMn_2O_4 spinel can be tuned by annealing at different temperatures.

Reviewer 3:

The reviewer summarized that the factors that influenced the high-voltage spinel cathodes were studied and revealed that particle morphology and surface facets plays a dominant role for their electrochemical properties. The reviewer reported that several polyanion cathodes were synthesized; however, it seemed that the low temperature performance of polyanion cathodes continued to be one of the challenges for potential applications in batteries.

Reviewer 4:

The reviewer explained that a good comparison of several preparation procedures for the synthesis of materials and their cycling behavior was presented. The reviewer asked if the researchers could explain the fact that the truncated Poly 2 shows poor rate capability despite a highly disordered structure and that Poly 2 traditional 900°C is better than 700°C.

Reviewer 5:

The reviewer mentioned that this was the first reporting period for this effort (25% complete) and that the program showed good to fair progress meeting the program objectives. The reviewer stated that the researchers observed that the morphology of the cathode particle plays a dominant role compared to other factors like cation ordering on the electrochemical properties. Some of the observations the researchers pointed to during the discussion, however, have been reported by others. The reviewer also noted that three polymorphs of LiVOPO_4 were synthesized. The reviewer felt that over the time period, this represented good progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer acknowledged that the research team appears to have had some good collaboration with high-voltage cathode and electrolytes developers.

Reviewer 2:

The reviewer simply stated that the project is well-coordinated.

Reviewer 3:

The reviewer confirmed that excellent collaboration has occurred in this program. The reviewer highlighted that the group is working with scientists at the University of Rhode Island, Pacific Northwest National Laboratories (PNNL), Hydro-Quebec, Oak Ridge National Laboratory (ORNL) and DuPont. The reviewer felt that these collaborations should bring value to the effort.

Reviewer 4:

The reviewer expressed that the presenter clearly understood the need for diverse collaborators, from academic to national laboratory to industry, and remarked that it was good to see all of these partners collaborating on the project.

Reviewer 5:

The reviewer was glad to see the collaboration with electrolytes group, to enable the use of these high-voltage spinels

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer simply stated the future research plans used a good approach.

Reviewer 2:

The reviewer explained that the research seemed to be focused on further optimizing the synthesis conditions for polyanion cathodes and developing an understanding of the factors that affect 5V spinel cathodes electrochemical properties. The reviewer cautioned that while the capacity and rate capability as well as cost are the focus of the future work, some progress on capacity decay understanding and prevention may be needed.

Reviewer 3:

The reviewer observed that the PI proposed to continue on their efforts to develop an understanding of the factors that influence the electrochemical performance of high-voltage cathodes. The reviewer stated that the researchers will continue to explore novel synthesis techniques and that the plans are good and are addressing the technical barriers.

Reviewer 4:

The reviewer recommended that the researchers use energy density (Wh/L) and specific energy (Wh/kg) as a guide in their exploration of other polyanion cathodes to see if these are competitive with other high energy density cathodes.

Reviewer 5:

The reviewer suggested that decision points need to be incorporated into the project to help with prioritization going forward. The reviewer asked if there were energy densities high enough given the operating potentials and specific capacities of some of these materials. The reviewer also asked if the researchers could utilize learnings from these first materials and apply them to similar structures with higher voltages and/or capacities.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer summarized that this project addressed the improvement of a key material for increasing tap density, cycle life, energy, and power that were suited for batteries was aligned with goals to reduce dependence on petroleum.

Reviewer 2:

The reviewer confirmed that the program's objectives were clearly in line with DOE objectives of petroleum displacement. The program's targets are long cycle life and high-voltage (4.7V) cathode materials.

Reviewer 3:

The reviewer explained that high energy density materials are required for vehicle electrification and widespread adoption of BEVs, yet there are few cathode materials in development right now. The reviewer remarked that this project is one of few that reaches out to new chemistries.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the funding available for this project appeared to be sufficient for the work.

Reviewer 2:

The reviewer felt that the resources were sufficient to achieve the stated goals of the program.

Design of High Performance, High Energy Cathode Materials: Marca Doeff (Lawrence Berkeley National Laboratory) - es052

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer expressed that the lithium nickel manganese oxide cathode electrode coating with spray pyrolysis method seemed to be interesting, but the reviewer voiced that very limited characterization data on the composite materials was presented. The partial substitution of cobalt with Ti appeared to the reviewer to be effective in increasing NMC cathode capacity, and noted a desire to see further study to reduce the capacity decay. It was unclear to the reviewer if the partial Ti-substitution would benefit to electrode/electrolyte interface stability.

Reviewer 2:

The reviewer felt that the approach seemed to be reasonable.

Reviewer 3:

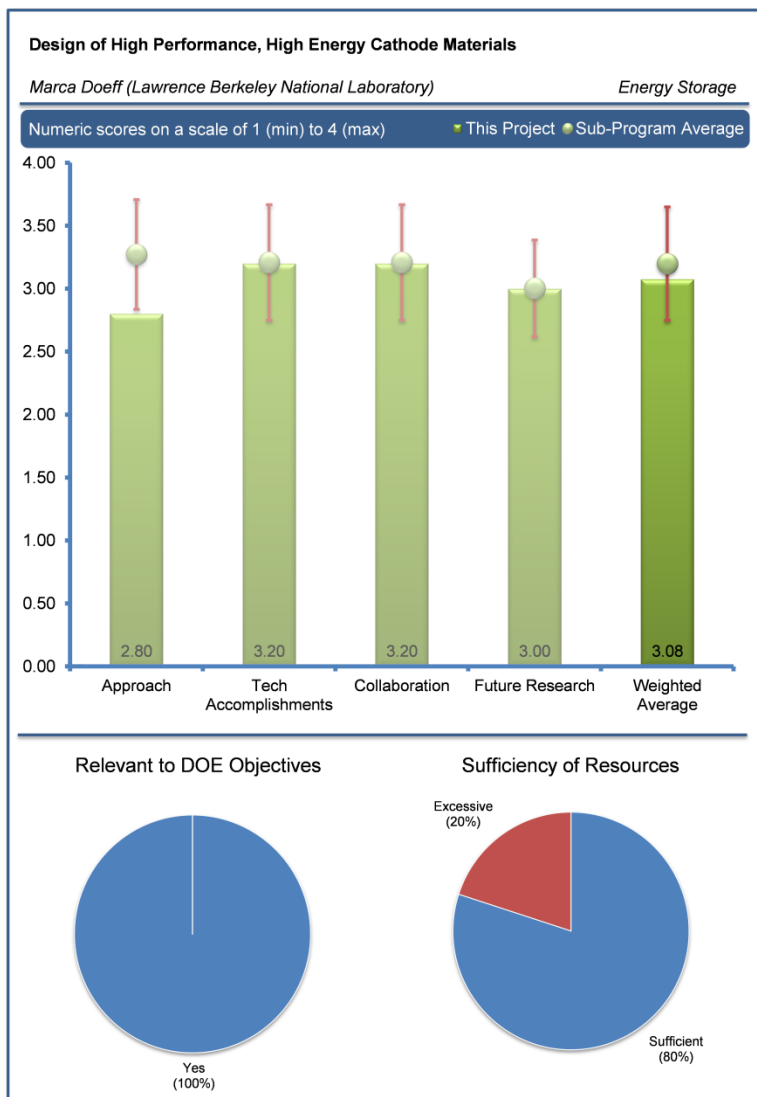
The reviewer explained that the program was developing high energy, affordable cathode materials to address the technology barriers of energy density, cost, and cycle life.

The reviewer expanded that the developed cathode will be a material that is a partial Ti-substitution of the NMC materials. The reviewer also noted that the investigators will also explore spray pyrolysis, and related techniques, to produce coated and composite high-voltage materials. The reviewer concluded by summarizing that the presenter's reasoning and the methods were clearly explained and are reasonable.

Reviewer 4:

The reviewer offered that it was good to see systematic studies on effect of composition and method of synthesis; noting further that the results were quite intriguing. However, the reviewer asked if the researchers are really getting the most out of the data. The reviewer was unable to clearly delineate the effects of synthesis versus composition (e.g., Slide 10-11). The reviewer suggested that the researchers should consider alternative ways to view the results visualization/data mining tools are available, as it is very difficult to compare when multiple variables are being considered. In addition, the reviewer suggested that researchers should look for effects on other properties, such as rate, cycle life as well as interactions, when multiple variables are changed at once.

The reviewer asserted that Ti-substitution is well-documented in the literature, and asked what was being done differently in the presented approach. The reviewer asked if the researchers have tried any of these processes/compositions at a larger scale, and if so, whether the benefits were still observed.



Reviewer 5:

The reviewer stated that the researchers had developed a good alternative approach to the high-voltage composite-layered cathode that possibly would not have a VF issue.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that this project demonstrated considerable progress this year. The reviewer highlighted that Ti-substitution in NMC materials was shown to enhance cell capacity, which the reviewer thought was a possible route to higher energy density cells if thermal stability and cycle life can be maintained.

Reviewer 2:

The reviewer exclaimed that this work encompasses a tremendous number of experiments/results which clearly showed that the research team is highly productive. The reviewer suggested that the researchers should use visualization software to ensure you maximize the return on the data you have.

Reviewer 3:

The reviewer highlighted that there was good progress on the understanding and synthesis of Ti substituted NMC, but suggested that the researchers needed to show more cycle life than 20 cycles.

Reviewer 4:

The reviewer described that the partial Ti-substitution for cobalt in NMCs seems to increase its capacity, but the capacity decay remains to be a challenge. The impact of partial Ti-substitution on discharge/charge rate of the cathodes was not provided in the presentation, so the reviewer supposed that this may be included in the future investigation. The reviewer mentioned that the characterization of the cathodes prepared with the spray pyrolysis method was not provided, suggesting that this approach may bring some breakthrough in preventing the voltage and capacity decay.

Reviewer 5:

The reviewer stated that the technical accomplishments showed a certain level of improvement, but criticized that the accomplishments were not very significant.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that the research team appeared to have had good ongoing collaborations with other National Laboratories and universities by working together to attack the technical barriers.

Reviewer 2:

The reviewer noted that there was good collaboration as a team member.

Reviewer 3:

The reviewer pointed out that good collaboration existed between the PI and other scientists at Lawrence Berkley National Laboratory (LBNL) and at the Stanford Synchrotron Radiation Laboratory.

Reviewer 4:

The reviewer suggested that the researchers try to get some breadth in their collaborations outside of LBNL. The reviewer thought this might bring in additional insights into understanding all the good data the researchers had.

Reviewer 5:

The reviewer asserted that the researchers need to coordinate/collaborate with groups working on the high-voltage electrolytes to enable the use of these Ti-substituted NMC at high voltages.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer described that the future plans were to continue the spray pyrolysis work on the composite electrode and evaluate and characterize the Ti-substituted NMCs. The reviewer noted that the experiments and computational effort towards understanding the origin of the first cycle efficiency improvement is interesting and is included in the future work plan. Overall, the reviewer remarked that the plans seemed to be sound, but suggested that an extension for the evaluation study to a wider temperature range may be useful to further see the effectiveness of Ti-substitution.

Reviewer 2:

The reviewer summarized that work would continue on the Ti-substituted NMCs, but the spray pyrolysis effort will be reduced. The reviewer felt that this was appropriate considering the results thus far.

Reviewer 3:

The reviewer emphasized that the researchers have shown good focus on the best performing materials. The reviewer asked if a thorough literature/patent search has been done on Ti-doped layered oxides. The reviewer cautioned the researchers to be careful to not re-invent the wheel here. The reviewer concluded by asking whether the researchers felt that some work on electrolyte evaluation on these new compositions should be done.

Reviewer 4:

The reviewer agreed with the presenter's emphasis on Ti-substituted NMC, but suggested that the project team might also want to explore Ti-substituted NCA since it has less first cycle irreversible loss than NMC and is denser, albeit less safe, than NMC.

Reviewer 5:

The reviewer asked what systems Ti-substituted NMCs served as a good model for as offered in the presentation. The reviewer pointed out that even though there is an improvement with Ti-substitution in the beginning, it starts to degrade, so the reviewer asserted that the reasons were not clear. The reviewer opined that the following presenter statement was unclear: it is possible that once this understanding is achieved that other routes could lead to higher capacities and better cycling in NMCs without the need for Ti-substitution.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer liked this project a lot, as it strived to get the most out of materials that were already in the marketplace. The reviewer remarked that, with the issues around layered-layered NMC and 5V LNMO, running NMC out to higher voltages was an attractive way to improve energy densities to enable vehicle electrification. The reviewer remarked that if elemental substitution could allow acceptable cycle life at higher voltages, that this was definitely something that should be looked at.

Reviewer 2:

The reviewer described that the project was developing high energy and high performance cathode materials that cost less for advanced batteries and that this was aligned with DOE objectives to reduce dependence on petroleum.

Reviewer 3:

The reviewer explained that the effort is directed toward identifying high energy density cathode materials that have a long cycle life; thus the objectives were clearly in line with DOE objectives of petroleum displacement.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the funding and resources available for this project appeared to be sufficient to conduct the research work.

Reviewer 2:

The reviewer indicated that the resources were sufficient to achieve the stated goals of the program.

Development of High Energy Cathode Materials: Jason Zhang (Pacific Northwest National Laboratory) - es056

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the technical approach towards tuning contents of disordered phase/lattice Mn^{3+} in high energy spinel cathodes by controlling the cooling rate and element substitution appeared to be effective. Understanding on high-voltage spinel has been applied in layered composites. The approach of using electrolyte additives and/or surface treatment may help to reduce the resistance change and capacity drop but the reviewer was not sure if it could help to reduce the voltage decay problems for layered compounds. The approach has not been differentiated from the prior research efforts on LMR-NMC layered compounds in terms of coating and additives.

Reviewer 2:

The reviewer said that the approach was good.

Reviewer 3:

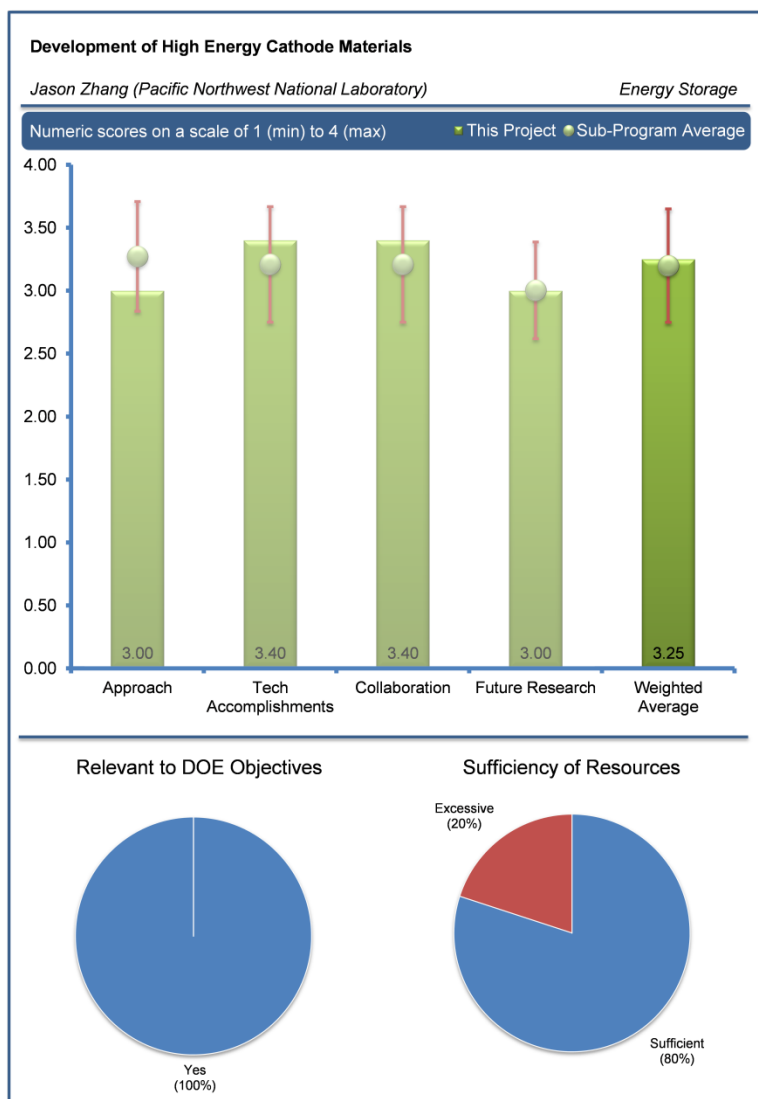
The reviewer observed that the program was addressing the technology barriers toward achieving an affordable, high energy density, long cycle life lithium ion battery. This will be accomplished by systematically investigating high-voltage spinels. The reviewer added that the investigators will improve the performance of lithium-rich, manganese-rich materials.

Reviewer 4:

The reviewer stated that this work provides excellent fundamental understanding of the HV spinel chemistry and asked if it was generally applicable. Some results seemed inconsistent with Professor Manthiram's results with regard to the effect of ordering in the material (C-rate results). In addition, the reviewer added that the project team's attention to the effect of the high voltage on the inactive materials is very valuable and is too often ignored.

The results for the electrolyte additive on VF should be presented using the Argonne protocol. The reviewer believed that the project team said that these results were in progress, so it would be good to get some comparison against the baseline. It was hard to tell with the data presented, if there was a kinetic component or not.

The project team's work on the effect of the cell casings at high voltage was noteworthy. Certainly, for researchers this was an important finding that needed to be communicated. The reviewer asked if anything was learned here that would be applicable for larger cell formats, how 18650 cells might need to change, and if there would be any issues with laminate/prismatic cells.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the high-voltage spinel cathode was systematically investigated and that the obtained information was applied trying to accelerate layered composites development. Electrolyte additives had been identified for potential improvement of Li-rich, Mn-rich layered composite cathodes. The method for cooling rate control was claimed to be used in preparing LMR-NMC cathodes, but corresponding comparison data was not provided.

Reviewer 2:

This reviewer asked what more than previously published $\text{LiNi}_{0.45}\text{Cr}_{0.05}\text{Mn}_{1.5}\text{O}_4$ composition was learned and if Cr was environmentally acceptable.

Reviewer 3:

The reviewer observed that the program demonstrated considerable progress this year. The investigators systematically investigated high-voltage spinel cathodes for Li-ion batteries and a new electrolyte additive was identified to mitigate the continuous side reaction on the electrode/electrolyte interface at high voltages.

Reviewer 4:

This reviewer noted that the researchers were making progress, but that the objectives were not quantitative. In addition, the researchers do not give a perspective on the electrolyte additives. The reviewer asked if it was necessary to test hundreds of additives to get one that worked, and if the one presented was novel or suggested from the literature.

Reviewer 5:

This reviewer felt that there was good data on correlating the performance of the high V spinel with oxygen stoichiometry. The reviewer suggested that the project team might want to cite the work by Tarascon on the effect of oxygen stoichiometry on spinel's performance. The project team's data on Li_2MnO_3 was also significant. It showed that Li_2MnO_3 transformed structurally when fully delithiated and may not be effective in stabilizing the Li Mn rich composite cathode.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that excellent collaboration exists in this program. The PI is collaborating with The State University of New York (SUNY) Binghamton, Argonne, Brookhaven, Hydro-Quebec, U.S. Army Research Lab and University of Rhode Island.

Reviewer 2:

This reviewer observed that the project had good collaboration with industry, academia, and national laboratories. The reviewer would like to make sure there was more collaboration than just supply of materials. The reviewer thought that this was a very strong team for which interactions would drive the project faster.

Reviewer 3:

The reviewer indicated that the research team appeared to have had collaborations with industry, universities, and national laboratories. However, it was unclear what roles of those collaborators played for the research.

Reviewer 4:

This reviewer said that the project needed to collaborate with other groups working on the voltage sag issue in the Lithium Manganese Rich (LMR) cathode.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer thought that understanding the voltage decay mechanism appeared to be a good plan. Future plans also included continuing the electrolyte additives development, investigating electrode/electrolyte interface, and direct synthesis of the stable cathode structures. It is suggested the PNNL team work more closely with the Argonne research team to use the information that Argonne team has learned on LMR-NMR. It appears the Argonne team claimed that additives and coating will not help to reduce the voltage decay.

Reviewer 2:

The reviewer felt that the future work proposed is good. The investigators will continue to understand the capacity degradation and voltage fading mechanism of Li and Mn rich cathode materials. They will then move on to electrolyte additive development.

Reviewer 3:

This reviewer asked what the specific plans for the capacity degradation and voltage fading mechanism of Li-Mn-rich layered composite cathode was.

Reviewer 4:

The reviewer noted that there are no decision points in the future plans. Clearly, the future work builds on what has already been done, but the reviewer asked how the project team would prioritize in the future.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer noted that the development of high energy cathode materials is the key to improving battery energy density for potential EV/ HEV applications and that it is aligned with DOE goals to reduce dependence on petroleum.

Reviewer 2:

The reviewer observed that the program's objectives were clearly in line with DOE objectives of petroleum displacement. It seeks to design high capacity, high-power and low-cost cathodes

Reviewer 3:

The reviewer felt that solving the remaining problems with the layered-layered material will ensure a good high energy cathode material for vehicle electrification. This is essential to widespread adoption of BEVs.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer thought that the funding and sources available for this project appeared to be sufficient to conduct the proposed study.

Reviewer 2:

This reviewer stated that the resources were sufficient to achieve the stated goals of the program.

Inexpensive, Nonfluorinated (or Partially Fluorinated) Anions for Lithium Salts and Ionic Liquids for Lithium Battery Electrolytes: Wesley Henderson (North Carolina State University) - es057

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer summarized that the project is directed at developing new electrolyte systems with additives leading to lower cost and higher performance. The reviewer exclaimed that the availability of Drs. M. Armand and Smart are significant additions to the strength and scope of the project. The reviewer remarked that success in this area is essential to significantly improve battery storage capability in advanced battery systems.

Reviewer 2:

The reviewer applauded that the researchers had a terrific approach to the design of better electrolyte diagnostics and to understanding why solvents behave as solvents do.

Reviewer 3:

The reviewer felt that the approach was fine.

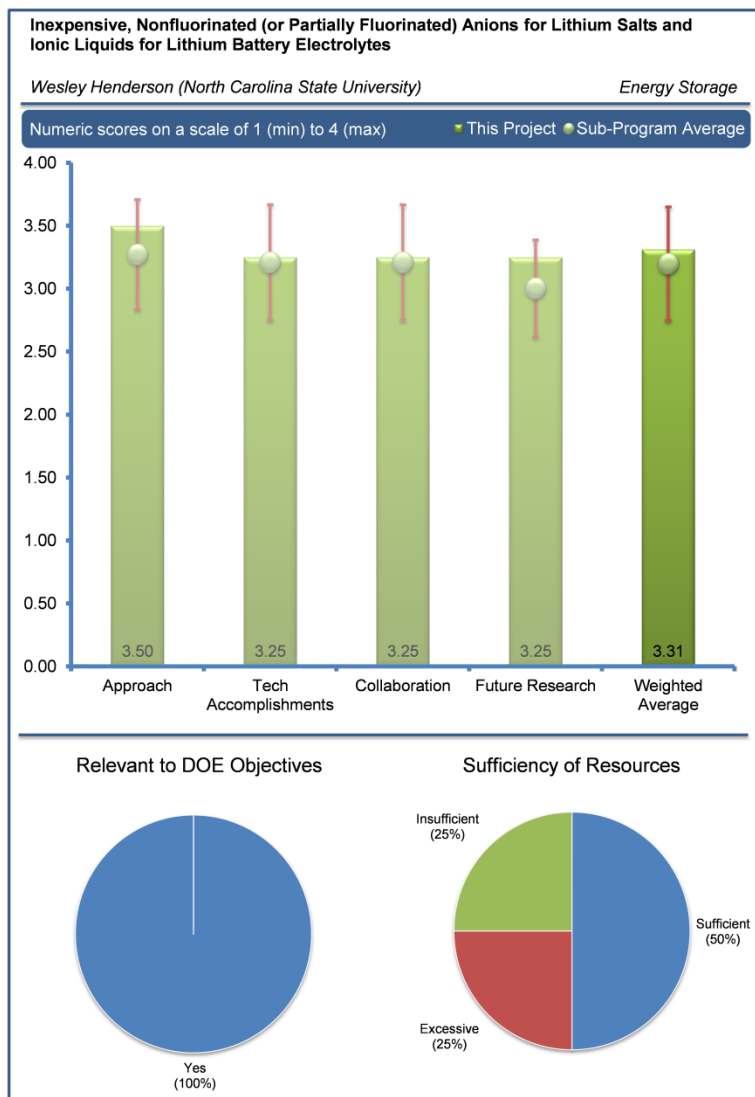
Reviewer 4:

The reviewer felt that the approach to determine the properties of battery electrolytes was very good. The reviewer, however, criticized that the approach to evaluating newly discovered electrolytes, including concentrated electrolytes, has not had a very practical outlook. The reviewer believed that a more serious consideration of cost perspectives, as well as performance in actual cells, should have been more prominent in the approach.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer highlighted that excellent progress was made in identifying new electrolytes. As a base, the project established the base of present LiBF₄, LiDFOB and LiBOB with cyclic carbonates used in present electrolytes and compared to the properties in ester gamma butyrolactone and GVL. The reviewer also reported that a new electrolyte based on LiTDI was identified and full characterization is underway. Also, new electrolytes based on LiTFSI-EC mixtures with high concentrations of lithium salt showed good promise in the reviewer's opinion.



Reviewer 2:

The reviewer explained that the technical accomplishments were good, as a number of new electrolyte types as well as the studies of more concentrated electrolytes as replacement for LiPF_6 have shown promise. However, the reviewer reported that, no indication of cell performance was presented.

Reviewer 3:

The reviewer asserted that the researchers have served the community well by creating phase diagrams and publishing valuable information about solvation numbers.

Reviewer 4:

The reviewer stated that ionic liquids have to be reconsidered for Li-ion batteries.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer acknowledged the excellent collaboration with Oleg Borodin. The reviewer indicated that lots of all the right people were involved.

Reviewer 2:

The reviewer summarized that the collaborations included: O. Borodin for quantum chemical calculations and molecular dynamics simulations; Bryant Polzin (ANL) for graphite anodes and cathodes used in testing LiTDI electrolytes; Marshall Smart for testing guidance and concentrated electrolyte guidance; Vincent Battaglia provided cathodes for testing; Steve Greenbaum (NYU) for NMR measurements; and Daniel Abraham for special electrolytes.

Reviewer 3:

The reviewer commented that the absence of cell testing was one of the points lacking in the approach and results. The reviewer felt that this could have been accomplished in collaborative studies, and recommends that this be included in any future plans.

Reviewer 4:

The reviewer asked who in the team was testing and expressed interests for the ionic liquid-based battery.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the future research would determine the properties of these electrolytes.

Reviewer 2:

The reviewer stated that this project was one of the few efforts the reviewer was aware of where researchers were using state-of-the-art technologies to predict how to make better electrolytes.

Reviewer 3:

The reviewer noted that no proposed future plans were presented.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that new high-performance electrolytes with good voltage range were essential for success in developing high performance Li-ion systems with superior energy storage capability.

Reviewer 2:

The reviewer simply stated that better electrolytes were the core to improved batteries.

Reviewer 3:

The reviewer explained that the relevance to DOE's goals would have been greatly assisted by more cell data.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer felt that the resources were adequate, but suggested that additional funding would accelerate new developments in this critical technology area.

Reviewer 2:

The reviewer suggested that the PI should develop some expertise in cell testing as well as the required equipment.

Nanoscale Heterostructures and Thermoplastic Resin Binders: Novel Lithium-Ion Anodes: Prashant Kumta (University of Pittsburgh) - es061

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

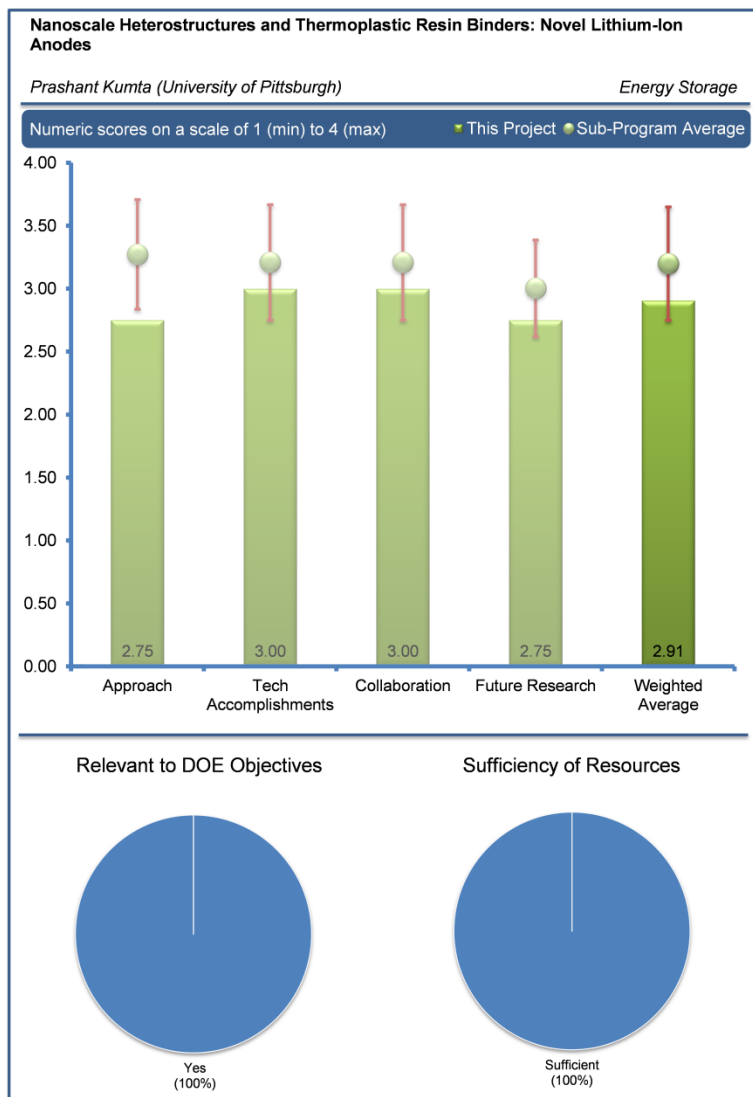
The reviewer described that this project has brought some interesting methods of preparation of silicon-based materials. The reviewer thought that many of the results were promising, but to date, none has solved all of the problems of Si. The best results, according to this reviewer, would appear to be with Si carbon composite with improved binder. The reviewer appreciated the listing of columbic efficiency as well as first cycle irreversible loss, loading and reversible capacity with the curves. The reviewer suggested that it would be desirable if all alloy field workers would adopt this practice. While some may argue that the composites do not give extremely high capacity, the reviewer felt that the order of 800-1000 mAh/g is sufficient to make a big improvement in the anode. The reviewer explained that this would enable the anode coating thickness to be reduced by a factor of two, which would result in considerably higher cell energy density. The reviewer also thought it was intriguing that chemical vapor deposition of Si gives good performance when done properly.

Reviewer 2:

The reviewer summarized that this program is attempting to address the technical barriers by identifying new alternative nanostructured anode materials that will provide higher gravimetric and volumetric energy density. To accomplish this, the reviewer explained that microcrystalline, nano-crystalline, nanoparticle and amorphous silicon-based anode materials will be investigated. The reviewer thought that this approach could improve the specific capacity, and hence available energy, of a Li-ion battery. The reviewer also mentioned that the program will identify new elastomeric thermoplastic binders that may prevent delamination.

Reviewer 3:

The reviewer said that while this appeared to be a very complete approach to the development of a Si-based anode via multiple pathways, the reviewer wanted to know if these were really practical. The reviewer acknowledged that these may be, but would like to see this question addressed. The reviewer went on to ask whether carbon nanotube composites were cost-effective. The reviewer also asked if the deposition of the interface control additive via ion/e-beam deposition was scalable and economical. The reviewer asked whether the researchers could make higher loadings/thicker films. The reviewer did like the high-energy milling approach with etching to get pure silicon, and suggested that this may be more practical. The reviewer asked whether the researchers had specific



ideas on how to improve the first cycle efficiency. The reviewer felt that the more holistic approach to the development of a silicon/binder system was beneficial.

Reviewer 4:

The reviewer indicated that the researcher needed to clearly state the impact of the amorphous versus nanocrystalline Si approaches and that researcher needed to show how the various synthesis approaches would be down-selected.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer described that this project had seen steady progress and uncovered several methods of creating stabilized silicon which could give good cycling and high columbic efficiency. Many of these methods appeared to this reviewer to be scalable and capable of low-cost production. The reviewer asserted that the use of reasonable loadings for the electrodes was important, as it leads more quickly to decision making regarding the various preparation methods.

Reviewer 2:

The reviewer pointed out that good progress had been achieved. The reviewer mentioned that several milestones were met during 2012, including: an improved cycling stability using an interface control agent for carbon nanotubes (CNT)/Si heterostructures; and the development of a scalable method for making hollow Si nanostructures that display high capacity.

Reviewer 3:

The reviewer observed that there has been a lot of work on this project, and that the project's overall goals are to explore a variety of approaches to the development of silicon anodes. The reviewer thought it would have been helpful to have a simple, clear table listing all of the approaches and the resulting performances. The reviewer asked whether fair comparisons are being made. The reviewer asked whether there is a clear winner in the approaches. The reviewer asked when/where will the project start to focus down on the most promising approaches. The reviewer also reported that the high-strength binder is interesting and suggested that post-mortem work should be done to validate if it really is high-strength, or not. The reviewer suggested that there may be chemical reasons why improved performance was observed.

Reviewer 4:

The reviewer cautioned that all of the presenter's good performance data was based on very low Si loading. The reviewer recommended that the researcher needed to demonstrate good cycle life at a loading level that was practical for high energy Li-ion cells to be relevant.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer voiced that it was good to see the involvement of Ford Motor Company and national laboratories in collaboration with the PI. The reviewer highlighted that customers can have a great impact on program direction.

Reviewer 2:

The reviewer noted that the program has good collaboration with other scientists and engineers. Specifically, the reviewer mentioned that the PI is collaborating with two members at his university (University of Pittsburgh) as well as Ford Motor Company, the National Energy Technology Laboratory (NETL), and LBNL.

Reviewer 3:

The reviewer suggested that this work might benefit from broader collaboration. The reviewer agreed that the researchers have some unique skills in the synthesis area; however this person thought that working closer with others might help focus the project on the most promising outcomes. The reviewer added that simply providing samples to another institution may not be enough collaboration.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the proposed future research was justified on data obtained this year and was well-reasoned.

Reviewer 2:

The reviewer was happy to see the testing of full cells planned for the coming FY. The reviewer pointed out that in some cases, cycling is surprisingly improved in the presence of a cathode material, but in other cases it is worsened; the only way to find out the reasons is to try various cathodes with the test anode materials. The reviewer hoped that the alloy group will develop a protocol for full cell testing so that the results are comparable between workers.

Reviewer 3:

The reviewer thought it was fine to start a program on trying many different approaches; however the next step needs to focus down on a couple approaches. The reviewer remarked that the researchers talk about low cost a lot, but asked where the process economics are to back up this claim.

Reviewer 4:

The reviewer recommended that the researcher needs to demonstrate that he can achieve good cycle life at higher loading levels of greater than 5 mAh/cm².

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer observed that this work was clearly relevant to DOE objectives. The reviewer explained that the possible energy density gain was substantial and the material cost was low. The reviewer emphasized that workers must be careful to maintain low processing costs in addition.

Reviewer 2:

The reviewer agreed that the program's objectives were clearly in line with DOE petroleum displacement objectives. The reviewer explained that the project sought to address the low specific energy and poor cycle life of present batteries and the high cost of the raw materials.

Reviewer 3:

The reviewer affirmed that the development of high energy anode and cathode materials is required for widespread adoption of BEVs. The reviewer confirmed that this project can provide approaches to successful high energy anode materials.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer felt that the funding required was sufficient to complete the objectives.

Metal-Based, High-Capacity Lithium-Ion Anodes: Stanley Whittingham (Binghamton University-SUNY) - es063

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that this was a well thought out project and that Dr. Whittingham continued to convey the reasoning behind the proposed work in a logical, clear manner. The reviewer summarized that the project sought to increase the volumetric capacity of the anode by a factor of two and to increase the gravimetric capacity of the anode to over 500 Ah/kg. To do this, the PI placed an emphasis on low-cost materials such as tin and silicon, both of which were wise choices, according to the reviewer. The reviewer noted that the investigators recognized that the side reactions with the nano-tin may be a problem and were taking steps to prevent this. The reviewer also offered that safety was being addressed and that the researchers were exploring methods to minimize dendritic growth of lithium during charge.

Reviewer 2:

The reviewer agreed that work on both silicon and silicon alternatives were important to achieve target energy densities to enable practical BEVs, and the researchers demonstrated a variety of techniques to prepare potential materials. The reviewer thought this should mitigate the risk that nothing will work. The reviewer highlighted that it was good to see the go/no-go decisions on each approach to focus down the project. The reviewer particularly liked the emphasis on cost reduction through low-cost starting materials or processing. The reviewer, however, questioned the premise that Si (or Si alternatives) would be safer than carbon-based materials. The reviewer explained that while there was ample evidence to show that carbon/graphite was not good for safety, the project team asked whether there were any large format data on batteries to quantify a safety improvement with Si or tin; or if it was only hypothesized.

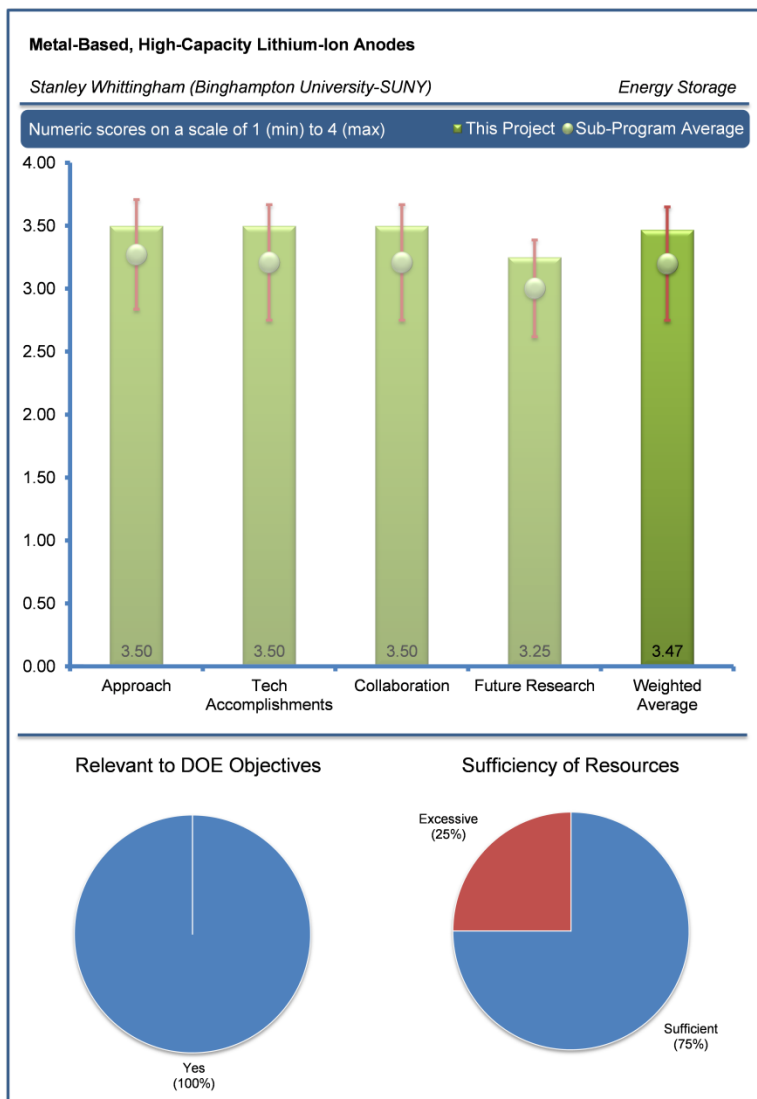
Reviewer 3:

The reviewer stated that the Sn_2Fe approach is promising.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer pointed out that this project was initiated in January 2011 and is 50% complete. The reviewer felt that excellent progress had been made toward achieving the goals. The reviewer commented that the limitation to the electrochemical behavior of



mechanochemical Sn has been determined and the electrochemistry of a new nano-silicon material was determined. The reviewer also mentioned that the reaction mechanism of the nano-Sn-Fe-C system was also determined. The reviewer remarked that this continued progress indicates that the project should be able to demonstrate continued progress in the future.

Reviewer 2:

The reviewer stated that Sn_2Fe showed better performance than SnCoC .

Reviewer 3:

The reviewer confirmed that good progress was demonstrated versus the project milestones. The reviewer indicated that the presentation may have been misunderstood, but it looked like some of the best performance (e.g., high capacity, stable cycle life, and good rate) was demonstrated by the SMOG material. The reviewer observed that the 2013 slide is the same as 2012, and asked why more work has not been done on this approach, especially since it looked encouraging.

Reviewer 4:

The reviewer explained that for a given cathode, a summary table comparing the Wh/L, Wh/kg, first cycle irreversibility and volume change of nano- Sn_2Fe versus nano-Si would have been very useful.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer expressed that outstanding collaboration and coordination was occurring in this project. The reviewer highlighted that Dr. Whittingham is collaborating with several national laboratories, the New York Battery and Energy Storage Technology Consortium, as well as a local company (Primet Precision Materials).

Reviewer 2:

The reviewer indicated that it was nice to see involvement with a small company (Primet Precision Materials).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future work proposed was very good and includes optimizing the synthesis methods (both mechanochemical and solvothermal) of the promising nano- Sn_2Fe material.

Reviewer 2:

The reviewer asked if the researcher had go/no go targets/timelines for the next year; explaining that this was an excellent approach to focus the project which the reviewer hoped would continue. The reviewer suggested that development of nano-silicon from low-cost Al-Si alloy should be emphasized because it looked promising, and would enable a robust supply chain.

Reviewer 3:

The reviewer indicated that the researcher needed to propose more specifics on how the project team planned to reduce first cycle irreversibility in nano-Si.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the program's objectives were clearly in line with DOE objectives of petroleum displacement. The reviewer explained that increasing the volumetric capacity of the anode by a factor of two would increase the cell energy density by up to 50%, which would lower the cost of tomorrow's batteries.

Reviewer 2:

The reviewer explained that the development of both high energy density cathodes and anodes was required for development and subsequent adoption of BEVs in the United States. The reviewer pointed out that despite much effort, silicon anodes were not ready; this project takes a multi-pronged approach to materials and processes and can focus down on which provide target performance and which can be made practically and economically.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer felt the resources were sufficient to perform the stated work in a timely fashion

Electrolytes - Advanced Electrolyte and Electrolyte Additives: Khalil Amine (Argonne National Laboratory) - es066

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer applauded the excellent approach and terrific collaborations.

Reviewer 2:

The reviewer agreed that the approach was good.

Reviewer 3:

The reviewer agreed that the approach was good, but felt that it could be improved with more attention to the properties of the additives after exposure to the cell environment, particularly after cycling. Also, the reviewer felt that in the case of MA, that it appeared that a good additive had been identified for 55°C cycling in the chosen cell, but no other comparisons were made so that the effects on room temperature and low-temperature cycling were not known. Also, the reviewer pointed out the effect on the abuse tolerance barrier was not determined. It was not clear to the reviewer what cell type was used for testing and how reproducible the tests were. The reviewer cautioned that this was very important for additive testing where the effects may be small under certain conditions. In this reviewer's experience, the performance of the standard electrolyte was surprisingly poor in the case of graphite NMC cell cycling tests at 55°C, which brings into question the test accuracy. The reviewer suggested that, for high-voltage electrolytes, the use of abuse testing might be of considerable importance.

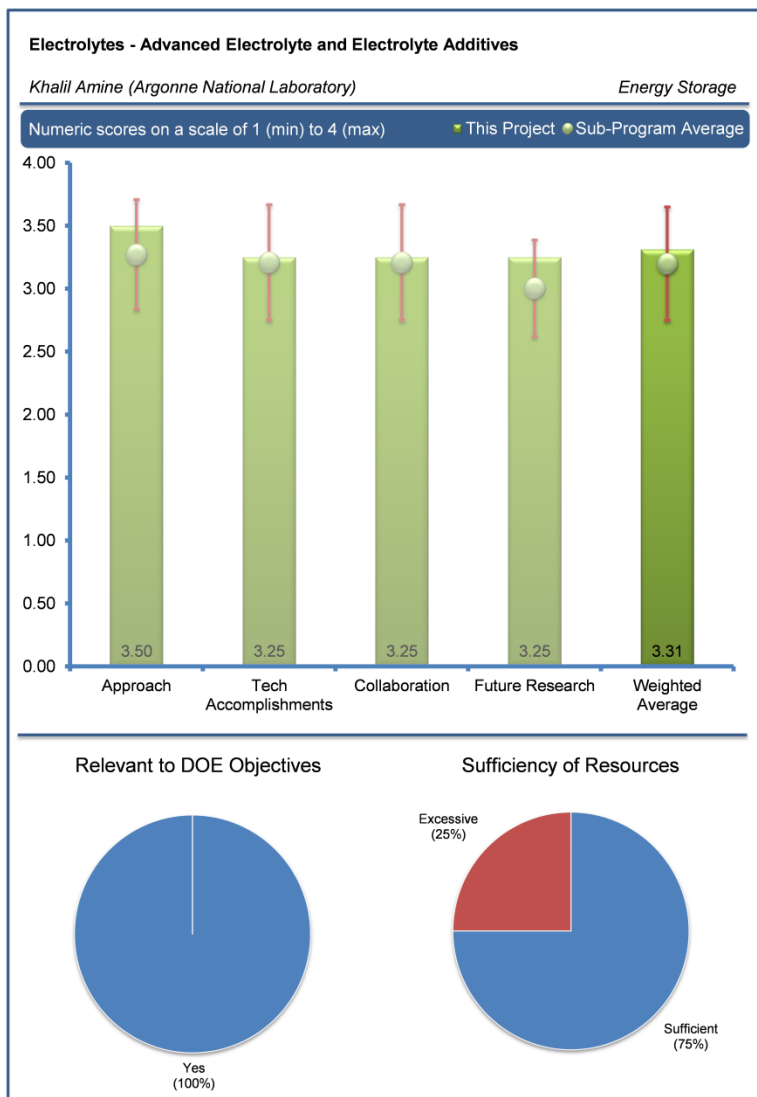
Reviewer 4:

The reviewer stated that the researchers hypothesized that additives that polymerize at greater than 2 volts made better solid/electrolyte interface/interphase (SEI) films. However, the reviewer saw no special justification for this assumption.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that it was encouraging that additives were identified for improved SEI formation, and that fluorinated solvents were identified for high-voltage cells since the last year. The reviewer would like to see more comprehensive testing in both of these areas.



Reviewer 2:

The reviewer pointed out that the researchers' calculations served as screens, but the reviewer's sense was that finding species that were reduced at +1 or +2 volts above lithium was not a very difficult task. The reviewer did not see what sort of failure mechanism the project team had; that is, the reviewer wanted to know how SEI properties related to improved performance. Overall, the reviewer summarized that the improvement was fair.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer acknowledged excellent collaborations with leaders in the field.

Reviewer 2:

The reviewer simply stated that the collaborations were adequate.

Reviewer 3:

The reviewer claimed the PIs do not indicate how collaborations occurred in the program, although it was noted that there were collaborators.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

In addition to the stated work on SEI formers and redox materials, the reviewer would like to see the high-voltage work continued, as this was needed for spinel materials as well as lithium rich materials. The reviewer would also like to see a larger group of tests be conducted on new, and existing, materials.

Reviewer 2:

The reviewer reinforced that new electrolytes are essential to the continued improvement of Li-ion battery performance. The reviewer described that the search has included a quantum mechanical screening of new electrolytes and the composition of the SEI film formation. The reviewer explained that once the film formation on the anode is understood, new electrolytes can be identified by quantum mechanical calculations, which will expedite the development of new electrolytes.

Reviewer 3:

The reviewer indicated that the future plans included improved modeling of decomposition reaction pathways leading to SEI formation, but asked that the researchers explain the improved modeling.

Reviewer 4:

The reviewer would have appreciated seeing a greater effort in understanding how and why the additives worked.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer affirmed that electrolyte solvents are a major barrier to further progress in Li-ion batteries.

Reviewer 2:

The reviewer voiced that electrolyte development is core to the program.

Reviewer 3:

The reviewer commented that improved Li-ion battery performance is essential to the success of the battery power electric vehicles; longer range and lower cost are essentials.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer explained that the PI is a careful worker, and one of few that have industrial experience. This reviewer agreed that sufficient resources are available to carry out the proposed work, but thought additional resources would speed the work and offer the opportunity to expand exploration so suggested that DOE may want to consider increasing the funding on this project. The reviewer highlights that the new Envia Systems battery system uses the new Si anode developed in the researcher's laboratory.

Reviewer 2:

The reviewer reported that the resources were extensive (but not excessive) for the task; thus, expectations should be especially high for this project.

Development of Electrolytes for Lithium-ion Batteries: Brett Lucht (University of Rhode Island) - es067

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that the approach is very well-focused on the cycle life barrier, although the abuse barrier and calendar life barrier are not discussed. The reviewer acknowledged that it is difficult to address the calendar life barrier in a program of this magnitude and time, but noted that the accelerated aging test was found to be quite useful. The reviewer was happy to see cycling at different rates and temperatures to get a better feel for the efficacy of the additives and electrolyte composition.

Reviewer 2:

The reviewer noted that the work is a continuation of the work to develop new high performance electrolytes for Li-ion batteries based on LiPF₆/methyl butyrate-based (MB) electrolytes.

Reviewer 3:

The reviewer stated that standard approaches to get improved performance, with some calculations to help along, were being used. The reviewer also mentioned that studying electrode surfaces after use is good.

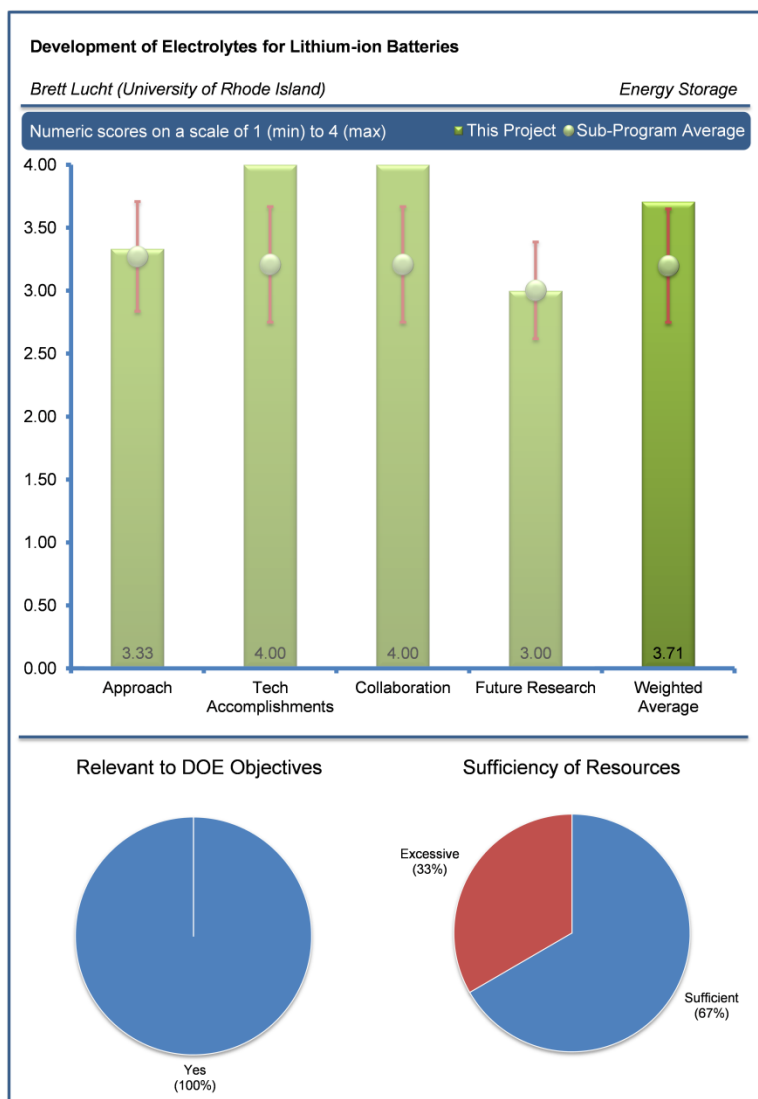
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer acknowledged that the program had some successes in the past year; in particular, the additive to the standard electrolyte for high-voltage cells showed considerable promise. The reviewer suggested that the evaluation of accelerated aging along with impedance and XPS studies would be valuable to apply to this situation. The reviewer also emphasized that the lowering of manganese transfer from cathode to anode is an important finding.

Reviewer 2:

The reviewer reported that an understanding of the role of electrolytes in capacity fade and cycling efficiency has been developed. The reviewer explained that new electrolyte formulations to decrease capacity fade and improve operating efficiency have been identified. The reviewer also mentioned that a new electrolyte to improve cycling and lower capacity fade has been designed/identified and proven.



Reviewer 3:

The reviewer commented that Lewis base additives improved performance, but asked whether this depended on how much water has leaked in. In real cells, maybe very little water leaks in, so the reviewer was not convinced one way or another whether this is important. The reviewer pointed out that LiFOP gives films with high impedance, so the performance is not very good. The reviewer criticized that insufficient effort to decide whether changes in SEI should be good or bad, rather than just being different. The reviewer also noted that the thickness changes were only semi-quantitative. The reviewer agreed that building half-cells out of used full cells is a good thing to do, but was not novel. The reviewer was unsure what new was learned in the program, other than testing some new materials. The reviewer also reported that delamination was observed in some cases, but it was not clear whether the electrolyte was responsible. In general, the reviewer did not feel that much new was learned.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer highlighted that the collaborations are well-handled by the PI, as the laboratory is set up for electrolyte property studies, it was necessary to find groups willing to do timely cell construction and evaluation.

Reviewer 2:

The reviewer summarized that the collaborations are comprised of leaders in the field including: D. Abraham (ANL); M. Smart [National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL)]; V. Battaglia (LBNL); J. Kerr (LBNL); A. Garsuch (BASF); F. Puglia (Yardney); and the LBL Spinel Focus Group.

Reviewer 3:

The reviewer affirmed that all the right people and organizations were on-board.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the future work proposed was on a solid basis and it was hoped that the new additive, and others developed, would prove generally useful.

Reviewer 2:

The reviewer summarized that the future work includes: developing an understanding of the role of electrolyte when cycling at higher temperature; additives for film formation; new electrolytes for Si anodes; and a mechanistic understanding of limiting reactions of electrolytes in Li-ion batteries. The reviewer also noted that the plans include synthesizing and characterizing new electrolyte combinations to reduce capacity fade on cycling.

Reviewer 3:

The reviewer did not have the sense that there was a novel future direction in mind.

Reviewer 4:

The reviewer asked what kind of improved cathode film forming additives for graphite/ $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$ cells to improve cycling performance at 55°C would be developed.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer explained that the work was very relevant, as the high-voltage cathode is definitely limited by available electrolytes.

Reviewer 2:

The reviewer commented that the need for longer cycle life and higher performance electrolytes in high performance anode and cathode systems is essential to meet the requirements for use of Li-ion batteries in transportation.

Reviewer 3:

The reviewer expressed that improved electrolytes are a core to the program.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer agreed that, with the good collaborations in place, the resources were seen as sufficient.

Reviewer 2:

The reviewer confirmed that the funding was the right order of magnitude for the proposed work.

Bifunctional Electrolytes for Lithium-ion Batteries: Daniel Scherson (Case Western Reserve University) - es068

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

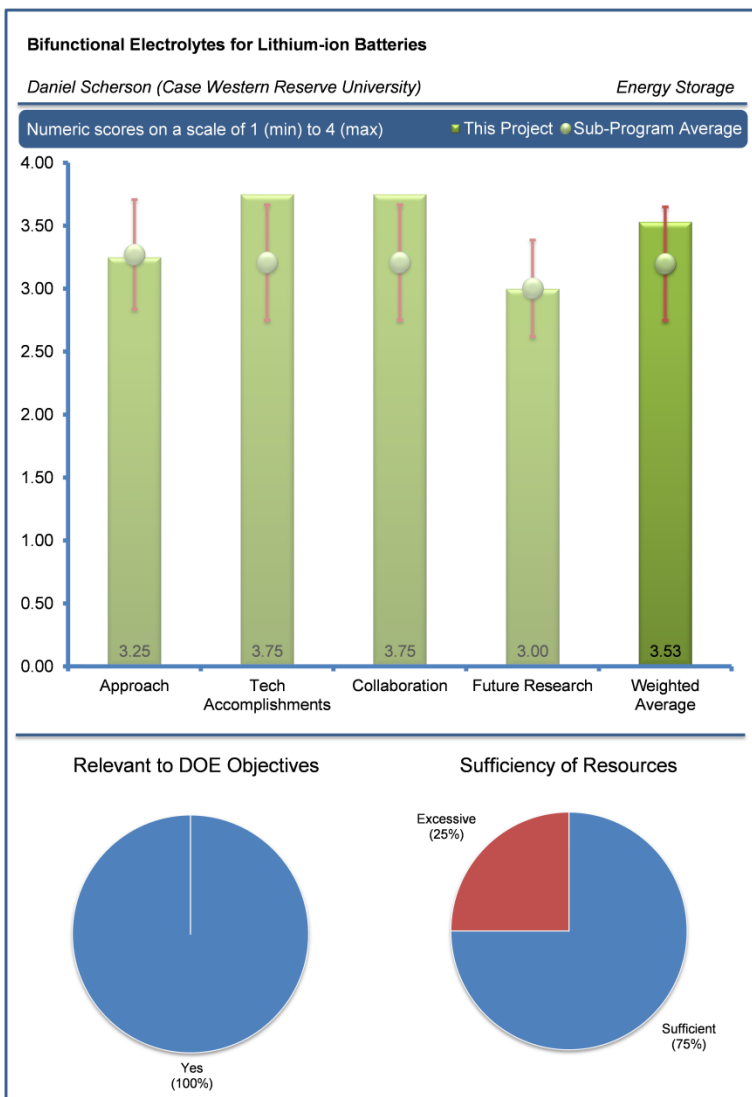
The reviewer explained that the approach was to identify and develop new fire retardant Li-ion based electrolytes based on boron and phosphorus. Specifically the project developed structure functionality to guide the development of new flame retardant electrolyte ions (FRION) electrolytes with increased abuse tolerance and then identify and develop new low-cost high performance electrolytes for Li-ion batteries.

Reviewer 2:

The reviewer described that the approach focused on developing novel lithium salts containing flame retardant functional groups, such as with boron and phosphorus moieties, to impart additional flame retardant properties to the electrolytes and thus make the Li-ion cells intrinsically safer. The reviewer explained that the approach is to design and synthesize such FRIONS and assess their compatibility with Li-ion anodes using both electrochemical and in-situ spectroscopic techniques. This understanding, according to the reviewer, will lead to further refining the salts to achieve the desired stability as well as abuse tolerance. The reviewer agreed that the approach looks interesting and felt that it can lead to new safer salts for Li-ion cells. However, the reviewer cautioned that, probably guided by solubility and/or compatibility restrictions, these FRIONS are being used in fairly low proportions (1%), such that the FRIONS may not have any noticeable impact on flame retardancy (or safety). The reviewer surmised that low solubility may be one limiting factor, as was also highlighted by another reviewer (and not answered satisfactorily). The reviewer thought that even with much higher proportions, some of the known flame retardant additives have not prevented thermal runaway in some of the abuse tests. On the other hand, the reviewer pointed out that these salts, in such low proportions, may have more significant effect on the interfacial properties of the electrodes, like LiBOB, vinylene carbonate (VC), etc.

Reviewer 3:

The reviewer explained that the project's scope was to design, synthesize, and characterize flame-resistant salts, which was a very ambitious idea. Incorporating flame retardant chemical groups to anions in lithium salts was also a good idea. The reviewer added that the researchers were aware of how trace impurities were very important. The reviewer noted that a lot of work has preceded this project's research into resistance to burning, and asked whether the project would result in new results.



Reviewer 4:

The reviewer simply stated that the approach was good.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed that several flame retardant electrolyte ions (FRIONS) based on boron and phosphorous compounds had been developed and characterized.

Reviewer 2:

The reviewer indicated that good progress has been made in the design, synthesis and evaluation of a couple of FRION salts; specifically, two new salts, lithium [B(DPC)₂], lithium [B(DPC)(oxalato)], and several LiCRBR salts were synthesized from inexpensive, commercially-available materials and were characterized using a wide array of spectroscopic techniques. The reviewer explained that these salts have been demonstrated to have high thermal stability and also good electro-chemical compatibility, when added to the conventional electrolytes. Further in order to understand the compatibility with battery electrolytes, the reviewer recounted that an in-situ spectro-electrochemical cell has been designed and constructed for performing in-situ Attenuated Total Reflectance (ATR)- Fourier Transform Infrared Spectroscopy (FTIR) measurements of highly reactive systems. Finally, the reviewer reported that gram-quantities of these samples have been sent to DOE laboratories (ANL and LBNL) for their assessment. Overall the reviewer felt that the progress was good, but suggested that the non-flammability of the electrolyte solutions containing only 1-2% of the flame retardant salt is questionable.

Reviewer 3:

The reviewer observed that new materials were synthesized, building the flame resistance into the salt. The reviewer thought that this was a very neat idea, but cautioned that lots of phosphorous compounds have been tried before, and asked the researchers if there were any reasons to expect different results here. The reviewer also liked the spectroscopy work.

Reviewer 4:

The reviewer indicated that not much improvement was observed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer asserted that collaborating with organizations that are experts in flammability is critical.

Reviewer 2:

The reviewer noted that the flammability of the new electrolytes were tested by Dr. Morgan at Dayton University and that Novolyte (a U.S.-based electrolyte developer), LBNL, and ANL carried out cell testing of the new electrolytes.

Reviewer 3:

The reviewer reported that there are several useful collaborations with industry and universities. Additionally, collaborations with the DOE laboratories have recently begun for the material assessment.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the future plans continue to build a knowledge base of new electrolytes with abuse tolerance and excellent performance in battery operation.

Reviewer 2:

The reviewer felt that the researchers have identified the right path forward.

Reviewer 3:

The reviewer summarized that future studies involve continuing efforts to design, synthesize and characterize new FRIONs and similar safety-enhancing bi-functional materials, and utilize in-situ ATR-FTIR to understand the reactions between the FRION salts and the lithium anode in conventional battery electrolytes, with and without these new salts.

Reviewer 4:

The reviewer remarked that the PI must explain what kind of new approach for design, synthesis, purification, and full characterization of FRIONs and other safety enhancing bi-functional materials will be used.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer reinforced that Li-ion batteries must have greater resistance to their tendency to erupt in fire. As a result, new electrolytes must be available for the next generation of higher performance vehicle batteries. The reviewer explained that this project offers excellent promise and is directed by experienced investigators. The reviewer noted that the early work has already identified several promising electrolyte compositions.

Reviewer 2:

The reviewer explained that Li-ion cells are not tolerant to electrical, thermal, or mechanical abuse, which may lead to thermal runaway. Various mitigation strategies are adopted such as battery management with cell-voltage controls, thermal management with active cooling, and mechanical containment systems for anti-intrusion. In lieu of these extraneous measures, it is better to have an inherently safe Li-ion battery less prone to thermal runaway. The reviewer pointed out that non-flammable electrolytes are being sought in various forms with ionic liquids or with the addition of a flame retardant additive. The present project is developing bi-functional electrolytes, where the flame retardant component is embedded into the electrolytes (as salt). As a result, the reviewer reported that the improvement in safety, as being addressed here, is crucial to the widespread use of Li-ion batteries for PHEVs and EVs.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that the budget of \$200,000 per year was consistent with the scope of the project.

Reviewer 2:

The reviewer commented that the resources were adequate for the present proposed work, but suggested that the funding should be expanded to assure success in this important area. The reviewer highlighted that higher capacity was the driving force of previous electrolyte development, but flammability would be essential to enhance the success for future applications.

Novel and Optimized Materials Phases for High Energy Density Batteries: Jordi Cabana (Lawrence Berkeley National Laboratory) - es070

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the researchers used a good mix of materials synthesis and characterization to determine the electrochemical properties related to ordering in LiNiMnO_4 .

Reviewer 2:

The reviewer noted that the researchers used a good approach in correlating the performance with structure/composition and working with a modeling group, such as Cedar, to explore new high energy materials.

Reviewer 3:

The reviewer summarized that the project was directed towards: understanding the correlation between the $\text{LiNi}_{1/2}\text{Mn}_{3/2}\text{O}_4$ structural properties and electrochemical performance; and synthesizing new Li-M-O-F materials for increased cell voltage and capacity. The reviewer added that this approach may also increase cell safety; for example, fluorine substitution of the $\text{LiNi}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3}\text{O}_2$ material showed improved thermal stability (Kim, 2005).

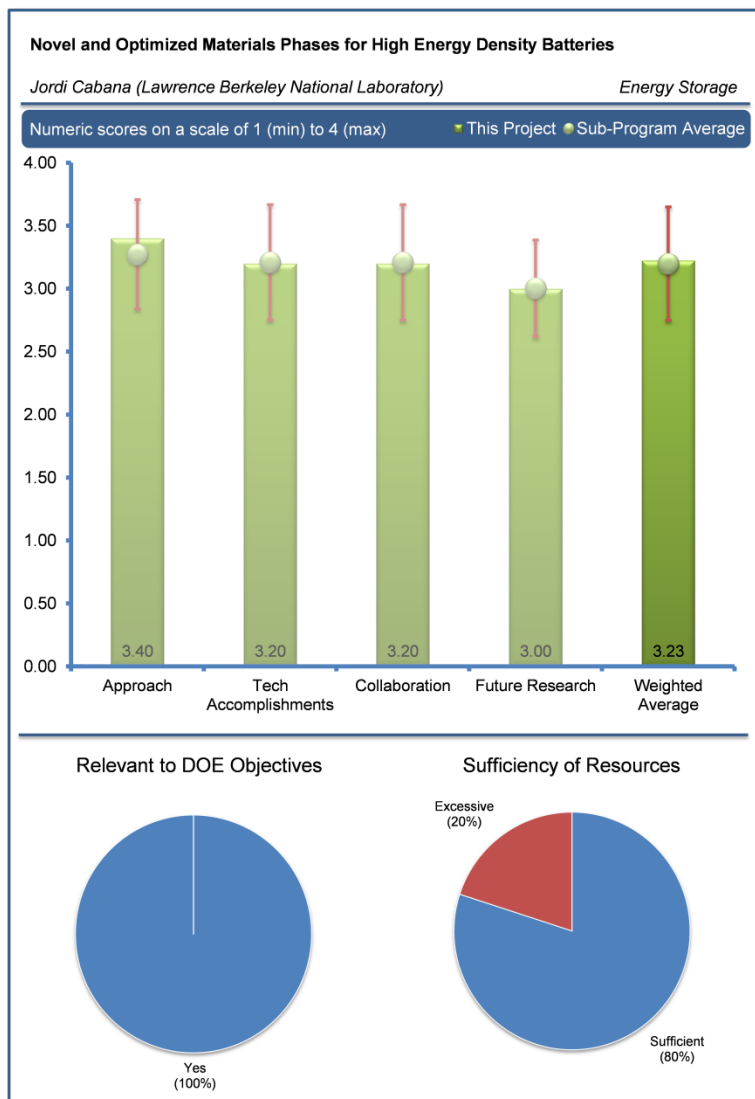
Reviewer 4:

The reviewer reported that the researchers used good hypotheses and well-designed experiments in this project. The reviewer thought that the work on LMOF compositions builds upon a lot of literature on fluorine substituted materials and may yield novel materials with improved stability. The reviewer highlighted that there is also good fundamental knowledge coming from innovative ways to look at the electrochemistry of the LNMO material. Overall, the reviewer indicated that this project is an excellent blend of synthesis, evaluation, and characterization work.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer explained that the program demonstrated fair progress this past year. The reviewer detailed that the investigators completed the crystal and chemical characterization of $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$ and that good information was obtained in the annealing study about a material that the PI describes as having a rich crystal-chemistry. The correlation between electrochemical performance and the



increasing disorder driven by an extended solid region was also shown. The Li-M-O-F cathode search for materials with substantial amounts of F was initiated.

Reviewer 2:

The reviewer affirmed that the work on correlating structure with electrochemistry is very interesting, and certainly builds the knowledge base. It appears other goals are on target, but the reviewer wished they were more quantitative.

Reviewer 3:

The reviewer mentioned that the work showed a stronger relation between ordering and performance than Mn^{3+} concentration, as well as a determination of the surface chemical/oxidation and effect of fluorine.

Reviewer 4:

The reviewer noted that the manganese-based spinels are known for its oxygen non-stoichiometry, and that when annealing under different atmospheres, one also needs to correlate the oxygen non-stoichiometry in the spinel with the manganese and nickel oxidation states.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the PI is demonstrating good collaboration with other groups that can enhance the investigation, including members within the Batteries for Advanced Transportation Technologies (BATT) program as well as from groups in Spain and France. Additionally, the reviewer stated the presenter noted efforts on partnering with Drs. Wang and Looney at BNL to screen the phase diagrams using in-situ synchrotron XRD.

Reviewer 2:

The reviewer asserted that the project includes a nice group of collaborators. The reviewer particularly liked the spinel focus group, suggesting that this should serve as a model for other technology/chemistry areas.

Reviewer 3:

The reviewer simply stated that the researchers were working with others in BATT and other groups.

Reviewer 4:

The reviewer indicated that the researchers are working with high-voltage spinel, and identified a need to collaborate with researchers working on high-voltage electrolytes.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the PI's planned future work is a logical extension of the work conducted this year. The reviewer asserted that the plans are sound with efforts shifting attention from understanding the $\text{LiNi}_{1/2}\text{Mn}_{3/2}\text{O}_4$ material's bulk effects to obtaining an in-depth understanding of the surface-electrolyte reactions. The reviewer also mentioned the PI will continue to explore Li-M-O-F in collaboration with the BATT computational teams. The reviewer asserted that prior computational studies by others have been highly successful in accelerating the material discovery and design process, so there is every reason to believe that this method will help here too.

Reviewer 2:

The reviewer asked the researchers to please add some decision points to their future work and whether there are certain targets the researchers want the LMOF work to reach. The reviewer also asked how the researchers will know if they are, or are not, successful.

Reviewer 3:

The reviewer agreed that the approach of focusing on surface effects is appropriate for continuation of project results to date.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer agreed that this project is relevant as it seeks to understand the correlation between the cathode material chemistry and structural properties with electrode performance. The reviewer asserted that such information is critical if DOE is to meet the battery energy density, cost, and cycle life goals.

Reviewer 2:

The reviewer commented that high energy density materials are required for vehicle electrification and widespread adoption of BEVs, yet that there are few cathode materials in development right now. The reviewer explained that this project is one of few that reaches out to new chemistries with the LMOF work. In addition, the reviewer noted that the high-voltage material is a good candidate with remaining challenges addressed by this project.

Reviewer 3:

The reviewer stated that the project contributes to the understanding of advanced cathodes for EVs.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer explained that the FY 2013 budget was \$450,000, which should be sufficient to complete the planned effort.

Interfacial Processes - Advanced Diagnostics: Robert Kostecki (Lawrence Berkeley National Laboratory) - es085

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed use of in-situ and ex-situ Raman, Fluorescence, FTIR, and electrochemical cell charge-discharge operations to characterize $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$ single crystals.

Reviewer 2:

The reviewer agreed that the approach is excellent.

Reviewer 3:

The reviewer expressed that the project showed excellent work developing in-situ methods to look at SEI formation, which is a critical issue with current organic electrolytes.

Reviewer 4:

The reviewer described that there was good use of in-situ and ex-situ spectroscopy techniques to understand the SEI on high-voltage cathodes.

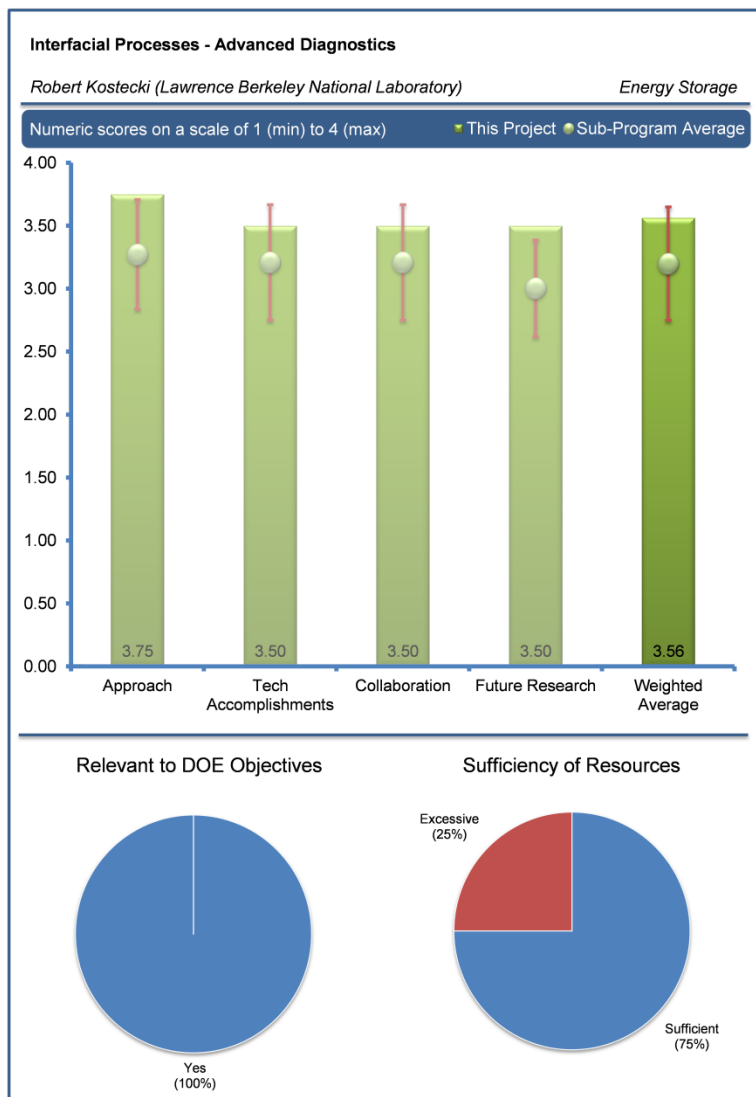
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer mentioned that the project developed new experimental techniques and methodologies to improve Li-ion performance. The reviewer also reported that the project determined that insoluble electrolyte decomposition products accumulate and form electronic and ionic barriers in cathodes which contribute to lowering cell performance. The reviewer also summarized the project finding that manganese and nickel dissolution were identified and the products migrating to the anode interfere with its normal operation. Finally, the reviewer reported that insoluble electrolyte decomposition products form resistive barriers and interfere with normal electrode operation and give rise to an impedance increase in the cell.

Reviewer 2:

The reviewer commented that significant progress has been achieved in identifying organic compounds and M-O vibrational states on the cathode surfaces.



Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer indicated that collaborations with the BATT Task Groups and industrial partners were in place to improve Li-ion cell performance and understanding.

Reviewer 2:

The reviewer noted that extensive collaborations with a number of groups were mentioned.

Reviewer 3:

The reviewer would have liked to see collaboration with groups working on high-voltage electrolytes so that the project team can leverage the insight on the SEI from this effort to design high-voltage electrolytes.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer described that the approach will apply the novel experimental tools developed in the first stage to develop improved Li-ion cell performance.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer explained that a basic understanding of the chemistry and materials is essential in the design and development of improved cell performance.

Reviewer 2:

The reviewer agreed that the project contributed to an understanding of advanced cathodes for EVs.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer felt that the project resources were adequate.

Development of Polymer Electrolytes for Advanced Lithium Batteries: Nitash Balsara (Lawrence Berkeley National Laboratory) - es088

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer acknowledged that this is an unquestionably difficult project as the requirement is for continuous electron and ion paths within the electrodes and continuous ion paths in the separator. The reviewer explained that the use of block copolymers only provides continuous ion paths within the electrodes, and then only if the conductive block is continuous with sufficient area of contact throughout to provide adequate ion conductivity. The electron network must be provided by a sufficient amount of electron conductive material. The reviewer noted that the authors have made such structures, but it was not clear to the reviewer that enough studies have been done using blocking and ion conductive electrodes to measure the capability of both paths in a systematic way.

Reviewer 2:

The reviewer summarized that the project involved developing a new process for: the preparation of nanoporous polymer separators; evaluating the effect of nanostructured electrolytes on dendrite formation; and developing a binder with anion and electronic conductivity.

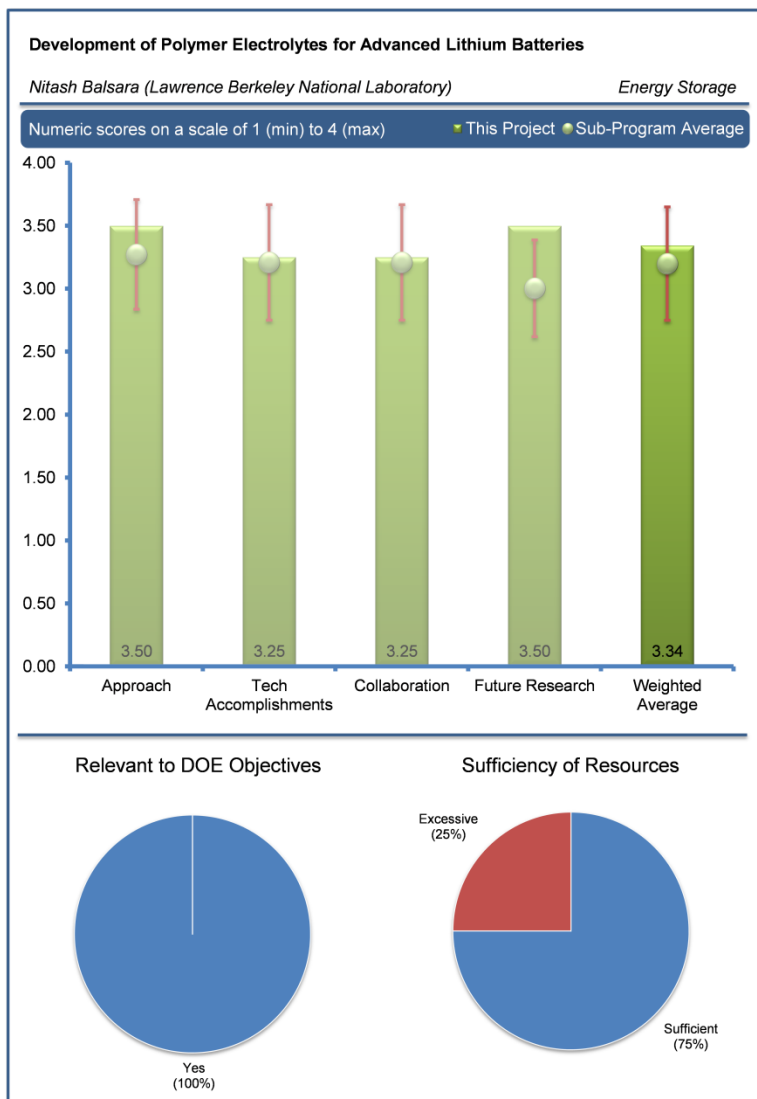
Reviewer 3:

The reviewer noted that specific barriers were identified, but criticized that the presentation was weak on quantitative data at the full cell level. Generally the reviewer felt the project was well-focused and that the overall approach in different areas was good with work being done by different students, with the PI providing general direction and serving as the representative to the BATT program.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer summarized that the project's accomplishments included: developing a process for preparation of self-assembled separators based on block copolymers; developing a cost-effective process for making nanoporous separator films; developing a binder that conducts ions and electrons; developing an iron phosphate - lithium metal cell with a polymer electrolyte; and developing a new concept for Li-S cells based on solid polymer electrolyte with ORNL.



Reviewer 2:

The reviewer agreed that the developments were good and indicated that most barriers appeared to have been overcome. The reviewer also noted that different work areas were represented by different students working for the PI on different projects, which resulted in a less than optimum integration.

Reviewer 3:

The reviewer offered that the block networked electrode still needs systematic work. Very little full cell data was reported, so it was not clear to the reviewer what the usefulness of the electron/ion conductive polymer blends will be. It was also not clear to the reviewer what effect the new separator material will have on safety or what is the cost saving potential. The reviewer asserted that these are important next steps, but the project seems to be ending without addressing them. The reviewer suggested that collaboration with a separator company would have been valuable in this respect and the reviewer recommended discussion within DOE to address this issue; otherwise, the work will probably not receive a fair test.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated there was more than adequate and relevant collaboration.

Reviewer 2:

The reviewer simply noted the collaboration with Vince Battaglia (LBNL VT program) and Nancy Dudney (ORNL).

Reviewer 3:

The reviewer explained that the collaboration with a spin-off company was fine for the block copolymer work, but criticized that there was a lack of collaboration in the other areas of separator development and redox polymer work.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

It seemed to the reviewer that the Li-S work was important for the future and the reviewer was happy to see the collaboration with ORNL which seemed to be a leader in this area. The reviewer, however, felt that it would be important to set up some collaboration with interested industrial partners in this area.

Reviewer 2:

The reviewer noted that the present project is ending, and the new program with BATT is focused on developing an all solid-state Li-S cell.

Reviewer 3:

The reviewer mentioned that the plans for work on Li-S system are of interest. However, the reviewer cautioned that there have already been many workers in this area, and asked what was new in this project.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer affirmed that this work is highly relevant to future high energy advanced batteries, as it supports a future all electric economy with important technology for the transportation sector.

Reviewer 2:

The reviewer stated that the project was in line with DOE objectives.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer felt that sufficient resources were available for the project at this stage.

Reviewer 2:

The reviewer observed that this program was nearly complete and it appeared to have made good use of its resources on a number of different technical topics.

Interfacial and Bulk Properties and Stability: John Kerr (Lawrence Berkeley National Laboratory) - es089

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer simply stated that the approach was good.

Reviewer 2:

The reviewer observed that single ion conductors yield greater coulombic capacity (Ah) and eliminate concentration polarization from cell operation.

Reviewer 3:

The reviewer suggested that integration of some results to the cell level, either by modeling or tests of prototype cell builds with testing, would make results more appreciated by others. The reviewer also suggested that time line charts of progress on specific quantitative goals chosen by the BATT team would also be helpful.

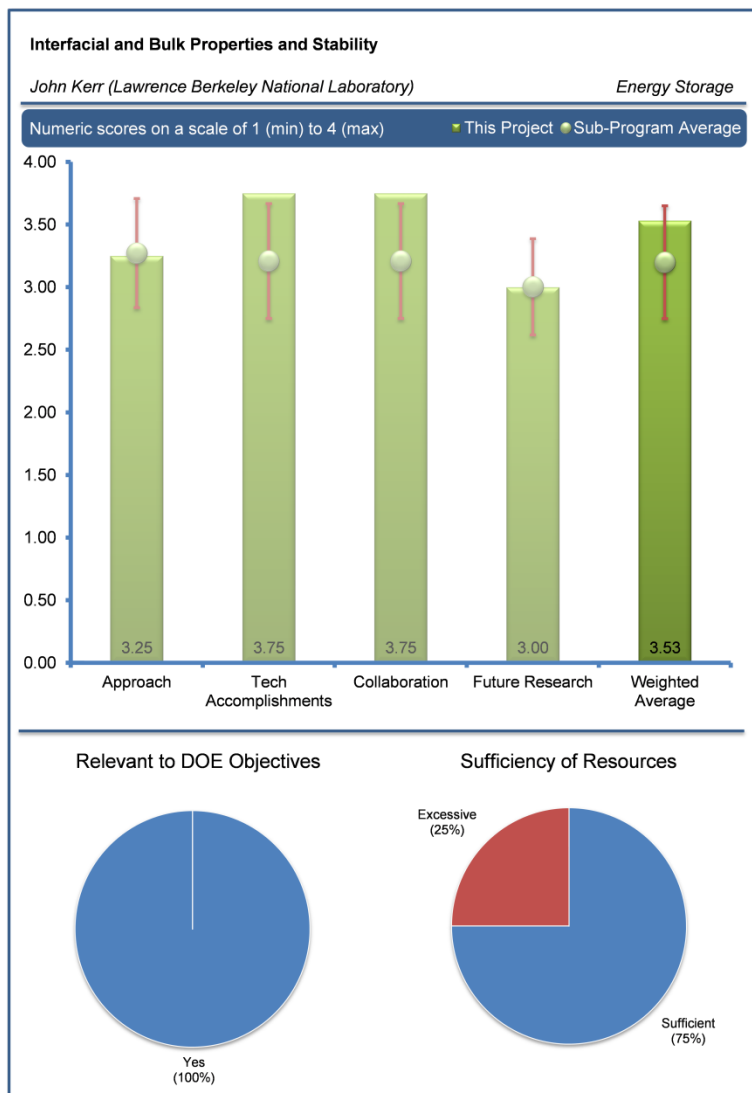
Reviewer 4:

The reviewer expressed that it would be difficult for this polymer electrolyte project to succeed. The reviewer added that the approach to date has shown definite progress, but high interfacial impedance has been a definite stumbling block. At this point, the reviewer cautioned that it does not seem to be known which interfaces are the largest contributors to impedance, and the reviewer would like to see some work directed to this area. The reviewer suggested that the project may be to the point of needing surface active agents as interfacial intermediates.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer highlighted that the project has come a long way and has now shown the feasibility of single ion conducting (SIC) electrolytes with actual battery materials. The reviewer explained that this has required substantial innovative chemical work to adapt a commercial polymer to yield a single ion conductor. The reviewer voiced that considerable work needs to be done to make a practical device, not to mention a competitive one, with existing electrolytes. It was not clear to the reviewer that the solvent additives may weaken the polymer structure to the extent that lithium dendrites may occur and result in battery shorting. It was somewhat disturbing to the reviewer that ether additives have a higher lithium impedance than carbonates. The reviewer suggested that perhaps tetraethylene glycol dimethyl ether was not the best choice for ether additive, since it may have more OH groups than cyclic ethers and yield a higher impedance.



Reviewer 2:

The reviewer commented that the project established that single ion conductors give higher performance in Li-ion cells and that cells with a single solid-state electrolyte single ion conductor give good performance.

Reviewer 3:

The reviewer simply noted that the technical accomplishments are good for the work performed.

Reviewer 4:

The reviewer had difficulty in determining from the presentation exactly what the key quantitative goals were and what the progress towards them was. Also, the reviewer felt it was difficult to tell on numerous collaborators where the responsibility lies, with the BATT or collaborative teams.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated that it seemed that there were a number of good collaborations in the project. The reviewer offered that it is important that as many people in the polymer field share the information to advance the field as a whole as it requires a lot of innovation to complete a practical cell.

Reviewer 2:

The reviewer listed the collaborations included: JPL, ABR, Los Alamos National Laboratory (LANL), Energy Research, and PHI Inc. The reviewer also noted the parallel work to the Office of Fuel Cell Technologies as well as Grant Smith (University of Utah), LANL, PHI Inc., Energy Frontier Research Center, and Center for Electrocatalysis, Transport Phenomena, and Materials.

Reviewer 3:

The reviewer commented that numerous relevant collaborative activities were noted and appreciated.

Reviewer 4:

The reviewer simply stated that there was good collaboration.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer confirmed that the need for work on reducing interfacial impedance is clearly evident; however, it was not clear what the approach would be.

Reviewer 2:

The reviewer indicated that future plans will continue on the present direction with synthesis of polyelectrolyte materials, characterization of new materials developed in the project including lithium metal anodes, composite cathodes, and determination of the composition of the SEI.

Reviewer 3:

The reviewer indicated that the proposed future work is a very logical extension of the current work towards achieving the overall goals. The reviewer mentioned that the PI noted that the project will conclude this year and asked if someone else in BATT will take over this work.

Reviewer 4:

The reviewer expressed that the continuation of TFSI and fluoroalkylsulfonate LiMDFB anions attached to both polyether and polysulfone backbones with a range of equivalent weights was okay, but cautioned that a strategy for decreasing the interfacial resistance was missing.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer agreed that this work was clearly relevant to DOE goals; a lithium metal battery could greatly enhance energy density if it has a high current efficiency on the negative electrode.

Reviewer 2:

The reviewer commented that a new single ion conductor electrolyte will significantly improve Li-ion cell performance.

Reviewer 3:

The reviewer acknowledged that this work supported the overall use of EVs to displace petroleum use with all electric transportation technology.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer simply stated that the resources were adequate.

Reviewer 2:

The reviewer indicated that adequate resources were devoted to this project and the single ion conductor technology option.

In-Situ Electron Microscopy of Electrical Energy Storage Materials: Ray Unocic (Oak Ridge National Laboratory) - es095

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer summarized that the work describes another detailed in-situ technique that can be accomplished in real-time. The detailed structural information possible is very good according to the reviewer. For some specialized problems like SEI growth, the reviewer questioned whether the PI was actually measuring representative SEI growth since the spatial development of the SEI was not at all typical of other findings. The reviewer asked whether it was possible that the method of measurement perturbed the situation to change the in-situ nature of the observations.

Reviewer 2:

The reviewer summarized that the project is developing a means to study the effects of nanostructured materials relating to performance and capacity loss on cycling, electrode degradation mechanisms, and safety. The reviewer also described that an in-situ liquid electrochemical cell using scanning transmission electron microscopy spectroscopy was developed to study the SEI layer on anodes. The project also accomplished a chemical analysis using Electron Energy Loss Spectroscopy (EELS) to study electrode surface changes on cycling of electrode structures.

Reviewer 3:

The reviewer mentioned that the project is developing in-situ techniques to evaluate SEI formation which is critical with current organic electrolytes.

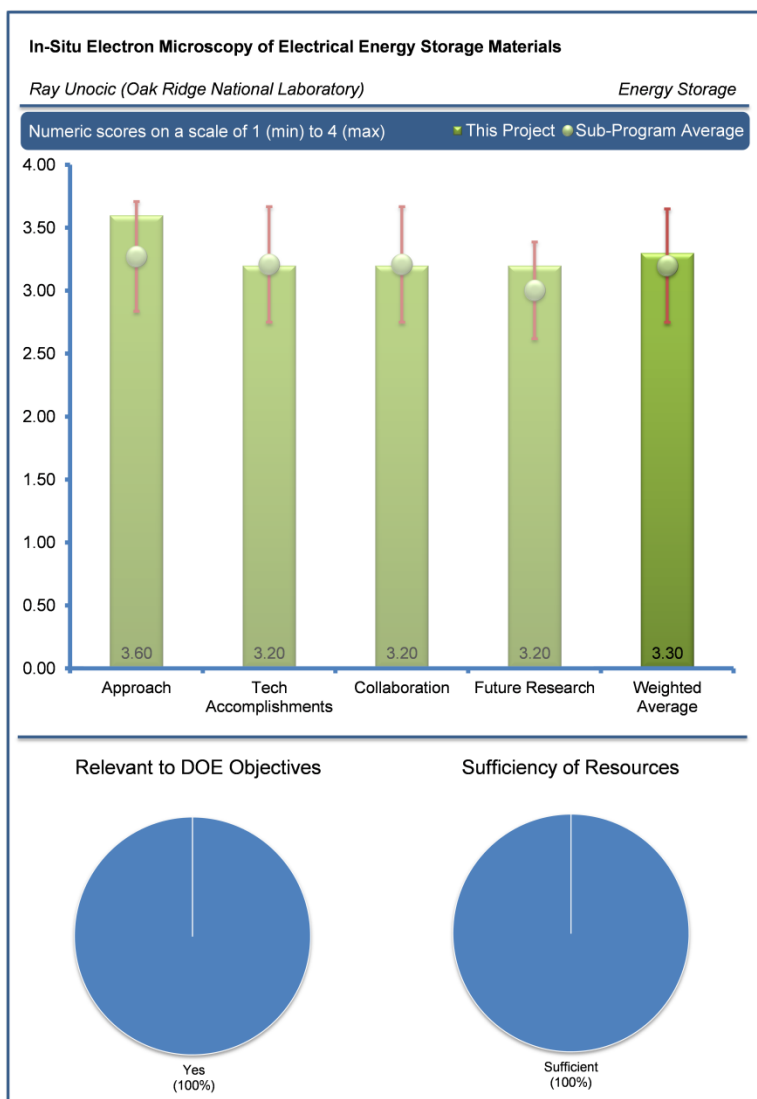
Reviewer 4:

The reviewer highlighted that in-situ transmission electron microscopy is a very useful tool for understanding the SEI growth mechanism on electrode material particles. However, the reviewer cautioned that this approach might miss the interaction with other components of the electrode such as the carbon additive that can contribute to the SEI growth mechanism.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that so far, a small set of results have been obtained, but acknowledged that the main advance has been in development of the technique itself, which appears to have made considerable progress.



Reviewer 2:

The reviewer indicated that the researchers developed the experimental tools for in-situ liquid cell microscopy technique and demonstrated the ability to conduct in-situ chemical analysis with Energy Dispersive X-ray Spectroscopy (EDS)-EELS.

Reviewer 3:

The reviewer pointed out that the manganese dissolution mechanism will be challenging.

Reviewer 4:

The reviewer confirmed that the developed technique was able to observe growth, but noted that it was less sensitive to composition than others in program.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer observed that collaborations were in place with the University of Texas at Austin, ANL, ORNL, and the GM Global Research and Development Center.

Reviewer 2:

The reviewer explained that now that the technique is well along towards development it would be useful to collaborate with structural and preparative material scientists to see what the technique can disclose about their materials and structures.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the future research will continue studies with different electrolytes, capacity fading on cycling, and dendrite growth mechanisms.

Reviewer 2:

The reviewer observed that each of the future plan projects would benefit from including collaboration with a material scientist with expertise in the particular area.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer agreed that the work was relevant in offering a method to help solve battery problems.

Reviewer 2:

The reviewer indicated that understanding the degradation mechanisms of Li-ion cathodes will lead to improved high performance materials.

Reviewer 3:

The reviewer commented that the project contributed to the understanding of advanced cathodes for EVs.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer felt that sufficient resources were available for proposed work.

Sulfone Liquids and Sulfate/Triflate Solids for High Voltage Electrolytes: Austen Angell (Arizona State University) - es100

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

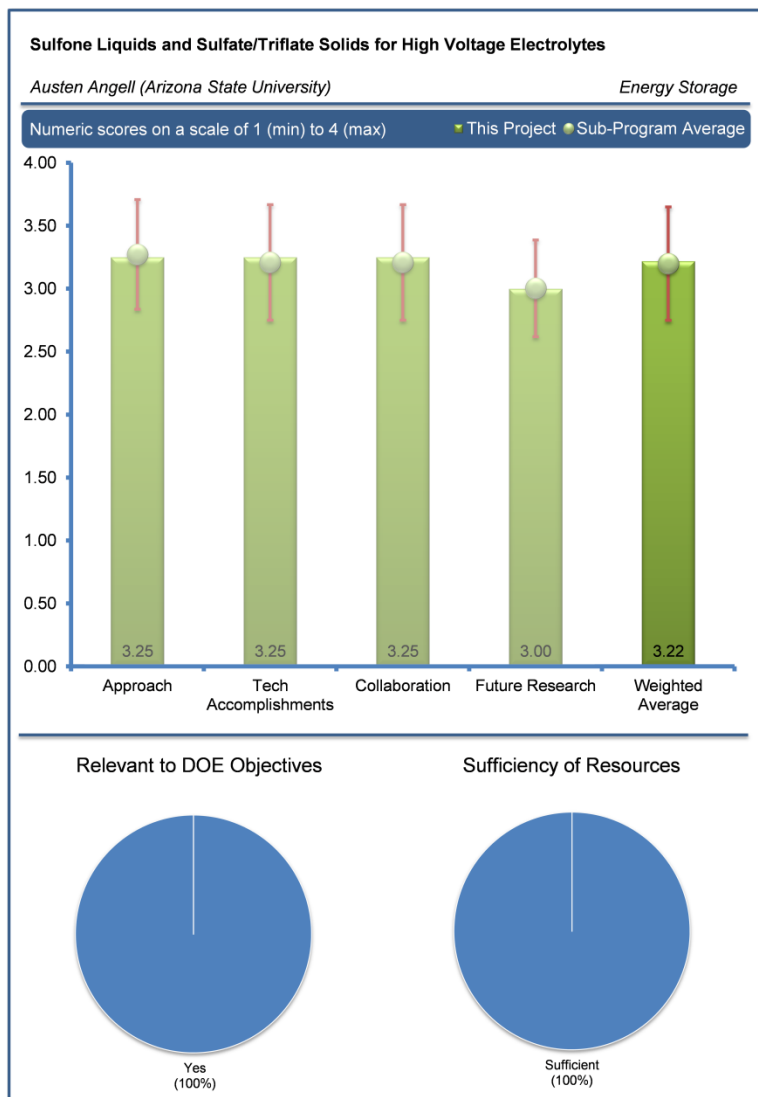
The reviewer observed several different investigations of improved electrolyte concepts applicable to lithium and sodium ion batteries. This reviewer also identified potential utility as high voltage electrolytes. The reviewer reported that each project was done by a different student. This reviewer concluded that demonstration at the cell level in full cells still had to be done.

Reviewer 2:

The reviewer noted development of new electrolytes based on ionic liquids composed of sulfone, superionic glasses, conducting polymers, and ceramics.

Reviewer 3:

The reviewer stated that the approach has been somewhat scattered over the past couple of years, but hopefully the new emphasis on polymer electrolytes will now receive more concentrated effort.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that the sulfone electrolytes have not been found to be satisfactory and a new approach is needed. The polymer electrolyte work is certainly a new approach and some progress has been made.

Reviewer 2:

The reviewer reported new materials with: solid electrolyte conductivity similar to that of most liquid electrolytes, electrolytes that do not dissolve manganese and nickel from the cathode, single species conductivity, and new sodium ion conductors.

Reviewer 3:

The reviewer indicated good progress in that several alternatives have been developed. These alternatives compare favorably with Japanese work on solid state crystalline electrolytes. This reviewer also noted work on sodium electrolytes.

Reviewer 4:

The reviewer would like to know how to make the electrolyte dense.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated that existing collaborations appear to be more than adequate.

Reviewer 2:

The reviewer reported project partnering with Utah, LBL, University of Rhode Island, and PNNL.

Reviewer 3:

The reviewer suggested that the PI collaborate with some battery makers and testers to accelerate the evaluation of ideas. This could have saved a lot of time in the sulfone work.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer noted that plans for future work are reasonable.

Reviewer 2:

The reviewer stated that this project is ending. Existing plans are adequate except for the need for full cell testing of new concepts.

Reviewer 3:

The reviewer felt that it is not clear from the presentation what the proposed future research will entail.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer felt that new electrolytes are definitely relevant to DOE goals.

Reviewer 2:

The reviewer noted that new electrolytes are required to meet the future goals for cell performance.

Reviewer 3:

The reviewer reported that this project is very relevant to the development of high energy batteries needed in the transportation sector for all electric vehicles with long range and high levels of market penetration.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that funding is in the right order of magnitude.

Reviewer 2:

The reviewer indicated that program resources are more than adequate to support this level of work.

Carbon/Sulfur Nanocomposites and Additives for High-Energy Lithium Sulfur Batteries: Chengdu Liang (Oak Ridge National Laboratory) - es105

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this work has developed very well. From the unsuccessful attempts to make liquid electrolyte lithium sulfur cells with adequate cycling, the work has moved in the direction of finding a suitable solid electrolyte having good compatibility with the sulfur cathode, and an improved cell was constructed. The reviewer reported that the positive electrode still had serious deficiencies so an improved polysulfide material was developed that has shown positive results.

Reviewer 2:

The reviewer indicated the approach to include improving the conductivity of the sulfur electrode using mesoporous carbons, block the polysulfide shuttle to extend cycle life, and develop new high performance electrode structures leading to an all solid state battery system.

Reviewer 3:

The reviewer stated that the approach is good.

Reviewer 4:

The reviewer reported the approach is developing Li-S battery chemistry and investigating critical polysulfide issues.

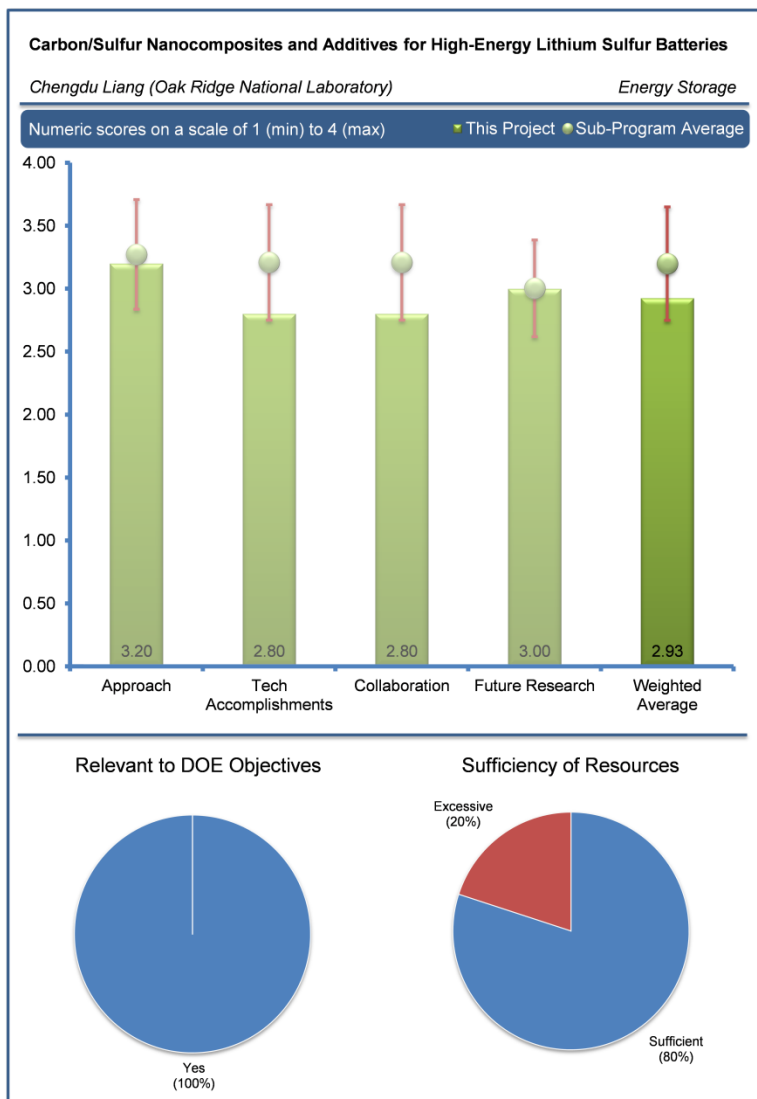
Reviewer 5:

The reviewer noted that the solid state electrolyte is a good approach to mitigate soluble polysulfide issue but room temperature (RT)/low temperature performance is a concern for solid state electrolyte.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the technical accomplishments were very good as an interesting new lithium/solid electrolyte/ complex polysulfide cell has been discovered.



Reviewer 2:

The reviewer summarized accomplishments such as developing all solid state cells with good cycle life and high rate performance and new solid state electrolytes with good conductivity.

Reviewer 3:

The reviewer asked how to further improve the Li_3PS_4 ionic conductivity and also enable it to work at room temperature.

Reviewer 4:

The reviewer felt the project made very good progress toward electrode optimization and understanding of polysulfide mechanisms.

Reviewer 5:

The reviewer stated that long-term stability of the solid state electrolyte versus Li still remains unclear. $\text{Li}_2\text{S-P}_2\text{S}_5$ system was explored in the 1980's and did not have long-term stability with metallic Li.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that work was carried out primarily at Oak Ridge with little outside collaboration.

Reviewer 2:

The reviewer stated good collaboration.

Reviewer 3:

The reviewer indicated collaboration mostly within ORNL.

Reviewer 4:

The reviewer felt that it would be helpful to go outside of ORNL to add to collaborations and get some additional input into the possibilities of this new system.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the PI has presented an excellent program for future research. The reviewer observed encouraging work with mixed cathodes in addition to those listed as at least in the case of $\text{TiS}_2\text{-S}$ mixtures, very good cycling with high capacity has been found (A. Garsuch et al, Abstract 160 221st ECS Meeting, 2012). There are other very good mixed conductors such as MoS_2 which could be considered.

Reviewer 2:

The reviewer stated that the proposed program is on the right path for continued progress to develop a commercial Li-S battery.

Reviewer 3:

The reviewer noted future work to develop new sulfur-rich compounds with ionic conductivity greater than 10^{-5} S/cm. Explore solid electrolytes of high ionic conductivity and low interfacial resistance.

Reviewer 4:

The reviewer stated that no future work was proposed to improve RT and low temperature performance, and to validate long-term stability versus Li.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted the project was highly relevant to improved energy density and specific energy.

Reviewer 2:

The reviewer stated that new high-performance, all solid state lithium-sulfur batteries could replace the Li-Ion cells in future designs.

Reviewer 3:

The reviewer commented that the project contributes to the understanding of advanced batteries for EVs.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated sufficient resources for the proposed work.

Studies on High Voltage Lithium Rich MNC Composite Cathodes: Jagjit Nanda (Oak Ridge National Laboratory) - es106

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the PI's approach to achieving good electrode performance is sound and justified (Slides 5-7). Cell limitations are clearly explained and a mitigation strategy is provided.

Reviewer 2:

The reviewer reported that the project addresses a number of approaches to better understanding performance limitations in layered-layered materials, and a means to mitigate. Multiple approaches reduce risk of failure. The researchers use good hypotheses to guide experiments, and understand the need for good characterization methods.

Reviewer 3:

The reviewer noted that the coating on particles [e.g., atomic layer deposition (ALD) coated on LiCoO_2] was shown by many groups to reduce reactivity and improve performance at high voltages. It was not clear how any coating on electrode (versus particles) can reduce reactivity, given that the majority of the high voltage electrode is still in contact with liquid electrolyte.

Reviewer 4:

The reviewer stated that there is a wide mix of approaches to address performance issues. The reviewer commented that the project does not give the impression of a fundamental understanding; it is more Edisonian.

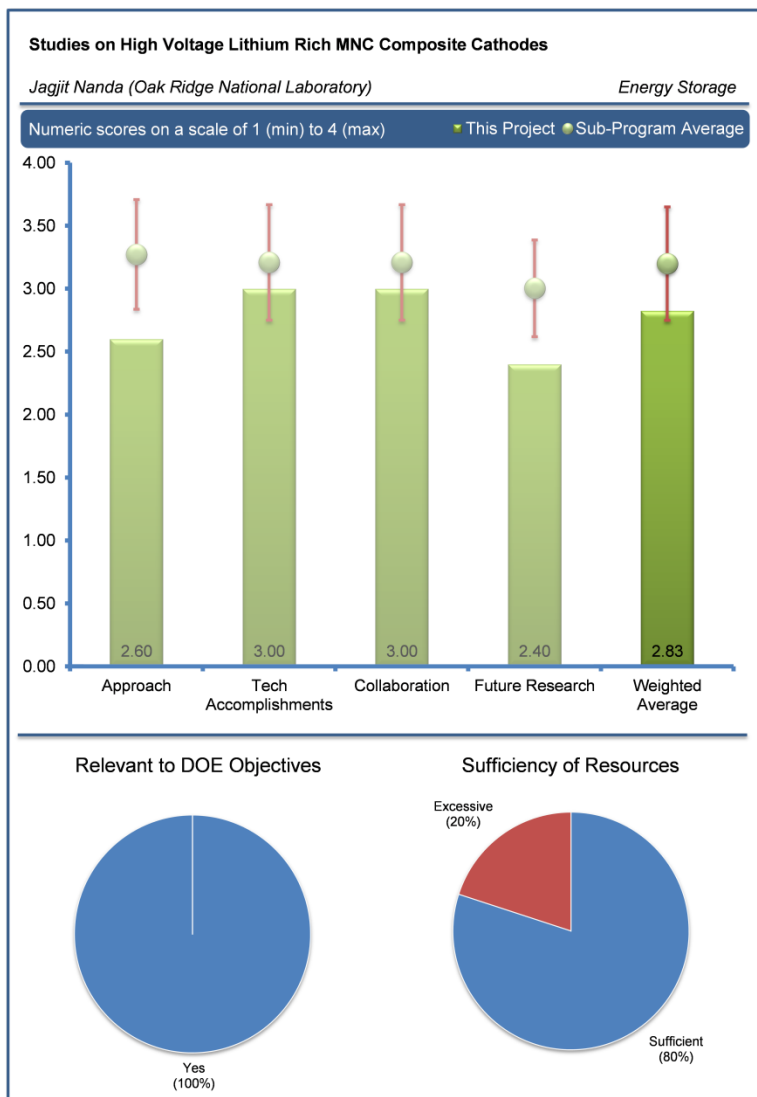
Reviewer 5:

The reviewer stated that the approach is good, but this approach has been already performed by Y.S. Park in Kangwon National University, Korea. The reviewer would like to know what the new approach is.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the program's progress since the last merit review has been very good. The EIS studies and materials characterization of the LMR-NMC materials and electrode has been completed. The reviewer reported that the interfacial stability of



the electrode by Lipon coating has been demonstrated and full cell studies of the material coupled with A-12 graphite are in progress. It is noted that the results of these investigations are being documented in the form of a journal article to the J. Mater. Chem.A.

Reviewer 2:

The reviewer investigated a number of systems and demonstrated some improvement in performance with LiPON coating.

Reviewer 3:

The reviewer indicated that there are not specific quantitative milestones or targets for this project and there would be some benefit to defining these. Nevertheless, the researchers are doing a lot of work and providing fundamental understanding for next experiments.

Reviewer 4:

The reviewer asked were the results based on single cell or multiple cells for each coating level. It was difficult to understand how few nm of coating on the electrode had such a big improvement on cycle life. The reviewer stated that the bulk of the electrode was still in contact with liquid electrolyte at 4.9V, which should result in electrolyte decomposition [and possibly carbon black (CB) decomposition] on long-term cycling, especially at slow rates such as C/10. So, it was surprising that the project team was able to obtain such good cycling data.

Reviewer 5:

The reviewer stated that the technical accomplishments are similar to other work. Thicker and thinner coatings have similar capacity retention on extended cycling at 60°C, but thicker coating degrades faster at room temperature. The reviewer would like to know if the PI can explain this behavior.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated good teamwork.

Reviewer 2:

The reviewer noted that good collaboration appears to exist in the program. The PI is partnering with excellent scientists within the national laboratories as well as partnering with industry.

Reviewer 3:

The reviewer noted that the researchers appear to work well with the entire team working on VF, and are incorporating the Argonne protocol for determination of VF. Collaboration with Daniel Abraham on the characterization is a key strength.

Reviewer 4:

The reviewer indicated a few collaborators.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the proposed work is clearly justified. Efforts will continue to stabilize the LMR-NMC phase without compromising capacity. This will include testing of materials that are synthesized by their collaborators.

Reviewer 2:

The reviewer reported that there was no follow-up work on the LiPON coated electrode, given the demonstrated good cycle life. The project needs to demonstrate good cycle life performance using LiPON coated electrode in full cells. The reviewer asked can the LiPON coating on the electrode be scaled up for manufacturing.

Reviewer 3:

The reviewer suggested providing more quantitative targets with decision points.

Reviewer 4:

The reviewer asked how the continued work on the capacity fade analysis at a full cell level for high voltage LMR-NMC cathodes will help the degradation.

Reviewer 5:

The reviewer said a mix of things, lacking focus.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer asserted that this project supports the DOE objective of petroleum displacement. Undertaking advanced materials research in the area of high capacity electrode materials for lithium ion batteries will help DOE accomplish the technical target goals for the EV and 40 mile PHEV.

Reviewer 2:

The reviewer stated that the layered-layered material has the potential to enable high energy density cells necessary for widespread adoption of BEVs in the United States. This project directly addresses some of the remaining issues in the development and commercialization of this material.

Reviewer 3:

The reviewer noted that the project contributes to understanding of advanced batteries for EVs.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the program appears to have the necessary resources to complete the milestones on schedule.

Progress of Computer-Aided Engineering of Batteries (CAEBAT): Ahmad Pesaran (National Renewable Energy Laboratory) - es117

Reviewer Sample Size

A total of 7 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the approach was excellent with very clear objectives; project start/stop dates, go/no go decision points and milestones. Multi-path development of Computer-Aided Engineering of Batteries (CAEBAT) tools has allowed for development of three modeling tool versions that are or will soon be commercially available. The reviewer indicated that this will allow customers to customize the model for their system and keep modeling development cost at a minimum.

Reviewer 2:

The reviewer reported outstanding results based on strong collaboration with other institutions and in particular with industry.

Reviewer 3:

The reviewer indicated that CAE models are critically necessary for automotive battery pack design, particularly for automotive manufacturers and Tier 1 suppliers. The closed/proprietary nature of the models under development limits their usefulness by researchers outside of the three project teams or for technology evaluation and cost analysis by federal regulatory agencies. The reviewer stated that it is not clear to what extent software will be made available outside of the specific collaborations.

Reviewer 4:

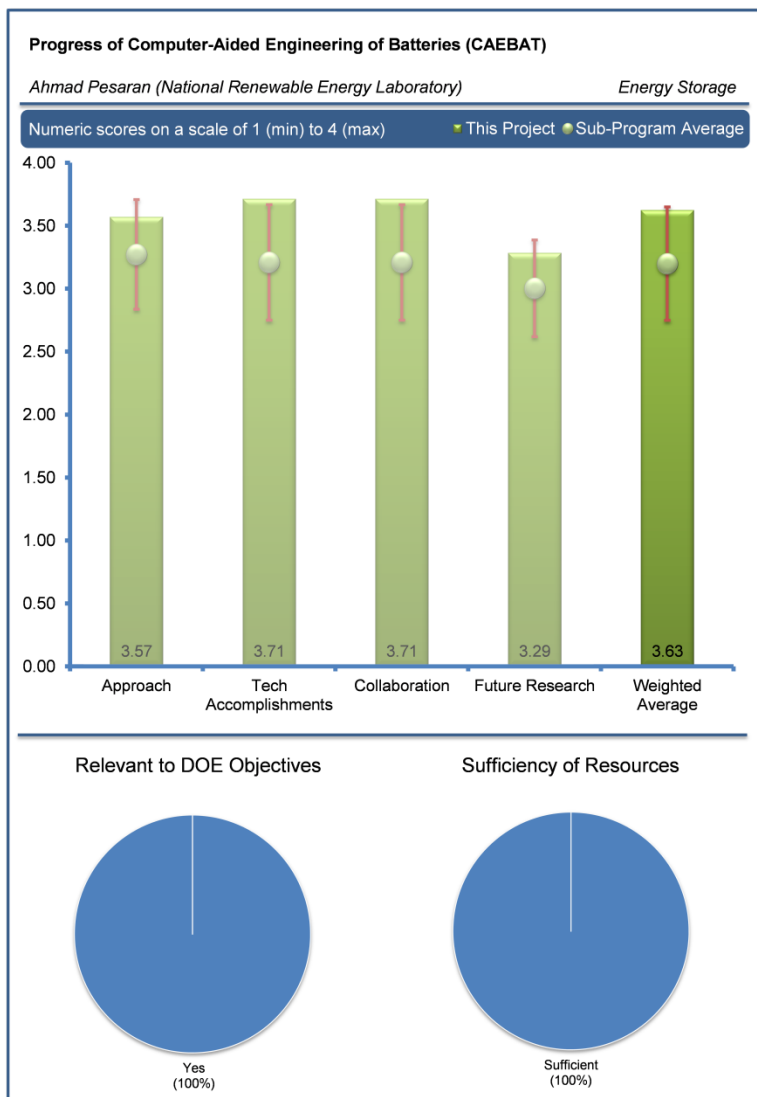
The reviewer reported that this is a well-structured, highly ambitious project with a considerable added value when successful. One necessary condition for its success is an effective coordination of activities within and between the three sub-projects with guarantees of timely and appropriate cross-fertilization. The reviewer noted that based on the evidence presented this seems to be the case, but it will remain one of the main challenges.

Reviewer 5:

The reviewer stated that the goals are very challenging in setting up the joint development work among the industry OEMs, DOE labs, and software companies.

Reviewer 6:

The reviewer commented this was a novel initiative and well structured. Some activities appear to be potentially redundant.



Reviewer 7:

The reviewer noted that it is useful to have an integrated model from materials to pack level. But it is not clear if this will really shorten the battery design cycle since validation testing takes time and difficult to shorten the validation testing time.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated excellent progress if one considers that not much work has been done in this area previously. The very comprehensive approach taken by the authors is ambitious and very good.

Reviewer 2:

The reviewer stated that NREL transferred their deliverables to the industry partners, which is a big accomplishment. Also, all three industry partners have released their codes. The reviewer commented that ORNL is also doing their part efficiently.

Reviewer 3:

The reviewer referenced comment in previous question on redundancy. The reviewer stated that progress has been excellent, and commercial products are being delivered. One of the software packages is considered a de-facto industry standard.

Reviewer 4:

The reviewer commented that technical progress reported over the last year is substantial. There seem to be good chances for reaching the project goal of delivering a tool that will allow shortening design time through the developed models and the interfaces between them. The reviewer questioned how the final product will be able to provide output and guidance on cost and safety.

Reviewer 5:

The reviewer stated that the project is on schedule to meet the initial goals despite stating that the project is only 40% complete. Big concern may be what the validated portion of the project objectives means. The reviewer reported that beta versions of the software have been released or will be released this year for commercial use.

Reviewer 6:

The reviewer suggested providing an example of how CAEBAT has shortened the battery design cycle since its initiation in 2010.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that the authors have done a great job in this area. The collaboration with industrial partners seems very important and in this project it appears that it has been a priority.

Reviewer 2:

The reviewer stated the project was a model for multi-level industry-government-academia collaboration.

Reviewer 3:

The reviewer stated that multiple real world end-user collaborators and interaction opportunities allowed this project to make excellent progress.

Reviewer 4:

The reviewer indicated that the list of collaborators was quite impressive. The division of the collaborators into three teams makes sense from a standpoint of project management.

Reviewer 5:

The reviewer stated that the necessary internal coordination seems quite okay. No evidence is presented on Slide 27 on interaction with non-project participants.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer felt that the authors are going in the right direction. The combination that goes from electrode level to cell and pack level research is very comprehensive and can give important information about thermal management, aging, cycle life, etc.

Reviewer 2:

The reviewer indicated that barriers are defined by both users and creators. Both have a forum whereby their issues may be addressed. Open s/w architecture facilitates flexible response to technological barriers. The reviewer recommended that design iteration throughput improvement be demonstrated, when compared to conventional, stratified analysis design software.

Reviewer 3:

The reviewer noted looking forward to seeing the results of future validation work.

Reviewer 4:

The reviewer reported that one key concern was the validation of the model and the inclusion of an aging and abuse modeling capability. This and several other areas are addressed in the proposed future work and the multi-collaborator approach will be followed again.

Reviewer 5:

The reviewer reported that the new solicitation will continue to develop the models which will accelerate the development process.

Reviewer 6:

The reviewer stated that the information provided on future work in Slide 28 is both logical and purpose-oriented. In addition to the research work, internal project coordination should also remain at high level in the future and probably will require even more effort in view of the 60% work remaining for the 1.5 years until project closure.

Reviewer 7:

The reviewer commented that instead of focusing on shortening the battery design cycle, it will have more impact to model degradation at the materials and cell level over the PHEV or BEV temperature range. This might shorten the testing time. In addition the modeling results from the materials and cell aging can feed into the modeling design at the module and pack level, in order to mitigate the aging impact.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reported that the ability of both battery suppliers and vehicle manufacturers to quickly identify the potential capabilities of various batteries under different usage scenarios is critical to helping OEM senior management to make the appropriate decisions on the development of an electrified vehicle powertrain. This project provides multiple tools to facilitate those decisions and reduces the need for additional in-house modeling activities and the associated costs.

Reviewer 2:

The reviewer asserted that the project supports the overall strategy of DOE of petroleum displacement by focusing on very practical problems such as cycle life and abuse tolerance that go all the way from one single electrode to a cell, and finally to a battery pack.

Reviewer 3:

The reviewer noted that the software programs can be used to facilitate the development of optimum cell-system combinations.

Reviewer 4:

The reviewer suggested that the objectives need to be achievable.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that this is a very interesting model of sharing the cost of a project with contractors. If the authors come up with additional or very important practical implications such as improving the life of the battery or if the authors manage to develop a simplified thermal management for a battery pack, the project team should consider the need for additional funding.

Reviewer 2:

The reviewer stated that the resources are in agreement with the project needs.

Reviewer 3:

The reviewer commented no issues.

Reviewer 4:

The reviewer offered that one sub-project led by GM is much larger in resources than the other two. It is unclear how this impacts the overall project structure and whether it may bias the final outcome of the project.

Development of High Energy Density Lithium-Sulfur Cells: Donghai Wang (Pennsylvania State University) - es125

Reviewer Sample Size

A total of 6 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the goal of this project at Penn State University (PSU) is to develop a full lithium-sulfur battery system for high energy density, efficiency, and good cycle life. The project has so far taken baseline measurements on lithium-ion (nickel-manganese-cobalt, or NMC cathode) cells, with the lab also concurrently developing a lithium-sulfur (Li-S) cathode material. The reviewer indicated that it has scaled up production of this material to 50 g batches. The thermal safety of many of the Li-S cell components has been characterized. Partners in this project have been developing two different anode materials and an electrolyte. The reviewer summarized that the idea is for each respective partner to create their best material, and for the project member to bring these together into cells down the line. Initial complete cells will be 1 Ah in capacity, with the goal of achieving 4 Ah-sized cells. Though these components have been brought together in full cells that have been tested, the most challenging part of the experiment lies ahead.

Reviewer 2:

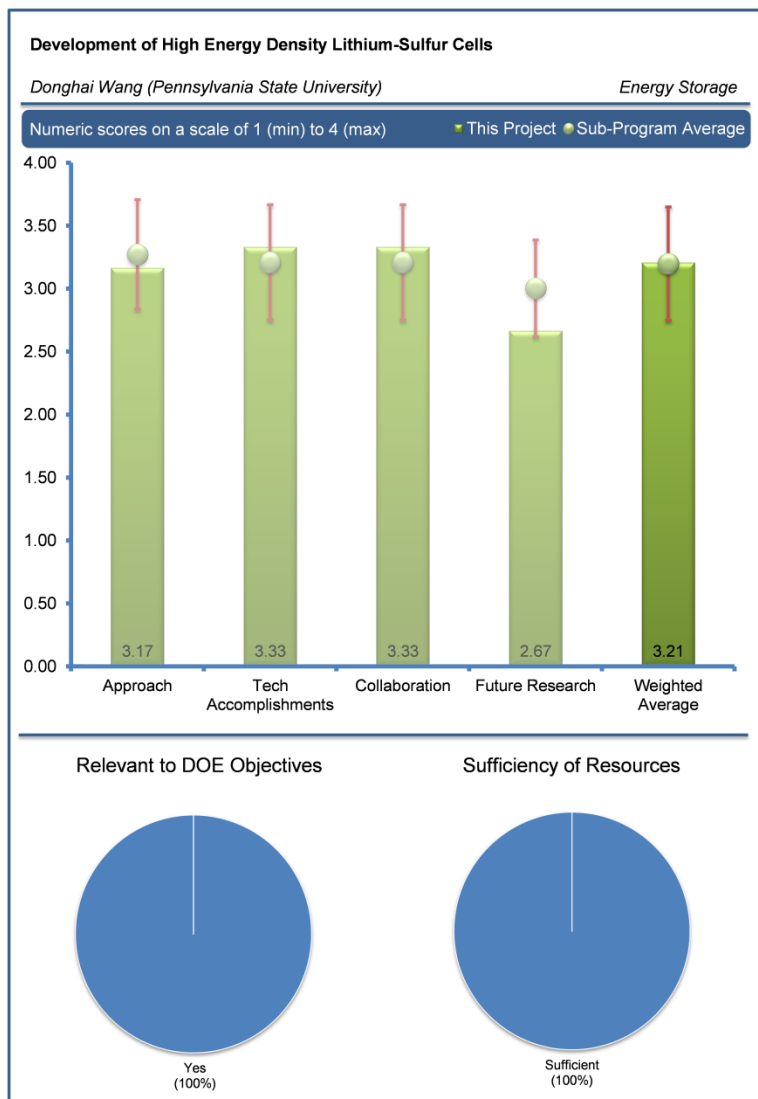
The reviewer reported an excellent approach to addressing the key material issues associated with the Li-S cell. The approach was greatly enhanced by the collaboration team that was assembled. The reviewer felt this allowed the teams to use their expertise on specific aspects of the cell rather than trying to handle all of the issues.

Reviewer 3:

The reviewer stated that the work structure was good. The study was particularly good in defining the tasks to be achieved, and in translating metrics to the material, and then maintaining a constant scaling method to the test vehicles, so that material performance could be tracked, and translated to a meaningful cell metric. The reviewer recommended more generous use of the baseline cell performance, for data tracking and comparison.

Reviewer 4:

The reviewer stated that the approach was focused and had a well-paced plan and progress.



Reviewer 5:

The reviewer commented that the approach does not include the ionic barrier on Li anode. The barrier is necessary to improve the cycle life and self-discharge.

Reviewer 6:

The reviewer noted that the polymer electrolyte for S cathode has been tried previously, and is not sure what is new here.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that the vast majority of the work shown is new since the 2012 AMR. The project aspires to make complete Li-S cells, and has already made early versions of this coupling, as well as the baseline NMC cells. The reviewer noted that it should be made clear in cycle life measurements going forward what depth of discharge was used for the tests in the PSU lab; INL should be measuring cells according to their standard protocols. The reviewer stated that component materials of the first batch of Li-S cells (anode, cathode, electrolyte) have been made and tested for their individual properties, such as cycling stability and thermal stability. In addition to the composite lithium-based anode that was in its original plans, this year the PSU team also investigated a silicon anode. The reviewer also indicated in progress since last year, the team has tested four generations of sulfur-carbon cathode materials that were developed for their sulfur-trapping properties and charging rate performance. New electrolytes from both ANL and PSU have been tested, and the capacity retention versus cycle number has greatly increased since the single electrolyte for which the team shared data last year (presumably the baseline electrolyte was LiPF_6). The reviewer reported that self-discharge of Li-S cells with PSU's novel electrolyte was greatly improved over that with a baseline electrolyte. The PSU team has also tested silicon/sulfur full cells (not 1 Ah pouch cells yet, probably coin cells), which so far have been successfully cycled (albeit with a short cycle life, with a great loss of capacity over only 40 cycles). The reviewer stated that the project team has analyzed the reason for the capacity loss and ascribed the cause to sulfur loss from the cathode. The project team also reported on some additional technical challenges the team needs to investigate further in the reviewer-only slides. The team has moved its milestones forward a few months and is thus accomplishing the phases of research earlier than it stated it would in its 2012 presentation.

Reviewer 2:

The reviewer stated that the progress is very good and should meet the project objectives on time. The cycling life, however, is still not where it needs to be. Additionally, the temperature performance while excellent the high temperature needs significant work to meet the cold temperature performance that is needed. The reviewer noted that more effort should be directed at this issue.

Reviewer 3:

The reviewer reported some minor issues in the method of presentation of data (e.g., no control/baseline clearly indicated on Slide 10). The reviewer commented please ensure the data presentations are self-supporting and unambiguous. Once this issue was cleared, all results were obvious, and supported the claims of progress. The reviewer suggested to please be more explicit on test procedures applied, when presenting data and results (e.g., cycling conditions used on Slide 12). The reviewer would like to clarify whether the same lab performed testing on both materials, for example.

Reviewer 4:

The reviewer stated that although progress has been made in self-discharge reduction, greater emphasis and focus on this would be desirable as the current capability in the best case seems to be show-stopping.

Reviewer 5:

The reviewer noted that the self-discharge was more than 72% per month; it should be about 2-3%/month at 40°C.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer indicated that the PSU group is collaborating with ANL on electrolyte development and testing, which is being done concurrently. It is also working with EC Power and Johnson Controls (JCI) on two different anode materials designs, and both of these companies are also working with PSU on overall cell design and testing. The reviewer stated that PSU also worked with ANL, JCI, and EC Power to set strong project baselines. Idaho National Lab is doing testing of its baseline cells.

Reviewer 2:

The reviewer noted that the project allowed the different collaborators to make full use of their technical strengths and this allowed the project to move forward.

Reviewer 3:

The reviewer felt that this is a strong team. Excellent collaboration exists. The reviewer recommended that the activities of each partner be more clearly called out on the slides (example Slide 12 – reviewers see who provided the materials, but not who made the cells and who tested them).

Reviewer 4:

The reviewer indicated a well-balanced team of partner capabilities.

Reviewer 5:

The reviewer felt it is not clear if the collaborators are proving the anode protection to eliminate anode reaction with Li polysulfides.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer stated that the PSU team seems to be pursuing the logical pathways to overcome the performance issues it has seen with the electrolyte and electrode materials. In the reviewer-only slides, the project team noted some particular challenges they are facing with their novel materials now that the team has begun to assemble these into cells. The reviewer indicated that the project team specifically noted the following: Self-discharge for high-loading electrodes has been difficult to curtail, and the team will need to investigate electrolytes that can prevent polysulfide diffusion and the polysulfide shuttle; and silicon-based anodes show significant voltage fading when paired with the sulfur cathodes. The team needs to find a way to counteract this fading or else focus on the composite lithium-based anode; hitting the energy density goal of 600 Wh/L will require increasing the stable capacity and cathode loading, which the team needs to work towards by optimizing the electrolyte, cathode composition, and coating techniques. The reviewer summarized that plans do build on their past progress and are generally focused on overcoming barriers.

Reviewer 2:

The reviewer acknowledged almost having given a score of 2. The investigators have correctly identified the most significant barriers to their research, but were very general in the approach to be taken in addressing these barriers. The reviewer felt given the challenges faced by this electrochemical system, the description provided by the PI may have been appropriate.

Reviewer 3:

The reviewer stated that there is a need for improved low temperature performance. It is not clear if work will continue on both anodes or there will be a downselect somewhere.

Reviewer 4:

The reviewer stated that the Si anode may provide better life and performance.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that developing a lithium-sulfur battery that has a very high energy density and that can be manufactured as a viable automotive product in a cost-effective fashion would go a long way towards helping to bring down the cost of PEVs. A battery that would make a PEV a cost-competitive purchase against a conventional internal combustion engine (ICE) vehicle absolutely supports the DOE objective of petroleum displacement.

Reviewer 2:

The reviewer noted that this project seeks to increase the energy density of the high voltage (HV) battery systems that will be the near term vehicle propulsion systems.

Reviewer 3:

The reviewer indicated that the Li-S system may offer a closer solution to beyond lithium-ion than its counterparts. It is essential that alternative approaches to resolving rapid capacity fade and fundamental cell design be investigated.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer commented that the project appears to have made significant progress since AMR 2012 on the funding the project has received.

Reviewer 2:

The reviewer stated that the resources are adequate for this project.

Reviewer 3:

The reviewer noted that the collaboration within the team appears to be sufficient, to support the activities called out in the project. There is appreciable risk in this project, with respect to electrolyte development. More fundamental science may need to be driven by the project, in order to achieve its goals.

Silicon Nanostructure-based Technology for Next Generation Energy Storage: Ionel Stefan (Amprius) - es126

Reviewer Sample Size

A total of 6 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that Amprius' approach to this work is to establish baseline measurements of its silicon nanowire anode structure (which has a unique property in that the Si nanowires are attached to the current collector metallurgically as opposed to through chemical characteristics) with commercial cathode materials such as nickel cobalt manganese (NCM) and nickel cobalt aluminum (NCA). It is making full cells with its anode materials and cathodes being developed in partnership with BASF and Yardney.

The reviewer indicated that the performance targets in the project objective have relaxed a little since 2012. Last year the target figures were greater than 900 Wh/L energy density, greater than 400 Wh/kg at 1,000 cycles, and in 2013 they were listed as greater than 680 Wh/L energy density, greater than 330 Wh/kg at 300-1,000 cycles. The reviewer reported that the energy density objectives grew more specific, at NCM 523 (523 is a particular NCM chemistry) or lithium cobalt oxide (LCO) cathode and balance of cell components exceeding 250 Wh/kg. But the PI mentioned during the poster session that Amprius had to change the direction of its research last year due to problems with the scale-up of its anode materials.

Reviewer 2:

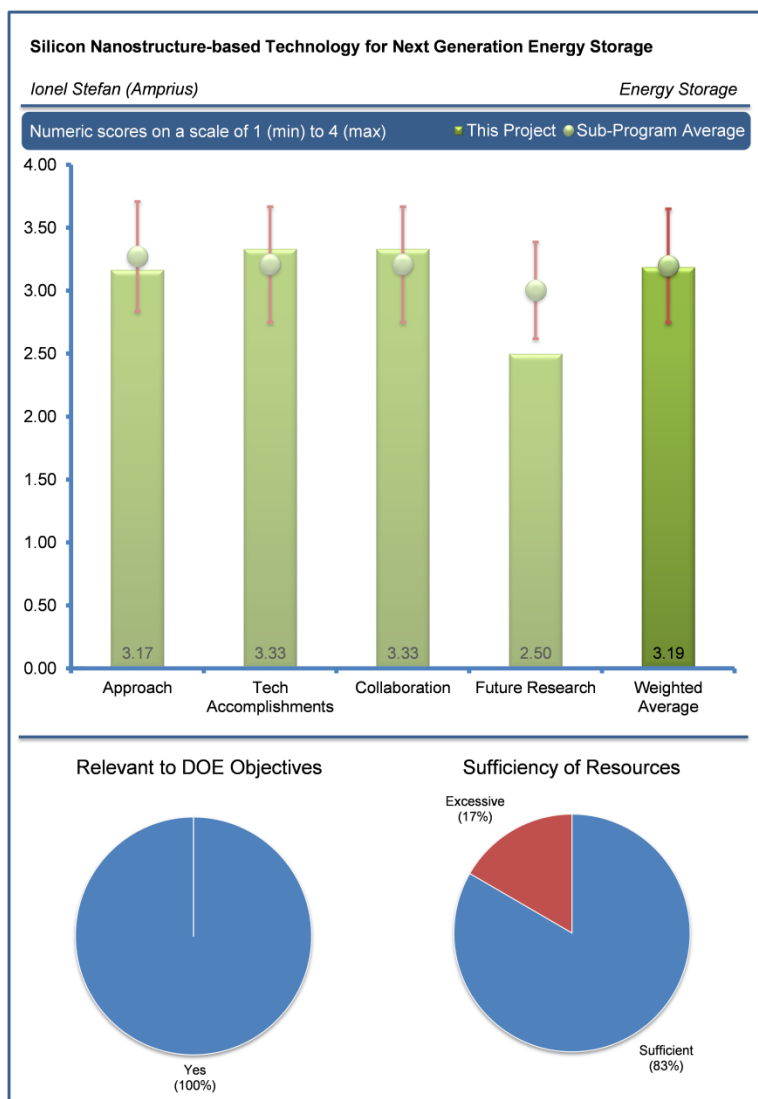
The reviewer noted that the boundaries and goals of the project were well defined. The investigation pathway design supports those goals and boundary definitions.

Reviewer 3:

The reviewer stated that the overall approach is sound and has clearly stated objectives that outline most of the main technical barriers of the objectives; the development and demonstration of a silicon anode that replaces the carbon anode to improve energy density, while maintaining life and performance. The reviewer articulated a main concern, that there is no reference to how the mechanical stability of the system is or will be addressed. This is a critical characteristic for this system. Also there is no clear reference to how temperature performance will be addressed. Finally the reviewer indicated that since neither of these issues is identified as barriers, the concern is that solutions will come about that do not support these issues.

Reviewer 4:

The reviewer commented that insight into challenges or practical feasibility of deposition process is missing.



Reviewer 5:

The reviewer stated that the approach can be improved by selecting higher energy cathode material, e.g., layered-layered compound and limiting the anode specific capacity to match the cathode to meet 1,000 cycles.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reviewed that Amprius has matched its silicon anodes to NCA cathodes in cells made in its laboratory and seen an improvement in cycle life. It has tried various formulations of electrolytes with additives that have had a strong effect on the cycle life of its cells. The reviewer reported it has created a cell that has achieved a cycle life of around 800 to 900 cycles before the performance diminishes to 80% of the initial charging voltage (cycles are at 80% depth of discharge). The PI mentioned that Amprius' research took a 90-degree turn over the past year due to a problem with scale-up of its materials. The reviewer noted that its plans clearly changed, as in 2012 the team had planned to have an anode with a 1,000-cycle life, which is a goal that they have had to relax.

However, even if the research did not develop in the originally intended direction over the past year, the team has much to show for its efforts such as: improved anode design to enable longer silicon cycle life; improved stability of the Solid Electrolyte Interface (SEI) that forms on the surface of the silicon electrode; identified additives that extend silicon cycle life; qualified NCM cathode materials to be integrated into the baseline cells; and designed, built and delivered 18 baseline cells matching graphite anodes with NCM cathodes. The reviewer reported that the full cells that Amprius is now testing show considerable loss in capacity, with capacity decreasing to 80% before 250 cycles with most additives tested. So there is greater understanding of these materials as a result of the work done over the past year, even though the cells are far from ready for prime time.

Reviewer 2:

The reviewer stated that the technical progress demonstrating improvements over the baseline appear to be excellent. Based on the data presented the cell performance improved significantly since the initial start of the program. The reviewer felt it would have been clearer if there was a NCA/Carbon Anode cell cycled the same as the three silicon anode full cells shown on Slide 10. The assumption was that the worse cell shown performed better than the baseline cell. Electrolyte formulations also show excellent improvements.

Reviewer 3:

The reviewer commented that some of the data was confusing, as to convincing that improvements were indeed made. During the poster session discussion it became clear that many of the issues pertained to cell build quality. A good baseline has been established and results are encouraging.

Reviewer 4:

The reviewer indicated that the cycle life goal of 1,000 cycles with higher energy cathodes for vehicle uses not reached. The self-discharge should be less than 1 % per month at room temperature.

Reviewer 5:

The reviewer felt there were insufficient details provided to be able to assess the progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that Amprius is collaborating with BASF, Yardney, and Nissan. It is working with BASF in optimizing cathode material. Yardney collaborates in optimizing cathode material, working on the cell fabrication and manufacturing. The reviewer indicated that Nissan is doing cell design. The efforts seem to be coming together well so far, and it will be interesting to see how the collaboration develops in the coming year.

Reviewer 2:

The reviewer stated that excellent collaboration with key partners (with the appropriate expertise) has and should help keep this project on focus. Support or collaboration with an electrolyte specialist may have been a good fit, but Amprius appears to be doing this work in-house.

Reviewer 3:

The reviewer noted that BASF and Yardney are good partners for high energy cell development.

Reviewer 4:

The reviewer indicated that the collaboration appears strong. The reviewer recommended more specific callouts on each slide, indicating sources of material and test results. It was not clear for example where Nissan had contributed.

Reviewer 5:

The reviewer stated that actual specific contributions and necessity of involvement given the stated roles of all partners is unclear.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that Amprius has work to do in its anode composition and properties, and in the uniformity and yield of its anode processes. It also has to work on electrochemistry issues (matching its anode with cathode material, electrolyte). It seems like there are many aspects of the cells using Amprius' anodes that need to be worked on, so the focus on overcoming barriers is broad (as opposed to a sharp focus on barriers). The reviewer detailed future work. Anode material efforts include optimizing size, structure, surface, and composition of the silicon nanowires to increase cycle life and volumetric charge capacity, as well as improving anode uniformity and production yield (this is a new research direction since 2012). Electrochemistry efforts include new electrolyte formulations for silicon SEI and high voltage cathode; formation and cycling protocol; and anode/cathode matching. Cathode development efforts include coating formulation development and validation for high loading and high energy density cathodes; and electrolyte compatibility validation. Cell design and testing efforts include iterating cell design for best energy density and safety performance. This reviewer indicated that in the reviewer-only slides, Amprius said that it had recently identified an alternative manufacturing path that preliminary results suggest will improve silicon uniformity, reduce anode- and cell-level swell, extend cycle life, and facilitate production scale-up.

Reviewer 2:

The reviewer reported that the future work states that the project team will optimize the silicon anode for cycle life and volumetric charge capacity, but temperature performance and mechanical stability are not mentioned. Neither is the temperature performance addressed for the other cell components. The reviewer commented that if the anode work is in its infancy and is not addressing the temperature issue in this project, the electrolyte and cathode efforts (which should be more advanced) should be addressing the low temperature performance issue in future work.

Reviewer 3:

The reviewer noted that the proposed cost of the Si active material is still very high. The targets should be greater than 300 Wh/kg and \$100/kWh at the cell level.

Reviewer 4:

The reviewer reported that insufficient details provided on results, thus difficult to assess the future work needed.

Reviewer 5:

The reviewer noted that the activities look good, but the PI should indicate what specific barriers are to be addressed by each area of investigation. Without this focus the approach appears to be scattershot/speculative. The reviewer provided as an example, Slide 18

indicates different cell designs. The reviewer inquired which is representative of the baseline, and what has been demonstrated. It is not clear what the gap to goals is, and how to close those gaps.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that Amprius aims to reduce the size and weight of the lithium-ion battery anode through its Si nanowire anode technology. Reducing the weight and volume of lithium-ion battery technology that can be cost-effectively used in plug-in electric vehicles will help to make these vehicles attractive compared to conventional ICE vehicles, which would aid in the DOE objective of petroleum displacement.

Reviewer 2:

The reviewer noted that the silicon's high anode energy density fully supports the DOE objectives by allowing for a decrease in the cost/mile to the general public to own and operate an EV.

Reviewer 3:

The reviewer stated that the cell design should appreciably improve cell energy density, and it is hopeful demonstrate good performance and cost reduction, all of which are essential to the adoption of BEV's, and therefore reduction in petroleum consumption by light-duty motor vehicles.

Reviewer 4:

The reviewer stated that Si anode replacing graphite is important for high energy density and lower cost.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that there seems to be sufficient resources in terms of both funding and partnerships to reach the stated milestones in the next 1.5 years.

Reviewer 2:

The reviewer stated that the resources are adequate for this project.

Reviewer 3:

The reviewer indicated that the rate of progress suggests that the work group is sufficiently staffed.

Development of Large Format Lithium Ion Cells with Higher Energy Density: Erin O'Driscoll (Dow Kokam) - es127

Reviewer Sample Size

A total of 6 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that Dr. Wu explained that Dow Kokam's approach to developing large-format lithium-ion cells with higher energy density is to approach it in two ways: by exploring cathode materials that are high-voltage, and both anode and cathode materials that are high-capacity. The project team has begun this project by obtaining baseline measurements on a cell with an NMC cathode and graphite anode. The team's baseline cells have excellent cycle life, with 87% capacity at 2,785 cycles. The reviewer stated that Dow Kokam now has a high-capacity anode, and it is developing a high-voltage cathode which still has issues (gas-generation during a cycle life test, though the cathode has apparently achieved 5V during cycling tests). It is also exploring high-capacity cathode materials, working with its partner Wildcat Discovery Technologies which is identifying the most promising materials that can optimize the desired cathode properties. The reviewer indicated that work seems to be at the stage of pursuing promising leads as of May 2013.

Reviewer 2:

The reviewer stated that the objectives and goals are clearly stated and the approach to reach those objectives and goals is outlined well. The approach as outlined allows for easier tracking of the progress.

Reviewer 3:

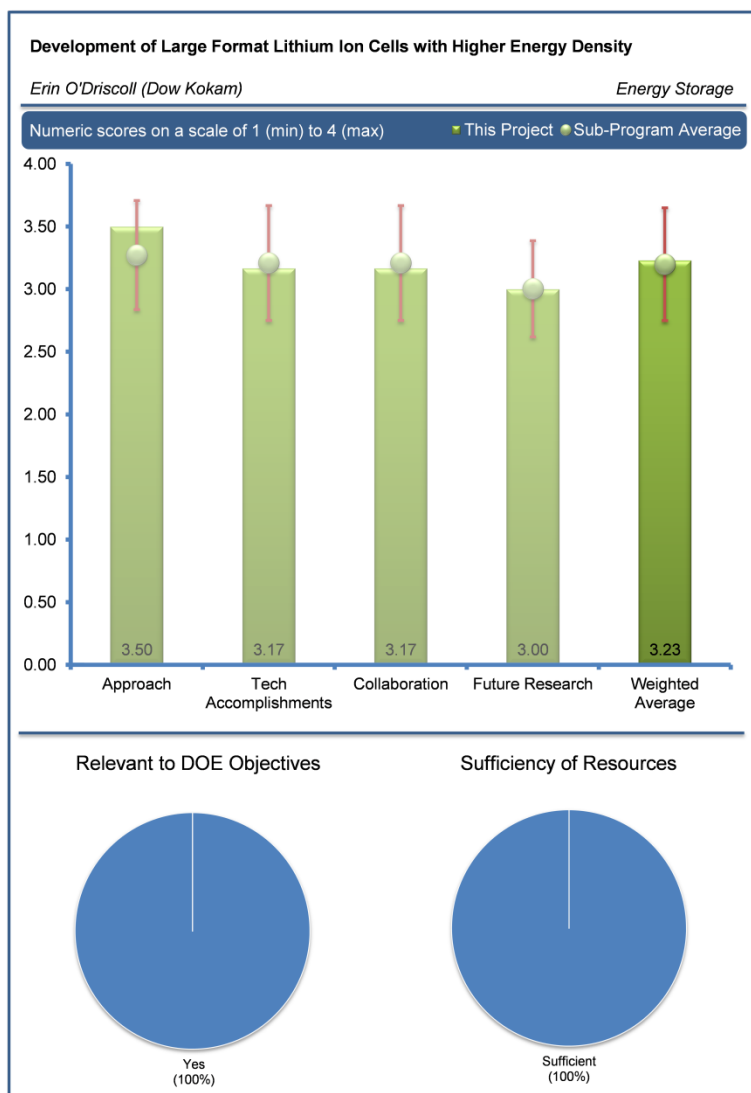
The reviewer indicated not being aware of a DOE target goal of 500Wh/L for a cell. The project phases were well selected and well defined. The sequence of work was reasonable, given the scope of work and the project and technical goals.

Reviewer 4:

The reviewer stated that the selection of higher than graphite specific capacity and higher than NMC cathode is critical to reach 300 Wh/kg, 600 Wh/L for vehicle applications.

Reviewer 5:

The reviewer commented being unclear on what is the project team's performance goal is 370 Wh/L or greater than 500 Wh/L.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that Dow Kokam has delivered baseline cells (NMC-graphite) to ANL for testing. It has also characterized high-capacity, silicon anodes and high-voltage cathodes that it will prepare to test in smaller-format (2 Ah) cells in the coming year. The reviewer stated that this measures up against a goal of developing a large-format lithium-ion cell with energy density greater than 500 Wh/L. The team reported that its high-voltage cathode material has demonstrated an energy density of 340 Wh/L in 64X95-mm format full cells with graphite anode, which still falls short of the goal. The reviewer indicated that the high-capacity cathode materials are considered the much more experimental thrust of their project. This part of the project is contingent on the progress that project partner Wildcat Discovery Technologies is able to make in discovering suitable materials. The reviewer commented that Dr. Wu noted that because there had been a fire in Dow Kokam's cell testing facilities early on in the project, Dow Kokam had been granted a six-month extension to their project, and thus progress would lag as a result.

Reviewer 2:

The reviewer noted that the program has the right teams working on the appropriate sections of the project. Cathode and electrolyte work is progressing well based on data presented. The reviewer indicated that the anode progress is not as well defined but, what little data is presented appears to be promising.

Reviewer 3:

The reviewer stated that the cathode development progress is encouraging. Issues are well defined, although the success of high voltage cathode (HVC) is a concern. The reviewer reported that multiple pathways to achieving the goals have been defined. What also lacks is the scalability effects of moving from the 2Ah cell to the large format cell design, and how that is to be inferred onto the goal chart. The reviewer noted that data was lacking in this presentation.

Reviewer 4:

The reviewer stated that the energy density is only 370 Wh/L with continued gassing.

Reviewer 5:

The reviewer indicated slow progress, only demonstrating 340 Wh/L using the high V cathode, and no cycle life data.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported that Dow Kokam is collaborating with Wildcat Discovery Technologies to identify high-capacity cathode materials, which is the heart of its experimental work here. Its other collaborations are with Oak Ridge National Lab for some materials characterization and failure mode analysis, and with a lab at the University of Missouri, Kansas City, for some analytical support.

Reviewer 2:

The reviewer noted that all areas of responsibility are clearly defined, with close collaboration between groups.

Reviewer 3:

The reviewer indicated that the right teams are working on the right sections. It is not clear however how project team members are interacting with each other to progress the overall project effort. This could result in an anode that is not fully compatible with the selected HCC/electrolyte couple.

Reviewer 4:

The reviewer commented that the contribution of Wild Cat on selection of the appropriate high specific capacity anode and cathode is not very clear because they are not material suppliers and their selection is not optimized for energy and gassing.

Reviewer 5:

The reviewer asked if there was any duplication of effort with other government funded high energy Li-ion cell.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the steps proposed for the coming year seem logical, with plans to make 2-Ah format cells with the high-capacity anode, and then taking steps to make other cells that combine the high-capacity anode with the high-voltage cathode. High-voltage electrolytes need to be tested as well. The reviewer reported that once some promising candidates for the high-capacity cathode material are identified and synthesized, these will be tested with the high-capacity anode in a cell. This full cell can then be measured to see how closely it achieves the goal of a higher-energy-density cell to achieve 500 Wh/L.

Reviewer 2:

The reviewer noted that the development pathway is well defined, although specific barriers could have been better defined/listed in the presentation, and specific sub-tasks to close gaps listed.

Reviewer 3:

The reviewer stated that the proposed future work is very good, but more focus is needed on the Si anode development. It is not clear that the difficulties of working with a Si anode are fully realized.

Reviewer 4:

The reviewer stated that the high-capacity anode (HCA) should be either Si, SiO₂, or Si/C composite, and high-capacity cathode (HCC) should be layered-layered or better capacity. Further, the reviewer observed that the High voltage cathode (HVC) needs a new electrolyte, and the development tasks are not very clear.

Reviewer 5:

The reviewer felt more specifics were needed on how the project team will down-select between HVC and HCC.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reported that a higher-energy-density, large-format lithium-ion cell suitable for automotive use would help to bring down the usage of costly materials (and their weight) in a battery for a plug-in electric vehicle. A less-expensive PEV battery would help to make these cars more cost-competitive with conventional ICE vehicles, which could help to lead to increased sales of PEVs. These PEVs would likely displace petroleum-consuming vehicles on the road.

Reviewer 2:

The reviewer stated that the increase in battery energy density is needed to make EVs an acceptable alternative to the gasoline powered vehicle. The objective of this project is to reach the DOE goals needed to offer that alternative.

Reviewer 3:

The reviewer noted that this project specifically targets the goals of improved energy density and low cost in large format cells, necessary to achieve longer term EV goals.

Reviewer 4:

The reviewer provided that Dow Kokam may be an automotive supplier with 300 Wh/kg and low cost cell or system supplier.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reported that the project appears to be proceeding well on the funding that it has received so far.

Reviewer 2:

The reviewer indicated that resources are sufficient.

Reviewer 3:

The reviewer indicated no issues seen with respect to resource usage.

Modular Process Equipment for Low Cost Manufacturing of High Capacity Prismatic Li-Ion Cell Alloy Anodes: Sergey Lopatin (Applied Materials) - es128

Reviewer Sample Size

A total of 6 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the goal of this project is to develop a high-capacity alloy material for an anode for a lithium-ion cell which has reduced cost (both per square meter and per Wh) and which also displays higher performance as a next-generation 3D (3-dimensional) anode. The alloy material CuSnFe (copper-tin-iron) has a higher capacity (mAh/g) than current copper (Cu) functioning as a current collector can achieve. The reviewer noted that the function of the Fe (iron) in the anode material is to reduce the grain size, which would mean that the anode can achieve a greater surface area. This in turn will facilitate a faster charge and increased capacity of the electrode. The reviewer summarized that the group is developing a high-volume manufacturing (HVM) prototype module for developing anodes in a continuous roll-to-roll process at low cost. The project entails using this module to test progressively next-generation materials with the high-rate deposition process.

The reviewer noted several baseline cells of 30 mAh capacity with a standard graphite coating on the anode current collector have been made and tested, and then other cells have been made with CuSn (copper-tin) on the anode (not yet with the Fe portion of the ultimate alloy). There are interim cycle life tests for these cells. The reviewer reported that the Cu metal current collector has been characterized by structural analysis, and then the final 3D anode has also been characterized after the graphite coating (baseline).

Reviewer 2:

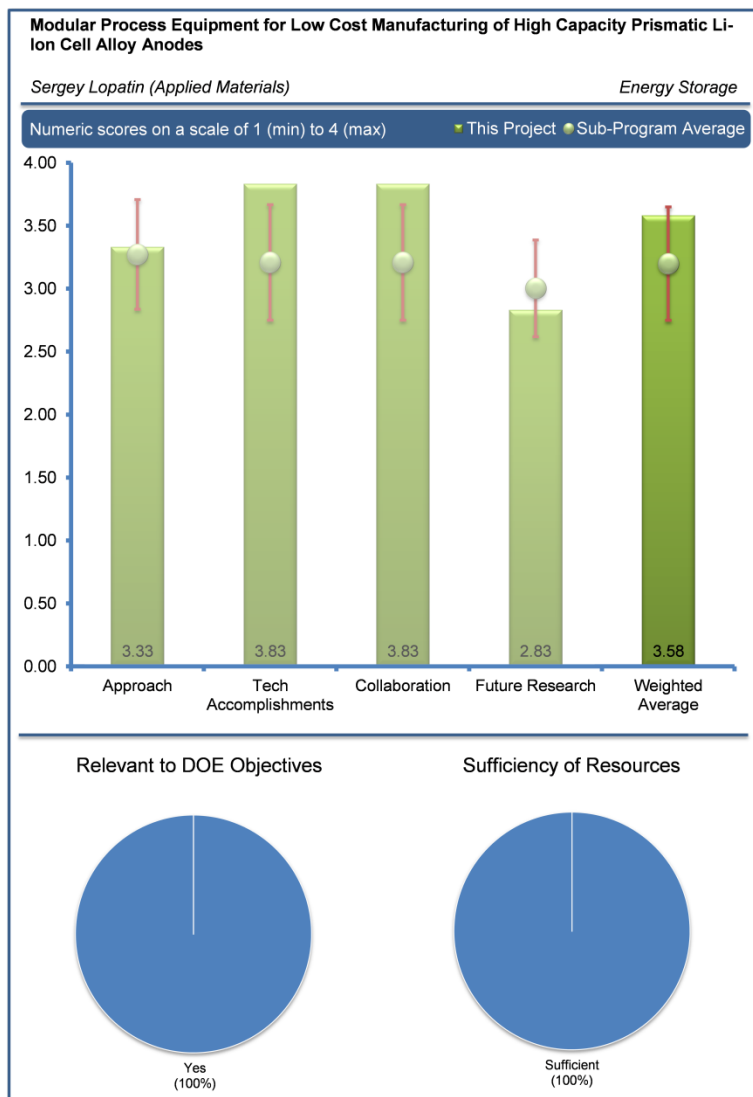
The reviewer states that the approach is sound based on the stated intent of the project. The project appears to be very ambitious as the material is being developed in parallel with the manufacturing process for that material. While ambitious, this approach helps identify any potential manufacturing pitfalls early, and reduces the possibility of development of a product that is extremely difficult to manufacture. The reviewer felt this approach also makes collaboration with a cell manufacturer and others more important.

Reviewer 3:

The reviewer indicated a comprehensive structured approach.

Reviewer 4:

The reviewer stated that the 3D electrodes with the cost goals of meeting \$150/kWh at the system level is a very challenging requirement for the automotive application and Applied Materials may have the know-how.



Reviewer 5:

The reviewer remarked on the excellent and interesting work and progress technically. The plan to demonstrate a commercially viable production process, economic feasibility, and mechanical robustness is unclear.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that it looks like the development of the module for processing the anode development took up a large part of the first year of the project. That must be why the project is at the halfway point and just the cells (made of NMC333, a variety of nickel-manganese-cobalt cathode material, with a copper-graphite anode) and some interim alloy (CuSn) anode cells have been made so far for baseline characterization. The reviewer reported that the baseline and interim alloy cells have been run through cycle life tests and characterized. The completion and testing of these cells represent the main fruit of the work done over the past year, as in 2012 the bulk of the results were characterizations of the microstructure of the material. The reviewer indicated that the Applied Materials team has also developed its materials processing equipment in order to be able to electrodeposit a 3D porous structure for a copper current collector and a 3D CuSnFe alloy anode coating. It uses water-based processing. The reviewer stated that the projected cell lifetime was estimated at ~800 cycles for 3D CuSnFe/graphite anode interim cells at 80% capacity retention at C/3 discharge rate.

Reviewer 2:

The reviewer noted significant progress was made on both key project fronts—material development and manufacturing process development, and data to support that progress was provided. Improvements in anode energy density towards stated goals for the anode material development effort were demonstrated for both of the primary material selections. The reviewer stated that the development of the process to manufacture these materials was also demonstrated and was evident by the consistent cell performance provided, which indicated good process control.

Reviewer 3:

The reviewer indicated the cycle life of 3D electrodes is very impressive.

Reviewer 4:

The reviewer felt it was not clear as to what the baseline cell was and it was therefore difficult to gage progress versus current state-of-the art. Technical accomplishments in process design and electrode design were otherwise excellent.

Reviewer 5:

The reviewer noted good technical progress and technical demonstration towards some DOE goals. Demonstration of feasibility or practicality towards automotive application is not apparent.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer summarized that the Applied Materials group is collaborating with a researcher at LBNL for matching the anode and cathode for cell balancing, conductive binder, and electrolyte additive evaluation. It is also collaborating with a researcher at ORNL for materials characterization and degradation analysis using advanced spectroscopic techniques (micro-Raman mapping, X-ray characterization, etc.). There are also three industrial partners in this effort: FMC Lithium, Navitas Systems (formerly A123 Systems), and the Nissan Technical Center. FMC Lithium is providing stabilized lithium metal powders and coating on anode structures for pre-lithiation. Navitas Systems is evaluating the Applied Materials electrodes using testing equipment for half coin cell, full coin cell, and full scale 63450 prismatic cell geometries. Finally, the Nissan Technical Center (North America) has a researcher who is conducting cell performance measurements and final cell validation to USABC requirements.

Reviewer 2:

The reviewer commented that the project provided clearly defined areas of responsibility that took full advantage of the expertise of each of the multiple collaborators.

Reviewer 3:

The reviewer noted a solid team, with clearly defined responsibilities.

Reviewer 4:

The reviewer indicated excellent collaboration and balanced nature of partners.

Reviewer 5:

The reviewer stated that Nissan and A123 provide the automotive requirements.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer summarized the plan for 2013, which was to continue demonstrating the baseline cell process with 3D Cu/graphite with thicker graphite and at higher charge/discharge rates, to submit 18 prismatic cells for DOE independent testing, to optimize the high-loading CuSnFe/graphite electrode when developing the interim cell further, to complete a cycling test in full-cell assembly, to have an interim cell sent for characterization and analysis at LBNL and ORNL to measure grain size, porosity, and other parameters. A reviewer-only slide lists a number of the technical risks and how the team intends to mitigate them. The reviewer concluded that the key technical risks have to do with improving the process for forming the electrodes.

Reviewer 2:

The reviewer stated that the future work planned for 2013 fits in with the project goals and timing. The assumption is that the Manufacturing Economics work will address the cost of incorporating new equipment to manufacture the material(s), but it is not clearly stated. The reviewer felt it is not clear that the mechanical stability of the system is being addressed or when it will be evaluated. The mechanical stability of this material may be a critical issue and should be addressed.

Reviewer 3:

The reviewer noted that lessons learned from baseline were not clearly defined, as to how they would impact future phases. The Phase elements have enough independence to continue with this risk in mind.

Reviewer 4:

The reviewer stated that the coating width to meet the cost goals is needed for the success of the coating equipment.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer offered that improving the capacity of lithium-ion cell anodes can help to improve the energy density of batteries made of these cells and used for plug-in electric vehicles. Improving the energy density of PEV batteries and delivering this at low cost will help to make PEVs an attractive alternative to conventional ICE vehicles. The reviewer indicated that if more consumers purchase PEVs instead of ICE vehicles, this will certainly lead to petroleum displacement.

Reviewer 2:

The reviewer stated that this project has very strong relevance for the DOE goals of reducing the use of petroleum products to power vehicles.

Reviewer 3:

The reviewer noted that this unique manufacturing approach delivers a unique anode, which could facilitate appreciably higher performing EV cells. Cost remains a question at this point, but should be part of the final deliverable.

Reviewer 4:

The reviewer responded yes, the project could provide fundamental advancement in basic Li-ion battery capability if technology was shown to be feasible and practical.

Reviewer 5:

The reviewer indicated that the equipment manufactured by Applied Materials will reduce the manufacturing cost of anodes.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reported that the resources may or may not be sufficient, but Applied Materials should show more forward movement if the project were to request additional funding.

Reviewer 2:

The reviewer indicated that the appropriate resources are in place.

Reviewer 3:

The reviewer stated no issues with resources.

Reviewer 4:

The reviewer stated that the capital equipment is cost shared with DOE and future customers.

High-Voltage Solid Polymer Batteries for Electric Drive Vehicles: Hany Eitouni (Seeo) - es129

Reviewer Sample Size

A total of 6 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that project has captured the barriers and approaches the solution from two different directions to increase chances of success. Both approaches should yield a product that could be used to support the development of a polymer battery that meets the performance requirements. The reviewer voiced that there is some concern that the low temperature performance issue does not appear to have sufficient focus. Also it is not clearly stated when the project will decide which approach will be focused on for the final deliverable.

Reviewer 2:

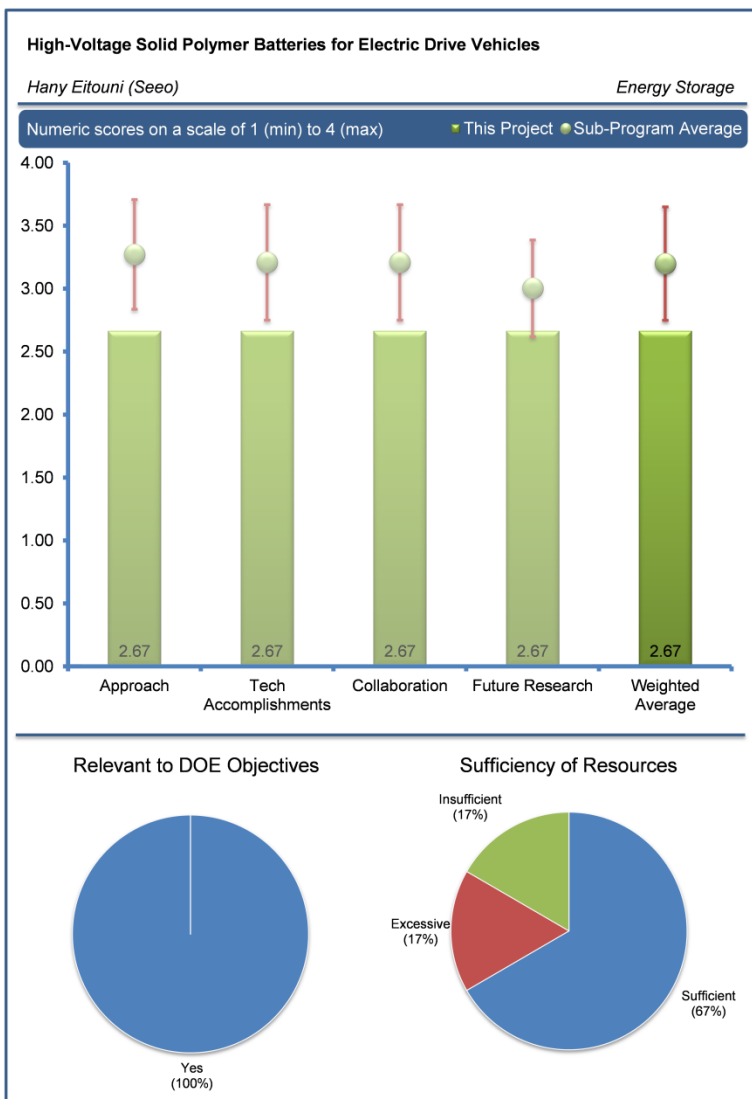
The reviewer summarized that the project has a very intriguing approach for developing a high-voltage solid polymer battery which entails exploiting the fact that solid polymer electrolytes do not flow and therefore cannot mix. Instead of having to use only one electrolyte throughout the entire cell which would therefore have to withstand the higher potential difference (above 4.2 V), Seo can instead continue to use the DryLyte solid electrolyte that it has already developed in the dry solid separator section, and then it can develop a new solid electrolyte within its cathode (a catholyte). The reviewer stated that the thinking is that the new catholyte will not need to be stable at the total voltage of the cell, but just at a "high enough" voltage to be stable within the cathode while still enabling the cell to perform at a high-voltage level in concert with the electrolyte. Having two different electrolytes layered this way appears to be a creative and potentially robust solution to the problem of achieving a high-voltage lithium-ion cell, which depends on having an electrolyte that will not be flammable at the high voltage. The reviewer concluded that the focus of this work is on developing this catholyte material, and the Seo team is taking two different approaches to accomplish this. This is a very creative, highly risky project with no guarantee that there will be a suitable material found at the end of the investigations.

Reviewer 3:

The reviewer indicated there was concern in meeting cycling goals. Focus was a little vague in how the specific performance targets were to be achieved. For example, the reviewer would like to know what tasks are targeted to tackle which specific goals.

Reviewer 4:

The reviewer stated that minimal insight into required temperature of operation and/or related limitations is missing.



Reviewer 5:

The reviewer noted that the solid state electrolyte conductivity is not acceptable at 25°C. Hence the cell operation is at higher temperature. This may not be acceptable for automotive application. The right approach should be a significant increase in the room temperature conductivity.

Reviewer 6:

The reviewer indicated uncertainty as to what is the uniqueness of the Seo polymer electrolyte versus previous polymer electrolyte efforts

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that at the 2012 AMR, the Seo team had no experimental results to report from this project. Therefore, all results reported at the 2013 AMR represent work done over the past year. The reviewer reported that the Seo team is taking two approaches to developing its solid polymer cell system, with its main approach consisting of using its high-voltage-stable polymer (or catholyte) as a binder for its cathode. The second approach is to coat the cathode material particles with organic and ceramic coatings and then to use the same solid electrolyte throughout the cell, as with its current solid polymer cell design. This is considered more of a fail-safe approach if the first approach does not prove to be workable. The reviewer reported that Seo is evaluating different salts to mix in with its polymer electrolyte and evaluating the stability of the salts by looking at corrosion on the electrode. So far, its primary approach of using the two different electrolytes is yielding promising results, with high-voltage polymers showing promise when matched to cathodes over the baseline polymer electrolyte. The reviewer stated that the team's work with coating cathode particles and then embedding them all within a single polymer electrolyte throughout the cell is at an earlier stage of investigation, but the team has verified that the particles are forming the organic coating as intended.

Reviewer 2:

The reviewer noted that it appears that the goals for phase one have been achieved, although it was difficult to identify what specific changes were being driven by which specific objectives.

Reviewer 3:

The reviewer said progress was noted on both approaches. The progress on the catholyte polymer approach appeared to be strong and was a bit clearer than the particle coating approach. The message on the graph showing particle adherence for the second approach was not very clear.

Reviewer 4:

The reviewer noted that the ceramic and conductive coating on the cathode particle will improve the internal resistance at room temperature.

Reviewer 5:

The reviewer indicated very little performance data (cycle life, rate capability at various temperatures, stability), and difficult to assess progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the IREQ has very deep knowledge of their Li metal polymer batteries and Li dendrite issues.

Reviewer 2:

The reviewer indicated that Seo is collaborating with the Institut de Recherche d'Hydro-Québec (IREQ) and two commercial suppliers of high-voltage cathode materials. IREQ is developing Li foil anodes for the cells being investigated. IREQ is also assessing

the manufacturing costs for high-capacity anodes and is leading safety, abuse and performance testing for final cells in this study. The reviewer said that Seo also noted it has commitment from its investors for the full duration of the project.

Reviewer 3:

The reviewer reported that the work performed so far shows little if any collaboration with identified partner. The overall program does have work that appears to have more collaboration later on near project end.

Reviewer 4:

The reviewer indicated little engagement with primary partner to date. Other partners were not identified.

Reviewer 5:

The reviewer noted there was insufficient collaboration.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the next steps seem very clear and seem to be the logical continuation of the work done thus far. The reviewer elaborated that the next step are to validate cathode, polymer and salt combinations in small-area full-cells. Investigate techniques for stabilization of cathode, salt and polymer composites. Develop block copolymers based on candidate materials and tune mechanical and electrochemical properties to minimize interfacial resistance with Seo anolyte. Develop, test and evaluate scale-up methods for high-voltage catholyte block copolymers. Deliver interim cells made of these materials to DOE for characterization. The reviewer noted that in the reviewer-only slides, Seo listed several issues that have been identified with the polymers being used, and approaches that the project team will take to mitigate them.

Reviewer 2:

The reviewer noted that while the future plans build on past progress, plans do not address some of the potential areas of concern such as low temperature performance improvement. Also, the reviewer commented that there is no clear go/no-go decision on which approach will be used.

Reviewer 3:

The reviewer indicated a lack of definition on barriers. This must be more clearly identified.

Reviewer 4:

The reviewer reported that there was no plan to address the critical issues of polymer electrolyte, i.e., long-term stability and RT/low temperature rate capability.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that high-voltage lithium-ion cells (which may be based on solid polymer technology) will be needed in order to maximize the energy density of the batteries to be used in PEVs. These will both decrease the weight of the battery and the amount of materials needed to manufacture the battery. The reviewer commented that if this can be done in a cost-effective manufacturing process, such developments will go a long way towards reducing the cost of PEVs relative to conventional ICE vehicles. Customers will be more likely to purchase and drive competitively-priced PEVs, and a greater number of these vehicles reaching the road would definitely displace petroleum.

Reviewer 2:

The reviewer stated that the project is relevant as improved battery energy density, with no negative impact on safety is critical to reaching the DOE energy goals.

Reviewer 3:

The reviewer commented that if the technology can demonstrate the performance goals set forth in Slide 1, it does meet the objectives of DOE.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that Seeo appears to be making very solid progress thus far with the resources received. Seeo noted that it has commitment from its investors for the duration of this project.

Reviewer 2:

The reviewer indicated that resources are sufficient for this project.

Reviewer 3:

The reviewer noted that fundamental cell development is underway. There is also fundamental material research required, and the science required in these endeavors may overwhelm the deliverables timeline.

Innovative Cell Materials and Designs for 300 Mile Range EVs: Yimin Zhu (Nanosys) - es130

Reviewer Sample Size

A total of 6 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported a solid approach to materials selection and optimization.

Reviewer 2:

The reviewer stated that the objectives of the project are clearly stated. The barriers are identified and the methods to address each of the barriers using specific cell component goals are spelled out.

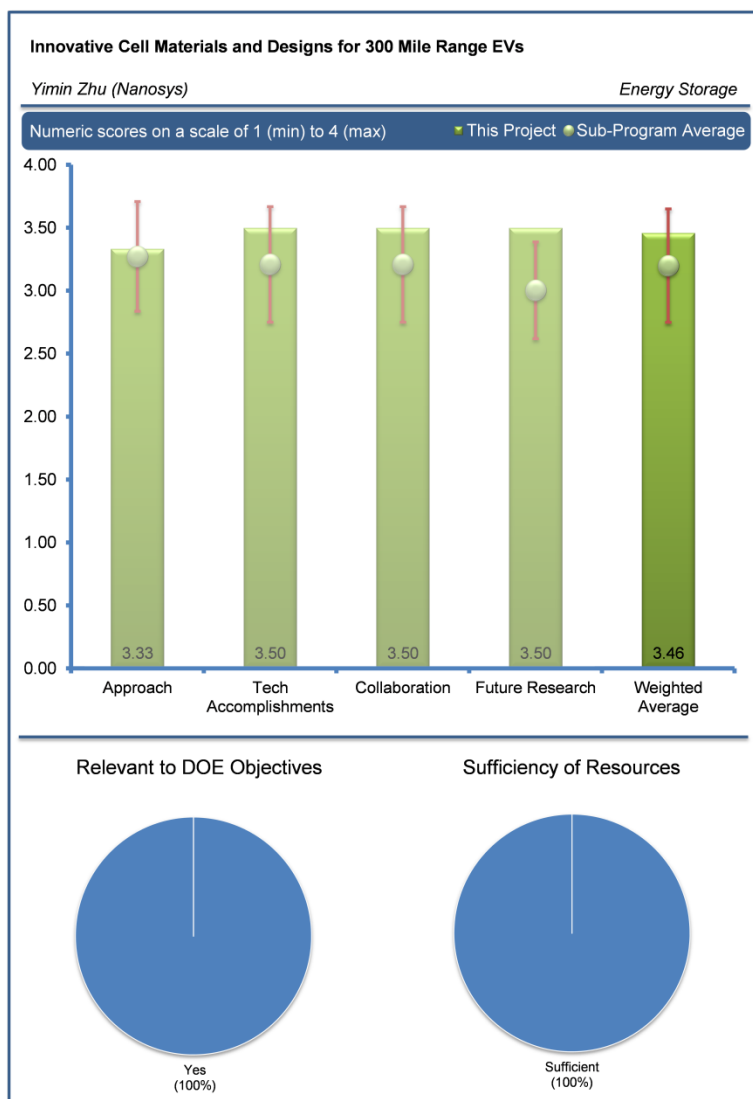
Reviewer 3:

The reviewer noted that the focus is on improving the specific capacity of anode and cathode material. The Si nanowire carbon composite has better chance of success with Mn rich cathode material. The calculations for 300 mile EV are not included. The reviewer felt that the targets for the EV should be better than 350 Wh/kg, 800 Wh/L, and \$100/kWh at the cell level. Nanosys is a material supplier and should target the cost of the anode to meet \$100/kWh at the cell level.

Reviewer 4:

The reviewer stated that the overall goal of this project is to develop battery materials that support a high-energy battery. Nanosys has a composite anode material consisting of silicon nanowires which use graphite powder as a substrate for the nanowire growth. Nanosys calls this material SiNANode, which is a nanowire with a lower surface area/volume ratio, and thus less side-reaction with the electrolyte and a better cycle life. The reviewer commented that it claims that this mix of its silicon nanowires and graphite is a cost-effective way of increasing the capacity of the anode over the standard graphite, and that it can control this capacity in its manufacturing process. Nanosys is currently able to manufacture at a scale of several kilograms per batch (and overall can make several tons a month). It is therefore partly along the way of addressing the issue of materials scale-up.

The reviewer indicated that Nanosys' goals for the battery components are as follows: For the anode, develop a 700~1600 mAh/g Si anode (SiNANodeTM) toward greater than 800 cycles; for the cathode, develop a 260 mAh/g cathode (Mn-rich) toward greater than 800 cycles; and for the cell, develop unique cell combining SiNANode with greater than 250 mAh/g cathode to eventually achieve 350 Wh/kg and 800 Wh/L, resulting in less than 150 /kWh (cell).



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that the project appears to track well against goals. The predominant issue remains cyclability for the high specific capacity anode materials. The reviewer recommended the use of a baseline data in more of the data presentations.

Reviewer 2:

The reviewer stated that the project accomplishments are on track to meet specific project performance goals. Project indicates that there is some concern about the electrolyte progress and may need to start considering the low temperature performance of the electrolyte in addition to its HV stability.

Reviewer 3:

The reviewer noted that a 600-800 mAh/g anode may be good enough for an appropriate cathode material.

Reviewer 4:

The reviewer stated that during the past year, the Nanosys team has completed a baseline SiNANode cycle life demonstration, improved the specific capacity of its SiNANode anode material to within its target range of 700~1600 mAh/g, improved the cycle life of its anode material at the desired composition to 510 cycles at 83% of capacity at 0.3C discharge rate, scaled up its anode manufacturing process to the level of several kilograms per batch, and claims to have optimized its cathode composition. The reviewer commented that Nanosys has delivered 18 cells with high energy density at the end of November 2012, on track with its project milestones. For the cathode, it claims that a manganese-rich (Mn-rich) cathode with a high capacity of greater than 250 mAh/g will be needed, and that it is screening these cathodes. However, the material is not identified. The reviewer indicated that Nanosys also states that a high-voltage electrolyte is being developed, but no further details are given.

Reviewer 5:

The reviewer indicated that some specifics (Wh/L, Wh/kg, rates) were not provided for evaluation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that collaboration with key material suppliers and a major user and cell builder supports this project very well.

Reviewer 2:

The reviewer noted that Nanosys is collaborating with LG Chem, as its test batteries are being made on LG Chem's production line. Nanosys also notes that it is collaborating with Dow Kokam on this project, though the specific nature of this collaboration is not revealed. The reviewer stated that the company also lists several other collaborations outside of the VTO-funded research, which is nice but not relevant to this review.

Reviewer 3:

The reviewer indicated good collaboration, although it was not clear what deliverables are provided by each collaborator for each piece of work.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that future work is closely aligned with the remaining gaps within the project.

Reviewer 2:

The reviewer stated that future work revolves around the key objectives of the project and the objectives are in line with the barriers that need to be overcome. The reviewer again reminded that temperature [low temperature (LT) in particular] needs to be included in future work.

Reviewer 3:

The reviewer reported that Nanosys researchers plan to focus on achieving high energy density and enhanced cycle life. More specifically, researchers will aim for cycle life enhancement for the 700~1000 mAh/g anode that it began to test in the past year. The project team plans pilot-scale manufacturing quantities of SiNANode product, along with cost-sensitivity modeling. The reviewer reported that the team will optimize the SiNANode and appropriate binders, and develop electrolyte additives (for the unnamed electrolyte) to improve cycle life. Following these steps, project team aims to improve the anode material further, to achieve a capacity of 1,600 mAh/g anode. The team also is targeting improved battery discharge rate performance and high electrode loading. The reviewer indicated that the third thrust is optimization of cathode composition and cell components. The team aims to minimize inactive components in the cell, address cathode electrode activation during cell formation cycles, evaluate the compatibility of the developed electrolyte, improve the cell design to achieve high energy density and long cycle life, and integrate the new binder and electrolyte and cell formation/testing protocol.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer indicated the increase in the energy density of the battery cell cells at good cost are needed to make this technology competitive with the gasoline vehicle. This project has an excellent chance of meeting the DOE targets designed to reach that goal.

Reviewer 2:

The reviewer stated that the project represents advanced Li-ion EV cell technology. It is consistent with the technology required to meet EV battery goals, necessary for widespread EV adoption. There is a concern that this work carries appreciable redundancy with other programs of its kind co-funded by the DOE.

Reviewer 3:

The reviewer reported that creating high-capacity batteries that could have energy density high enough to reduce the size of the batteries significantly could lead to cost-competitive PEVs. Nanosys states that its explicit goal is to create materials that could support a cell that would be the foundation for a battery to go into a 300-mile-range PEV. The reviewer felt that if PEVs become as affordable and convenient as conventional ICE vehicles, then a greater number of consumers may purchase them and therefore begin to displace the ICE vehicles on the road, and therefore also the petroleum consumed by the ICE vehicles.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that the funding appears to be sufficient.

Reviewer 2:

The reviewer stated that resources were adequate.

Reviewer 3:

The reviewer reported that no issues were observed.

High Energy Novel Cathode / Alloy Automotive Cell: Jehwon Choi (3M Company) - es131

Reviewer Sample Size

A total of 6 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the approach was clear; the key barriers were identified; realistic targets were clearly established; and the concept was presented in a technically sound and clear format.

Reviewer 2:

The reviewer reported a focused and well-defined plan and approach.

Reviewer 3:

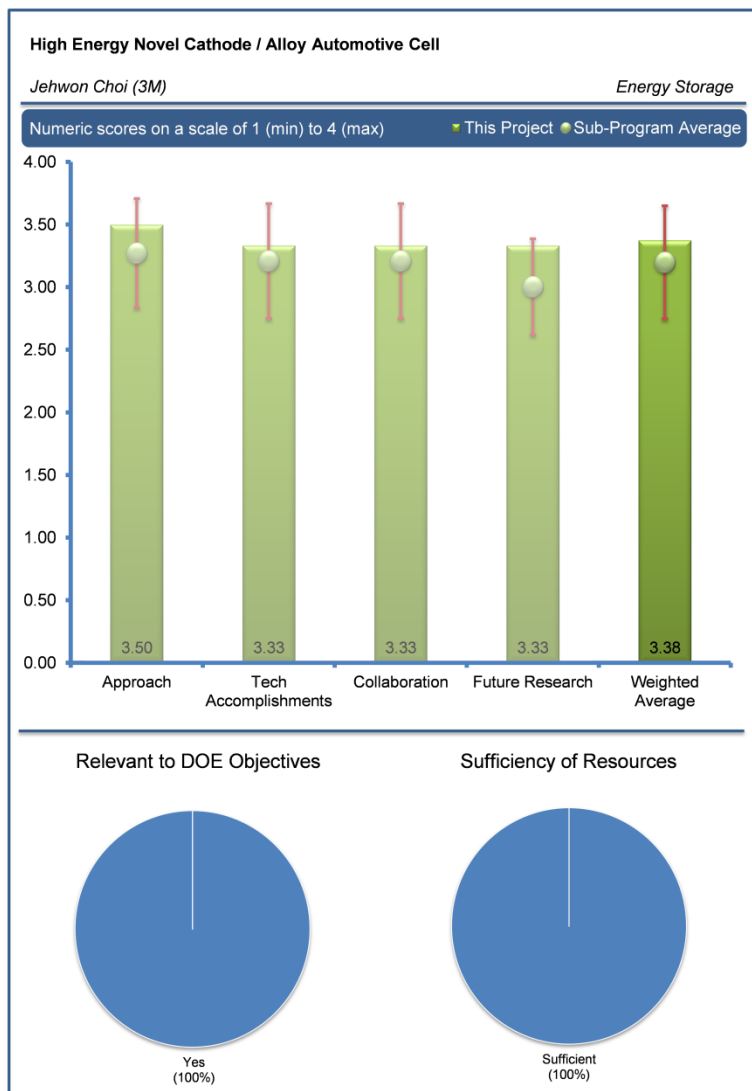
The reviewer stated that the improvement in the energy and reduction in cost are the right approach for the automotive systems.

Reviewer 4:

The reviewer summarized that the project objectives are to develop a high-performance battery cell for electrical vehicle with high energy density and low cost by integrating advanced chemistries. Desired features include at least 40% (1.4X base Wh/L) increase in energy density compared to baseline cell performance (NMC111 and Graphite), 35% increase in energy for advanced high voltage cathode, 70% increase in volumetric capacity for alloy anode, at least 25% lower cost per unit energy at cell level for a comparative integrated advanced materials cell to a baseline materials one. The reviewer noted that the 3M team has pursued a core-shell structure for its NMC cathode material, with a core that has a composition skewing towards nickel (Ni, increasing the capacity) and a shell that has more manganese (Mn, which should improve cycle life). The idea is that combining these two properties within a cathode material would lead to a stable high-energy cell. It has presented data on a half-cell that shows stability over a number of cycles. The reviewer reported that the anode research focuses on developing an alloy with a proprietary structure that uses silicon as its basic active material (as opposed to the commonly used graphite). The alloy particles are less than 20 nm across, mixed in with graphite, conductive carbon, and binder to form the anode. The reviewer summarized that the idea is to reduce electrode expansion over the course of charge/discharge cycles, as this expansion and contraction has been shown to lead to cracks in the material which contribute to the degradation of the electrode. The reviewer reported that the team is matching its high-energy cathode and anode materials and putting them into a cell. The team has tested these cells with a couple of different electrolytes to identify effective electrolytes. An unidentified electrolyte has increased the cycle life by 50%, though the cycle life needs further improvement to be able to reach 800 cycles above 80% of initial charge.

Reviewer 5:

The reviewer stated the project is well designed and managed, but the performance improvements are modest, when compared to EV battery objectives.



Reviewer 6:

The reviewer indicated good approaches but also should include the high voltage layered composite cathode materials as part of the cathode energy factor comparison.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that overall cell energy improvement was demonstrated, and cyclability issues identified. The 40% increase in energy density is modest.

Reviewer 2:

The reviewer noted good progress demonstrating performance in relevant 18650 cell form factor.

Reviewer 3:

The reviewer indicated thus far, the 3M team claims to have demonstrated materials development with a viable high-energy NMC cathode. It has shown a stable voltage curve and an improved cycle life when the cathode and anode are combined with an electrolyte in an 18650 cell. The reviewer commented that in the latest phase of this project (during 2012 and the first part of 2013) the cell energy showed ~40% improvement over that of a baseline NMC/graphite cell coupling. Also, an experimental electrolyte is helping a cell to extend its cycle life by 50% before its capacity is reduced to 80% of the initial charge level (do not know the depth of discharge in these measurements, though). The reviewer stated that the 3M team characterized its anode technology as almost commercialized and currently being tested in cells. It claimed that the cathode material was undergoing limited sampling with partners.

Reviewer 4:

The reviewer indicated that the energy and life improvements validate 3M's approach.

Reviewer 5:

The reviewer stated that the data presented clearly showed significant technical progress toward the project target goals. The cathode work demonstrated a significant improvement over current production NMC 111 as stated. Electrolyte work contributed to improved cycle life for the 3M anode and NMC 111 - when cycled to 60% beginning of life (BOL) capacity. However, at 80% BOL capacity the performance of the electrolytes is the same. The reviewer noted that this supports the need for continued electrolyte work. Not clear on the value of the thin and thick cell design data set, unless, the point is being made that a big hurdle left is scaling the cell design format up to an EV cell Ah capacity. Si electrode expansion work was well documented excellent and appeared to meet the project target goal.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated this was a tight project, but with solid peer review processes.

Reviewer 2:

The reviewer reported that the 3M team is collaborating with researchers at Dalhousie University in terms of technical discussion for most of lithium-ion battery-related areas. Project team has also consulted with ANL experts on battery testing procedures, specifically protocols for EVs. The reviewer recommended that the partners who are doing sampling of these materials/cells should provide feedback.

Reviewer 3:

The reviewer noted that while most of the experimental and development work was done by the sponsoring organization, much consulting was involved to keep the project moving. Ideally, it would have been good to have a cell manufacturer as a collaborator to build a larger cell format for use as a test vehicle.

Reviewer 4:

The reviewer stated that Jeff Dahn's group will help with the final goals.

Reviewer 5:

The reviewer expressed the need to collaborate with groups working on high voltage electrolytes to enable the use of high voltage HE NMC.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported that the proposed future work is to refine the performance of the cells so that they approach readiness for commercialization.

The reviewer detailed future research. First, improve cycle life, including improve Si alloy design; improve composite (Si alloy/Graphite) design; and optimize high energy NMC design.

Second, increased 18650 testing, including develop improved electrolytes – 3M recognizes that an entirely new electrolyte system may be needed to achieve a cycle life where capacity is retained at a level of 90% even after 800 charge/discharge cycles; develop and test 18650 designs under range of conditions; and initiate EV protocol testing.

Reviewer 2:

The reviewer indicated that most issues identified in the project summary sheet that need to be addressed are addressed in the proposed future work. This included evaluating the cells under different conditions. The reviewer stated that the assumption is that those conditions include low and high temperature testing. While the project only called for 18650 cell format builds, incorporating the material into a larger cell format would have been a good future goal. This view is only being expressed because of the slide showing the performance of a thin versus thick cell design.

Reviewer 3:

The reviewer reported that alternatives to potential outcomes are considered. Next steps are logically planned out.

Reviewer 4:

The reviewer felt that some minimal (at least) investigation of relative abuse tolerance would be useful.

Reviewer 5:

The reviewer said that some future work should be devoted to reducing the first cycle loss in the HE NMC.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that this work is very relevant as it drives toward a viable and significant increase in energy density for current battery technology, while offering a significant cost reduction. Overcoming these barriers is essential to meeting the DOE objectives for petroleum displacement

Reviewer 2:

The reviewer stated that while the goals of a 40% energy improvement are modest, the material development approach and demonstration is solid, and the kind of approach essential in advancing the state of the art.

Reviewer 3:

The reviewer noted that an improved cell that is high-energy could lead to a viable long-range and lightweight battery pack for a PEV. If PEVs can be made with batteries that use less material, then the cost of the battery will be reduced. The reviewer indicated that a more affordable battery will make PEVs more affordable to consumers, and it will increase the likelihood that they will purchase a PEV. The more PEVs on the road, the fewer vehicle miles traveled on petroleum. Thus, this research does support petroleum displacement.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources appear to be sufficient to support the work that 3M is pursuing in this project.

Reviewer 2:

The reviewer indicated that existing funds for this project are sufficient.

Reviewer 3:

The reviewer commented no issues.

Utilization of UV or EB Curing Technology to Significantly Reduce Costs and VOCs in the Manufacture of Lithium-Ion Battery Electrodes:

Gary Voelker (Miltec UV International) - es132

Reviewer Sample Size

A total of 2 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that new electrode coating process will reduce capital, space and operating costs while minimizing solvent recovery and cell assembly costs.

Reviewer 2:

The reviewer reported that the project goals are very ambitious, and the authors have demonstrated great progress.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that technical accomplishments for this work are very good. The project is 50% completed and the authors are demonstrated a very good cathode performance using UV curable binder. The reviewer concluded that it will be of great interest how a full cell performs when both electrodes contain an UV curable binder.

Reviewer 2:

The reviewer stated that electrode materials were produced and assembled into NCM cathode and /Timcal C-45 anode using polysiloxane based UV curable binder and assembled in coin cells for testing. The reviewer reported over 2,000 cycles to 60% capacity in test cells, cells have good high rate performance, cells with LiFePO₄ produced and cycled as cells with silicon anodes, cells have good high rate and cycle life. Prototype coater designed and constructed.

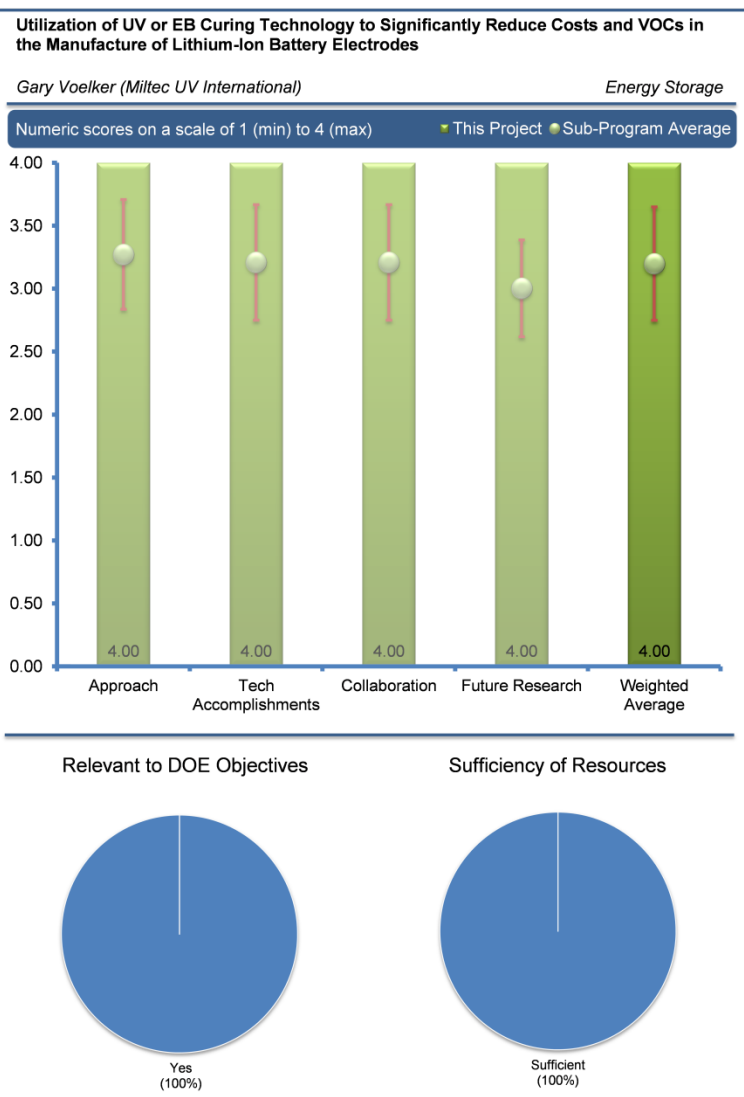
Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported close collaboration with ORNL personnel in developing the overall process.

Reviewer 2:

The reviewer stated that the collaboration with other institutions is very good. The sharing of some of the cost by a company such as Miltec is very encouraging.



Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that future work will likely include producing electrode structures for assembly into prototype vehicle cells for confirmation of the new electrode coating process.

Reviewer 2:

The reviewer reported that the proposed future research is pointing in the right direction. A full cell testing where both electrodes use curable binder can have very important implications in cell manufacturing. Probably, in the future, additional work should be done with different cathode chemistries.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that the ability to use new binder opens up new avenues for material choices. New electrode process does not use regulated solvents in its operation.

Reviewer 2:

The reviewer said yes, it is supporting the overall strategy of DOE of petroleum displacement by focusing in a very practical problem that can lower the cost of electrode manufacture tremendously.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated if the authors managed to demonstrate in a full cell, and at least with one cathode chemistry, that their approach is feasible and can lower the cost of electrode manufacture, the project team should receive additional resources.

Reviewer 2:

The reviewer indicated that the resources are used efficiently and effectively.

Significant Cost Improvement of Li-Ion Cells Through Non-NMP Electrode Coating, Direct Separator Coating, and Fast Formation Technologies: YK Son (Johnson Controls) - es133

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the main barrier that the PI is addressing is the public's acceptance of electrified vehicles. To meet this challenge, the battery must be cost effective. The reviewer reported that Johnson Controls' approach to lowering cost by greater than 50% is to make significant improvements in the Li ion manufacturing process by developing a non-NMP electrode coating process and a direct coated separator. This is a good approach and if successful has a very high chance of lowering battery costs. The reviewer criticized that no specifics or a pathway on how to accomplish this was provided.

Reviewer 2:

The reviewer reported good and sensible approaches to reduce Li-ion cells cost.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

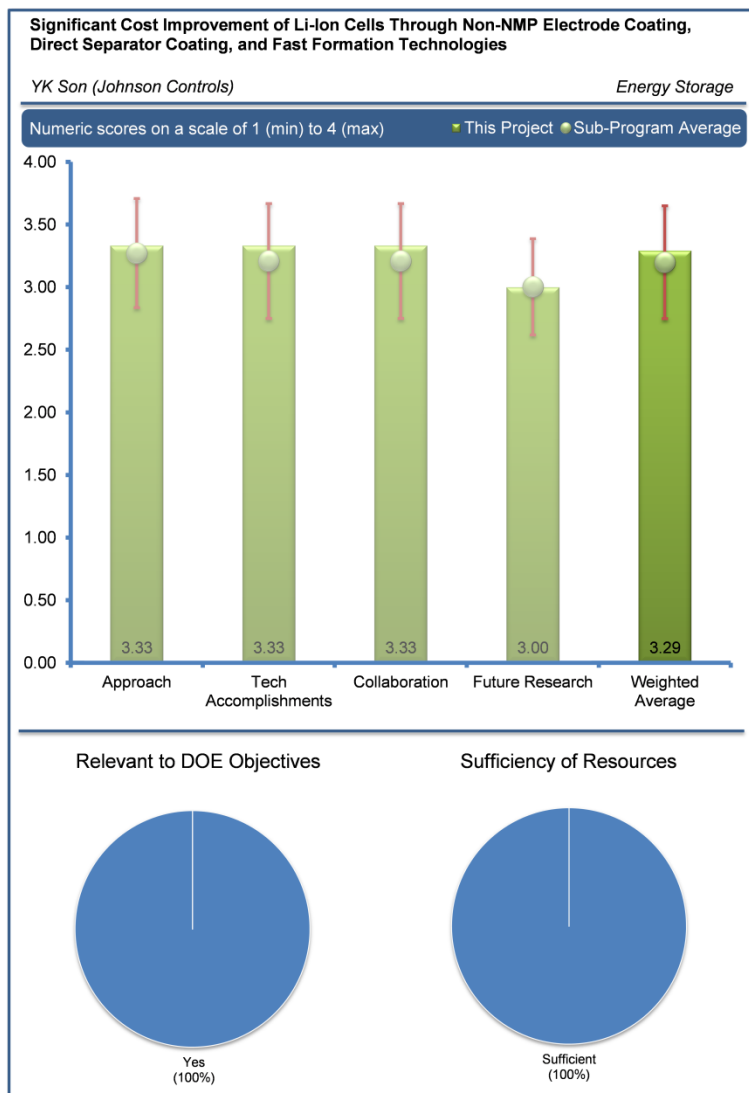
The reviewer indicated that lamination shows most promising results compared to others.

Reviewer 2:

The reviewer noted that good progress has been made this past year. The baseline 3Ah and 15Ah pouch cells and coin cells were completed. The reviewer stated that experiments were conducted on cells using dry-coated and water-based electrodes. The dry coating process did not meet the performance specs and it is unclear if the water-based electrodes will meet the cost objective (greater than 50%). The reviewer reported that efforts were directed to develop direct coated separator technologies. Lamination was shown to yield the most promising results. A fast formation process investigation was also undertaken.

Reviewer 3:

The reviewer noted that progress seemed slow since the project inception in 2011. The reviewer commented that they did not have sufficient data to evaluate the progress on shortened formation.



Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported that very good partnerships have been formed under this program. Johnson Controls is collaborating with Entek Membranes, Maxwell Technologies, and University of Wisconsin.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the plan seems to be clear.

Reviewer 2:

The reviewer reported that the future plans outlined during this review are justified. Future plans build on the challenges confronting the technology improvements and the results to date.

Reviewer 3:

The reviewer indicated good proposals but need more progress.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that this project, as outlined, is highly relevant because it supports the DOE objective of petroleum displacement. To accomplish petroleum displacement, there must be a viable battery option and the public will not accept a battery option unless it is cost effective and the performance is good.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that this program appears to have the necessary resources to complete the tasks successfully. The total project funding includes \$3.6 million (from DOE) and \$3.67 million from Johnson Controls and the sub-recipients.

Dry Process Electrode Fabrication: Mike Wixom (Navitas Systems) - es134

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the program seeks to: identify a binder system for a solvent-free anode fabrication that is stable over 500 cycles to full state of charge; and produce a free standing dry process cathode that retains 50% capacity at the 1C rate. It is not clear how the investigators plan to accomplish this because no information was provided.

Reviewer 2:

The reviewer indicated that the use of solvent-less binder and extrusion is generally effective to thicker and dry electrode fabrication but the process and electrode adhesion/cohesion could be vastly improved over what is achieved. The reviewer stated that the process overcomes use of hazardous solvents in the coating process but the approach is questionable in terms of speed of fabrication as compared to the coating process. Therefore the relative cost savings is questionable on scaling up this process that also requires lamination part.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

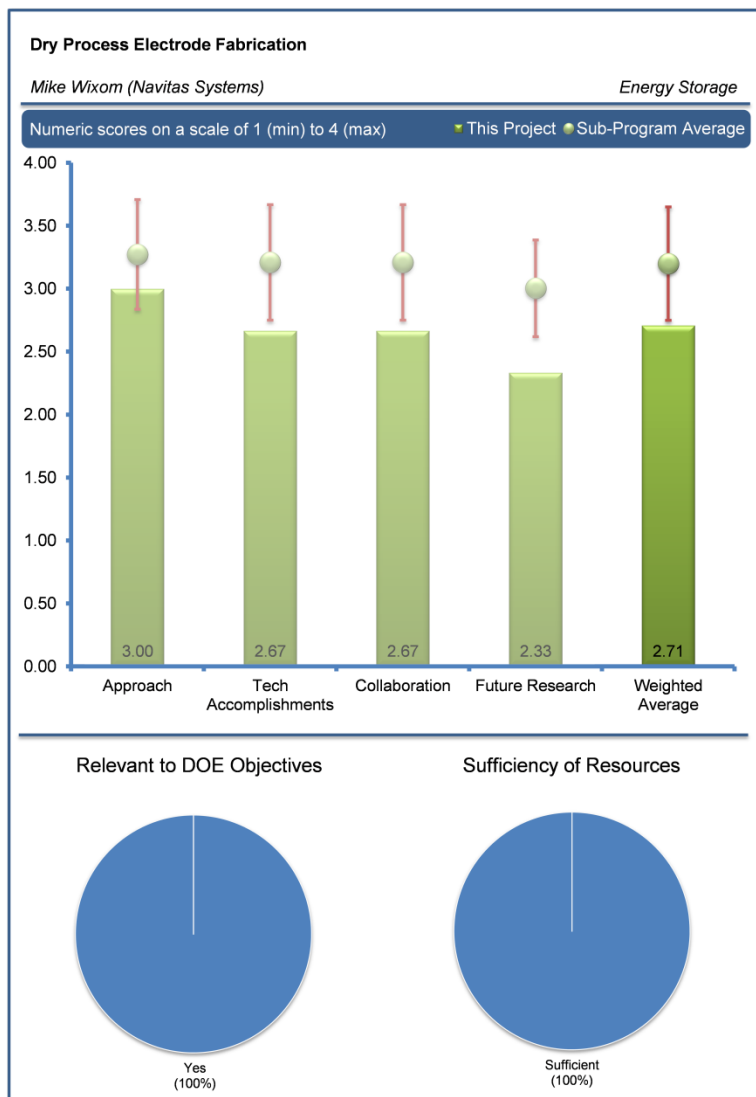
The reviewer felt that the accomplishments this year appears to be fair. It would have been helpful to the evaluation process if the PI had clearly identified the accomplishments on the slides.

Reviewer 2:

The reviewer suggested explaining the strength of these dry coatings.

Reviewer 3:

The reviewer felt that given the time line of the project, the technical accomplishment/progress is not adequate. The cathode adhesion/cohesion, loading level, and porosity are far from optimum level for decent rate and cycle life. The reviewer stated that the choice of electrode thickness at greater than 100 micron to make any impact on energy not good enough and will not achieve higher loading for metal oxide cathodes. The reviewer remarked it is not clear whether the choice of current collector is metal grid or foil. The reviewer indicated that this will influence process speed and the quality of the electrodes vastly. The data presentation is very poor and deceptive without any controls for comparison.



Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer said only fair, at best, collaboration exists in this program.

Reviewer 2:

The reviewer reported the need for clarification on why one collaborator was dropped. The reviewer would like to know if it is a business decision mandated from the acquisition of parent company. The reviewer also asked was the initial collaboration with Maxwell aimed at battery/ capacitor hybrid to achieve HE+HP system. The reviewer indicated that need for some quantification on what level of consulting with Zn-air industry going on and how is appropriate for Li-ion electrodes.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer reported that future efforts appear to be routine. This includes reducing the electrode thickness, blending high energy density cathodes, fabricating cells, etc.

Reviewer 2:

The reviewer stated that the proposed reduction in electrode thickness is counter to what the initial strategy of 2X loading. The reviewer also explained that processing aids and/or pore formers add to cost and speed. The reviewer suggested that overall the project needs a better milestone definitions and quantifications for the statements.

Reviewer 3:

The reviewer queried how there was reduction in the electrode thickness.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that this project is highly relevant and supports DOE objectives of petroleum displacement. In order to convince the American public to drive an EV an affordable battery is necessary. The reviewer highlighted that the focus of this project is to identify a low-cost method of processing electrodes.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer reported that the funding for this 3-year effort appears to be sufficient. The DOE share is approximately \$3 million and the contractor's share is \$1 million.

Stand-Alone Battery Thermal Management System: Brad Brodie (DENSO International America) - es135

Reviewer Sample Size

A total of 2 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer summarized that a comprehensive model of the total battery system has been developed and it can be configured to match any battery system.

Reviewer 2:

The reviewer stated that the authors have managed to simulate the drive profile current and voltage response. It will be of great interest to do something similar with different battery chemistries to understand the limitations of the computer program.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the accomplishments have been very good. In the future the project team should indicate with additional details which are the assumptions the team has to introduce in their model and how those assumptions may change based on the different cathode chemistries, for example.

Reviewer 2:

The reviewer reported that the work was accomplished in good time. Designs include a combination of liquid and vapor heat control systems in order to provide reliable control of battery operations.

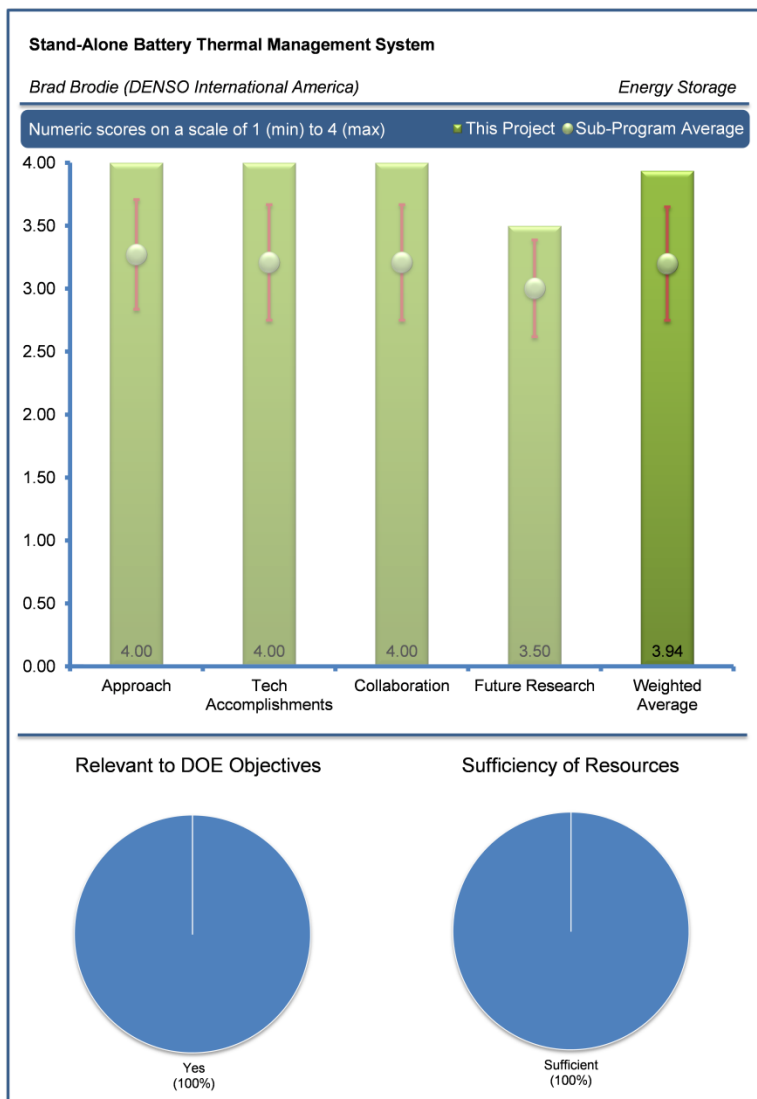
Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported good collaborations with Chrysler and PNNL were held to assure that sound principles were used, and that they corresponded to vehicle needs.

Reviewer 2:

The reviewer stated that it seems that the collaboration with other institutions has been good. The project team should interact even more strongly with Chrysler.



Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that future work will validate the model and apply it to real systems in bench testing.

Reviewer 2:

The reviewer felt that the authors may find that their model is not applicable for every cathode and anode chemistry. That should be clearly stated. The approach of comparing all results and choosing the one that meets the project objective appears reasonable and practical.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that thermal management is essential for long life of the battery system. The model has the capability to meet the standards of the proposal.

Reviewer 2:

The reviewer said yes, it is supporting the overall DOE strategy of petroleum displacement by focusing on a 20% cost reduction at the battery pack level; that saving is critical and very important.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reported that the project already has a cost sharing from DENSO and that is very good. If the authors manage to prove an overall 20% cost reduction of the battery pack, the project team should ask for additional support.

Reviewer 2:

The reviewer stated that the necessary resources were available to carry out the project.

Innovative Manufacturing and Materials for Low-Cost Lithium-Ion Batteries: Steve Carlson (Optodot Corporation) - es136

Reviewer Sample Size

A total of 2 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought that this was another interesting presentation where the lowering of the cost of a battery is the main topic. The reviewer felt that the authors have demonstrated great progress under a very ambitious goal of cost reduction.

Reviewer 2:

The reviewer listed the goals were to reduce the cost, weight and volume of cell inactive components by 20-40% while developing a new electrode assembly process.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that the authors developed a thick ceramic separator with a very narrow pore size distribution. It would be of great interest to the reviewer to know how this separator reacts with the different cathode chemistries.

Reviewer 2:

The reviewer listed accomplishments as having developed ceramic separator with narrow pore size distribution and thickness. The reviewer also relayed that ANL cost model predicted process could reduce electrode cost by 20%.

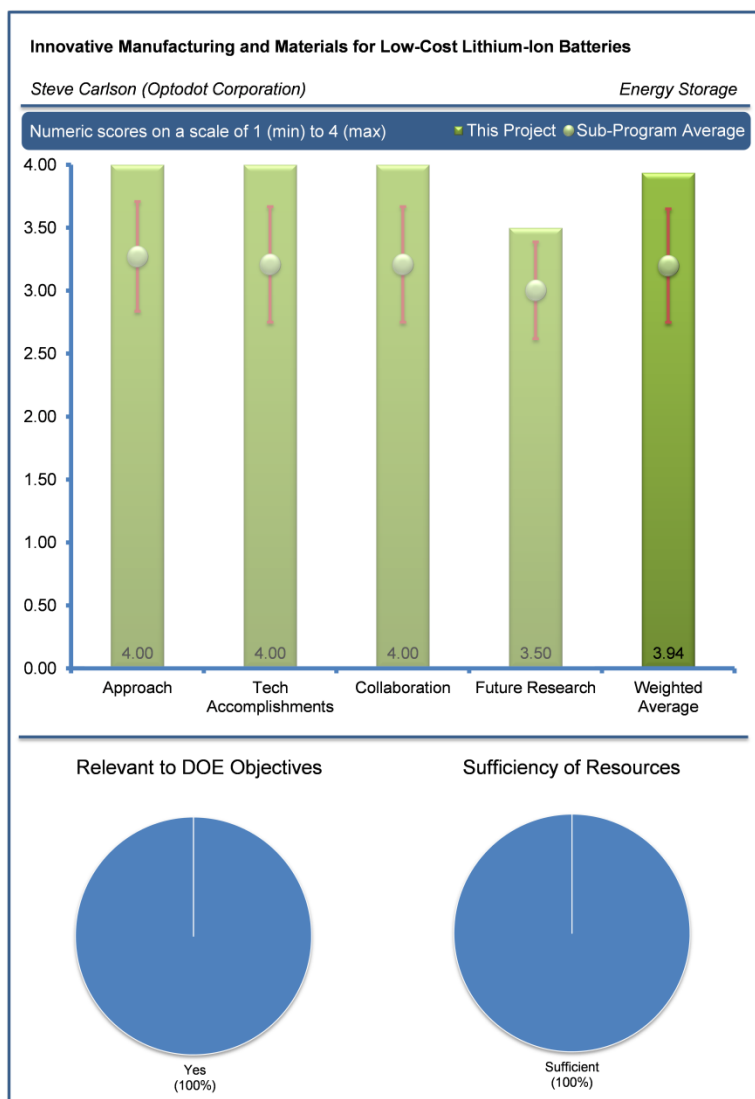
Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer thought that it was very important to have industrial partners such as Madico and Dow Kokam.

Reviewer 2:

The reviewer listed that the project was working with Madico for manufacturing processes (mixing and coating), Dow Kokam for electrode coating, Rhode Island University for cell cycling tests, and Ashland for polymer binder selections.



Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer felt that the future work was well directed, and anticipated that the scale-up of some of the improvements that the authors describe is going to be critical.

Reviewer 2:

The reviewer reported that the future work would consist of: optimizing and scale-up of anode, cathode and current collector designs for improved process efficiency, incorporating improved electrolyte into cell process, assessing the cost of cells using improved manufacturing processes, and delivering cells for testing to confirm advantages of new process.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer felt that this project did support the DOE goals because cost reduction is one of the most important variables to consider when the goal is petroleum displacement, and the authors are well coordinated towards that goal.

Reviewer 2:

The reviewer predicted that new more efficient electrode fabrication leading to lower cell costs would be needed for future EVs.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found there to be an efficient use of resources.

Reviewer 2:

The reviewer reported that the project already has a cost sharing from Optodot. If the authors managed to prove an overall cost reduction the authors should ask for additional support.

LEESS Battery Development: Kimberly McGrath (Maxwell) - es139

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

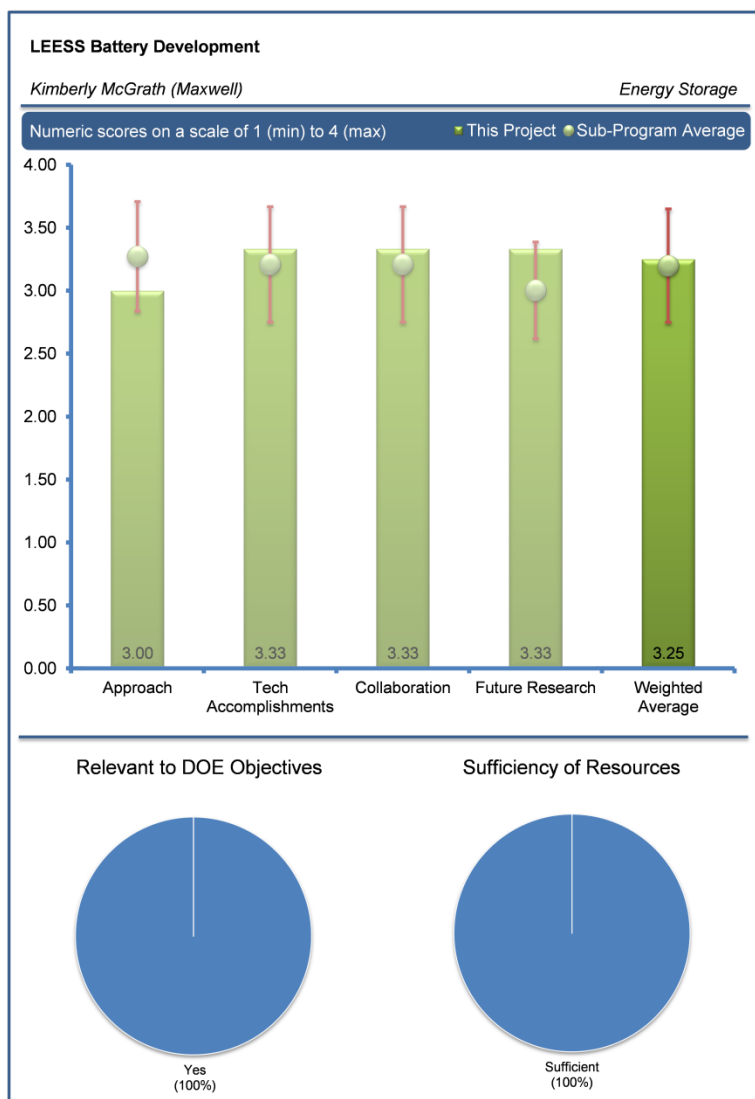
The reviewer thought the project utilized a good approach with specific targets.

Reviewer 2:

The reviewer reported that the program is scheduled to end March 2014. The overall approach taken thus far has been generally good and continues to be so. Efforts are focused on the systems level as well as improved materials. However, the reviewer noted that the specifics on why a certain type of material was selected for investigation or a design was chosen was not conveyed.

Reviewer 3:

The reviewer related that there were not many pursuing the Li-ion-based capacitors other than Maxwell in United States. However, the reviewer said that it remains to be seen at the system level whether this hybrid approach is better than lithium iron phosphate (LFP) based high power battery systems.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer found the project to be very well organized and the target, goals, and timeline to be very well addressed.

Reviewer 2:

The reviewer reported that good progress had been achieved to date. Significant weight and size reduction of the modules were projected based on partial scale prototype modules. The reviewer relayed that although data was provided on the conductivity of the improved electrolyte, no data on cell cycling (coin cells or small laboratory cells) at the low temperatures were provided.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer understood that good collaboration existed between Maxwell Technologies, Porous Power Technologies, the University of Rhode Island, and the national laboratories.

Reviewer 2:

The reviewer thought there was good collaboration and that it was appropriate in terms of fundamental work versus product related functions; the reviewer listed all of the collaborators: Porous Power, University of Rhode Island., INL, NREL, and Sandia National Laboratories (SNL).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer felt that the proposed future work was a logical extension of the completed efforts to date. Gen-3 cells will be fabricated utilizing the best materials identified to date. The reviewer related that, once built, the module will be fabricated and sent to the national laboratories for performance, heat modeling and abuse testing.

Reviewer 2:

The reviewer concluded that testing at the national laboratories was critical to the project.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer felt that the program was relevant and supported the DOE objective of petroleum displacement. It seeks to provide an affordable energy storage device and to improve its performance. The reviewer reported that the goals were clearly defined; \$920 project goal assuming a production of 100,000 units per year.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources appeared to the reviewer to be appropriate for the level of effort.

Lithium Source For High Performance Li-ion Cells: Keith Kepler (Farasis) - es140

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer felt that the project had a good approach.

Reviewer 2:

The reviewer thought that this alternative approach by use of lithiated Fe/V oxide as Li source is good, but warned that the difficulty of extracting Li from the proposed structure, synthesis and the stability of the lithiated lithium iron oxide (LFO) etc., could all limit the practical use, and therefore add little to the energy improvement at the full cell level.

Reviewer 3:

The reviewer reported that the effort seeks to develop an affordable, safe, low-cost, lithium ion battery by developing high capacity cathode materials that are low cost. The materials under consideration are pre-lithiated and enable the charging of the anode. It would enable the use of partially charged cathode materials. The reviewer concluded that this was a logical approach, and could succeed.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that this program was completed, and that good progress was achieved last year. The LFO degradation process was characterized by Raman spectroscopy, the material utilization was increased to greater than 850 mAh/g, and the synthesis procedure was scaled to 1 kg batch sizes.

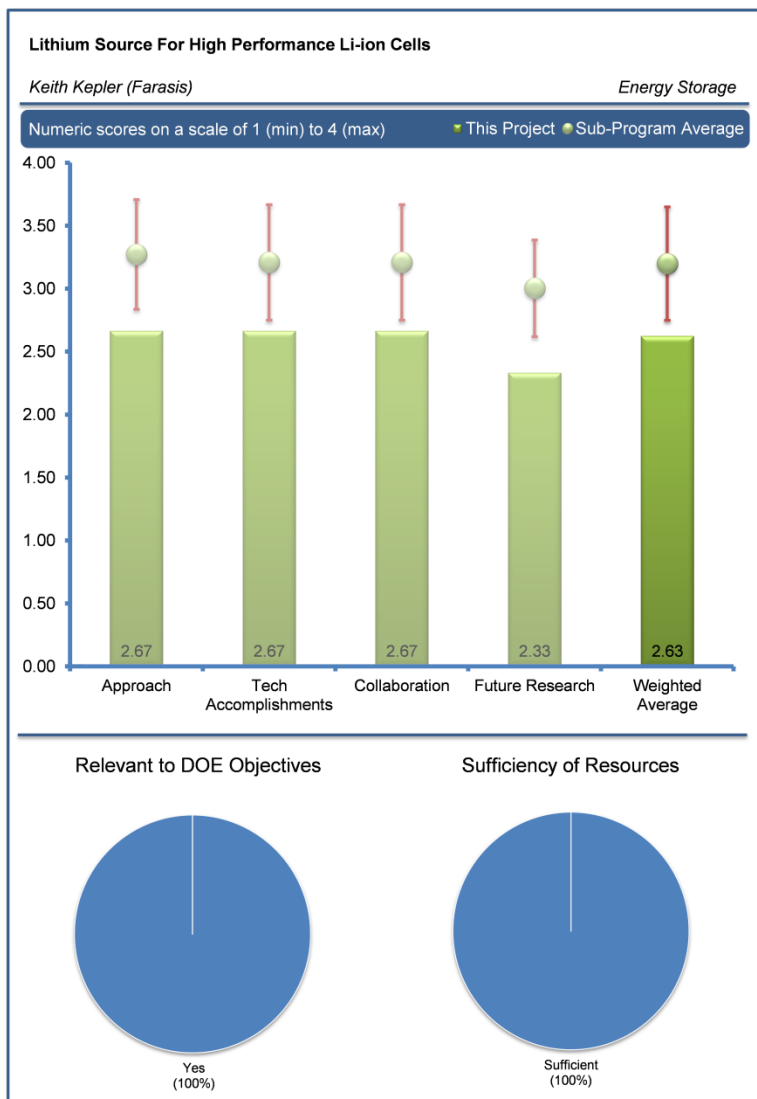
Reviewer 2:

The reviewer was not clear on capacity data and stability, and noted that in Slide 21 the capacity data for LiV_3O_8 , should be explained.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer saw an indication of collaboration with ANL, but it was unclear what form this took.



Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported that the program has concluded. The primary investigator PI did note the need for future optimization of LFO for capacity and stability, as well as evaluation of manufacturing methods and impact on cell variation and performance.

Reviewer 2:

The reviewer confirmed that the project has been completed, but would really like to see the impact at the cell level before any future funding related to this effort is put into effect.

Reviewer 3:

The reviewer would have liked to see a discussion of the current issues and an explanation of how these issues will be addressed for future optimization.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer thought that this project was relevant and supported the DOE objective of petroleum displacement. The effort undertook to identify new electrode materials that would allow a high energy density, affordable, safe, lithium ion battery to be developed.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer felt that resources were sufficient. The project has concluded.

Reviewer 2:

The reviewer stated that no details were provided.

Implantation, Activation, Characterization and Prevention/Mitigation of Internal Short Circuits in Lithium-Ion Cells: Suresh Sriramulu (TIAX LLC) - es142

Reviewer Sample Size

A total of 6 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found that there was excellent control study of the safety impact of nail penetration on Li-ion cells with different chemistries.

Reviewer 2:

The reviewer reported that the purpose of TIAX's research was to investigate the standard nail penetration test used to assess the safety of Li-ion cells. The test entails driving a metallic nail through a charged Li-ion cell at a prescribed speed, and if no smoke or flame appeared after this abuse, the cell was deemed to have passed the test. However, the reviewer noted that the connection of the test to actual failures of the cell in the field was tenuous, and the TIAX team sought to evaluate the nail penetration test and see whether it is a valid gauge of a cell's safety.

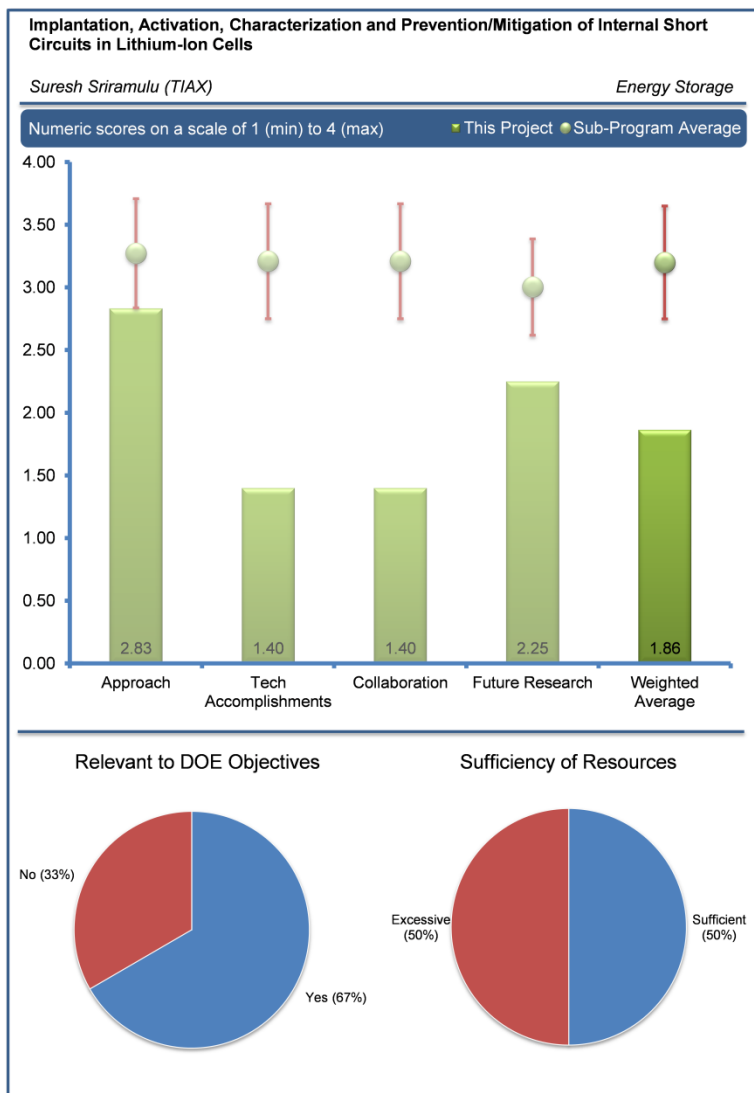
The reviewer went on to inform that TIAX built a test chamber which controls the relevant parameters for the nail penetration test, which is not standardized among manufacturers. It also was equipped for acquiring sensitive voltage, temperature, and pressure data, as well as high-speed photography for capturing visual results. The reviewer relayed that the team also conducted computer simulations to disentangle the mechanisms behind the phenomena that they observed experimentally.

The reviewer concluded that TIAX was doing a great service to the battery field by questioning and systematically assessing this common test.

Reviewer 3:

The reviewer thought that from one perspective, the purpose of the project appeared to be to invalidate in general the utility of nail penetration tests on actual cells and the use of differential scanning calorimetry (DSC) measurements in the study of relative thermal stability of individual electrode materials. Other than this, the project purpose appeared to the reviewer to be unclear.

The reviewer further offered that this project appeared to illustrate response of Lithium Cobalt Oxide (LCO), Nickel Cobalt Manganese (NCM), and Nickel Cobalt Aluminum (NCA) cells in nail penetration tests which would be unexpected based on related DSC results, implying that the differential scanning calorimetry (DSC) and/or nail penetration tests were not useful. However, the reviewer reported that no details or background regarding internal cell construction, separator, nail penetration, etc., or the possible impact of these on response were offered or implied.



Reviewer 4:

The reviewer stated that there was no information on the program cost or timing-- information that was critical to fully understanding the approach. The approach as outlined was not followed. The reviewer concluded that no clear objective, no clear test plan, and no results were shown that supported the ambiguous objective of this project.

Reviewer 5:

The reviewer felt that while the approach described should help to characterize the test, the test results failed to indicate that in fact the nail penetration test had been characterized.

Reviewer 6:

The reviewer said that the cause of one cell out of 10 million cells was not discussed in detail and supporting information.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer thought that it made sense to discard the typical nail penetration test to simulate the internal short.

Reviewer 2:

The reviewer observed excellent results dispelling the misconception of materials DSC data's correlation with safety performance in an actual cell.

Reviewer 3:

The reviewer relayed that TIAX compared commercial 18650 cells with two common chemistries. The cathode materials were harvested from the cells and then rebuilt into coin cells, with DSC measurements done to characterize the thermal stability of the materials. The superior thermal stability characteristics of NCM at higher temperatures have led to the conventional wisdom that NCM cells would be safer (in thermal terms) than LCO cells. However, the reviewer noted that the TIAX team showed that a commercial LCO cell withstood a mild temperature rise upon the nail penetration, while the supposedly safer commercial NCM cell experienced violent thermal runaway under the same circumstances.

TIAX's tests have established some important results, which the reviewer listed as: state of charge (SOC) of the battery strongly influences the nail penetration test outcome, with higher SOC's corresponding to a higher degree of destruction of the battery by flames; local temperature measurements showed that any temperature rise due to the nail penetration does not correlate with any explosions (violent thermal runaway); computer simulations used to simulate the phenomena arising from the nail penetration experiment showed that what is observed is not consistent with internal short circuits; cathode DSC measurements (used to measure thermal stability) do not predict cell safety, which is instead based on complex interactions between heat release, heat transfer and cell design.

Reviewer 4:

The reviewer felt that the apparent, but not clearly stated, objective of the project was to evaluate multiple test variables (which were clearly identified) that could be used in a nail penetration test and to show the effectiveness (or non-effectiveness) of the test in stimulating an internal short.

The reviewer revealed that no data was presented that showed any of the work related to those variables. Rather, the results provided was mostly on cell material performance, rather than the test method itself, which was the actual objective of the project. The reviewer heard comments made about the handbuilt chamber being well built, but no data was provided to support that claim.

The reviewer noted a lack of detail presented, and would have liked to see nail speed control capability; tip diameter, nail material, etc. in the presentation. About how the test was performed little data was presented; other than that, cell SOC matters, which has been well-documented for years.

Reviewer 5:

The reviewer felt that there was little evidence of anything novel generated within this project, and held that most information was already known by the industry.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer observed good internal collaboration between the engineers and scientists.

Reviewer 2:

The reviewer reported that no other collaborators were noted.

Reviewer 3:

The reviewer cited no significant evidence of any collaboration.

Reviewer 4:

The reviewer assumed there was no collaboration, as there were no details provided.

Reviewer 5:

The reviewer confirmed that there was no information on the collaboration.

Reviewer 6:

The reviewer wanted to note that the poor rating corresponds to the fact that this project showed little collaboration with partners. Because this project was about questioning a common test of battery safety, this was not product-oriented research that would likely make money for a company in industry, and it is not likely to yield the kind of breakthrough result that would reward an academic laboratory with tenure and grant money. The reviewer found that this project did yield results that provided a service to the battery industry. The reviewer did not think the experiment could have been done any better through collaboration, so disagreed with the poor rating.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported no indication that this project would be continuing further.

Reviewer 2:

The reviewer confirmed that there was no future work outlined.

Reviewer 3:

The reviewer agreed that no future work was proposed.

Reviewer 4:

The reviewer stated that it was unknown; no details were provided.

Reviewer 5:

The reviewer saw no need for future research.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer thought that this project helped to advance the quality of safety testing for Li-ion batteries for PEVs. The reviewer reasoned that ensuring that the batteries used in PEVs are safe will help to support customer adoption of these vehicles, which will displace oil-consuming cars on U.S. roads.

Reviewer 2:

The reviewer felt this project did not provide any useful information based on the project's objectives. The reviewer judged the most relevant information was something done outside the stated objective, which was that DSC results may not be a good indicator of how a chemistry responds in thermal runaway caused by a nail penetration test.

Reviewer 3:

The reviewer saw nothing of significance generated in this project, which could be applied to materials and cell development for electrified vehicles.

Reviewer 4:

The reviewer reported that the actual technical content reinforced some similar past work by others.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer did not even know what the resources were, but the project team seemed to have completed the project all right.

Reviewer 2:

The reviewer reasoned that since no resource amount was identified and little new information was provided, the resources provided for this project must be excessive.

Reviewer 3:

The reviewer concluded that one engineer should have been sufficient, if the presentation represented all the findings of the project.

Reviewer 4:

The reviewer said that funding levels were unknown, as no details were provided.

Novel Anodes Materials: Jack Vaughey (Argonne National Laboratory) - es143

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought that the approach taken in this project was excellent; well thought out and a clearly planned execution. The reviewer reported that investigators will characterize a series of silicon-based electrodes with a variety of 3-dimensional structures and then develop techniques to investigate the effect of cycling on the electrode. The reviewer felt that, if successful, this program will result in a better understanding of how the active materials interact with their surrounding during cycling.

Reviewer 2:

The reviewer reported that the approach combines a variety of methods to prepare silicon anodes with development of characterization tools. The best characterization methods need to be broadly applicable to discern differences between silicons made via different processes. The reviewer thought that these characterization tools – particularly the Si NMR and tomography are vital to understanding the technical barriers to practical implementation of silicon anode materials, as well as addressing those issues. The reviewer would like to see the characterization techniques applied more broadly – at the electrode level – to a variety of silicon materials and binders being marketed by organizations. The reviewer believed that the approach of tailoring the surface chemistry to get synergies with binders will very valuable in getting systems to work.

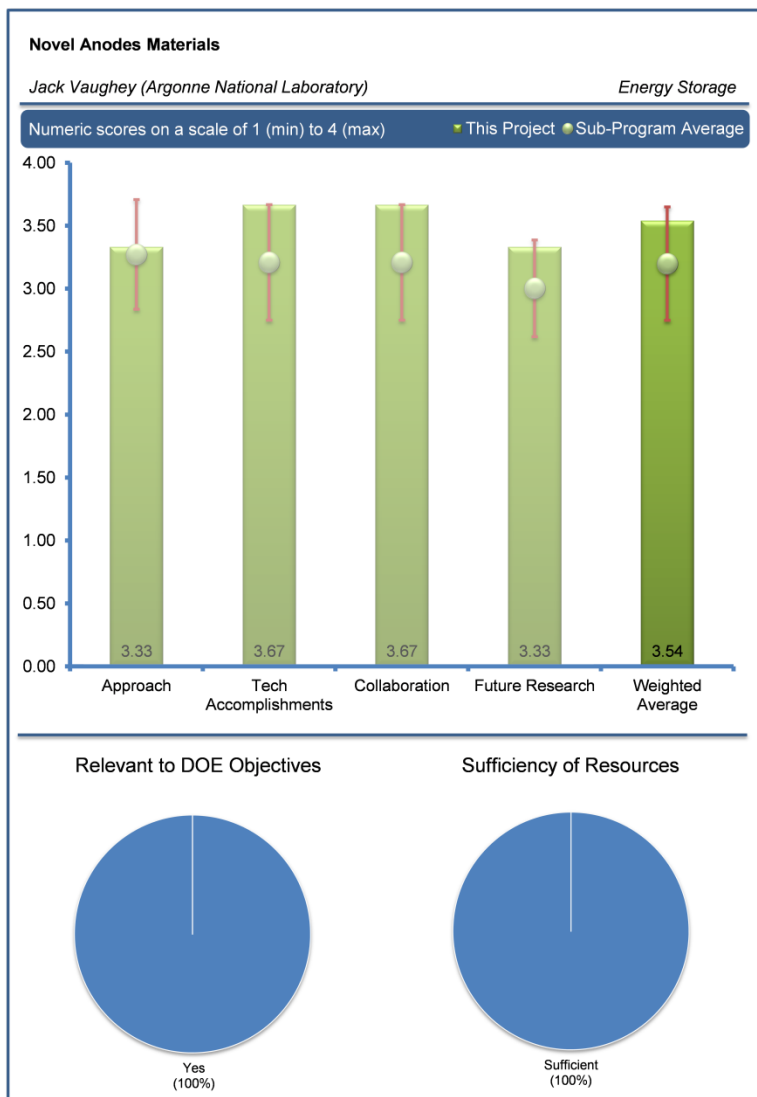
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer thought that the characterization work, particularly the tomography, was outstanding, and suggested that it should be applied more broadly beyond just silicon anodes. The reviewer found electrodeposition to be interesting as well, and would like to understand better the economics of this approach relative to other means to prepare silicon materials for use as anodes.

Reviewer 2:

The reviewer observed an excellent application of tomography to gain insight of Si interaction with other components in the electrodes.



Reviewer 3:

The reviewer felt that good progress had been made this year. The researchers have demonstrated an in-situ probe that will help the researchers make their assessment and have also identified methods to incorporate high levels of Si into the electrode structure. Various characterization methods (electrochemical and chemical) were used to assess the Si anodes.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer saw that an excellent group of collaborators have been assembled to complete this effort. The PI and co-PIs were partnering with outstanding investigators who could significantly contribute to this project.

Reviewer 2:

The reviewer reported that the researchers brought a broad range of skills – from deposition to characterization to electrochemistry, to this project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer concluded that the proposed future work was a logical extension of this year's results. Collaborative efforts will continue to examine the Si anode using various techniques.

Reviewer 2:

The reviewer was glad to see that the researchers will apply the tomography to the BATT silicon material, to provide a baseline for future comparisons. The continued focus on high quality characterization techniques is a big plus here. The next step needs to be use of the characterization techniques to explain real differences in competitive approaches to Si anode development and commercialization being done by a variety of companies/institutions. The reviewer suggested that the researchers emphasize the work described on electrolyte/silicon interactions.

Reviewer 3:

The reviewer felt that, to have a viable anode for high energy Li-ion cell, the researchers will need to demonstrate methods to incorporate Si at more than 5 mAh/cm²; not the proposed 2 mAh/cm².

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer concluded that this project was relevant to DOE's petroleum displacement objective. It aims to develop high energy density anode materials that have good cycle life and are safe.

Reviewer 2:

The reviewer reported that there were a number of presentations on Si anodes at this review, showing slow progress in practical implementation of these materials. The researchers on this project are developing the tools necessary to understand and address the limitations. Ultimately, the reviewer judged that high capacity anodes will be required to get energy densities high enough for significant markets of BEVs.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer found the resources allocated for this project to be appropriate, and should allow the work to be successfully completed in a timely fashion.

Development of Si-based High Capacity Anodes: Jason Zhang (Pacific Northwest National Laboratory) - es144

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer felt that the program had a very good approach to meeting the technical barriers confronting a Si-based anode. The investigators are focusing on mechanical and electrical stability of the electrode and these are key to its implementation in a cell.

Reviewer 2:

The reviewer found this to be among the best anode projects/presentations. There was clear focus on the end goal, hypothesis-driven experiments, and data driven next steps. The project addresses practical issues such as loading. One improvement could be an external evaluation of process economics. The reviewer pointed out that, although the research concluded that this was a low cost process, the assumptions/calculations needed to be shown.

The reviewer concluded that overall, the development of a process to make the anode material, coupled with subsequent improvements with binder and electrolyte optimization was well laid out in this project.

Reviewer 3:

The reviewer saw very creative approaches to mitigate the volume change issue of Si anode. The reviewer recommended raising the goal to more than 5 mAh/cm² to achieve the next generation high energy density Li-ion objective.

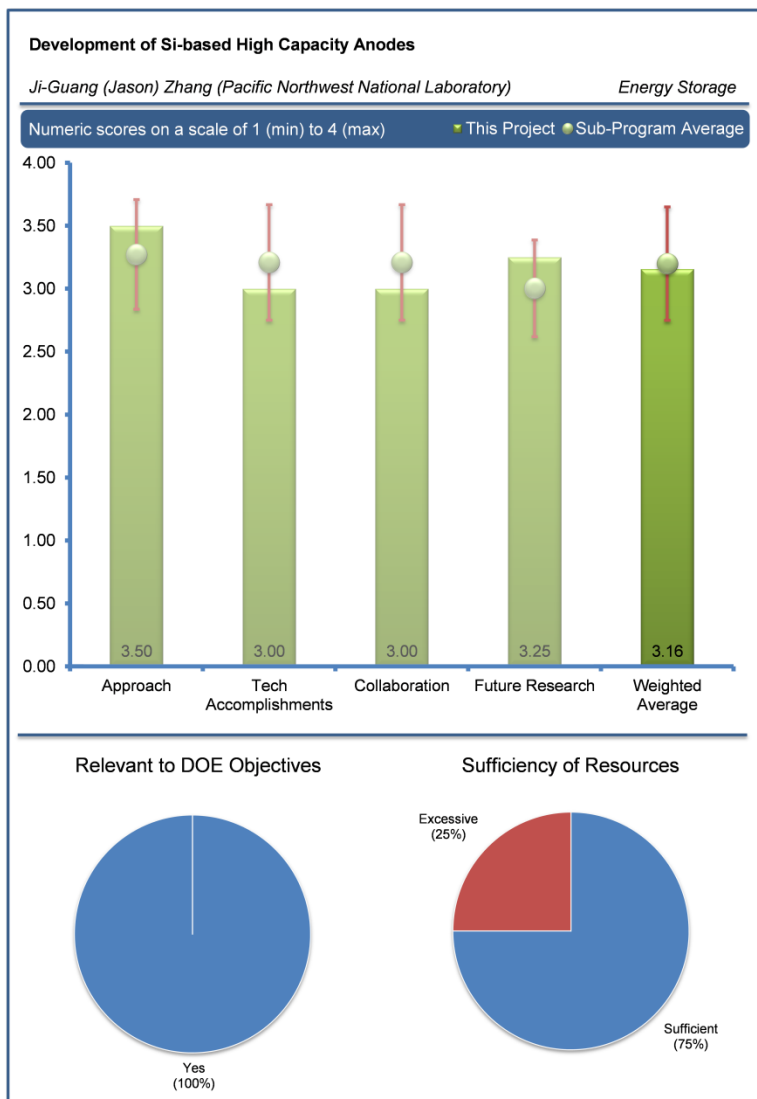
Reviewer 4:

The reviewer stated that there was a good and simple approach.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer felt that good progress has been made this past year resulting in a number of publications and presentations. Several key milestones have been met, including improvement of the Si-based anode so that it delivers at least 700 mAh/g over 150 cycles, and improving the columbic efficiency to more than 98%.



Reviewer 2:

The reviewer reported that the researchers had made good progress on achieving their targets. The reviewer would like to see more activity and ideas on pre-lithiation to help address poor first cycle efficiency. The reviewer asked the researchers to compare the FEC to a better baseline material.

The in situ TEM is superb, and the reviewer looked forward to seeing more in the future, as the reviewer felt it was a very powerful technique to differentiate SEI/electrolyte interaction effects on active versus inactive materials.

Reviewer 3:

The reviewer found it an interesting observation that volume expansion was about 66% after lithiation, which is much less than the approximately 300% volume expansion compared to other Si.

Reviewer 4:

The reviewer cautioned that the good cycling data was based on low loading, around 2mAh/cm² or less.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated that good collaboration existed. The Pacific Northwest investigators were collaborating with the University of California, San Diego (macroporous Si), Princeton University (preparation and characterization of graphene), and the Vorbeck Materials Corporation.

Reviewer 2:

The reviewer judged the effort to be well coordinated.

Reviewer 3:

Other than the graphene suppliers, the reviewer did not see too much collaboration. The reviewer was not sure that it was hurting the progress, but thought that there could be benefits to broader interactions/collaborations.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer concluded that the proposed future work was built upon recent efforts and should result in continued advancement of the Si-anode technology. The use of operando transmission electron microscope (TEM) should shed considerable light to the SEI on the Si-based anode and the capacity fading mechanism.

Reviewer 2:

The reviewer recommended that a holistic approach involving anode composition process as well as binders and electrolytes would be needed to be successful. The reviewer found that the future work addressed all of these aspects.

Reviewer 3:

The reviewer asked if there was any approach for improving first-cycle efficiency and irreversible capacity loss, or any plan to improve the Si loading and control the capacity fading rate.

Reviewer 4:

The reviewer thought that the PI needed to be more specific on plans to increase the loading to more than 5 mAh/cm² and on how to improve the cycling stability using additives.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer concluded that a practical, high energy anode is required to achieve widespread adoption of BEVs, and that this project's holistic approach can accelerate the development of such batteries.

Reviewer 2:

The reviewer explained that this program was relevant to DOE's objective of petroleum displacement because it sought to develop an affordable, high energy density anode material.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer saw that the funding during FY 2012 appeared appropriate for the work to be completed.

Atomic Layer Deposition for Stabilization of Amorphous Silicon Anodes: Chunmei Ban (National Renewable Energy Laboratory) - es145

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the molecular layer deposition was novel, and a very different approach than others. The approach allowed control over many important parameters and the researchers are doing a great job in leveraging what is known in the literature to make a better SEI into designing their coatings. The reviewer asked if other chemistries would be explored, and how broadly this could be applied to other battery materials (e.g., cathodes).

Reviewer 2:

The reviewer saw this program as addressing two key technical challenges, energy density and rate capability, facing the implementation of a silicon-based anode. The proposed methodology is sound. The investigators will utilize atomic layer deposition processes and explore hybrid ALD and molecular layer deposition (MLD) coatings for improved mechanical integrity and electrochemical performance. The reviewer concluded that the resultant material should be both electronically and ionically conductive and mechanically strong.

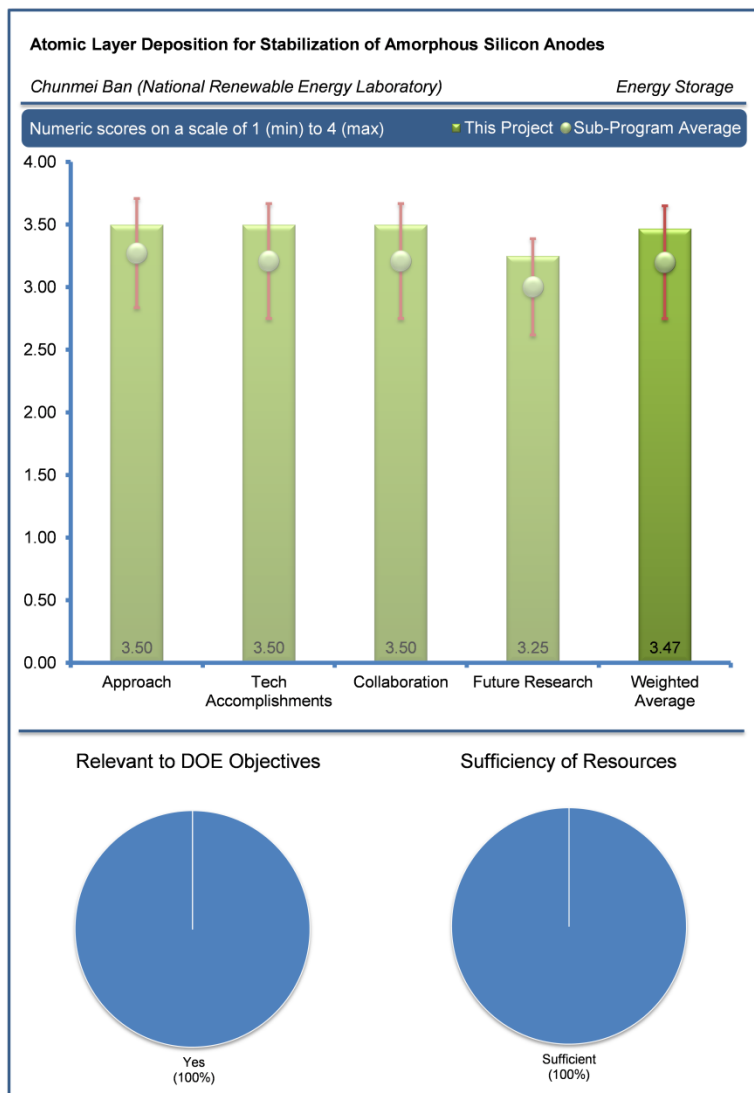
Reviewer 3:

The reviewer felt the program had an innovative approach to control Si anode swelling at the electrode level.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer saw that good progress had been made this past year. The investigators have developed a technique that improved the stability of a Si anode by an aluminum alkoxide polymer coating, and also demonstrated improved performance of a Si-polyacrylonitrile (PAN) composite anode.



Reviewer 2:

The reviewer reported that the milestones were very quantitative and that the researchers were hitting them. In addition, there were good hypotheses, and data to support/refute those hypotheses. The characterization was very appropriate and supported the approach. The reviewer would like to see some other performance targets such as power in the future.

Reviewer 3:

The reviewer felt the performance results of MLD coated Si anode was more promising than that of Si-PAN composite, and recommended that future efforts focus on the MLD approach.

Reviewer 4:

The reviewer stated that although ALD is a good approach, cost effective issues have to be addressed for practical applications.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that excellent collaboration existed. The PI has assembled a research team that is among the leaders in their field.

Reviewer 2:

The reviewer reported there was a broad range of collaborators, and thought that it was also nice to see this type of approach being applied to cathodes (see interaction with Burrell/ANL on Li-rich materials).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer judged the proposed future work to be sound and built upon the efforts to date. Investigations to characterize the ALD/MLD coatings will be performed and the optimal concentration will be identified. In-situ structural characterization will be performed to gain a better understanding of the structural evolution of the coated electrodes during cycling.

Reviewer 2:

The reviewer thought that the approach looked promising enough that more work on scale-ability and practical implementation should be addressed.

Reviewer 3:

The reviewer reported that the proposed future plans were good, but again warned that cost issues have to be addressed.

Reviewer 4:

The reviewer felt that the researchers needed to demonstrate that the project can achieve similar good cycle life on a thicker Si anode (i.e., more loading) and also with a thinner MLD coating that does not compromise rate capability.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer concluded that the program was relevant and supported the DOE objective of petroleum displacement. Efforts are directed toward developing a low-cost, high energy dense anode material that has good rate capability. A high performance battery will be necessary if the public is to accept an EV.

Reviewer 2:

The reviewer deemed that development of cost-effective high energy anodes is vital to technology required for widespread adoption of BEVs in the United States. The reviewer was hopeful that the learnings from this project may enable such an anode material.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reported that the resources appeared to be sufficient for this investigation.

New Layered Nanolaminates for Use in Lithium Battery Anodes: Yury Gogotsi (Drexel University) - es146

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer felt the approach was reasonable.

Reviewer 2:

The reviewer found that the technical approach is fair and addresses the technical barriers. The investigators will conduct a rapid screening of as many MXenes as possible to identify the most promising chemistry. The reviewer thought the project a little Edisonian in nature since it appeared that the effort was characterized by trial and error discovery. The investigators will also study the effect of carbon and binder additives as well the solid-electrolyte interface in order to improve electrochemical performance. The reviewer was disappointed that this system may have a narrow voltage stability window.

Reviewer 3:

The reviewer felt there was a need to identify other high energy anode materials with minimum swelling. The MXenes, however, were not attractive from an energy density perspective. The reviewer concluded that the theoretical lithiation/delithiation voltages were too high, making theoretical energy density of the couple comparable with that of SOA Li-ion couple at best.

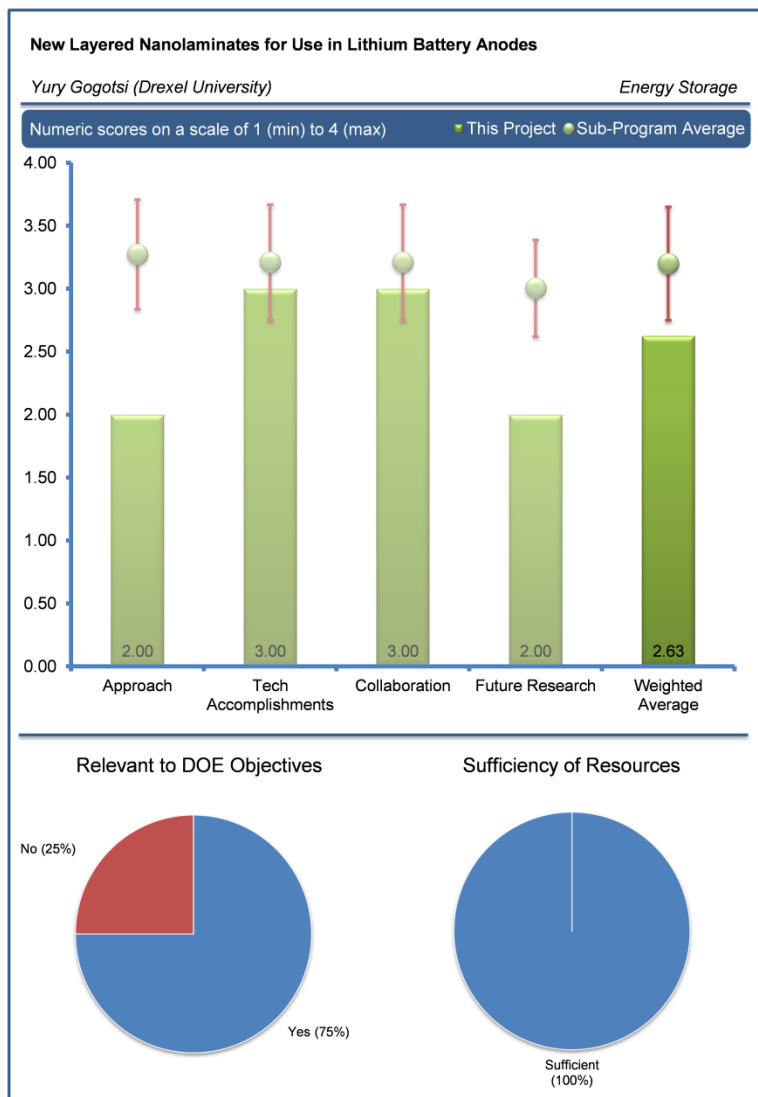
Reviewer 4:

The reviewer questioned if this was the right material, despite seeing alternatives to graphite and silicon. The target is only 400 mAh/g at cycling rates of 1C, but the operating potential is higher than graphite. The reviewer did not think the target was aggressive enough, and did not have confidence that the performance of the material will even hit the relatively low target. The researchers need some guidance – theory/calculations to predict redox potentials and theoretical capacities. Otherwise, the researchers are just trying things. The reviewer asked if post-mortem analysis helped the researchers at all, because there was no hypotheses that the researchers could test against to further their knowledge and improve the success of subsequent experiments.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that the technical accomplishments achieved since the last program review were good and that the tasks were on schedule.



Reviewer 2:

The reviewer stated that the project has demonstrated feasibility at reasonable loading level for a new anode material.

Reviewer 3:

The reviewer saw that the researchers have made some progress, but felt that targets needed to be more aggressive and quantitative. A stable performance by the end of the year is not meaningful – the reviewer strongly suggested the need for an energy retention target at certain numbers of cycles. There needs to be a very clear go/no go decision on this technology. The reviewer recommended defining what the key problems were and addressing those first to determine the level of progress that was needed this year to encourage the project to go further.

Reviewer 4:

The reviewer revealed that the capacities are not even close to any of the recent SnCoC systems.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer saw that good collaboration existed and were appropriate. These included efforts with ORNL, Paul Sabatier University, and Linkoping University.

Reviewer 2:

The reviewer said that the collaboration was good.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer felt that the proposed future work was fair. More M2Y MXenes will be produced and it appeared to the reviewer that some reasoning as to why certain materials should be good was taken.

Reviewer 2:

The reviewer thought that the proposed improvement for capacity had to be clearly defined.

Reviewer 3:

The reviewer saw no need to focus on low cost production until the researchers demonstrate interesting performance. The researchers need to develop and test hypotheses in the future. The plans are study, develop strategies, etc. The reviewer suggested to develop strategies now, based on hypotheses, and have future plans on the specific experiments to prove/disprove the theories.

Reviewer 4:

The reviewer recommended that, rather than focusing on making MXenes less expensive or reducing the first cycle irreversibility, future work needed to focus on tuning to lower the lithiation/delithiation voltage to make the Wh/L and Wh/kg attractive, and to identify other high capacity MXenes. The reviewer suggested a goal of identifying a MXene with a MXenes/cathode couple's theoretical energy density greater than 1,400 Wh/L and 390 Wh/kg.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer concluded that this project was relevant to DOE meeting the objective of petroleum displacement. In order for the consumer to accept an EV, there must be an affordable, high performance battery. The reviewer reported that this effort seeks to develop novel anode materials that offer the combined advantages of graphite and silicon-based anodes with a higher capacity than graphite and less expansion, longer cycle life than the silicon nanoparticles.

Reviewer 2:

The reviewer felt that more aggressive targets were required, and that the targets as written will not have a significant impact on overall energy densities for automotive applications.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

It appeared to the reviewer that the project has sufficient, if not excessive, funds to complete the tasks successfully within the required time frame.

Synthesis and Characterization of Structured Si-Carbon Nanocomposite Anodes and Functional Polymer Binders: Donghai Wang (Pennsylvania State University) - es147

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought that the approach was good, and reported that the investigators planned to synthesize novel Si-C nanocomposites with controlled nanostructures and composition and to develop novel binder polymers for improved cycle life.

Reviewer 2:

The reviewer thought the project had a good approach.

Reviewer 3:

The reviewer felt this work was much needed to correlate performance of Si anode with controlled structure and composition.

Reviewer 4:

The reviewer thought the researchers were doing a good job exploring a multitude of different carbon/silicon microstructures. Data (electrochemistry and analytical) on these can be used to better design structures with adequate cycle stability. The approach is systematic and well designed – effects of particle size, pore structure, carbon coating are all investigated. The reviewer thought the hierarchical pore structure approach may be an excellent means to achieve a balance of properties. The reviewer concluded that the binder work exploring the relationship between swelling and ionic conductivity is very relevant and should be expanded to consider other properties (e.g., adhesion).

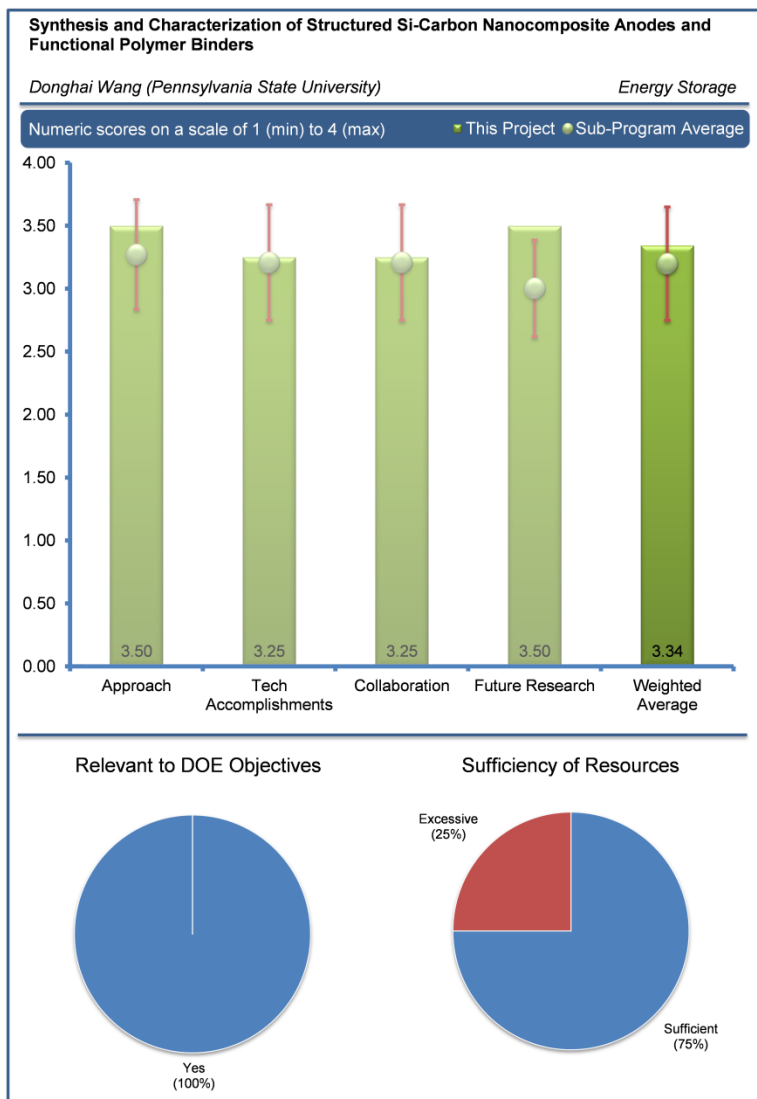
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that there was excellent data that will help guiding design of Si anode, especially in reducing the fade and first cycle irreversible loss.

Reviewer 2:

The reviewer reported that the team was doing a large amount of work, and good progress was being made toward milestones. The reviewer would like to see more quantitative targets as the targets are currently given as increasing or decreasing, but do not quantify by how much. The reviewer could not tell how much overlap there was with the 2012 project, as the structures in the presentations look different. The reviewer concluded that this was the best systematic study of the effect of particle size that has been seen.



Reviewer 3:

The reviewer noted that fair progress was achieved this year. The investigators identified a Si-C nanocomposite material with a specific capacity of 1000 mAh/g over 200 cycles. Various aromatic binder materials were investigated and showed that the presence of carbonyl groups in the best performing material (SPEEK) was responsible for good cycling performance.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer saw evidence of good overlap and synergies between this project and the excellent work at PNNL, but asked the researchers to please take advantage of some of the novel techniques there – the in situ TEM for example.

Reviewer 2:

There appeared to the reviewer to be collaboration with other scientists (J. Zhang, J. Liu, G. Liu) as well as other organizations (Johnson Control, PA Nanomaterials), but the involvement was not clearly defined.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer found the proposed future research to be sound, and based on overcoming technical obstacles. Efforts will continue to optimize the composition and nanostructures of the Si/SiO_x-carbon composites for improved electrochemical performance as well as understanding the binder/Si-C interactions.

Reviewer 2:

The reviewer thought the future work was built well from promising results, but would like to see more specific targets with decision making points. The work on structure-property relationships on binder polymers is very important, and the reviewer was glad to see an emphasis on this.

Reviewer 3:

The reviewer suggested that future work should also focus on demonstrating similar good cycle life with increased loading, reduce swelling and demonstrate good cycle life using C coated Si approach.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reasoned that this project is relevant. Promotion of EVs and the batteries that power them will reduce oil consumption. This project seeks to improve the anode for the lithium ion battery by investigating high performance silicon anode materials.

Reviewer 2:

The reviewer stated that silicon-carbon composites are a potentially attractive high energy density anode candidate that would enable BEV adoption. This project encompasses the space of carbon-silicon-binder in novel and interesting new forms/combinations to optimize performance.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer judged that sufficient resources exist to complete this effort in a successful, timely manner.

Wiring up Silicon Nanoparticles for High Performance Lithium-ion Battery Anodes: Yi Cui (Stanford University) - es148

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought that the approach to understand the Si swelling issue and to mitigate the swelling was very innovative.

Reviewer 2:

The reviewer relayed that the researchers were exploring novel silicon structures, and did an excellent job getting fundamental knowledge on silicon expansion. These results can provide direction to the industry as to how best to get silicon to work. The cycle life/capacity on some of these structures looked very promising. The reviewer noted that the researchers were also looking at more practical concerns such as high electrode loading.

Reviewer 3:

The reviewer wrote that the approach was good.

Reviewer 4:

The reviewer reported that the effort seeks to develop Si anodes because Si anodes have a low discharge potential and the highest known theoretical charge capacity. Although Si anodes promise more than ten times higher capacity than existing graphite anodes, Si anodes have limited applications because Si's volume changes by 400% upon insertion and extraction of lithium. This results in significant capacity fading. The reviewer relayed that the project is focused on solving this problem and seek to understand and design novel nanostructure Si that can address these issues.

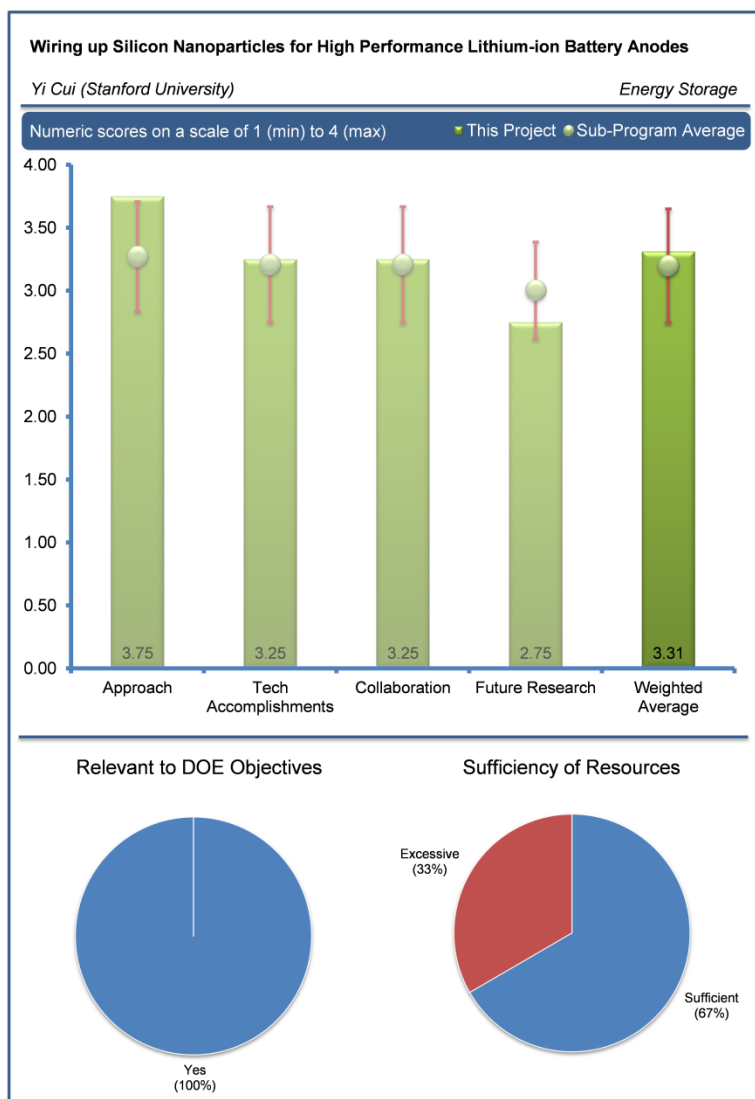
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer found that excellent progress was made last year. The investigators designed and fabricated a novel yolk-shell structure for silicon anodes. The reviewer relayed that the void space allows the silicon particles to expand freely with cycling without breaking the outer shell, which stabilizes the solid-electrolyte interface.

Reviewer 2:

The reviewer thought that the cycle life performance of some of these structures at high capacity looked very good. The researchers concluded that they have scalable low cost methods to make some of these structures. The reviewer would like to see the assumptions and models used to determine this conclusion.



Reviewer 3:

The reviewer reported very useful data on the critical Si OD and the feasibility performance data on the doubled-walled hollow Si.

Reviewer 4:

The reviewer felt that loading of silicon should be improved. The reviewer reported that PI has developed three types of Si: Carbon-silicon core-shell nanowires; hollow Si nanophere anodes; and Si yolk-shell structure, but asked how these were compared in terms of performance and stability.

The reviewer suggested that, since nanowires have been developed before, it would be better to indicate the importance of hollow Si nanophere anodes and Si yolk-shell structure. The reviewer considered that publishing results in a top scientific journal and receiving numerous invitations to speak in national and international conferences to be good, but not technical accomplishments.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer saw that good collaboration existed between the PI and other scientists. These collaborations can directly benefit the effort.

Reviewer 2:

The reviewer reported good collaboration.

Reviewer 3:

The reviewer was glad to see the coordination/collaboration with PNNL as well as a start-up, Amprius. The researchers are taking good advantage of available novel characterization techniques.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported that the PI proposed to further understand the nanoscale design to optimize Si anodes. The project team also planned to develop surface modification to increase the coulombic efficiency. The reviewer found that these plans were sound and should lead to continued improvement of the Si anode.

Reviewer 2:

The reviewer asked if the PI had specific ideas or hypotheses on surface modification that would improve the first cycle efficiency. The reviewer would also like to see more specific work on the process economics to make any of the structures.

Reviewer 3:

The reviewer was not clear on how the surface modification will be performed to increase the first cycle coulombic efficiency, and recommended that future plans be better defined.

Reviewer 4:

The reviewer suggested that the PI reduce the first cycle irreversible loss and verify the good cycling data at a higher loading level of greater than 5 mAh/cm² for high energy density Li-ion cells.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer felt that the project was relevant and that it supported the overall DOE objectives of petroleum displacement. The objective is to develop a high capacity anode material for Li- ion batteries. The reviewer stated that developing affordable batteries that offered long driving ranges was one of the biggest challenges to increasing the sales of hybrid or EVs.

Reviewer 2:

The reviewer reasoned that high energy Si anodes could enable long-range capability for BEVs which was required for widespread adoption. This project explored novel structures that may be required to get the desired performance.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer thought that the funding appeared to be sufficient.

Synthesis and Characterization of Silicon Clathrates for Anode Applications in Lithium-Ion Batteries: Kwai Chan (SwRI) - es149

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought that using Si clathrate was an innovative approach to solving the detrimental volume change issue of Si anode, but mentioned that for a given cathode, even the highest capacity Si_{46} clathrate would result in a theoretical specific energy (Wh/kg) comparable to that of graphite/cathode couple.

Reviewer 2:

The reviewer evaluated the approach taken in this project to be fair. It aims to synthesize silicon clathrate anodes that are designed to exhibit a volume expansion much less than that which occurs during the lithiation of crystalline silicon. Because of the small volume changes during lithiation, silicon clathrate anodes have the potential for high specific energy density, while avoiding capacity fading and improving battery life. The reviewer was concerned about the volumetric energy density of this system.

Reviewer 3:

It was not clear to the reviewer if this was a high energy material or not - the electrochemistry did not look too promising. It was especially unclear to the reviewer why so much time was spent scaling up to 200g, as much smaller quantities than this could be ball milled and electrochemistry could be done on small samples. The reviewer worried that the researchers would spend a lot of time perfecting a synthesis of a sub-par material. Currently, it is outperformed by graphite and the reviewer did not see a clear path to improvement.

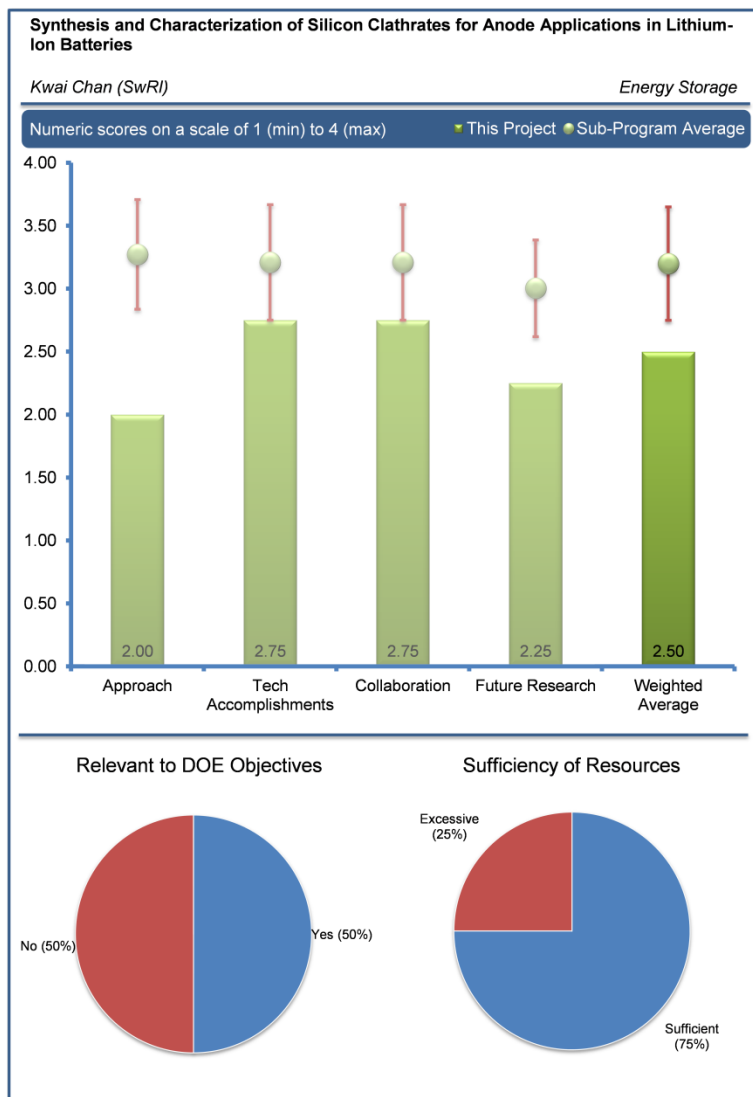
Reviewer 4:

The reviewer declared that clathrates are not stable phases, especially Si_{46} .

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer found that good technical accomplishments were demonstrated this past year. Several clathrates were synthesized and a possible reaction pathway for the formation of empty clathrates was identified. The reviewer also reported that patent applications were filed.



Reviewer 2:

The reviewer reported that the reviewers synthesized clathrates and demonstrated the feasibility of clathrates.

Reviewer 3:

The reviewer said that the project appeared to be way behind due to the scale-up/synthesis, yet it was unclear if this was needed. The reviewer asked the researchers to focus on improving the electrochemistry first, and pointed out that the theoretical capacity was only 478 mAh/g, which may not be a worthy target. The reviewer also wondered if the researchers thought that the learnings from the project might be more generally applicable to similar chemistries with the potential for higher energy density.

Reviewer 4:

The reviewer reported that the results of this project have to be verified after $\text{Ba}_8\text{@Al}_8\text{Si}_{38}$ samples are cycled at LBNL. XRD patterns of the new and old batch of $\text{Ba}_8\text{@Al}_8\text{Si}_{38}$ were confusing, leaving the reviewer to wonder why there was so much change in the pattern.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer saw that good collaboration existed in this effort. Collaborators included Dr. Chan (Arizona State University) who was providing materials and process expertise, Dr. Chen (CeSMEC) who was providing technical expertise on multi-anvil synthesis, and Dr. Peng (Arizona State University) who was providing first-principles computation expertise and density function theory (DFT) computations.

Reviewer 2:

The reviewer called the collaboration good.

Reviewer 3:

The reviewer suggested that this project would significantly benefit from collaboration with an electrochemistry and/or battery group. The reviewer did not think the project could be successful without it.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer considered the planned future work to be excellent, and noted that it is built upon the progress achieved to date. The plan involved the characterization of Si clathrates previously synthesized as well as post-mortem analysis of previous clathrate anodes to gain a better understanding of the structural and mechanical states of the material at various lithiation levels.

Reviewer 2:

The reviewer stated that the samples cycled at LBNL are critical for this project.

Reviewer 3:

The reviewer asked the researchers to please focus on the electrochemistry and proving the material was worth more effort.

Reviewer 4:

The reviewer recommended that the researchers focus on reducing the lithiation voltage in order to be competitive with graphite's energy density.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer found this proposal to be relevant and supportive of the DOE objective of petroleum displacement. The reviewer reasoned that developing a high performance Li-ion battery that could offer a long driving range was the biggest challenge to electric/hybrid electric vehicles, and this work could potentially lead to the development of a high performance battery.

Reviewer 2:

The reviewer did consider this project to support DOE objectives at the current time, as the reviewer did not see energy density advantages.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer thought the budget looked sufficient for the level of effort.

Addressing the Voltage Fade Issue with Lithium-Manganese-Rich Oxide Cathode Materials: Anthony Burrell (Argonne National Laboratory) - es161

Reviewer Sample Size

A total of 6 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer felt the approach was very thorough, and thought that focusing on the effects of synthesis and understanding the resulting phases would help.

Reviewer 2:

This seemed to the reviewer to be the best approach to solve this problem with the resources available. The reviewer thought that the author documented the teams and their designated functions well. The reviewer also liked the fact that time had been spent at the beginning of the project to define the protocols and test methods that were available to the team members and the public.

Reviewer 3:

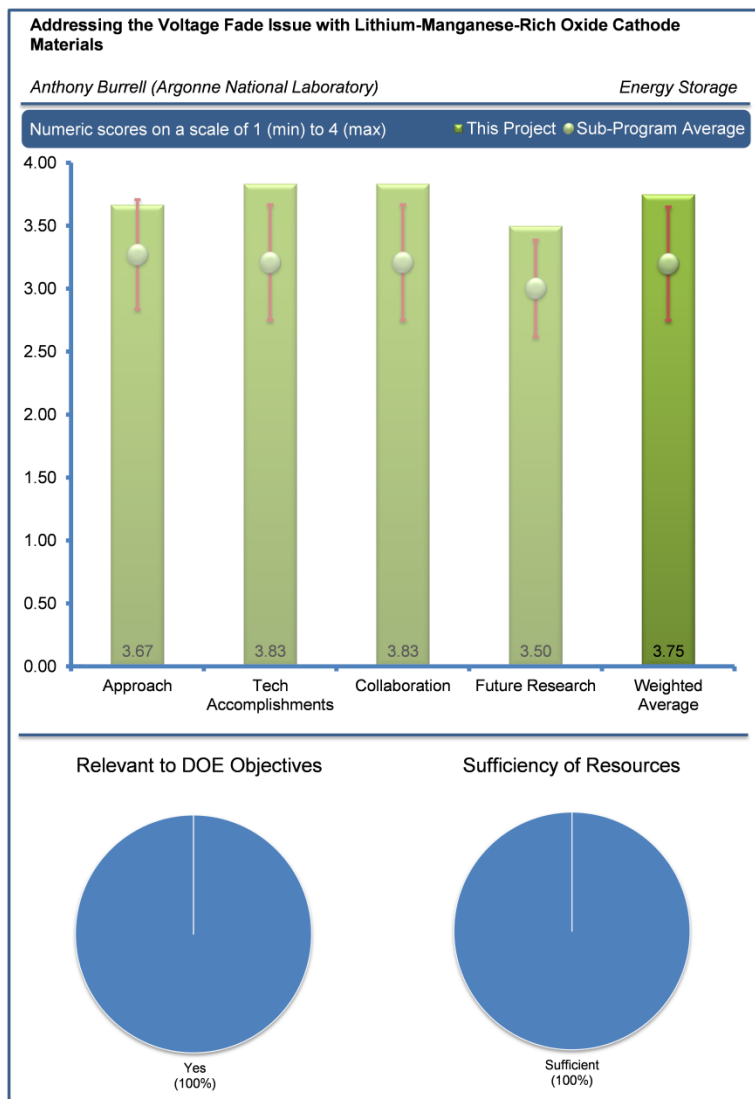
The reviewer considered this one of the good presentations and a serious attempt to solve the problems associated with the Li-Manganese-Rich Oxide Cathode Materials (LMR-NMC) chemistry. The author provided several valid approaches towards understanding the VF issue with LMR-NMC chemistry and plausible mitigation steps. The reviewer stated that this was clearly teamwork, but the big question was if the project team could solve this within a short time frame.

Reviewer 4:

The reviewer thought this was a very difficult subject, almost a new area of research. The authors were tackling the problem from every possible aspect, and following a multi-disciplinary approach. The reviewer also reported that the project team was also identifying where the project should not concentrate its resources.

Reviewer 5:

The reviewer reported that the effort here was an integrated, all-out approach with an impressive team of several investigators and with methodologies ranging from experiment to theory to address an apparently difficult problem of VF (or energy loss) in LMR-NMC cathode materials. Based on the cost model, it is essential to increase the specific capacity of cathodes in a Li-ion cell to 250 mAh/g to meet the cost targets of the EV battery, and the LMR-NMC cathode is the only material that can provide such high capacities. Several experimental variables, including composition of oxide cathode, surface coatings and synthetic conditions, are being examined to quantitatively determine their effect on the VF. The reviewer reported that various sophisticated characterization techniques are being adopted to understand the changes in the local structures of the LMR-NMC cathodes during cycling (VF).



Finally, these experimental studies are being augmented by theoretical studies to understand the connection between the electrochemistry (irreversible capacity loss, hysteresis and VF) and structural aspects of the LMR-NMC oxides. The reviewer reasoned that since this VF is deemed as the most important deterrent factor for a successful use of these materials, these studies are extremely relevant and important. Thus far, the problem appeared to the reviewer more fundamental and related to inevitable structural changes occurring upon cycling, yet these studies will contribute to a good understanding of this phenomenon.

Reviewer 6:

The reviewer thought that there was nice clarification and definition of exactly what the problem was; for example, how VF is measured.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

It was clear to the reviewer that lots of work was being conducted in multiple directions and that there is considerable progress. The direction regarding coatings and additives has reached the no-go decision point, making it clear that these functions, while controlling capacity and fade, do not affect the VF.

Reviewer 2:

The reviewer thought that, within a year, the PI and team at Argonne had done very well to fix the VF issue associated with LMR-NMC chemistry. The reviewer felt that the new synthesis approaches, such as Li_2MnO_3 template and Na-exchange, were steps in right directions. The reviewer's worry is that anything that is new will take again 5-10 years for commercialization, which may be too late. The PI and team have the best synthesis and characterization team at their disposal to solve this issue.

Reviewer 3:

The reviewer said that good progress had been made towards understanding the VF of LMR-NMC cathode, a major issue for an otherwise promising class of materials for EV applications. After defining quantitatively the VF parameters, the effect of several experimental variables, including composition, surface coating and synthetic conditions on the VF have been studied. The reviewer reported that no clear-cut correlations have emerged from these studies, thus far. Meanwhile, various ex-situ (Neutron Pair Distribution Function, HRXRD, etc.) and in-situ (TEM) techniques were being adopted to gain further understanding of these materials. Even though no mitigation strategy had evolved yet, it appeared to the reviewer that this problem needed to be worked around, by deliberately starting off with materials having pseudo-spinel or be conservative in the use of these materials (e.g., low charge voltages).

Reviewer 4:

The reviewer stated that understanding that surface modification does not help is a huge step.

Reviewer 5:

The reviewer knew how difficult the VF issue was and explained that the authors have clearly identified what not to do. Now, the authors should focus on additional research to identify what is clearly involved in VF. The reviewer felt that only when that is clearly identified then is there hope for a solution.

Reviewer 6:

The reviewer thought the combinatorial approach was smart, and noted different VF rates in different materials. The reviewer felt that the conclusion that additives and coatings do not affect VF was an important conclusion, and felt the single particle studies were very good.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer declared that there was awesome collaboration, going way beyond ABR.

Reviewer 2:

The reviewer said that this seemed to be an excellent effort – everyone the reviewer had talked with was supportive. The reviewer was also impressed that the team was growing so that other areas of expertise could be accessed and used.

Reviewer 3:

The reviewer reported that there were multiple team members and collaborators from ANL, other DOE laboratories and elsewhere, as was expected from the nature of the project.

Reviewer 4:

The reviewer observed that this was a very big, well-coordinated team, but thought that deeper engagement with the material makers, cell-suppliers, and OEMs might help.

Reviewer 5:

The reviewer felt that collaboration was clearly the strong point in this group. A variety of individuals have managed to work as only one team. The reviewer was hopeful that something should come out of this work.

Reviewer 6:

The reviewer felt that this was very collaborative and the PI and team have reached out to other national laboratories and partners for technical help and collaboration.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported that the team had effectively eliminated some pathways, and that a clear pathway forward was defined. The reviewer stated that this was as good as it gets.

Reviewer 2:

The reviewer thought the project was headed in a good direction, and thought that very careful analysis of phases resulting from different synthesis conditions and formation conditions could additionally be revealing.

Reviewer 3:

The reviewer found the proposed work to be clear, and for the most part a lot should be able to be accomplished. The reviewer further suggested that maybe some effort should be focused on additional metal substitution in the composition to produce a more stable layered structure.

Reviewer 4:

The reviewer observed that the hysteresis seemed to play an important role in VF, and recommended that the authors should also study standard cathode powders and compare with powders associated with the VF.

Reviewer 5:

The reviewer said that from the very beginning, the PI teams were focused on overcoming barriers such as capacity and VF and thermal abuse tolerance. The reviewer gave full credit to the team in coming out with ways to quantify the VF and efforts towards standardization of the experimental results, and suggested that the project team should now do the following: like their electrochemical performance test protocol they should provide guidelines for standardizing a few compositions of Li-rich MNC that folks should work on and focus; the new composition should be guided by theoretical insights and modeling estimation.

Reviewer 6:

The reviewer relayed that the future plans were aimed at gaining a fundamental understanding of VF, first cycle irreversible capacity and voltage hysteresis of the LMR-NMC cathode materials. Since DOE had made considerable investment on these materials, and

these materials were the most promising cathodes for achieving high energy (and low cost) for Li-ion batteries, these issues (especially the VF) would have to be well understood and controlled, if possible. The reviewer reported that, in addition to continuing studies in this direction, future efforts would also look into studying the effects of dopants to design more tolerant oxide materials to the structural transformations occurring upon charge-discharge cycling.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer thought that the project was very relevant to the DOE objectives of petroleum replacement. If the team managed to partially resolve or mitigate the VF issue, the goal will be significantly closer.

Reviewer 2:

The reviewer reasoned that high energy density Li-ion batteries would enable mass vehicle electrification which would then reduce dependence on fossil fuel consumption and reduce greenhouse gas emissions.

Reviewer 3:

The reviewer considered that this may be an important material for future automobiles, and is one of the best candidates. The reviewer concluded that this project is focused on the key issues.

Reviewer 4:

The reviewer observed that this type of cathode material was one of the few that has the capacity and energy density that could meet the USCAR requirements for EV/ PHEV. The reviewer went on to point out that unfortunately, this material has a serious drawback which could be a show stopper. The reviewer found it important to provide the effort and resources to solve this problem as quickly as possible, and declared that this approach offered such a way to do so.

Reviewer 5:

The reviewer thought that, for a successful utilization of Li-ion batteries in EVs, it was essential to enhance their gravimetric and volumetric energy densities, beyond what could be provided by the current technologies. The reviewer found high voltage high capacity cathodes in the class of lithium and manganese rich NMC (LMR-NMR) cathode materials, $x\text{Li}_2\text{MnO}_3:(1-x)\text{LiMO}_2$ (M equals Ni, Mn, Co), to be quite promising for high specific energies. However, these materials exhibited VF upon cycling and voltage hysteresis from charge and discharge. The reviewer concluded that to mitigate these effects it was important to have a good understanding of these phenomena in terms of the complex electrochemical – structural relationships of these materials.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer declared that we cannot wait for smaller teams to spend 10 years to resolve this issue; it needs to be done as soon as possible, so that the resources provided on this project are large but sufficient.

Reviewer 2:

The reviewer recommended that if the authors can show that improvements are possible, and manage to identify the VF mechanism, that the authors should request additional resources.

Reviewer 3:

The reviewer found the resources to be adequate for the project to achieve the milestones in a timely manner.

Reviewer 4:

The reviewer concluded from both the budget and resources that the PI and the team have more than the project team could ask for to solve the VF issue, but recommended that this support be continued until a good solution is found in the next one to two years. Then, suggested this reviewer, re-evaluate where things stand. The reviewer noted that, given the investment that was already made, it would be wise to bring it to some stage for automotive application.

Development of Industrially Viable Battery Electrode Coatings: Robert Tenent (National Renewable Energy Laboratory) - es162

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer declared that there was a good approach that would create significant impact if feasible.

Reviewer 2:

The reviewer found the approach to the work to be solid, and thought that the direction of working toward atmospheric pressure coatings was certainly important for obtaining a low cost process. The reviewer recommended that all efforts be directed to this goal as additional processing costs to the basic material cost are an important hurdle to overcome. It appeared to the reviewer that coatings will be very important to high voltage cells as the development of a truly stable electrolyte at high voltage has proven to be very difficult.

Reviewer 3:

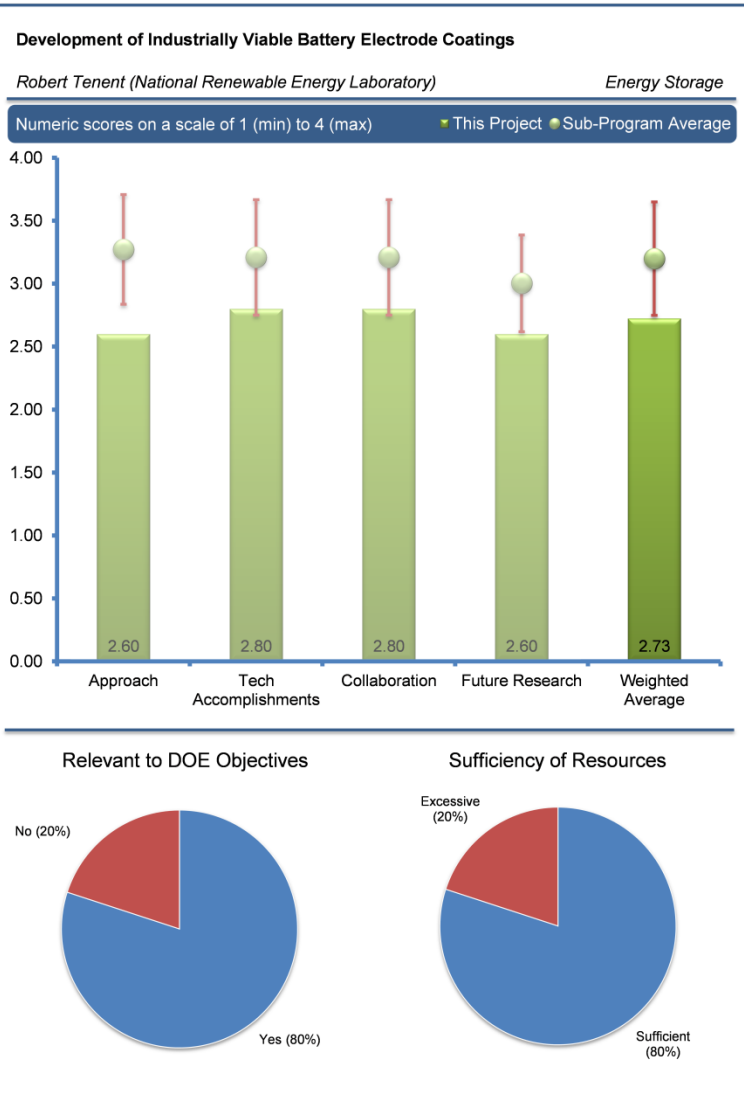
The approach appeared to the reviewer to be straightforward and well thought out. There are several critical issues associated with a program such as this, and others within this group. The reviewer thought that one major consideration in developing advanced process capability to accomplish complex materials processes is to make sure that the impact of the proposed technique in achieving the desired performance gain continues to stay in step with the investment in a higher level process development. The reviewer concluded that if the product of the process does not show progress toward the targeted improvement, there needs to be oversight related to how far the process should be developed.

Reviewer 4:

The reviewer cautioned that while ALD is conceptually interesting, commercial viability is a concern, and it is questionable whether it addresses the critical needs of low cost and high throughput. There are other coating processes which may be more commercially viable. The reviewer found the initial assumptions about ALD troubling.

Reviewer 5:

The reviewer thought that binder compatibility concern at ALD process temperature was not adequately addressed, and reminded the team to be aware of binder recrystallization and potential changes in porosity after exposure to heat. The reviewer observed that tri methyl aluminum (TMA) precursor hygiene issues and cost were not addressed, but based on the discussion it appeared the best case was an added cost of 0.05 \$/Wh.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the detail on the process development was quite comprehensive and well done. The reviewer believes that careful analysis of the benefit of the product of the process as it relates to target performance improvement needs to continue so that the process development does not get ahead of itself.

Reviewer 2:

The reviewer reported that the workers have brought the project up to the point of demonstration of a full, ambient pressure ALD coating machine for large format electrodes. It may be more important that a fluidized bed particle coater has also received attention as complete particle coating may be essential for high voltage materials.

Reviewer 3:

The reviewer stated that progress was made with various technical challenges from 2012, but noted that there were still fundamental questions if this method would be practically feasible – coating uniformity and speed are still major challenges.

Reviewer 4:

The reviewer felt that some good things have been demonstrated related to the in-line atmospheric processing (AP)-ALD prototype and multi-deposition head, but that the results are indicative of the low feasibility of the ALD approach.

Reviewer 5:

The reviewer concluded that the process is far from scalability for application to coated electrodes at 20 m/min and more than 30 cm lane width. The reviewer felt that the project needed better definition of target and baseline electrode composition, architecture and success criteria.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer thought that collaborations appeared appropriate for the program.

Reviewer 2:

The reviewer saw what seemed to be a good collaboration, although observed no industrial participant.

Reviewer 3:

The reviewer noted that battery industry coating operation expertise was lacking.

Reviewer 4:

The reviewer stated that the necessary collaborations with national laboratories with facilities not available at NREL were important. The reviewer would also like to see some collaboration with material suppliers (especially US based companies) to keep a focus on costs and practicality.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pronounced this a solid program for future work.

Reviewer 2:

The reviewer felt that it might be worthwhile in the very near future to develop some go-no go criteria, or at least specific performance targets, for the continued development of the process based on impact at the cell level. The reviewer also suggested that generic process details be shared across the DOE space to other programs that might benefit from such a technique, even if not battery related.

Reviewer 3:

The reviewer said that the researchers seemed to be hedging on the push-pull approach, and thought that this project looked to be very questionable from a cost and line speed perspective. Also, the reviewer asked how this issue would be improved, as opposed to exacerbated, due to the difficulties related to non-uniformity on flat substrates in the push-pull approach.

Reviewer 4:

The reviewer thought this project could be a little bit more focused given the program maturity – too many options were still on table (e.g., push/pull versus reel to reel, powder versus electrode, AP or vacuum, etc.).

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that high voltage materials are the best way to higher energy at the present. The coating of materials is probably going to be necessary for high cycle life cells.

Reviewer 2:

The reviewer judged that electrode coating was a viable candidate to pursue in terms of improving cell performance along a number of parameters.

Reviewer 3:

It was unclear to the reviewer how this approach truly addressed the key needs related to cost and throughput. The abuse tolerance benefit seemed questionable, but the future testing at Sandia will be interesting.

Reviewer 4:

The reviewer suggested that the researchers consider a go/no-go decision based on the ability to meet cost and throughput if applied to coated electrodes.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer observed that resources appeared adequate.

Overcoming Processing Cost Barriers of High-Performance Lithium-Ion Battery Electrodes: David Wood (Oak Ridge National Laboratory) - es164

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought the project had a very clear approach and objectives, and was well thought out.

Reviewer 2:

The reviewer predicted the work to have a significant impact, if it was feasible.

Reviewer 3:

The reviewer did not get the impression that the program encompasses a systematic coating formulation approach that would be required for a viable waterborne electrode coating. The approach uses common materials and does not seem to address issues such as rheology, wetting, film formation, application, and drying through the formulation parameters.

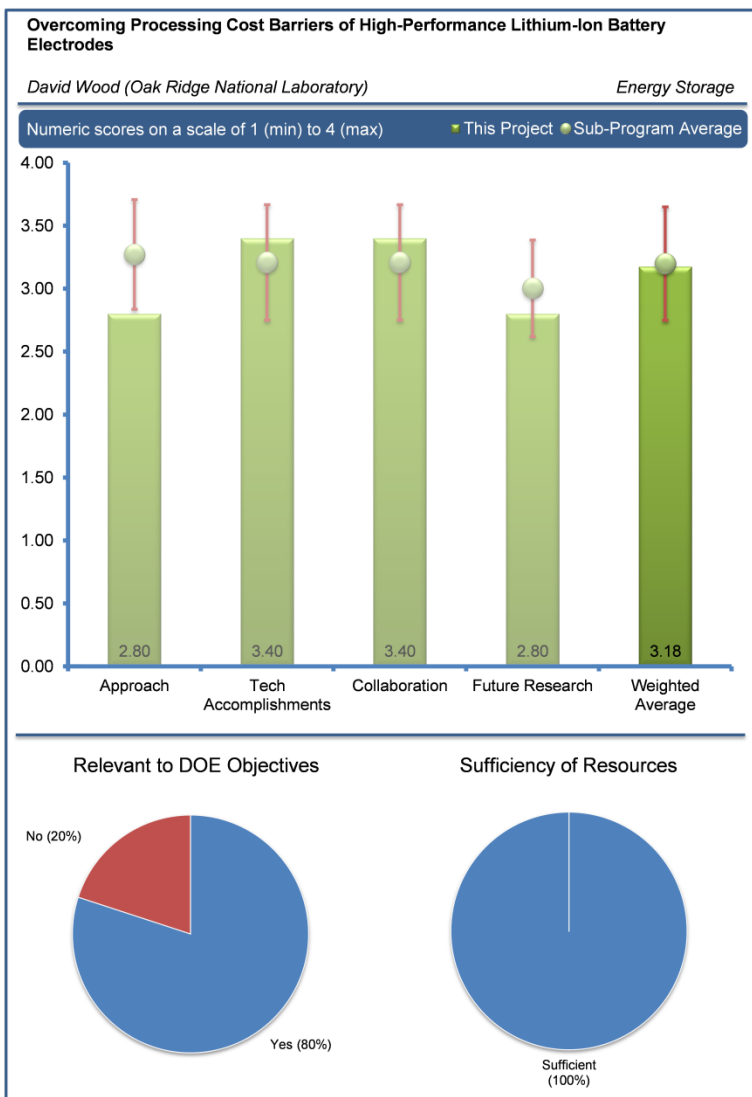
Reviewer 4:

The reviewer reported that the use of water based slurries has been in use in Japan and other countries for many years. It was difficult for the reviewer to see what advantages this work would bring to anodes, but the workers should at least show comparison to SBR-CMC based anodes to learn if any advantages can be obtained. The reviewer is also concerned about the use of hydrophilic polysaccharides such as xanthan gum and easily oxidizable materials such as the imine polymer. No studies of the stability of the polymers alone seem to have been done.

The reviewer was surprised that no discussion of material costs is presented, since cost is to be the main barrier to be addressed.

Reviewer 5:

The reviewer had concerns about residual water content and sensitivity to rehydration following bake-out, and therefore suggested adding a high self-discharge test to look for soft shorts associated with soluble oxidized transition metal oxides. The 88% active electrode material content seemed low to the reviewer, who suggested consideration of cost and return on investment (ROI) of modifying present coating capex for aqueous cathode processing. The reviewer asked how new binders affect electrolyte wetting, and recommended that high temperature stability evaluation look at Tg and binder recrystallization or reflow – TGA will not see this.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer saw very good progress; and noted that the important aspects of providing a baseline for the study were developed. The important questions had been answered or were in the process of being answered. The reviewer remarked the project was well done.

Reviewer 2:

The reviewer felt that the results are moving in the right direction, but could be far advanced using the knowledge base of waterborne coating experts.

Reviewer 3:

The reviewer reported that progress was made with LFP cathode system, but cautioned that this system is unlikely to play a large role in automotive applications and there was still more work left to demonstrate success with NCM and other cathode systems.

Reviewer 4:

The reviewer thought that the performance of the Li- iron phosphate cells were below standard. The reviewer commented that the excellent room temperature cycle life of commercial cells was not even approached and that the rate capability was rather poor. The reviewer wondered if this was a matter of binder, processing or base material, and why no studies seemed to have been made.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that ORNL is doing excellent job involving industry and bringing process awareness to this program

Reviewer 2:

The reviewer thought that the project had a decent set of participants, but that more attention should be paid to paint and coatings manufacturers who have a wealth of knowledge in the issues at hand. The electrode formulations are essentially coatings, and there is a lot of knowledge that could be applied here.

Reviewer 3:

The reviewer reflected that it was good to see collaboration with commercially significant materials suppliers.

Reviewer 4:

The reviewer thought it would be useful to collaborate with HydroQuebec, who have done many studies of water based slurries for electrode manufacture, and who is also a participant in the BATT program. The other national laboratories have not shown much experience with these materials.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the proposed future research was very good, and thought that the program should be able to provide a solid platform for materials suppliers to develop improved materials for this potentially significant process.

Reviewer 2:

The reviewer recommended that more elaborate testing of electrodes should be done in future work. Adhesion, cohesion, and other properties seemed to be ignored up to the present.

Reviewer 3:

The reviewer suggested that more effort should be put to demonstrate that surfactants used in slurry preparation will not negatively impact cycle life.

Reviewer 4:

The reviewer stated that rheology and film shrinkage are the major fundamentals to be addressed moving forward.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer evaluated this to be very relevant. Moving from non-aqueous to aqueous deposition technology holds many cost and environmental benefits and the reviewer felt this was a very important program.

Reviewer 2:

It was not clear to the reviewer where the major cost reductions would come from. There needs to be major simplification in the coating, processing, and drying methodologies, enabled by true coating formulation, for this program to succeed.

Reviewer 3:

The reviewer said that the national laboratories have always had a problem in reproducing cells or coatings made in the industry, so this presented a real challenge to the workers. To be relevant, the project needs to have good comparisons with actual state of the art and not some in-house standards.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reported no issue.

Roll-to-Roll Electrode Processing and Materials NDE for Advanced Lithium Secondary Batteries: David Wood (Oak Ridge National Laboratory) - es165

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found the combination of techniques to be very sound, but there did not seem to be a sense of the cost of such non-destructive evaluation (NDE). Also the reviewer hoped that partners would be willing to supply randomly selected electrode stock to compare with coated electrodes subjected to the full recommended NDE on an apples to apples basis. The reviewer concluded that if cost figures of conventional controls can be supplied by manufacturers that would also be a benefit for comparison.

Reviewer 2:

The reviewer judged the technical approach to be well defined and logically laid out. At the goal level, the reviewer thought it could be important to have more specific data on the justification for the program. The reviewer asked how much scrap was generated due to the issues addressed in this program, just how big an issue this was, and wondered what the size of the opportunity was. While it may be that techniques developed within this program could be used for fundamental study of materials properties related to performance (the secondary goal), the reviewer did not know that it should be convoluted within what is otherwise stated to be a quality control (QC) tool development program.

Reviewer 3:

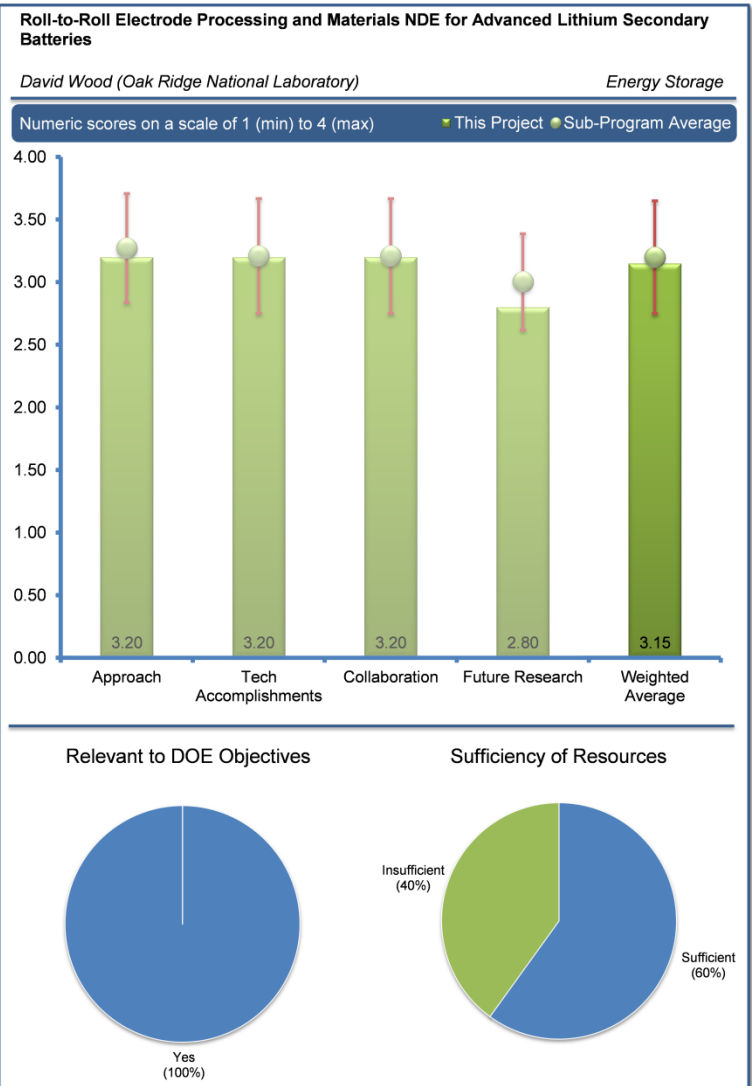
The reviewer found that this program addresses some critical needs to the manufacturing process and needs to have significant effort dedicated to it. Some of the approaches may be questionable from a high throughput manufacturing perspective. The reviewer suggested that a thorough evaluation of QC protocols from conventional industrial coating processes may be helpful, as some lower technology methodologies may be sufficient.

Reviewer 4:

The reviewer revealed that development of in-line QC tools will have significant impact on production capabilities.

Reviewer 5:

The reviewer was not aware of a need to replace beta gage, and stated that it would be a valuable and appropriate national laboratory role to correlate observable defects with performance or life degradation. The reviewer wondered what the false negative/false positive rates and repercussions were. The reviewer would like the researchers to restate success goal as percent reduction in scrap at electrode



coating operation. The present 99% cell-level goal was unrealistic, and the root causes for failure include factors that would not be caught by the methods being developed.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer thought that the results were certainly interesting. However, the reviewer had a concern about how the sampling was done. For example, the standard deviations in the selected sections of Toda 523 coatings seemed nice and small, but when observing the overall run, there were large motions in the measured thickness not reflected in the selected ranges. This called into question the operation of the slot die coater as it seemed to be somewhat out of control. Likewise in the graphite run, there seemed to be a steady drift up in the thickness of the electrode that was not reflected in the small sections. The reviewer wondered if the coater was operating under thickness control conditions.

Reviewer 2:

The reviewer noted the high precision thickness measurement, and thought that the results were interesting. The reviewer suggested that it could provide more relevance if it were compared to another (incumbent) measurement tool, and wondered if this was better than what is being used now. The reviewer also found the IR thermography to be very interesting, and asked the researchers to confirm if it was picking up issues not capable with currently used techniques, as the project team suspected. The reviewer thought that the material performance studies could perhaps be of interest, but should not necessarily be in this program.

Reviewer 3:

The reviewer thought that the thickness measurements seemed feasible, but that in-line x-ray fluorescence (XRF) was more challenging. Overall, the commercial feasibility of these approaches was still unclear.

Reviewer 4:

The reviewer had concerns over the standard deviations observed in the laser thickness measurements, and could not truly expect to be well below 2% in terms of accuracy to make this worth the cost. The reviewer agreed that cost improvements could be made by reducing scrap of the finished electrode film, but dispersion and deposition defects must be addressed to make substantial impact on cost.

Reviewer 5:

The reviewer noted the program change in scope to include LMR-NMC, and wondered if there were any adjustments in goals, objectives and resources. The reviewer saw nice technical progress with these materials, but noted that this competed for resources with original goals.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer thought that there appeared to be a good set of collaborators for the project.

Reviewer 2:

The reviewer said that collaboration seemed good with both battery manufacturers and the material suppliers involved. The collaboration with battery manufacturers would be greatly enhanced if an electrode sharing program could be implemented.

Reviewer 3:

The reviewer stated that the uniformity specifications were speculative and needed more industry feedback before further commitment to XRF.

Reviewer 4:

The reviewer felt that this project begged for an industrial coating partner, and asked if that had been considered or pursued.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer suggested that data sharing programs with the industry to the extent that could be done without violating proprietary considerations would be a valuable addition to future work.

Reviewer 2:

The reviewer would like to see more emphasis on validating an improved QC capability that results in a measurable improvement in the overall process.

Reviewer 3:

The reviewer stated that the researchers should understand precision and long term stability of the proposed measurements, and understand commercial feasibility, perhaps by direct engagement with experienced cell makers.

Reviewer 4:

The reviewer found it reasonable for the existing focus on finished films, but would like to see a greater emphasis on, at minimum, the deposition process and a vision of how to integrate feedback loops and automation.

Reviewer 5:

The reviewer suggested that the researchers look at the possibility of in-line QA for real time assessment of moisture content and the possibility of optimizing line speed or drying rates e.g. it may be possible to ramp up drying rate once moisture content drops below a defined threshold.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that this program addresses some real deficiencies and needs with respect to the electrode manufacturing process.

Reviewer 2:

The reviewer felt that the national laboratories have always had a problem in reproducing cells or coatings made in industry, so this presented a real challenge to the workers. To be relevant, the reviewer suggested that the project team needed to have good comparisons with actual state of the art and not some in house standards.

Reviewer 3:

The reviewer thought that this would have relevance if a significant QC technique which could provide tangible cost and reliability improvement were to be developed.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer declared that this was not an aspect of manufacturing to treat lightly. In order to make U.S. manufacturing competitive and superior, this was an area to hit hard. The reviewer suggested that the researchers explore contribution from existing manufacturing experts, especially in the coating sectors.

Reviewer 2:

The reviewer thought that the program change in scope to include LMR-NMC should be noted, and wondered if there were any adjustments in goals, objectives and resources. The reviewer saw nice technical progress with these materials, but this competed for resources with original goals.

Reviewer 3:

The reviewer found the resources to be adequate.

Process Development and Scale-up of Advanced Cathode Materials: Greg Krumdick (Argonne National Laboratory) - es167

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought that the approach was generally good, but it was not clear how many preparations have been made and how statistics have been applied to the many variables listed in the work. The authors should be aware that many of these variables interact rather strongly. Also, the reviewer reported that the concentration on particle cracking did not seem to have a basis in cell performance, so it may not be a critical aspect.

Reviewer 2:

The reviewer judged the approach to developing a complex materials scale up to be well thought out and logically presented. Obviously with the significant effort required for this task, the choice of specific material to scale is of the utmost importance.

Reviewer 3:

The reviewer reported that the project focuses on addressing synthesis and scale up challenges with Li rich cathodes. The impact can be significant if the project is successful. The reviewer found the approach to be sound and based on detailed exploration of various synthesis and other parameters to understand the impact on cathode particle properties.

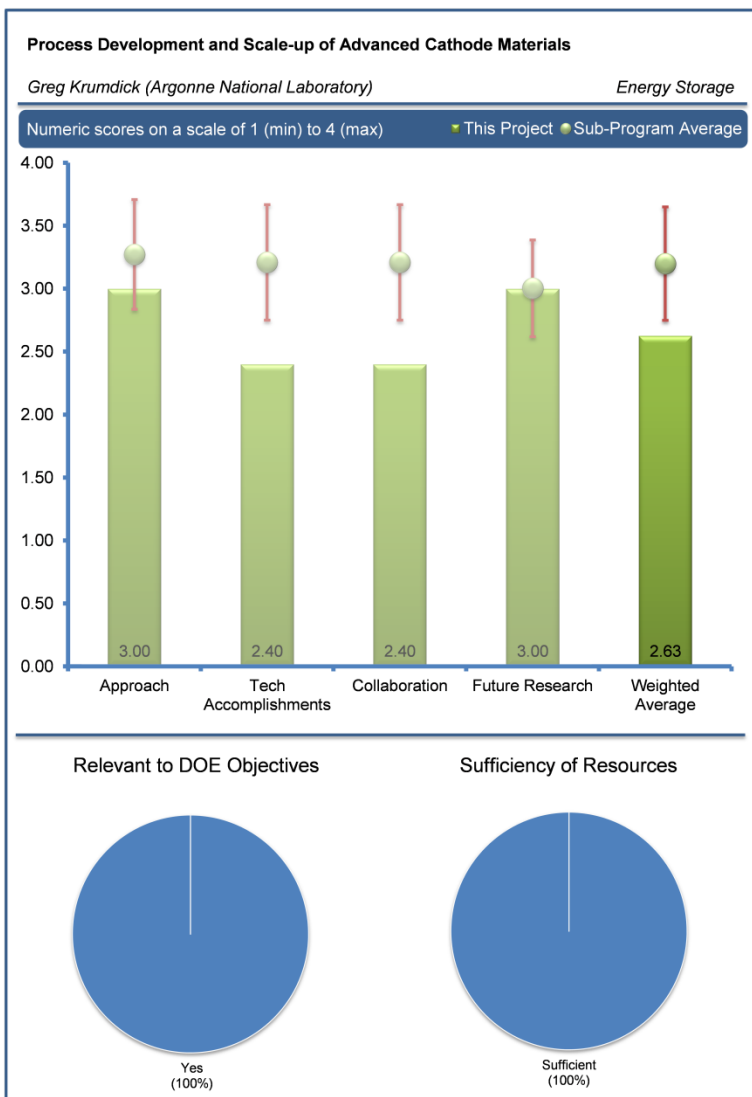
While the technical approach was sound, the reviewer felt there was not enough discussion around how practical various approaches were and what the potential penalties of different approaches were. It will be very important to understand if there are some fundamental issues with scaling of various approaches.

Reviewer 4:

The reviewer thought that it was a reasonable approach to evaluate a variety of advanced cathode particles, especially when there are not useful suppliers of such materials at sufficient scale.

Reviewer 5:

The reviewer noted that 82% of active material content in electrode was low. Fixing the binder percent with varying tap density and particle size may be unrealistic and contributing to differences in observed performance. Optimizing binder content and dispersion may require changes in formulation, but a rigid apples-to-apples comparison (fixed formulation) may not be appropriate. The reviewer thinks this will be a tough challenge, as it does expand the scope.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that two techniques for cathode material scale up have been developed. Highly detailed studies on the material characteristics developed by each process have been accomplished. The reviewer thought that it will be important to lay out the target criteria that define success. Material/process optimization can (and typically is) be an ongoing activity in the commercial world. The reviewer suggested that some significant thought should be put into the issue of whether there is a definable end point to this work, or if it is an ongoing optimization effort.

Reviewer 2:

The reviewer reported that good progress was made to understand the impact of various synthesis variables on particle properties and results are analyzed and summarized in a logical and useful way. It was hard for the reviewer to judge how much progress was made toward overcoming the key barriers. It seemed that the conclusion was reached that there will always be a tradeoff between tap density, particle stability, and performance, and that one would have to choose which property is more important and design the particle for specific application by accepting tradeoffs. The desired particle needs to be small, spherical and dense. The reviewer wondered if perhaps it was time to consider alternative approaches to synthesize Li rich materials with less tradeoff.

The reviewer also noted that there was no discussion on how this approach and its ability to vary particle size impacts one of the key barriers with Li rich materials which is VF. Surely there must be some data already available that will answer the question is smaller particle size beneficial for VF.

Reviewer 3:

The reviewer did not see any designed experiments involved in the scale up results. With the number of variables, there should be some effort to eliminate some of the less sensitive variables from the study.

Reviewer 4:

The reviewer found it troubling that the inconsistency of particle morphology between the bench scale and pre-pilot scale was not explained and did not seem to be addressed. One could question the value of that process. The reviewer relayed that the problem seemed to be overcome with the continuous particle growth improvement, but cautioned that scalability was still an issue.

Reviewer 5:

The reviewer felt that the presentation could have been clearer on critical to quality (CTQ) gaps and past progress against these gaps especially in terms of cracking, porosity and tap density.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

It appeared to the reviewer that the appropriate collaboration work was occurring within the national laboratory system. The work appeared well coordinated and highly detailed. As there were no commercial partners at this stage, it was unclear to the reviewer whether that was preferred at this stage or not.

Reviewer 2:

The reviewer would like to see some interaction with material suppliers to see what the suppliers would like to see in the way of a scaled up process in order to implement new materials received from national laboratories.

Reviewer 3:

The reviewer revealed a fairly limited team of contributors, and the absence of a small business with expertise in complex particle manufacture, which was needed.

Reviewer 4:

The reviewer asked how this work was coordinated with extensive outside efforts with LMR-NMC.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer thought that, with such a large effort required for any new candidate material/process, it was critical to provide the proper guidance as to the specific choice and why.

Reviewer 2:

The reviewer concluded that the low tap density of the hydroxide material seemed to be the main problem with that preparation, and recommended that the focus should be to try to improve the tap density.

Reviewer 3:

The reviewer did not fully understand the cracking issue, and the path forward looked to rely too heavily on trade-offs.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reasoned that advanced active material sets were a critical item in the development of higher energy, lower cost Li-ion battery technologies, and that advancing the field for highly promising candidates was a critical activity. The choice of work, as well as the general approach to interaction with industry is a critical aspect in achieving that relevancy.

Reviewer 2:

The reviewer stated that this type of capability is needed to help identify next generation cathode and anode materials to get to longer term DOE and battery industry goals.

Reviewer 3:

The reviewer recommended speeding up and validating material spin off to industry; this program could provide an interesting role.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Process Development and Scale up of Advanced Electrolyte Materials: Greg Krumdick (Argonne National Laboratory) - es168

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought that the evaluation and scale up process was well laid out with documentation and decision points, and that the flow chart was easy to follow. More insight into how new materials are identified and introduced to the process would be helpful. The reviewer anticipated that the database should be a valuable tool and one would hope there would be insight into structure-property relationships, which is not addressed in the presentation.

Reviewer 2:

The reviewer felt the first half of the approach was spot on; essentially providing a database and perhaps a platform capability for the evaluation of new materials as components in electrolyte development. The reviewer declared that this is a complex task, as the electrolyte is a combination of materials that would typically require some optimization with the introduction of a new component.

The reviewer found the second phase of the approach to be a little tricky; determining which components should be scaled up, who should scale up, etc. is the key to this area. If this is mainly aimed at evaluating laboratory scale materials developed through, say, the national laboratory system, and then scaling up promising ones because there is no industry source, then that is a reasonable goal. The reviewer concluded that it needs to be a little clearer as to what the higher level objective of this part of the program is.

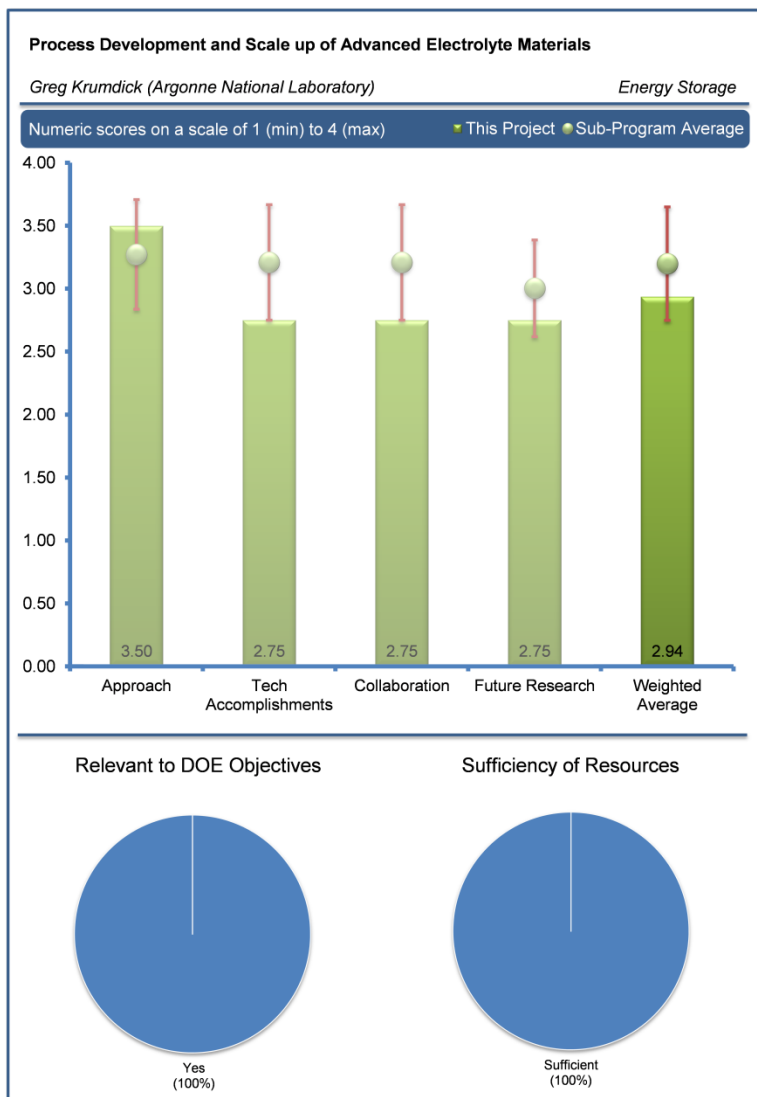
Reviewer 3:

The reviewer found that the funnel and selection criteria were working well. In some cases, it may make sense to toll manufacturer synthesis and focus program resources on blending and validation.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

It appeared to the reviewer that a very competent effort occurred in the scale up in a number of candidate materials. Complexity in the program must certainly come from the diversity of skill sets it might take to approach such a wide variety of synthetic techniques. The reviewer felt that the process of deciding which material was deserving of scale up still stood as a higher level issue.



Reviewer 2:

The reviewer observed that some new materials have been scaled to the kilogram scale and intellectual property protection initiated. With the level of funding and the simplicity of most of the synthetic routes shown, one might expect more materials to have been screened and scaled. The reviewer understood that there had been considerable effort into building the synthetic lab and pilot infrastructure and analysis protocol, which was great. The facilities seemed to lend themselves to high-throughput techniques, so this would be an expectation moving forward.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer reported good collaboration within the national laboratory network and some universities, but would like to see more outreach to industrial partners so this work can better impact commercialization.

Reviewer 2:

The reviewer revealed that although the outreach was aggressive, there was still a lack of industry response or follow through. The reviewer found that academia and national laboratories were collaborating well, but needed to create some incentive to get an industry response.

Reviewer 3:

The reviewer stated that no data was presented related to feedback from any of the materials that were developed. The reviewer asked if the project team went back to the originating organizations and validate at the functional level. Several presentations were listed, and this reviewer inquired as to a possible highlight from those relating to the use of the material.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer felt the goals moving forward were a bit more aggressive and suggested that the researchers may want to push it even further, in terms of the number of electrolyte materials evaluated prior to scaling.

Reviewer 2:

The reviewer said that it was not clear what gaps were to be addressed.

Reviewer 3:

The reviewer would like to see more development of the justification process for the materials chosen to be scaled.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer reasoned that electrolyte technology is a key part of improved battery performance in the future, and, that at a minimum, having a comprehensive database of materials and a platform for testing is very relevant.

Reviewer 2:

The reviewer felt that the program provided a needed link between battery electrolyte discovery and commercialization and was an effective way to validate new materials.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer felt that funding seemed appropriate for the output.

Analysis of Electric Vehicle Battery Performance Targets: Jeremy Neubauer (National Renewable Energy Laboratory) - es174

Reviewer Sample Size

A total of 7 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the approach was outstanding because it involved a great deal of interaction with the vehicle OEMs while providing vehicle relevant data, continuing refinement, and reviewing of the model with the DOE and the OEMs. The approach allowed for various vehicle types to be analyzed with respect to two different battery systems that are part of the DOE and vehicle OEM objectives. The reviewer also commented that the project demonstrated the versatility of the NREL Bill of Material (BOM) as well.

Reviewer 2:

This reviewer first commented on the need for this sort of work at the 2009 AMR and is very glad to see this effort is now underway.

Reviewer 3:

The reviewer observed a well-structured approach using a requirements cascade process while communicating on collaborating with the end-user.

Reviewer 4:

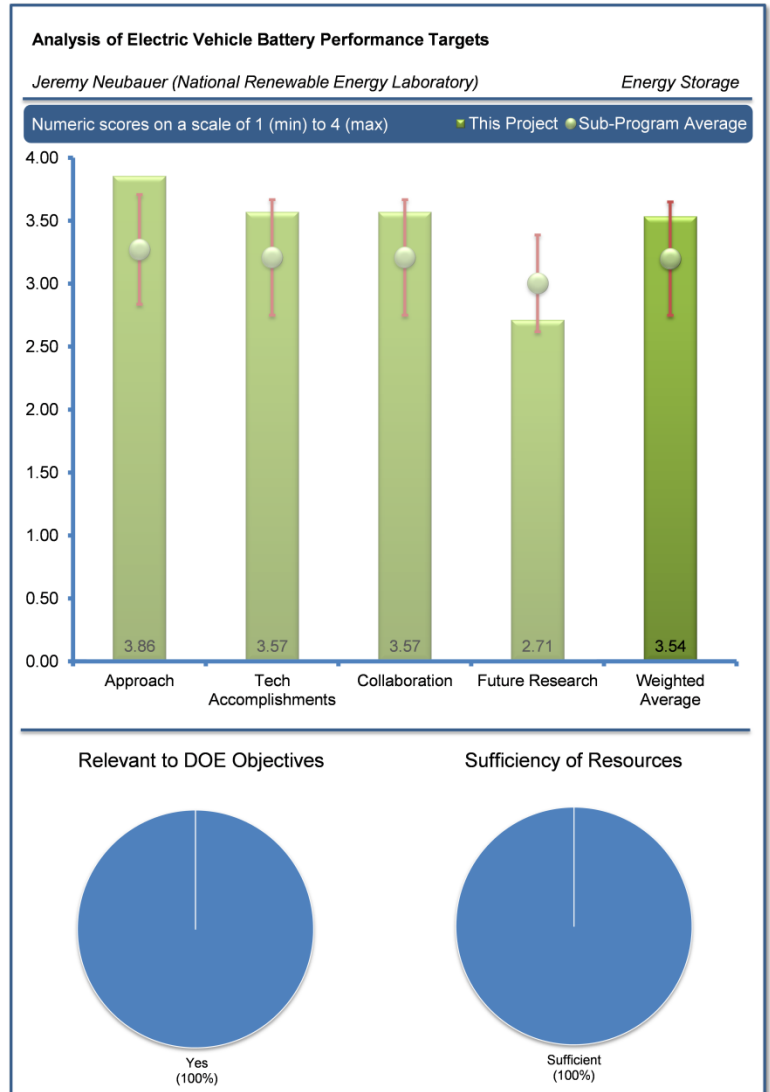
According to this reviewer, there is a need to update the performance matrix requirement. The reviewer added that the project had a sound tech target analysis approach.

Reviewer 5:

This reviewer commented that targets are derived from the OEM's vehicle and driving profile assumptions.

Reviewer 6:

The reviewer remarked that the results presented show End of Life (EOL) targets that correspond to given mass factors and driving ranges for a number of vehicle types. Although it is mentioned in the presentation, it is not explained which methodology will subsequently be used to translate the EOL performance and cost targets into their BOL equivalents. The reviewer stated that the same applies for breaking down pack-level targets into targets for the individual constituents.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

According to the reviewer, the intended goal of publishing the new battery electric vehicle (BEV) battery technology targets are on track to meet the project schedule.

Reviewer 2:

According to this reviewer, the complete list of targets was reported.

Reviewer 3:

The reviewer observed that the analysis is solid, which includes a generation of main parameters, which will affect the selection of final requirements. The reviewer pointed out that the input set was not exhaustive, but the analysis framework was capable of accepting additional inputs and constraints, while continuing to deliver meaningful outputs.

Reviewer 4:

This reviewer described that the project team made good progress but seemed slow since the project initiation in 2010.

Reviewer 5:

The reviewer stated that the project does not in itself address directly DOE goals, but is aimed at establishing targets to further guide program efforts. As such, it is a necessary element of the VTO. The reviewer noted that the progress realized within the project cannot be evaluated on the basis of the information provided in the presentation slides.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that the collaboration with USABC partners was excellent. The reviewer added that focused input from non-USABC OEMs could provide additional insights and output from the project.

Reviewer 2:

This reviewer observed that the project team was customer-oriented, with solid collaboration between industry end-users, as well as having a voice of customer inputs through other research groups.

Reviewer 3:

The reviewer stated that key stakeholders in this project have been intimately involved throughout the process, from establishing the approach to providing the data to establishing and refining the targets.

Reviewer 4:

The reviewer commented that the work approach, presented on Slides 7-11, has been developed with major stakeholders, which is absolutely required for assuring the relevance of the outcome. The reviewer cannot judge on collaboration or integration of the project activities with other program efforts.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that future work will be based on specific stakeholder input and feedback related to various selections. The reviewer added that the calculated target goal values will be based on those selections.

Reviewer 2:

The reviewer commented that technological target analysis should be expanded to include performance matrix at the materials level, and integrate the materials performance matrix with the cell and pack performance matrices, in order to meet the PHEV or BEV goals.

Reviewer 3:

The reviewer noted that performance inputs based on actual real-world driving (not just from standard reference profiles) could provide additional insights and outputs from this project.

Reviewer 4:

This reviewer opined that the next steps were notably ambiguous, given how the end users chose to utilize the results.

Reviewer 5:

The evaluator pointed out that future work identified did not include any effort on transforming EOL into BOL and pack into cell-level targets.

Reviewer 6:

This reviewer remarked that there was no need for future research.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer stated that the program quantitatively defines the EV battery goals required for a practical plug-in electric vehicle, based upon voice of customer.

Reviewer 2:

The reviewer remarked that the DOE and the different OEMs need to clarify what is needed to make the all-electric vehicle competitive with the ICE vehicle. The reviewer added that this analysis will help identify the direction that battery suppliers and automotive OEMs should take to increase the probability of this to happen.

Reviewer 3:

This evaluator pointed out that program team indirectly arrived at updated targets that would guide further program efforts.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

According to this reviewer, the resources are sufficient with the involvement of the OEMs and DOE.

Reviewer 2:

This reviewer stated that there were no issues.

Reviewer 3:

This reviewer remarked that no information was provided on the budget share or was available to the project activity within the overall BOM project. Therefore question cannot be answered.

Promises and Challenges of Lithium- and Manganese-Rich Transition-Metal Layered-Oxide Cathodes: Kevin Gallagher (Argonne National Laboratory) - es177

Reviewer Sample Size

A total of 6 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

According to the reviewer, the approach adopted was based on updating the cost model of the Li-ion battery pack. The reviewer stated that performance characteristics of the cathode material are required to have a quantitative understating of the material level performance effect on the overall cost. Specifically, the VF phenomenon of the LMR-NMC cathodes contribute to energy loss upon cycling. The reviewer added that this increases the cost of the battery pack, which this task quantitatively addresses. Thus, this task aligns well with the VF studies that are on-going at ANL while defining the performance metrics, i.e., specific capacity and average discharge voltage for the LMC-NMC cathode for the Battery Pack (BatPac) to meet the cost targets. The reviewer also noted that since the cost and performance are inter-related, it is important to understand the cost implication of performance shortfalls. The approach is based on using the battery pack developed earlier at ANL and the likely production cost estimates provided by OEM manufactures, with an assumption of a high volume production of modules by 2020. The reviewer concluded that the approach appears sound, but the results are still sketchy, mainly because of the inconsistent cycling data with the LMR-NMC cathode.

Reviewer 2:

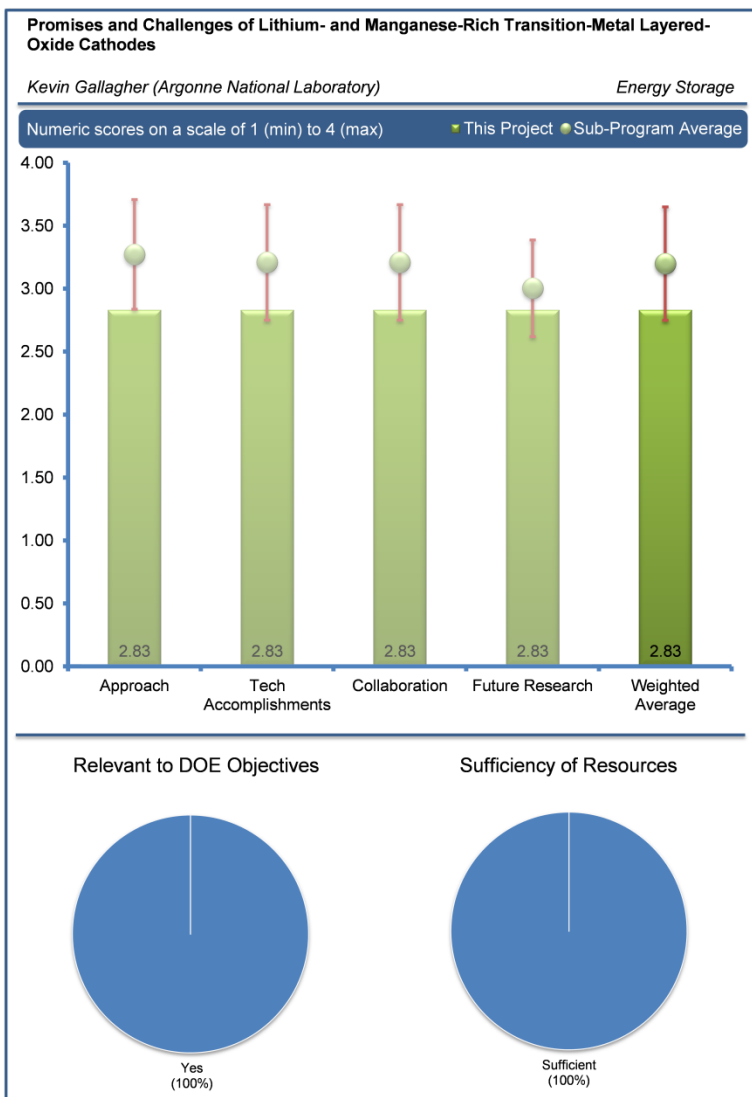
This evaluator remarked that the project started only a few months ago, and very important results were obtained in a short period of time.

Reviewer 3:

The evaluator noted that the project work was based on projecting various performance targets of LMR-NMC using BatPac analysis. The work was very relevant towards addressing barriers associated with LMR-NMC cathode chemistry developed at ANL.

Reviewer 4:

The reviewer was concerned about the project's approach. The reviewer opined that both targets and evaluation should be done based on Wh/L and Wh/kg values, achievable at commercializeable mAh/cm² values, using real observed values for mAh/g, g/cc, voltage (V) average-discharge, first cycle, and efficiency. Full cell models should be used to evaluate the achievable Wh/L and Wh/kg values. The reviewer added that some validation is needed to show that the full cell models are believable. An example of how this is



important is that if one designs a lithium-rich material having 225 versus 275 mAh/g, not only is the average discharge voltage likely to change significantly, but also the achievable electrode density will also change significantly. The reviewer concluded that figuring out whether lithium rich materials can be valuable is important, but is concerned about this approach.

Reviewer 5:

This reviewer commented that the project uses ANL's model to map out the performance and cost space, but seems too much like an engineering exercise rather than a scientific project.

Reviewer 6:

This reviewer said that the project's approach to leverage ANL's VF Team and interact with OEMs and cell suppliers sounded good, but was not clear if this was achieved. The reviewer also noted that the schematic on Slide 4 was unclear.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

According to the reviewer, there was a very interesting correlation between positive voltage and capacity. The reviewer also noted that according to the authors, the cell voltage is clearly one of the most important parameters in a battery. The VF issue is clearly shown as one of the most important barriers.

Reviewer 2:

This evaluator commented that the project execution appears to be good.

Reviewer 3:

The reviewer remarked that PI has carried out a detailed analysis of the LMR-NMC chemistry and addressed the relevant barriers. Where these understandings can lead to address the current issues associated with LMR-NMC or similar high voltage (V) chemistry should be asked by the PI. The reviewer questioned where progress has been made in last year compared to year before. The lithiated transition metal oxides (Li_2MnO_3) templating is a synthesis attempt that may or may not solve the VF. The reviewer added if the PI can explain how his model is relevant to such an effort (Slides 14 and 15).

Reviewer 4:

According to the reviewer, reasonably good progress has been achieved in carrying out the cost analysis for the batteries for PHEV applications, particularly in the context of the VF and the resultant energy loss of the LMR-NMC cathode. The performance metrics for The LMR-NMC, which may be used as a guideline for the material development, have been updated with the required specific capacities comply with the cost target. The reviewer went on to say that as these cost projections require further validation by comparing with similar cost models or from real data, based on the information from an unspecified battery manufacturer and with the assumption of a high volume production. Otherwise, the actual costs do not mean much, and only trend from these results would be valid. The reviewer also noted that one difficulty associated with this model is that it is largely based on area-specific impedance (ASI) data. Instead, the model will be a more robust if it is based on the real-time performance data taken from the manufacturer's prototype cells over a range of temperatures, discharge rates, and lifetimes.

Reviewer 5:

This evaluator opined that the program should start with BatPac code, and then calculate cost to the OEM for building battery pack, assuming there is a future high volume system. The reviewer pointed out that the program identified a tradeoff between cell voltage and capacity, which may be useful, but was the only thing that has been done this past year.

Reviewer 6:

This reviewer observed that only one publically available software program was used. The reviewer adds that it would have been move interesting if the data had been used on several available programs, and a comparison of similarities and differences were made. The author pointed out that efficient calculations can be made in fraction of a second. Further, this reviewer commented that the data obtained from the software did not show anything that was unexpected.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer observed that the authors are collaborating with a large variety of researchers from the National Laboratories and industry.

Reviewer 2:

This reviewer noted that there were project team conversations with suppliers.

Reviewer 3:

The reviewer thinks that discussions with leading material suppliers could help guide the approach to setting cathode material performance targets. Otherwise, the reviewer said that the teamwork appears good.

Reviewer 4:

This reviewer expressed that the PI should discuss or provide a description of whether BatPac model is used by cell manufacturers and OEMs including their comments. This is important since most of the industrial partners have their own cost and performance models.

Reviewer 5:

This reviewer stated that project has no external collaborations being an entirely ANL in-house effort, but there is collaboration with the VF team. The reviewer added that there appears to be some collaboration with the battery manufacturers (OEMs).

Reviewer 6:

This reviewer pointed out that the author makes no reference as to how coordination with partners achieved or what information was sought or received. The reviewer suggests that the author should spend one minute discussing the coordination and information issues, even if the needed important information is unattainable.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer remarked that with the given budget, the scope of the work is adequate. However, the PI should think beyond the LMR-NMC chemistry.

Reviewer 2:

According to the reviewer, next year's work is the most important part of the project. That is, to document State Of the Art (SOA) performance and barriers that may prevent commercial acceptance, and to research initial performance, life and safety performance, low-temperature performance, and system level State Of Charge (SOC) and power management issues. The reviewer was unsure if this research should have been done first, and then incorporated in to the computer model. The designers of the software should be considered to be a partner so that the model can be better customized.

Reviewer 3:

The reviewer said that the proposed future research should carry out further assessment of PHEV and EV battery costs with Li-ion battery packs containing LMR-NMC cathode material, after taking into consideration all the performance barriers of this material such as VF and hysteresis, poor low temperature performance, power capability, and poor cycle life. The reviewer added that this model will be extended to the EVs and PHEVs with advanced Silicon (Si) anode to generate similar cost information.

Reviewer 4:

This reviewer opined that it is important to increase the data base, and that a strong interaction with the industrial partners should be clearly encouraged.

Reviewer 5:

The reviewer commented that the future project was unclear. Although the challenges are listed, the reviewer questioned how the unclear approach gets close to finding an answer. Regarding future work, the reviewer stated that the project looks like it is ready for close-out.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said that the project is very relevant.

Reviewer 2:

This reviewer agreed that the project supports the DOE's objectives to increase petroleum displacement. The study focuses on the critical technical and cost issues.

Reviewer 3:

According to the reviewer, this project is quite relevant to the overall DOE goal of partly replacing conventional vehicles with HEVs or EVs, in order to minimize the national dependence on petroleum resources. The (high) cost of batteries for PHEVs is a serious impediment to a widespread use of Li-ion batteries in vehicles. The reviewer also pointed out that the overall project objective is to develop cost assessments that are based on the appropriate models and used for predicting the performance-based costs for battery packs that are relative to the cost goals. The project objective is in support of the overall goal of developing a PHEV-40 that has a price lower than \$3,400, a weight not exceeding 120 kilograms (kg), and a volume 80 liters (L) or lower. The reviewer added that studies will guide the manufacturer and material researcher in addressing the cost barrier for Li-ion batteries, especially when including the high energy LMR-NMC cathode.

Reviewer 4:

This reviewer commented there should be support of computer modeling simulation calculations to prove or disprove the feasibility of the DOE objective for this project.

Reviewer 5:

The reviewer remarked that the project is useful, but nothing that should be done at a National Laboratory.

Reviewer 6:

The reviewer agreed that the project supports the DOE's objectives. However, due to a concern about the approach, the reviewer did not think the project will have a significant impact.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer remarked that resources are sufficient. However, the authors should get additional support if the developments related to lower battery cost and VF improvements are clearly shown.

Reviewer 2:

This reviewer noted that the resources are adequate.

Reviewer 3:

The reviewer stated that the resources are adequate for the planned effort.

Reviewer 4:

The reviewer commented that resources are only required for one person where the project has a canned software already available.

Composite Electrolytes to Stabilize Metallic Lium Anodes: Nancy Dudney (Oak Ridge National Laboratory) - es182

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the well-presented approach is very clear with outstanding and clearly useful results to date. Technical barriers are well understood. The reviewer added that a follow-on full cell testing is very important to the success of this program.

Reviewer 2:

This reviewer remarked that the approach was good.

Reviewer 3:

According to the reviewer, the approach is novel and also solid when backing up the experiments with modeling. The problems of interfacial impedance have likely been underplayed in past work because of the concentration on vacuum based preparations of micro batteries with small interfacial impedance. The reviewer added that for thick electrodes, the interfaces are critical.

Reviewer 4:

The reviewer opined that the project should develop a solid electrolyte cell with a Li metal anode using two dissimilar solid electrolytes with single Li positive conductivity. The reviewer went on to say that the success will result in cells with Lithium-Sulfur (Li-S) cells with 500 Wh/kg and Lithium-Air (Li-Air) cells with 700 Wh/kg. Progress will demonstrate the proof of principle for the composite electrolytes and a stabilized Li metal anode.

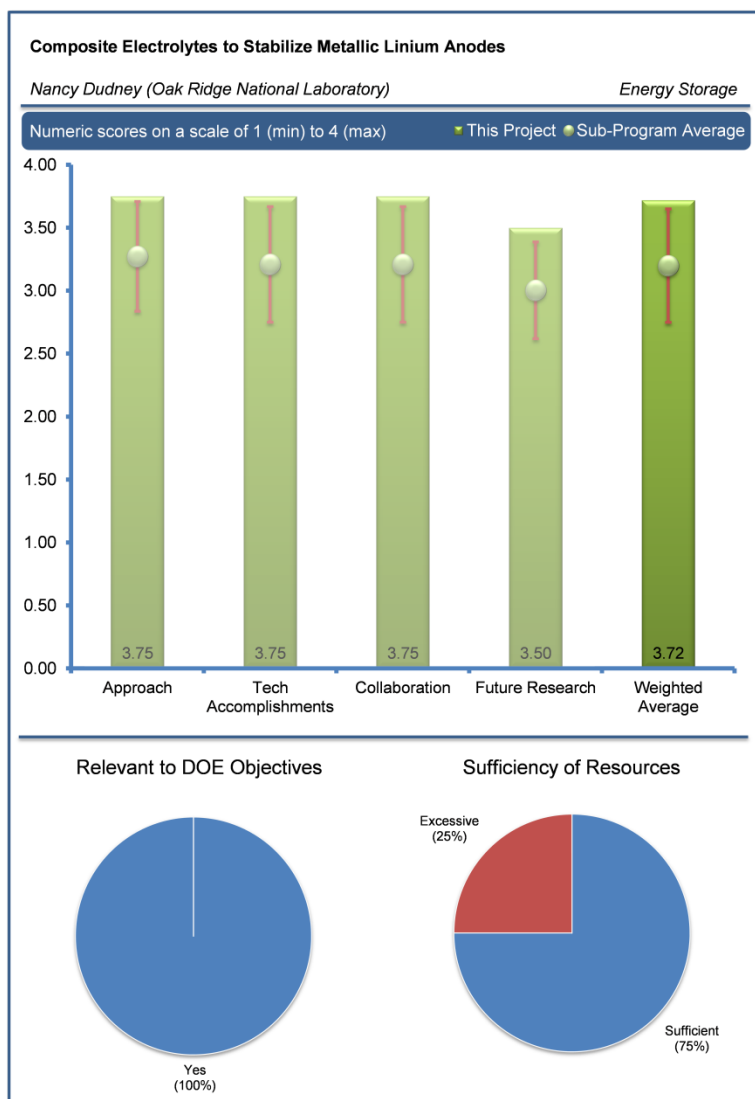
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer remarked that clear results in work to date show how approach leads to useful results. The reviewer added that the research team had learned quickly on all fronts of the project, and continued to have clear objectives for future work.

Reviewer 2:

This reviewer stated that reasonable progress has been obtained. The evaporated Li anode films have a lower resistive interface and protect the Li metal anode, which is the key to longer life.



Reviewer 3:

The reviewer indicated that the previous study from the group has shown decrease in impedance with the lithium phosphorous oxynitride (LiPON) coating on electrodes. The project currently shows that the LiPON coating increases the impedance for which the reviewer requested an explanation.

Reviewer 4:

This reviewer said that the technical accomplishments have shown the need for low interfacial impedances along with the interfaces that need to be worked on. Effort is now needed to lower these interfacial impedance values.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer expressed that the collaborations are very useful in that other teams are providing materials for test and evaluations.

Reviewer 2:

According to the reviewer, the collaborations are good and include many of the key players. The reviewer added that it might be useful to add John Kerr of LBNL to the collaboration list for his different approach to the polymer electrolyte and because he is very cognizant of the interfacial impedance roles.

Reviewer 3:

This reviewer affirmed the projects collaboration with Michigan State University, University of California, Berkeley, nGimat, and O'Hara Corporation.

Reviewer 4:

This reviewer commented that collaboration is good.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the plans very clearly show how current work will lead to future work. The reviewer also affirmed the project's clear plans for overall evaluations and potentially useful results.

Reviewer 2:

This reviewer opined that the team should define the best combinations of polymer and ceramic materials for improved performance, develop a strategy to maintain the lithium metal-electrolyte interface, and characterize the performance of advanced cell designs.

Reviewer 3:

The reviewer was unsure on how the sintering of ceramic materials will be carried out in the presence of low melting polymers. The reviewer pointed out that while this sintering could be a difficult step, it seems essential to increase the area of particle to particle contact of the ceramic material. The reviewer affirmed that the area increase is best done by sintering.

Reviewer 4:

This reviewer observed that developing a dense and thin electrolyte will be challenging.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that the project relevance is high because of the need to solve the dendrite problem with lithium electrodes, and to be able to use thick lithium.

Reviewer 2:

This reviewer said that the project success will carry Li-Air and Li-S cells into competition for use EV batteries.

Reviewer 3:

According to the reviewer, the project is directly relevant to DOE's efforts to develop the high energy batteries needed for EVs to be used extensively in the transportation sector.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer remarked that the resources were adequate for proposed program.

Reviewer 2:

The reviewer noted that program is adequately funded at this time. The reviewer added that it is important for program to have a follow-on phase with additional funding in future years.

In situ Solvothermal Synthesis of Novel High Capacity Cathodes: Patrick Looney (HRL Laboratories LLC/Brookhaven National Laboratory) - es183

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the approach was good.

Reviewer 2:

According to the reviewer, the development of the in situ synthesis technique is outstanding and it should be applied to current battery materials. The reviewer was unsure why materials made in different ways perform so differently. There are often minor analytical differences that cannot explain the electrochemical differences. The reviewer inquired that perhaps the differences could be understood from what happens during synthesis. The novel cathode development was less clear to the reviewer. The cathode does not look like a high energy material because the voltage is too low. In addition, the reviewer questioned how the project team is going to lithiate it.

Reviewer 3:

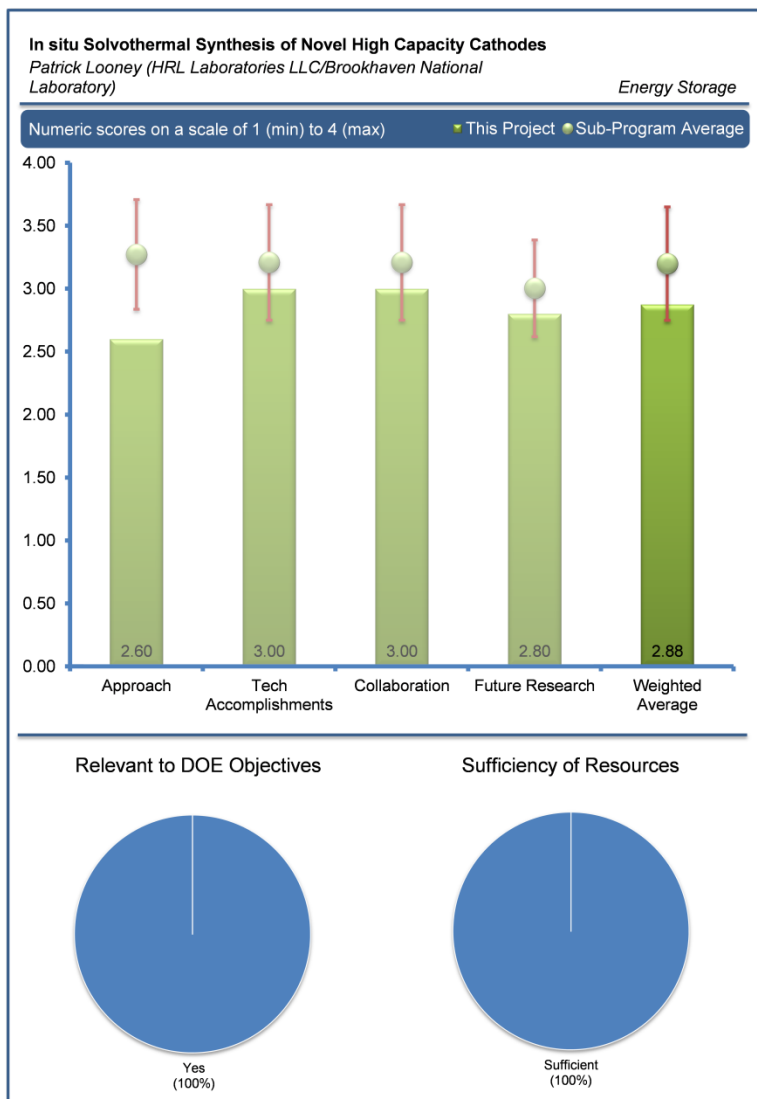
The reviewer described the project as having a good approach to achieve a high energy density, via a high capacity cathode, versus a high voltage cathode. However, the reviewer added that $\text{Cu}_{0.95}\text{V}_2\text{O}_5$ is not the right cathode due to Cu^{1+} during discharge. The dissolved Cu^{1+} will plate on the anode and eventually produce shorts. In addition, the reviewer pointed out that the Vanadate materials have an approximate density of 3.6 grams per cubic centimeter (g/cc), and thus the volumetric energy density, Wh/L, will not be competitive with LiCoO_2 .

Reviewer 4:

This reviewer commented that the project team should develop synthesis routes for phase pure CuV_2O_5 materials using a unique in situ reactor integrated with synchrotron characterization.

Reviewer 5:

The reviewer remarked that approach taken by this project is fair. The investigators will develop a specialized in situ reactor designed to investigate synthesis redactions in real time using time-resolved XRD. The reviewer added that one of the key hurdles in using solution-based synthesis techniques is the difficulty in understanding the reaction pathway, and thereby optimizing the reaction for the desired material properties. This technique will allow the investigators to explore reaction pathways and investigate the structural evolution of intermediate reactants in real working conditions. The reviewer pointed out that there is a concern if the $\text{Cu}_{0.95}\text{V}_2\text{O}_5$ is a viable material. The cycling performance does not look good at this point.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

According to the reviewer, good progress has been achieved to date. The in situ reactor has been developed that will allow time resolved XRD, which is key for the understanding of the synthesis reaction mechanism. The reviewer also stated that ability to probe synthesis reactions in real time will provide a better understanding of how temperature, pressure, time, and the initial concentrations affect the reaction pathways. The reviewer added that the project investigator has already synthesized some materials and determined the lithium reaction process, along with possible mechanisms responsible for poor cycling stability.

Reviewer 2:

This reviewer commented that the researchers should set some targets for the cathode development work, and ensure they are working on commercially relevant materials.

Reviewer 3:

The reviewer mentioned that the observed structural change of CuV_2O_5 , decomposition and Cu formation, upon lithiation resulted in a unique in situ synthesis or characterization capability. However, the performance of CuV_2O_5 is limited.

Reviewer 4:

This reviewer queried how charge neutrality is maintained if the Cu is 2+ and V is 5+, initially. The reviewer observed good synthesis results and excellent in-situ studies.

Reviewer 5:

This reviewer expressed that the project did not produce convincing results for the application. The reviewer was also unsure on how to improve the capacity and the stability.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the collaboration and coordination with other institutions was good.

Reviewer 2:

This reviewer pointed out that the project team has a diverse set of skills, and is more than just supplying samples.

Reviewer 3:

According to the reviewer, the PI has established collaborations both with BATT investigators and with external partners on technique development, synthesis, and characterization.

Reviewer 4:

The reviewer remarked that the project team is collaborating with a number of researchers.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer expressed that project's proposed future work is excellent and the effort will continue to investigate CuVO cathodes by using the project's novel approach.

Reviewer 2:

This reviewer affirmed that the continuation with CuVO cathodes will provide fundamental information, but the proposed transition to olivine will provide more relevant information.

Reviewer 3:

As stated earlier, the reviewer expressed a request to see the in situ technique applied to more common battery materials. The reviewer is not sure that the project team should focus so much on development of new materials, for the team has a very unique opportunity to optimize synthesis of existing materials. This could result in improved performance and/or lower cost.

Reviewer 4:

According to the reviewer, the project needs to address Cu^{1+} dissolution issue if the project team wants to pursue CuVO cathode. The proposed Olivine cathodes are high voltage, not high capacity cathodes, and thus will need high voltage electrolytes. The reviewer encouraged the team to pursue high capacity cathodes that do not require the use of high voltage electrolytes to enable high energy density Li-ion cells.

Reviewer 5:

The reviewer said that the strategy to improve the performance and voltage stability is needed to be discussed.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer stated that the proposal is relevant and supports the DOE objective of petroleum displacement. Developing a high energy density cathode material for a high performance Li-ion battery that could offer long driving range is the biggest challenge for electric or hybrid-electric vehicles.

Reviewer 2:

The reviewer noted that the project addresses the high energy density battery materials necessary for widespread implementation of BEVs in the United States.

Reviewer 3:

This reviewer commented that the project gives insight to cathode synthesis and degradation mechanisms.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer remarked that resources appear to be sufficient to successfully complete the tasks in a timely fashion.

Lithium-Bearing Mixed Polyanion (LBMP) Glasses as Cathode Materials: Andrew Kercher (Lawrence Berkeley National Laboratory) - es184

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer noted that the project has a new approach.

Reviewer 2:

According to the reviewer, the approach taken in this investigation is fair and is based on the high theoretical capacity and electrical conductivity of mixed polyanion glasses. The investigators will combine structure and property modeling with cathode glass processing or characterization and electrochemical testing. The reviewer noted a concern about low conductivities and the reversibility of this system.

Reviewer 3:

This reviewer observed that project was investigating Li glasses as an alternative to crystalline materials.

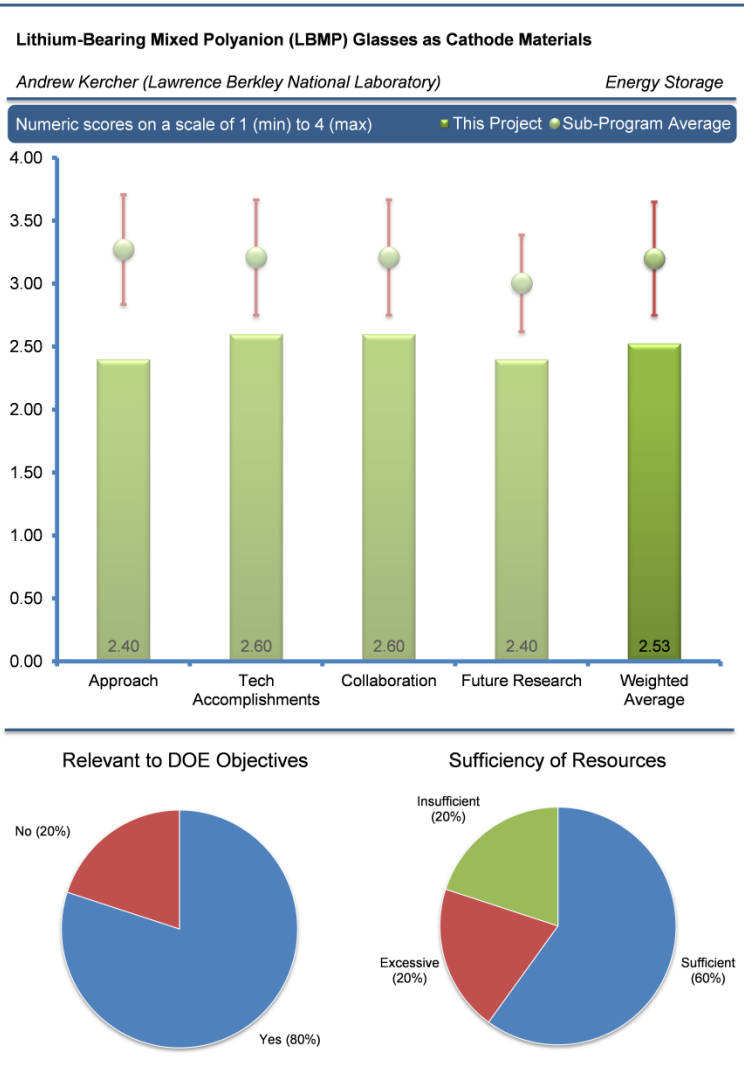
Reviewer 4:

The reviewer noted that even the most electronic conductive glassy active material with 10^{-6} S/cm will be masked by the much more conductive carbon (C) additive in the cathode. The reviewer then concluded that it was difficult to understand how the glassy phase will have improved performance over the crystalline phase. In addition, the reviewer was unsure if glassy materials will have more processing issues than crystalline materials.

Reviewer 5:

According to the reviewer, the work would benefit significantly with more collaboration on the electrochemistry. The reviewer added that the researchers need to make fair comparisons. The reviewer noted the example that LiFePO_4 is an interesting case where is a need to fairly compare the rate performance. Conventional LiFePO_4 has terrible conductivity, which is overcome by small (nano) particle size and carbon coating. The reviewer was unsure if the PI can do the same, and if so, does the glass have any advantage. The rate performance comparison may be a good example for a proof of concept. The reviewer expressed that the PI should ultimately be looking at higher energy density materials.

The reviewer also said that the researchers appear to lack some fundamental understanding of the baseline battery materials. In addition, there does not seem to be good knowledge of the electrochemistry happening in the materials being studied, where others could help with this lack of understanding.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed that good progress has been achieved to date. The investigators have demonstrated an improvement in the rate of performance and specific capacity of the mixed polyanion content. The reviewer added that the project team has also developed a computational model of the electrochemical performance of a polyanion glass.

Reviewer 2:

The reviewer stated that the substitution seems to be important for conductivity improvement, and that improving the conductivity is a major challenge.

Reviewer 3:

The reviewer reported prepared delithiated FePO_x glasses and investigated vanadium (V) substitution for phosphorous (P) demonstrating higher performance. This reviewer added that demonstrated mixed polyanion glass has higher performance than simple polyanion glass. The reviewer noted Computer Coupling of Phase Diagrams and Thermochemistry (CALPHAD) modeling to predict the performance.

Reviewer 4:

This reviewer affirmed that the project team had not done the sufficient work to validate the conductivity improvement and to demonstrate the charging in this feasibility phase.

Reviewer 5:

This reviewer remarked that the project results do not look very promising so far. The reviewer opined that the modeling should be emphasized to help improve the chances of success.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

According to the reviewer, good collaborations are occurring between the investigators and others who can assist the program. The reviewer added that discussions that are occurring between potential collaborators that are BATT program members, which include Vince Battaglia of LBNL, who may assist in the benchmark testing of the material in pouch cells.

Reviewer 2:

This reviewer stated that the collaboration was good.

Reviewer 3:

The reviewer noted that the collaborations were primarily planned.

Reviewer 4:

This reviewer is unsure if there is any evidence of collaboration outside ORNL so far. The project would benefit from LBNL participation.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked that the proposed future work is good and is based on the results achieved to date. This year, the investigators will pursue phosphate glasses of manganese (Mn), Cobalt (Co), and Nickel (Ni). The reviewer noted that these glasses promise to yield 30% greater specific energy densities than the lithium iron phosphate (LiFePO₄) system. The reviewer added that in FY 2014, the

investigators, guided by their model predictions, will explore borate and silicate glass systems. These materials have projected specific energies greater than 1000mWh/g.

Reviewer 2:

According to the reviewer, future work should focus on validating that the glassy phase has improved electronic conductivity. This will result in improved performance over crystalline phase in an electrode. The reviewer also mentioned that the volumetric energy density is a concern for these polyanion glassy phases due to the extensive diphosphorous septoxide (P_2O_7) and divanadium septoxide (V_2O_7) polyanions. In addition to pursuing polyanion materials with 30% higher specific Wh/kg energy than $LiFePO_4$, the project team should also aim for 30% higher Wh/L energy density.

Reviewer 3:

The reviewer observed that the researchers do not have many results to build from. The reviewer opined that the project team should prioritize their targets and determine what questions or data are needed to maximize the team's confidence that the prioritized approach is good, and then should only focus on answering those questions.

Reviewer 4:

This reviewer stated that the proposed future work is not clear. The reviewer was unsure the plan is to improve borate and silicate systems.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer stated that the project is very relevant and supports the overall DOE objective of petroleum displacement. The reviewer adds that it is vital that a high performance, high energy dense battery is developed for electric and hybrid vehicles.

Reviewer 2:

The reviewer commented that the project had new cathode materials with potentially lower degradation mechanisms.

Reviewer 3:

Up to this point, this reviewer is unsure if there is promise with this project.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer noted that the level of resources appear to be sufficient to successfully complete the tasks in a timely manner.

Reviewer 2:

The reviewer expressed a lack of confidence that milestones would be met in this project. The reviewer is also unsure if the solution is necessarily to add more resources or just re-structure the project.

Cell Fabrication Facility: Current Research Activities in Electrode and Cell Prototyping: Bryant Polzin (Argonne National Laboratory) - es185

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

According to the reviewer, the approach is good to be able to bring an advanced material to the facility and to have the engineers in the facility make the cells. However, the reviewer commented that it would be desirable to see the facility have much higher throughput in order to give the engineers and operators more experience.

Reviewer 2:

This reviewer pointed out that the program brings in critical capability for cell prototyping in the quest for higher energy density batteries. The reviewer added that the partnership strategy was effective.

Reviewer 3:

This reviewer opined that the yield, throughput, reproducibility and failure mode statistics should be tracked and reported for each build.

Reviewer 4:

The reviewer affirmed that the effort is an important piece within a larger scope that is well described. The reviewer added that it would be helpful to provide a more specific description of the role of this specific effort within the larger scope. It is possible that the AMR format does not accommodate the review of multiple components of a larger program very well. The reviewer went on to say that it would be worthwhile to perhaps have some thought as to the best way to allow complex, multiparty programs to be reviewed.

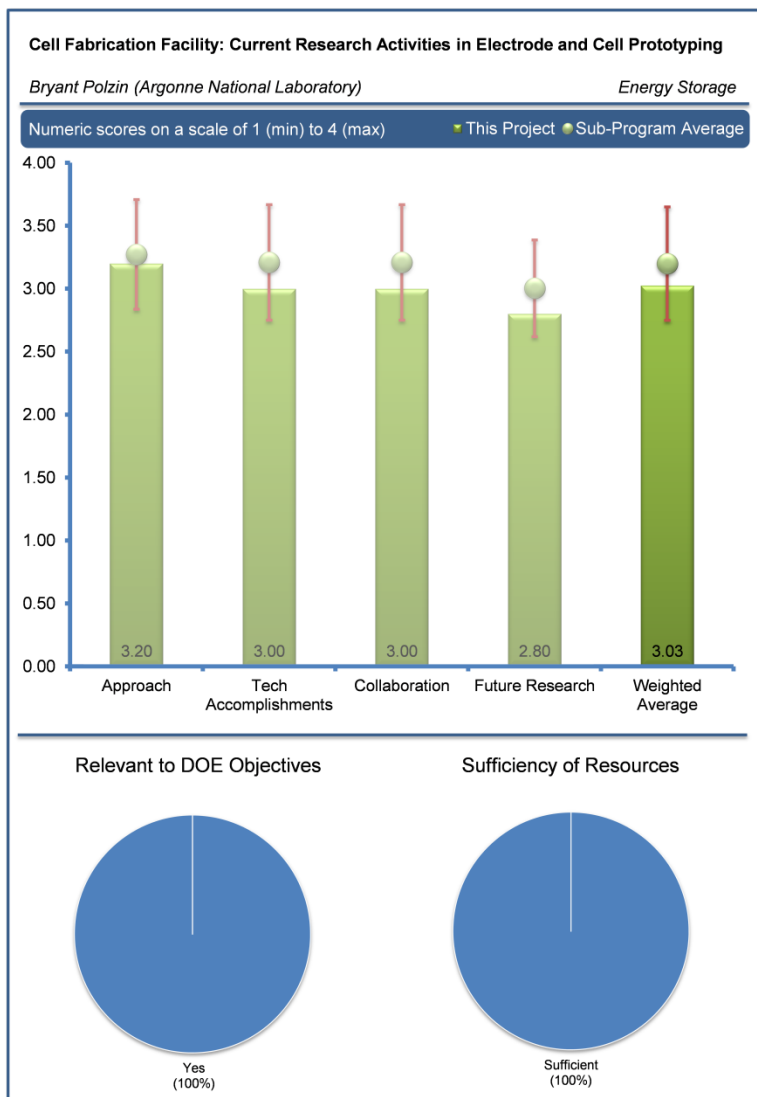
Reviewer 5:

The reviewer was unsure of the real difference between project ES185 and ES030. The reviewer continued that having cell making capability that is open to various R&D groups is valuable, but wondered how this works in practice. The reviewer inquired how this is different and/or better from the TIAX, LLC model that also has a fully functional line.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer noted the project's ability to prototype with less than 100grams (g) of developmental electrode is valuable.



Reviewer 2:

This reviewer said that the project did some good work on some very difficult topics. It could be helpful to provide a little more context for the individual accomplishment areas.

Reviewer 3:

According to the reviewer, the project team demonstrated ability to evaluate a wide breadth of electrode technologies.

Reviewer 4:

The reviewer opined that many more than nine cell builds should be done in a year's effort. The reviewer added that the capacities for the wound cells are quite low, where commercial capacities of 2.5 to 3.3 Ah and a 18650 cell size, are readily available. The group reports only 1.4 Ah for the test material. The reviewer states that it is somewhat more difficult to compare the pouch cell capacities. However, the project team should be trying to obtain better results for energy cells. The reviewer expressed the need to see more data at different rates as well.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that the project had a good collaborative team, at multiple levels.

Reviewer 2:

This reviewer indicated that the project seems to have the correct collaboration level.

Reviewer 3:

This reviewer commented that the collaboration is extensive, and that might be useful to have a partner, with more commercial knowledge, collaborate to indicate where the deficiencies are.

Reviewer 4:

The reviewer expressed a need to see more outside involvement and some goal for utilization that includes outside users.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

According to the reviewer, this program provides a very useful service within both the National Laboratory system, as well as in the commercial community. The intent of the future activities is quite appropriate. The reviewer went on to say that the key is to maintain a system of managing the choices made in relevant topics of interest. The reviewer affirmed that there are many competing ideas for the available time at this facility.

Reviewer 2:

The reviewer described that the capability would benefit from deeper awareness and skill in area of slurry mixing, rheology, dispersion uniformity and repeatability. The capability would benefit particularly pertaining to the ability to work with developmental anode materials and high voltage cathode materials that bring challenges to binders and conductive additives.

Reviewer 3:

This reviewer affirmed the continuation of existing plan, but perhaps to explore broadening utility and collaboration efforts would be useful.

Reviewer 4:

The reviewer expressed need to see a continuing review of the equipment used. For example, the winder seems very primitive, and to would be beneficial see where equipment should be upgraded.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer noted that this is much needed capability for DOE.

Reviewer 2:

The reviewer pointed out that as discussed elsewhere, there is a true need for a stable, yet flexible, demonstration platform to evaluate the benefits of new materials, etc., at the cell level. This is an important effort within the system, and the participants appear to be working very hard and providing a solid effort in the development of this platform.

Reviewer 3:

This reviewer remarked that it is important to developing new materials.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that resources are sufficient for the stated milestones, but noted a concern with regard to the duplication of capabilities and the ability to keep technology updated at multiple facilities. At this point, the project seems to be an operating budget rather than development program. The reviewer was unsure what gaps are being addressed.

Linking Electrochemical Performance with Microstructural Evolution in Lithium Battery: Dean Miller (Argonne National Laboratory) - es186

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer commented that very nice work was presented, in particular, the single particle electrochemistry. Additional work should probably be done with standard particle chemistry rather than only the high voltage ones.

Reviewer 2:

According to the reviewer, the project objective is to establish a correlation between electrochemical performance and the structural or morphological changes occurring in the battery active materials. Such fundamental understanding of the material changes is useful not only to understand but also mitigate the performance issues such as VF, hysteresis, and particle fracture upon cycling. The reviewer also noted that in this project, impressive in-situ techniques, such as the Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), and XAS, are being developed to study the single particle, single grain electrochemistry and characterization. In situ techniques are generally superior to ex situ studies, as they allow the monitoring of the material changes as they occur. The reviewer added that techniques are also more definitive without the issues of sample harvesting or preparation.

Reviewer 3:

This reviewer remarked that unlike other microscopy work, this work brings a certain sense of novelty by connecting local atomic structure with global electrochemical performance. The single particle work is also exemplary.

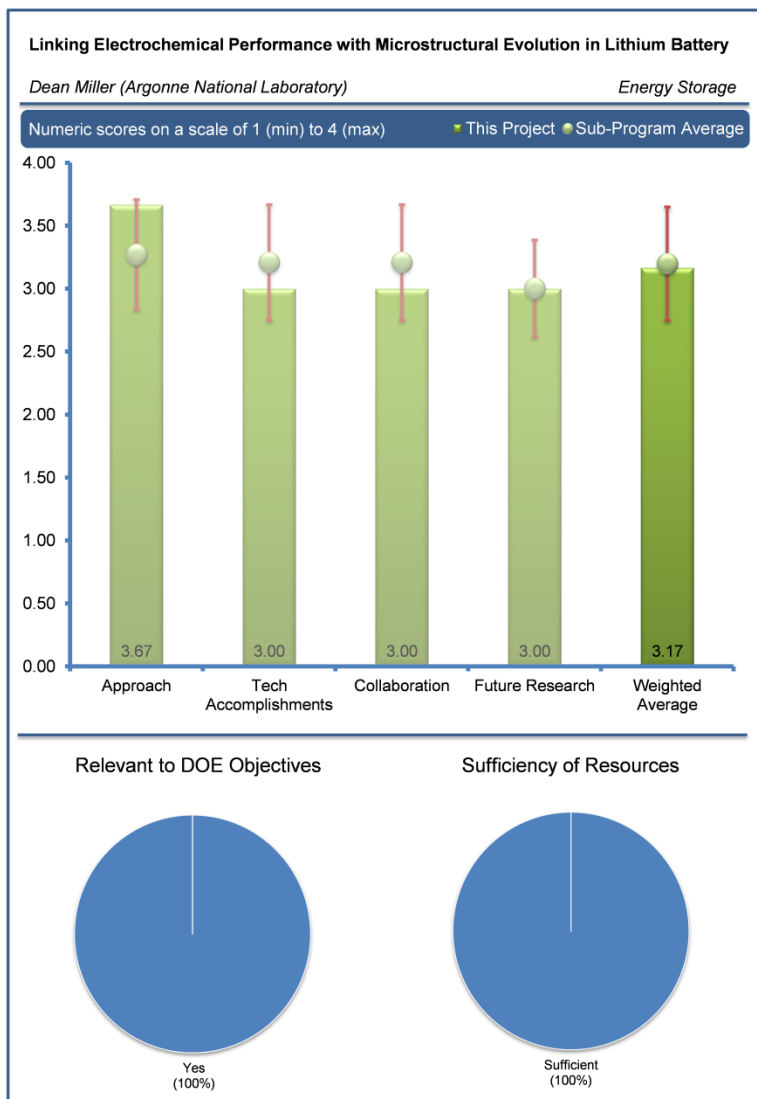
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer remarked that the progress is outstanding, considering the quality of the measurements and that the project only recently started.

Reviewer 2:

The reviewer expressed that good progress has been made in understanding the real-time material changes upon cycling, using the single particle electrochemical studies under SEM and in situ TEM. The reviewer points out that some of the interesting findings are



that there is considerable non-uniformity from particle to particle (TEM observations), and also that there is an evolution of microstructure in the cathode particle right from the start (cycling under SEM) that correlates well with the bulk performance. More interestingly, the single particle studies of the LMR-NMC cathode also show similar VF behavior as the bulk electrode, suggesting that this phenomenon is more fundamental and requires materials modification rather than engineering solutions. Overall, the reviewer said that these results are quite impressive.

Reviewer 3:

The reviewer pointed out that the PI has done a good job again in explaining the observed effect of VF in LMR-NMC chemistry, and correctly emphasized about the local inhomogeneity of the electrode. But, the reviewer added that the right question to ask is whether microscopy can provide any solution for mitigating of the VF rather than just characterizing it.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that there are good collaborations within ANL and with the VF team.

Reviewer 2:

This reviewer mentioned that the collaborations could be better. The reviewer added that maybe in the future, an industrial partner may develop after the interesting results are presented.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed that the type of in situ measurements, where a real particle is studied while the voltage is varied, is crucial. It could be of great interest to the real battery performance, including VF and cycle life. The reviewer added that the authors should consider the study of standard NCM powders too.

Reviewer 2:

According to the reviewer, the proposed future research is to continue similar single particle studies of the lithium-rich layered metal oxide composite cathode and correlate the structural evolution with the VF and hysteresis. Possibly working different ratios of the composite oxides, dilithium manganese trioxide (Li_2MnO_3) and NMC, will provide insight into the microstructural evolution upon cycling.

Reviewer 3:

This reviewer expressed that it would have been nice if the PI and project team had proposed to do similar work on doped or new LMR-NMC compositions to quantify with respect to base line HE 5050 chemistry. The reviewer added that it will probably be done as new compositions become available.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer expressed that the project is very relevant to the DOE objectives of petroleum displacement. What happens on a single particle, while the voltage is changed, can provide invaluable information to real battery cathodes.

Reviewer 2:

According to the reviewer, the project is relevant to the overall DOE goal of partly replacing the conventional vehicles with HEVs or EVs to minimize the national dependence on petroleum resources. The high cost of batteries for PHEVs is a serious impediment to a widespread of Li-ion batteries in vehicles. The reviewer added that high energy density materials are expected to provide increased range and reduced cost, thus enabling a widespread use of EVs and PHEVs. Lithium-rich layered cathode material is promising in this

direction, but is hampered by issues such as voltage and hysteresis. The reviewer affirmed that it is essential to have a fundamental understanding of these phenomena to mitigate these issues, as it is being addressed in the present project.

Reviewer 3:

This reviewer noted that the project's effort, although very indirect, is directed towards studying the materials aspects of high energy density chemistry.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer noted that additional resources should be considered, in particular if the authors manage to find an industrial partner interested in these types of studies.

Reviewer 2:

The reviewer commented that the resources are adequate for the scope of the project.

Reviewer 3:

This reviewer said that the resources were okay.

Solid State NMR Studies and Local Structure of Voltage Fade Materials: John Vaughey (Argonne National Laboratory) - es187

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the project has made very important progress for a project that only started a few months ago. The NMR studies are first rate.

Reviewer 2:

According to the reviewer, the objective of gaining a structure-based understanding of the VF behavior of LMR-NMC cathode materials, the approach being adopted in this project is to undertake a fundamental study to understand the structure factors (short-range and long-range) that contribute to the VF of Li-rich layered composite oxides, using solid-state ^6Li NMR. It was shown in the past that ^6Li NMR can be used to differentiate the local lithium environments (i.e., Li in the transition metal or in the Li plane). The reviewer added that this would be another useful technique to track the structural changes, together with the VF, in the LMR-NMC cathode upon activation (formation) or cycling. The reviewer also stated that the project is well designed to address the main technical barrier of the LMR-NMC cathode materials (its VF and hysteresis), and has good feasibility to provide the expected information on these cathode. Furthermore, the reviewer pointed out that this project is well integrated with the other projects on LMR-NMC cathode and will contribute to a good understanding of this phenomenon.

Reviewer 3:

The reviewer commented that the project has very good approach for studying the dynamics of the VF for LMR-NMC chemistry. But the reviewer is unsure how the approach helps towards discovering a new chemistry or cathode composition. The PI and team, no doubt, have a good fundamental understanding of the NMR method and their applicability to battery electrode materials.

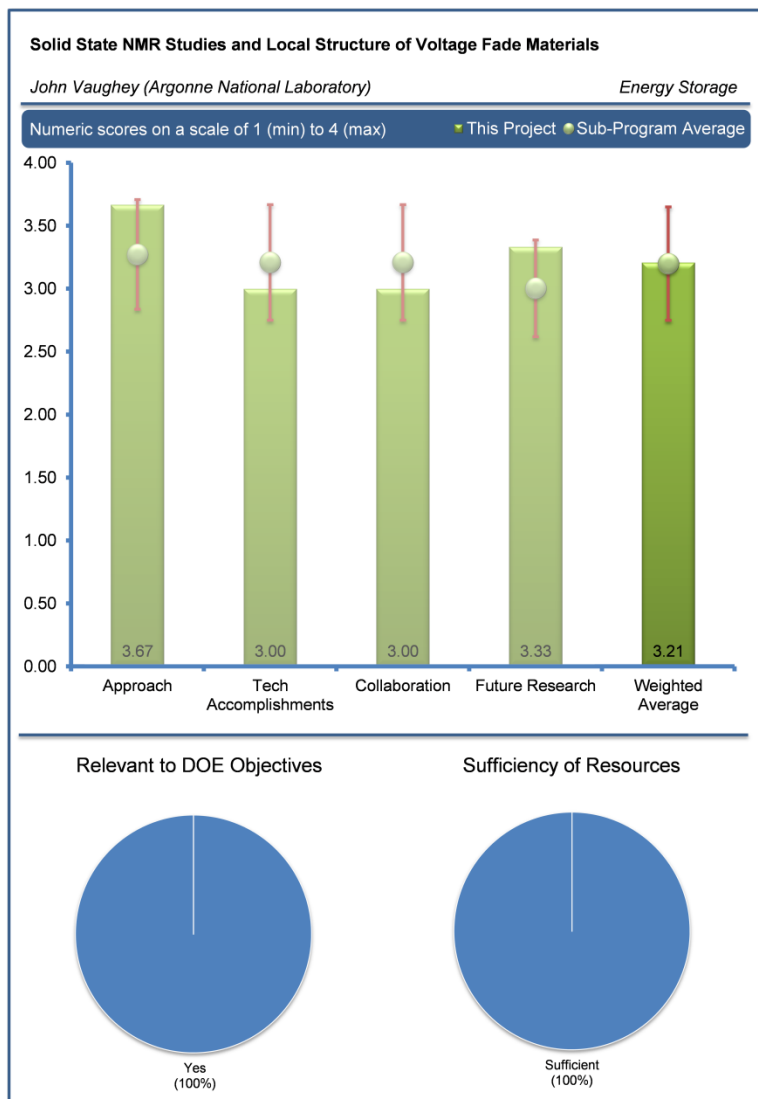
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer observed that the NMR studies were very important and nicely presented.

Reviewer 2:

The reviewer commented that after setting up the on-site solid-state NMR facility, good project progress has been made towards understanding the structural changes occurring in the LMR-NMC cathode upon activation and upon cycling. For example, it was



shown that there is a significant lithium-transition metal disordering observed for LMR-NMC upon charge-discharge cycling, which is synchronous to hysteresis and VF. The reviewer added that also, the first cycle electrochemical activity of disordered Li_2MnO_3 studied separately is real via Li removal/insertion, and the loss of ordering is similar to the Li_2MnO_3 component in VF composites (LMR-NMC). Finally, there is no proton insertion into the structure of Li_2MnO_3 (as may be expected from acid-leaching), only surface deposition. The reviewer went on to say that these findings, though preliminary in some cases, are significant, suggesting that the solid-state ^6Li NMR technique could be used to track the disorder of LMR-NMC cathodes, which seems to correlate well with the VF (and may be hysteresis as well).

Reviewer 3:

According to the reviewer, the project had a good and in-depth study. The reviewer expresses the need for the agreement between the NMR results and neutron pair distribution function (PDF) study for cycled LMR-NMC electrodes. The reviewer added that this is nontrivial since comparisons are not easy. The PDF analysis is based on modeling and needs to be fully understood before interpreting those results. The reviewer remarked that the PI has a detailed guideline (Slide 18) as to how and what the project team will compare from both the results and the study. The reviewer expressed the need that for both studies, the cells are going to be cycled under identical conditions (VF protocol).

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that the PI had a relevant set of researchers from other National Laboratories to collaborate with.

Reviewer 2:

The reviewer said that there are collaborators from ANL's VF team.

Reviewer 3:

This reviewer mentioned that at some point, the authors should be able to find an industrial partner.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer stated that the future research focused on additional analytical measurements seems very appropriate.

Reviewer 2:

The reviewer remarked that hopefully combining NMR and Neutron PDF will yield more information, and encouraged the PI to include work on the doped LMR-NMC composition available thus far. The reviewer provided as an example studying magnesium (Mg) and ruthenium (Ru) to see if any prevent Transition Metal (TM) migration or other results.

Reviewer 3:

According to the reviewer, future plans are to continue the Nuclear Magnetic Resonance (NMR) studies with the fully enriched cell, ^6Li enriched cathodes, and the $^6\text{LiPF}_6$ electrolyte to understand quantitatively as a function of state of charge. Plans are also to continue to combine the quantitative NMR studies with electron paramagnetic resonance (EPR) and Neutron Diffraction data for a better understanding of the lithium-transition metal ordering. The reviewer added that all these studies are aimed to obtain further understanding of the VF of LMR-NMC cathodes.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the DOE objectives are clearly supported in this project. The analytical measurements are giving invaluable information that can help resolve the VF issue.

Reviewer 2:

This reviewer said that yes, the project meets the DOE objectives.

Reviewer 3:

The reviewer stated that for a successful utilization of Li-ion batteries in EVs, it is essential to enhance their gravimetric and volumetric energy densities, beyond what can be provided by the current technologies. High voltage high capacity cathodes in the class of lithium and manganese rich NMC (LMR-NMR) cathode materials, $x\text{Li}_2\text{MnO}_3 \cdot (1-x)$ lithium M dioxide (LiMO_2) where M equals Nickle (Ni), manganese (Mn), or cobalt (Co), are quite promising for high specific energies. The reviewer said that, however, these materials exhibit VF upon cycling and voltage hysteresis from charge and discharge. To mitigate these effects, it is important to have a good understanding of these phenomena in terms of the complex electrochemical, where structural relationships of these materials.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer stated that the resources of \$120,000 is adequate for the project to achieve the milestones in a timely manner.

Reviewer 2:

This reviewer said that resources are okay.

Reviewer 3:

According to the reviewer, the resources seem to be sufficient. However, if the authors manage to find an industrial partner, and also give additional insight onto the voltage fade mechanism, they should ask for additional resources.

Electrochemical Characterization of Voltage Fade in LMR-NMC cells: Daniel Abraham (Argonne National Laboratory) - es188

Reviewer Sample Size

A total of 3 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

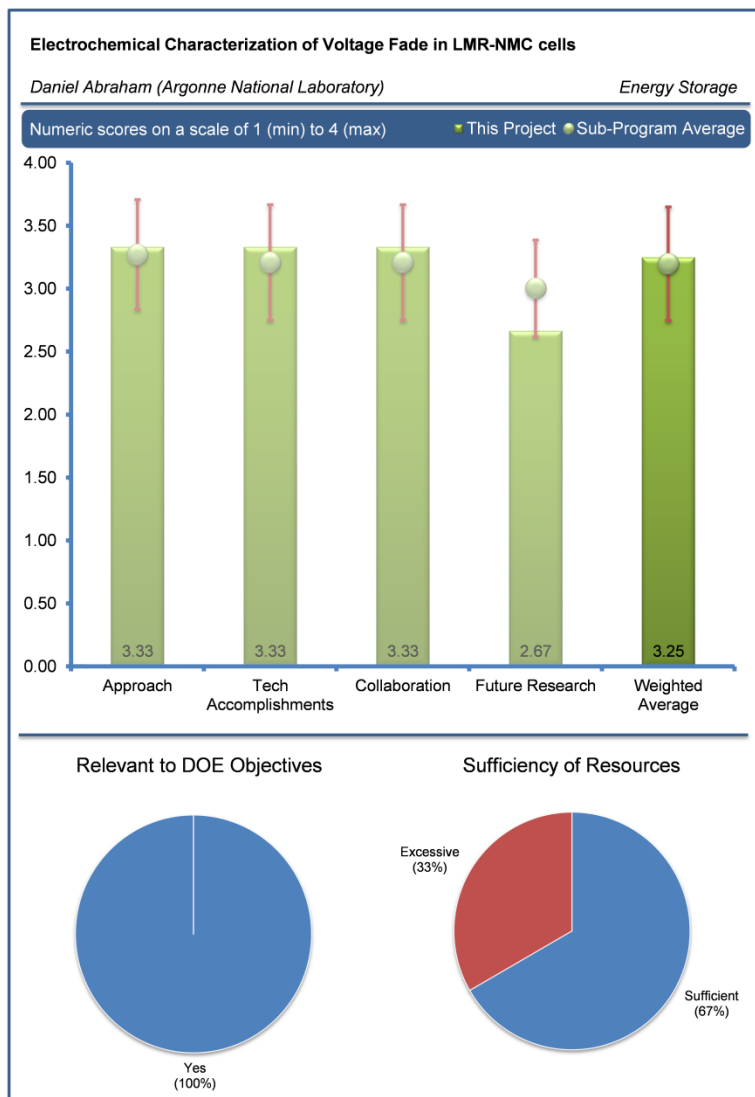
The reviewer stated that the PI and project team have presented a very concise presentation capturing all elements of VF in LMR-NMC. Quantifying or benchmarking the electrochemical performance of LMR-NMC is very important for solving this issue. The reviewer also noted that the project's goal is to use this approach for any new chemistry that has the potential for minimizing or eliminating the VF.

Reviewer 2:

This reviewer noted that the electrochemical characterization, a powerful tool, is used in this research to evaluate diagnosis and compare cathode materials that are interested.

Reviewer 3:

This reviewer observed that the approach is a subset of a compendium of investigations. It focusses on the definition of baseline and its characterization.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer opined that the presentation is a noticeably very clear poster presentation, which delivered the message with key bullet points and which also had placeholders for pointing work of other PI's on the VF team. The experimental results were arranged with clear conclusion and facts. The reviewer expressed a need for the synthesis PI's come up with a new composition for Daniel and his colleagues, and apply these diagnostics to show that there is voltage (or capacity) fade, or not. The reviewer expressed that the latter being the good news. The reviewer also pointed out that another noteworthy aspect that is the new or modified positive electrode composition that minimizes the resistance. This effort should be followed wide across the PI's.

Reviewer 2:

According to the reviewer, some interesting research work has been accomplished. The project demonstrated that VF is unaffected by changes in electrode constitution (oxide, carbon, binder ratios) and electrolyte additives. The reviewer added that the VF was also shown to not depend on electrode kinetics. The reviewer was unsure if the resistance-corrected voltage is accurate, considering the relaxation for the interruption technique employed.

Reviewer 3:

This reviewer noted that the project met the objectives of this test, but did not remove any barriers. The goal is to better understand the VF problem, in terms of bulk characteristics.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer indicated that the PI could deliver such nice results because of having all the key experts doing their job with a clear goal. This project's collaboration should be encouraged.

Reviewer 2:

This reviewer commented that the research team appears to have had good ongoing collaborations with other members of overall VF project.

Reviewer 3:

The reviewer stated that the project is predominantly an ANL effort, with recent expansion to National Laboratories along with some involvement with materials suppliers.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

According to the reviewer, future plans were to continue the electrochemical cauterization of the cathode materials with different composition and test conditions. Efforts also include coordination of other researchers' activities. The reviewer observed the plan seems to be sound, but recommended the team adopt an impedance spectroscopy study to gain more information.

Reviewer 2:

This reviewer said the project plan is good, but this project element does not intend to overcome barriers.

Reviewer 3:

The reviewer was unsure of what is the next step. As the reviewer previously mentioned, the PI should extend this work on other 5V systems as well, while also keep testing on new LMR-NMC composition, with dopants, that comes out of ANL and elsewhere.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said that yes, this task is aimed at high energy density batteries for automotive application.

Reviewer 2:

The reviewer stated that the project involves understanding VF in LMR-NMC. This is a material of appreciable interest in the goal of reaching the EV cell goals. The reviewer added that it should be noted that other cathode materials exist also with also promising potential performance.

Reviewer 3:

According to the reviewer, conducting electrochemical characterization of high capacity LMR-NMC cathode VF will help the development of advanced batteries, and this study is aligned with DOE objectives to reduce dependence on petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer remarked that the PI and project team has everything at their disposal to meet the goals and milestones.

Reviewer 2:

The reviewer observed that funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 3:

The reviewer noted that resources are consistent with what a very large private firm would employ, but could be considered moderately excessive when compared to lean private organizations.

Examining Hysteresis in Lithium- and Manganese-Rich Composite Cathode Materials: Kevin Gallagher (Argonne National Laboratory) - es189

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

According to the reviewer, the work presents a comprehensive and well developed approach that includes an excellent balance between fundamental electrochemical evaluation and analytical characterization. This approach has provided a good foundation for continued success of the project.

Reviewer 2:

The reviewer remarked that the work is based on projecting various performance targets of LMR-NMC using BatPac analysis. The work is very relevant towards addressing barriers associated with LMR-NMC cathode chemistry developed at ANL.

Reviewer 3:

This reviewer noted the project has a solid organization and generation of hypotheses.

Reviewer 4:

This reviewer stated that the hysteresis examination was part of a multi-institution effort to identify factors that contribute to VF in lithium- and manganese-rich NMC oxides.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

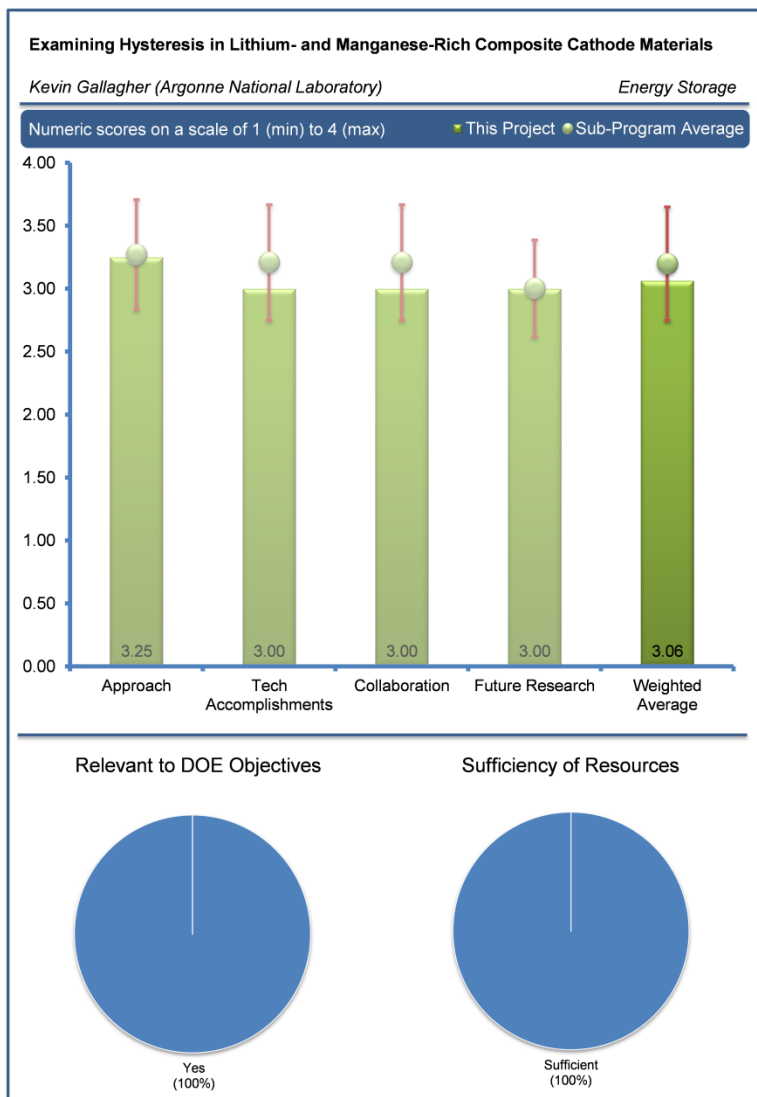
This reviewer noted that the project's milestone achievement is tracking according to the PI's plan.

Reviewer 2:

This reviewer commented that the hysteresis has been well characterized and linked to VF. Testable hypotheses have been created.

Reviewer 3:

The reviewer said that the team has measured hysteresis and correlated it to VF. The hysteresis was correlated to Mn migration. The reviewer added that the temperature impact on hysteresis is unknown and hopefully can be included in the future plan.



Reviewer 4:

The reviewer noted the project's relevant analysis of decoupling capacity verses voltage effects and the cost. This reviewer also observed various performance targets.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer said that the research team appears to have had good ongoing collaborations with other members of the overall VF project.

Reviewer 2:

This reviewer noted that the coordination is mostly internal, although material has been made public.

Reviewer 3:

According to the reviewer, the collaboration inside ANL is good, but could better leverage expertise and capabilities at other institutions. The reviewer was unsure if relevant, but the consultation with Sethuraman and Srinivasan at LBNL on the topic of hysteresis may yield some useful synergies (this may be proposed on Slide 19).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer noted that other groups will be the benefactors of this project. The goals for this project may, on its own, be overly ambitious.

Reviewer 2:

The reviewer stated that future plans were to continue the study hysteresis of VF mechanism and initiate open current voltage (OCV) numerical model for LMR-NMC.

Reviewer 3:

The reviewer said that the future work describes what is planned, but timeline should be carefully managed if completion is expected by September of 2013.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer remarked that a cathode with a stable high energy density is critical for BEV applications. LMR-NMC is perhaps the best candidate at the present time, and should be aggressively studied to improve this VF issue.

Reviewer 2:

According to the reviewer, the project is conducting hysteresis study, which is part of the efforts to reduce VF of the LMR-NMC cathode, which would also enable it for use in advanced batteries. This study is relevant to the DOE objectives to reduce dependence on petroleum.

Reviewer 3:

This reviewer noted that project is in the context of comprehending hysteresis and VF so that LMR-NMC can be made into a material sufficiently robust to be considered for EV applications.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the resources appear to be managed effectively across all aspects of the project, including the diagnostics and modeling team.

Reviewer 2:

The reviewer stated that the funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 3:

This reviewer noted that resources are potentially excessive when compared to private sector initiatives.

Arresting VF: Theory-Guided Synthetic Approaches to Cathodes: Christopher Johnson (Argonne National Laboratory) - es190

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that this was a presentation where the reviewer really saw how the PI's effort is tied into the overall goal of the VF team. This reviewer added that this effort is extraordinary and should be normal for other PI's presentations as well (Slides 6 and 7). Theory guided synthesis should be always undertaken rather than random intuitive efforts.

Reviewer 2:

The reviewer commented that the approach nicely compliments the other projects within the VF team, and is logical and well developed. The connection between theoretical and experimental aspects of the work is nicely demonstrated, specifically the work on the effect of alternative metals. The reviewer added that the effort is comprehensive, and the project team is not taking short cuts and doing a nice job.

Reviewer 3:

The reviewer noted that the approach was innovative and appeared to have good potential to reduce or eliminate VF.

Reviewer 4:

According to the reviewer, the project plan is solid, but as this is a synthesis exercise, the team should consider additional support from academia and industry, specifically those engaged in this material type of work.

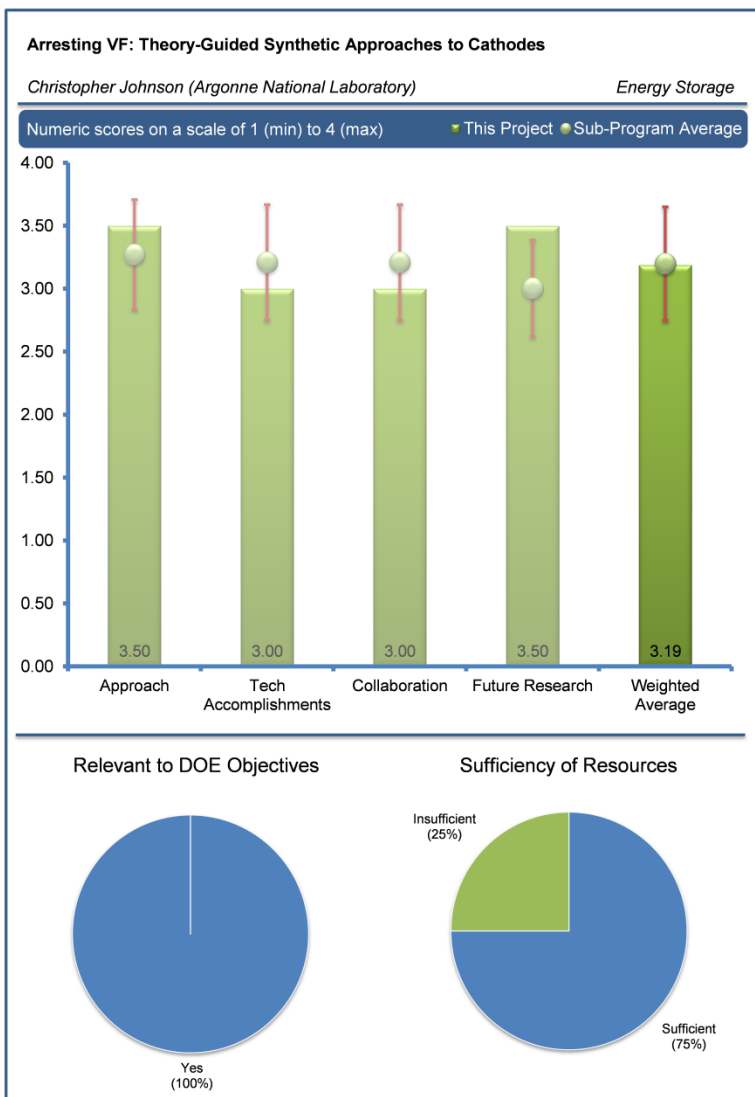
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer noted that the materials approach is pretty solid although the project team still sees VF with the Ru substitution. To see that titanium (Ti) can suppress ozone (O_2) evolution from Li_2MnO_3 structure was encouraging.

Reviewer 2:

According to the reviewer, the output for this portion of the project exceeded expectations, and will positively impact DOE's goals and objectives. While the mechanism for VF has not been conclusively identified, the team has methodically addressed their project plan, and is making good progress on FY 2013 milestones. The reviewer went on to say that the exploration of different synthesis



routes, and the conclusion that all routes exhibit similar characteristics, is an important data point. This exploration sets the stage for productive experimentation in the coming months.

Reviewer 3:

This reviewer noted that much progress has been made in a methodical manner. Progress has been slow, given the magnitude of synthesis and characterization work required.

Reviewer 4:

The reviewer observed that the link between synthesis on LMR-NMC and theory (or modeling) was evaluated. Multiple synthesis routes to VF was evaluated and the investigation is promising. The reviewer added that the investigation of the temperature impact on VF of the new materials may be included in a future study.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the research team appears to have had good ongoing collaborations with other members of the overall VF project.

Reviewer 2:

This reviewer said that the project team is good.

Reviewer 3:

This reviewer noted that the collaboration with existing partners is good, but further assistance is recommended.

Reviewer 4:

The reviewer stated that the project team should continue to develop and leverage analytical collaborations within ANL and outside, for example, Michigan Technological University (MTU). The shutdown period may be a good time to initiate and accelerate these collaboration activities.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer was pleased to see the emphasis on iterating with the other groups. The future work is logical and the appropriate extension of past activities and conclusions.

Reviewer 2:

The reviewer noted that future plans, which seem to be sound, were to conduct more synthesis, characterization with advanced analytic techniques, and cell testing.

Reviewer 3:

This reviewer expressed that it would be positive to see what results the PI team can get for chromium (Cr) and molybdenum (Mo) substitution in some of the LMR-NMC compositions. The effect of Co, or no Co, should be studied since Co helps to maintain the layering.

Reviewer 4:

This reviewer remarked that tasks need to be completed, for insufficient progress has been made in VF resolution and to alter the current path.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer observed that in the context of the project, the material studied is one of the optimal materials to meet the EV cell goals.

Reviewer 2:

According to the reviewer, the research of the LMR-NMC cathode VF will help the development of advanced batteries. The research is also aligned with DOE objectives to reduce dependence on petroleum.

Reviewer 3:

This reviewer noted that the R&D effort is directed towards the batteries for the automotive application.

Reviewer 4:

The reviewer commented that a cathode with a stable high energy density is critical for BEV applications. LMR-NMC is perhaps the best candidate at the present time, and should be aggressively studied to improve this project's VF issue.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer said that there is excellent coordination with other teams and to keep up the good work.

Reviewer 2:

This reviewer stated that the funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 3:

This reviewer noted that the resources are quite adequate.

Reviewer 4:

The reviewer expressed that additional resources should be canvassed from industry and academia. Much work is under way regarding of LMR-NMC variants. The reviewer added that the project work would benefit from collaboration with such LMR-NMC synthesis efforts.

Impact of Surface Coatings on LMR-NMC Materials: Evaluation and Downselect: Ali Abouimrane (Argonne National Laboratory) - es191

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

According to the reviewer, the technical approach is appropriate to test the hypothesis, the potential influence of surface modifications on VF, particularly in a high voltage system where interfacial conditions are likely very important. Furthermore, the project team has pursued a nice variety of surface modifications, ALD at particle and electrode level, aluminum phosphorus quadoxide (AlPO_4), and aluminum trifluorine (AlF_3), and evaluated their impact in a consistent and technically valid manner. The reviewer added that the team may have explored a broader set of electrolyte additives. Overall, the project is well designed and managed.

Reviewer 2:

This reviewer remarked that the approach is clearly a good effort towards studying the effect on various ALD based coating in the LMR-NMC composition.

Reviewer 3:

The reviewer stated that the approach was trying to reduce VF through coating and using electrolyte additives. The reviewer noted that the approach was interesting.

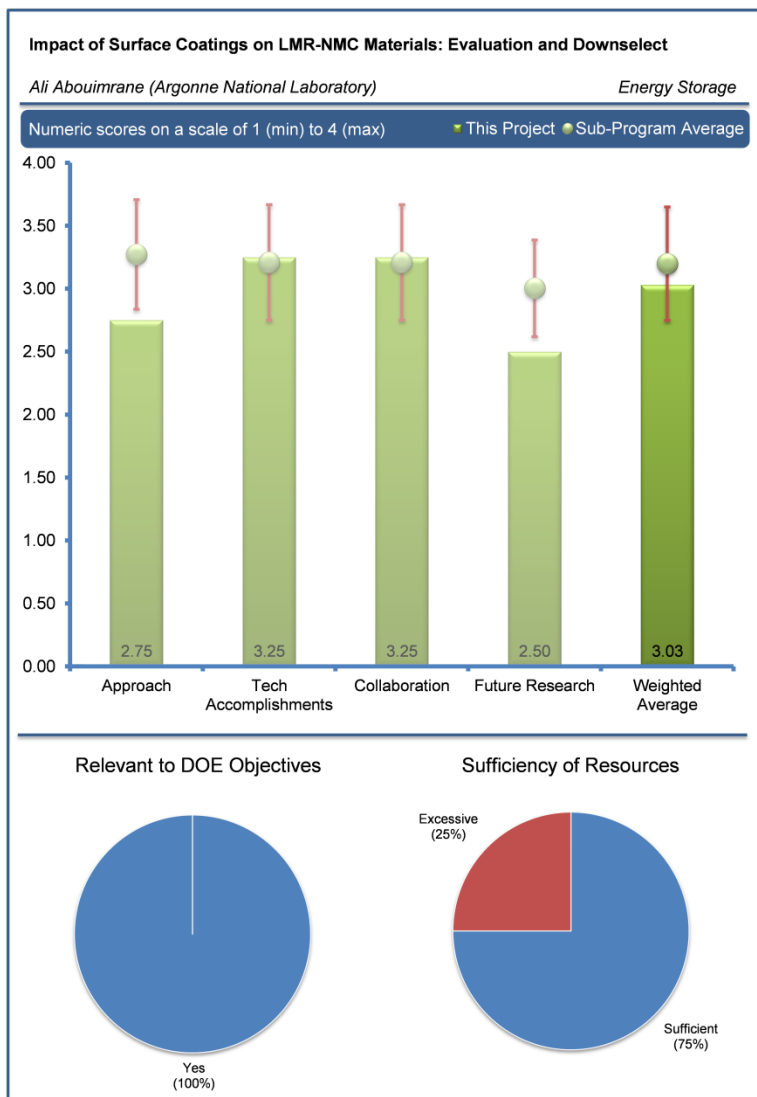
Reviewer 4:

This reviewer said that the project's theory was weak in that it assumed similar causes regarding impedance growth, as seen in other materials.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the project team has successfully completed all relevant milestones in a relatively short amount of time. While not successful in solving the issue of VF relative to clear performance indicators, the team has evaluated a very plausible concept in a comprehensive fashion.



Reviewer 2:

This reviewer stated that the project clearly demonstrates that the coating does not solve the VF issue but can improve the stability with respect to high voltage cycling.

Reviewer 3:

This reviewer noted that it was determined that VF is not a surface chemistry phenomenon.

Reviewer 4:

According to the reviewer, the LMR-NMC surface modification with the coating and electrolyte additive seems that it could not fix the VF problems, although the coating helped to keep the capacity and did not increase resistance. That appears to link the VF to bulk structure (or properties) change.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer observed that the PI clearly had a good collaboration and working relationship with host of relevant organizations.

Reviewer 2:

The reviewer stated that the research team appears to have had good ongoing collaborations with other members of the overall VF project.

Reviewer 3:

This reviewer noted that the project team has broad collaboration within ANL, but not outside.

Reviewer 4:

This reviewer said that the collaboration appears to have been limited to ANL. Some consultation with external groups may have been beneficial.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

According to the reviewer, the project team's conclusion to stop surface modification efforts makes sense in light of the observed results of this study. The recommendation to focus on composition is consistent with several other projects from ANL. The reviewer added that there may be room to explore more electrolyte additives, although this may be addressed by other groups unknown to the reviewer.

Reviewer 2:

The reviewer stated that the future plans were to conduct more synthesis Ni (or Mn) and cobalt free LMR-NMC as well as substitute, Mn with Mg or chromium (Cr). The reviewer added that the plan seems to be sound.

Reviewer 3:

This reviewer noted that additional research will not likely impact the outcome of the study.

Reviewer 4:

This reviewer expressed a need for more explanation about next year's work. The proposed work seems to overlap with other PI's at Argonne, for example, doping of LMR-NMC with Mg or Cr.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

According to the reviewer, the development of high energy density cathode materials is essential to enable the next generation of Li-ion batteries. This work is directly aligned with these efforts, and supports the DOE's objectives of petroleum displacement.

Reviewer 2:

This reviewer affirmed in the context that the material studied is one of the optimal materials to meet the EV cell goals.

Reviewer 3:

The reviewer stated that the research of LMR-NMC cathode VF will help the development of advanced batteries, and that it is aligned with DOE's objectives to reduce dependence on petroleum.

Reviewer 4:

This reviewer commented that yes, the project work is in the area of batteries for transportation.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that the funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 2:

This reviewer noted that resourcing appears adequate.

Reviewer 3:

This reviewer expressed that the resources are okay.

Reviewer 4:

The reviewer opined that this particular project should be closed, and if deemed reasonable, the balance of tasks should be merged with other associated projects.

Thermodynamic Investigations of Lithium- and Manganese-Rich Transition Metal Oxides: Wenquan Lu (Argonne National Laboratory) - es192

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the approach has excellent structure to fundamentally characterize material thermodynamic behavior.

Reviewer 2:

According to the reviewer, the PI nicely connects fundamental aspects of entropy with electrochemical measurements, providing unique insight into the structural evolution of the LMR-NMC under high-voltage cycling conditions. The project is well designed, with a systematic approach to evaluating the electrochemical characteristics as a function of temperature and state of charge, and to yield the entropy as a function of state of charge. The reviewer said that furthermore, the effect of formation and cycling cut-off voltages is well presented and should provide useful information to other teams. Finally, the microcalorimetry study nicely compliments the other aspects of the project. The reviewer expressed that the PI did a nice job.

Reviewer 3:

This reviewer observed that the PI has a novel approach of measuring the entropy changes at the materials level in the form of disorder, and correlating this with observation at the cell level.

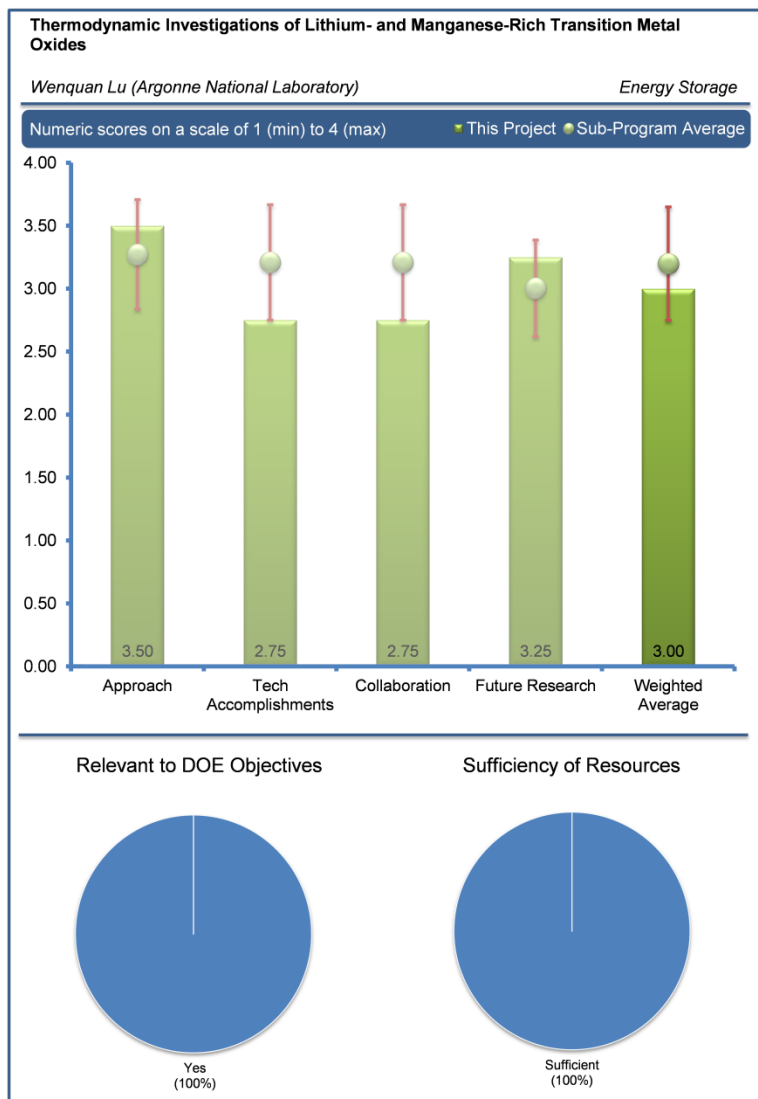
Reviewer 4:

The reviewer stated that the thermodynamic study of LMR-NMC was an interesting approach, and it may be helpful to understand the root cause of VF.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

According to the reviewer, the project team is making excellent progress on milestones, and has made valuable observations on the thermodynamic aspects and the impact of different cycling conditions on VF. The assessment of milestone completion is accurate, and the team is extending their work, where appropriate, to more fully understand the problem at hand.



Reviewer 2:

This reviewer pointed out that the project's analysis is generating a comprehensive understanding of how the role of each material structural element plays in its operation, and thereby leads to those features that are engaged with the VF phenomenon.

Reviewer 3:

The reviewer stated that the research revealed that the VF is affected by both formation and cycling cut-off voltages. It is suggested the impact of formation and cycling cut-off on VF at different temperatures can be included in the future study.

Reviewer 4:

This reviewer observed the project as a very in-depth study. The reviewer is unsure if the PI can correlate the entropy change measured indirectly from electrochemical & thermal measurement in terms of lithiation and delithiation with NMR and microscopy counterparts. The measured change can be useful since entropy should increase as there are more movements of TM and Li during high voltage cycling.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

According to the reviewer, the research team appears to have had good ongoing collaborations with other members of the overall VF project.

Reviewer 2:

This reviewer remarked that the project team is good, although additional assistance from external sources would be beneficial.

Reviewer 3:

The reviewer observed that limited collaboration is apparent for groups outside of ANL. However, it appeared that the internal scientists are more than competent to perform the work.

Reviewer 4:

This reviewer noted that collaborations are not listed.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer remarked that the analysis is solid and iterative, particularly if (or when) coupled with findings from associated work groups.

Reviewer 2:

This reviewer commented that the project's future plan seems to be a sound plan. The reviewer added that the entropy change investigation will be helpful to lead to the better understanding of the root cause of VF.

Reviewer 3:

According to the reviewer, the proposed future work is appropriate, and it incorporates current technical progress into a clear set of extended efforts, entropy and microcalorimetry, along with new techniques such as Electrochemical Impedance Spectroscopy (EIS).

Reviewer 4:

This reviewer mentioned that microcalorimetry studies should be continued for all new compositions, coatings and electrolytes.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the research of the LMR-NMC cathode VF will help the development of advanced batteries, and it is aligned with DOE's objectives to reduce dependence on petroleum.

Reviewer 2:

This reviewer observed that in the context of the project, the material studied is one of the optimal materials to meet the EV cell performance goals.

Reviewer 3:

The reviewer observed that program supports DOE's objectives of petroleum displacement by developing a high energy density cathode material that will significantly advance the next generation of Li-ion batteries appropriate for EV applications.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the project team is resourced appropriately to complete the planned work.

Reviewer 2:

According to the reviewer, funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 3:

This reviewer noted that the resources are okay.

Reviewer 4:

The reviewer encouraged the synthesis of this information into associated groups, as part of routine analysis.

First-Principles Models of the Atomic Order and Properties of LMR-NMC Materials: Roy Benedek (Argonne National Laboratory) - es193

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer expressed that the approach was innovative to be able to understand the VF mechanism using first-principle modeling, and would help to lead to directions for materials synthesis.

Reviewer 2:

The reviewer stated that sound scientific principles are applied in a rigorous analytical manner.

Reviewer 3:

According to the reviewer, the project team is pursuing a theoretical approach to better understand the VF issue of LMR-NMC. The project is feasible and appropriate; however, the objective is somewhat open ended and the connection of the milestones with the broader objectives of the VF team could be clarified. The scope of calculations, number of configurations and number of atoms within the simulations, could be expanded to improve confidence in the conclusions. Furthermore, the reviewer added that including experimentally motivated imperfections may be illuminating.

Reviewer 4:

This reviewer pointed out that the theoretical modeling to determine stable dopants and/or estimating the interaction or activation energy to transition metals, Mn and Ni, in different environments is critical for understanding of the VF issue. The first principle approach is an idea for this.

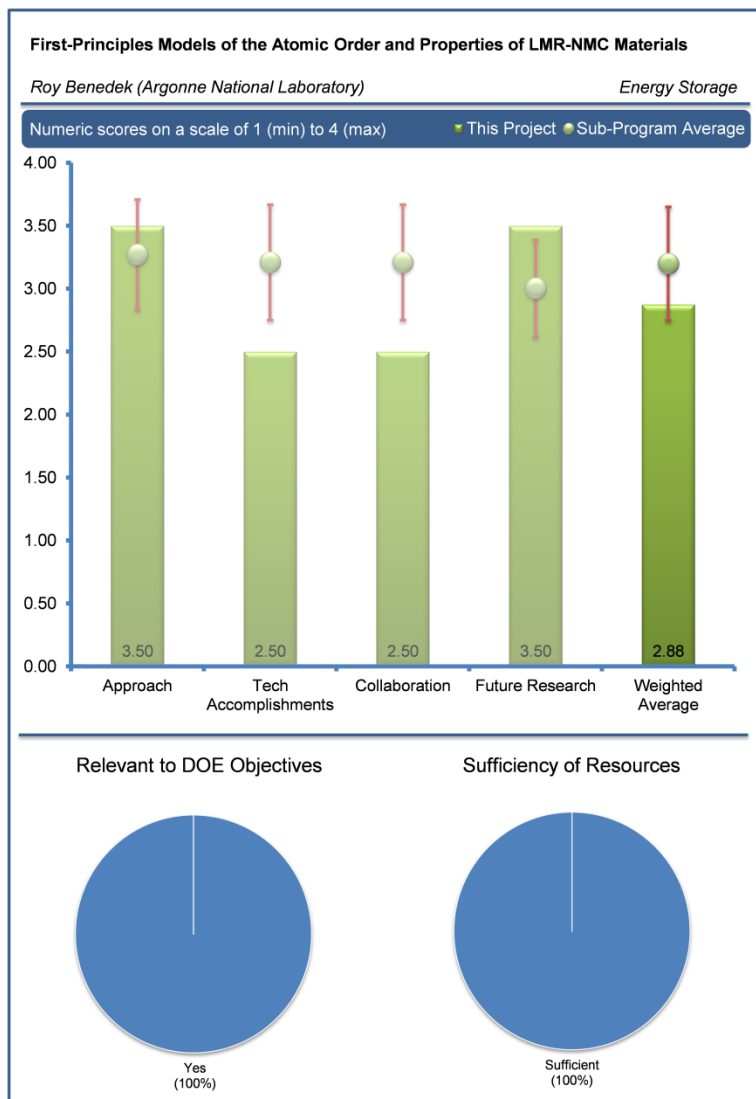
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the first principles methods were successfully used to understand the atomic scale structure and voltage fade mechanism. It was a direct support to possible VF free LMR-NMC synthesis efforts.

Reviewer 2:

The reviewer commented solid analysis using first principles, and forms the grounds for the generation of a synergistic hypothesis with some associated projects.



Reviewer 3:

The reviewer remarked that the project team has calculated the properties of a reasonable number of atomic configurations for LMR-NMC. In some cases, it is not clear if the noted technical accomplishments were achieved or if they still remain as open questions, which may be related to presentation style. Within the perspective of this particular project, the progress relative to milestones has been good. The reviewer added that, as mentioned above, the milestones are definitely aligned with the rest of the VF project, but this association should be clarified for future meetings.

Reviewer 4:

According to the reviewer, the PI has demonstrated certain feasibility studies where different atoms such as first row and second row elements, Ti, Cr, V, Mo and Ru, could substitute the Mn atom to stabilize the phase. But, recent experimental results with Ru and Fe both show negative results as far as VF. The reviewer added that the modeling predictions clearly need to be more robust to narrow down to a few elements.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer observed that the research team appears to have had good ongoing collaborations with other members of the overall VF project.

Reviewer 2:

This reviewer noted that authors are collaborating with Chris Wolverton's group at Northwestern University, which adds value to the work in terms of availability of Density Functional Theory (DFT) codes and other information.

Reviewer 3:

According to the reviewer, the simulation work has generated a series of recommendations related to the substitutions for Mn. These recommendations should be explored with the support of the synthesis team; however, the presenter indicated some resistance to this support. The reviewer expressed a need to propose that higher level program management revisit the deliverables and proposals of this project, and also to promote the program management's exploration in the synthesis team.

Reviewer 4:

This reviewer noted that the collaboration is predominantly an internal effort. This project is at the point where collaboration with associated teams should occur.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future plan seems to be a good. The further theoretical study has the potential to lead to the better understanding of the root cause of VF.

Reviewer 2:

The reviewer noted that related to the comments above, the proposed compositional modifications should be addressed by the synthesis group. Furthermore, the correlation between the modeling results and analytical results will be an important validation point and is nicely addressed by the PI.

Reviewer 3:

This reviewer said that the next steps would validate or invalidate some of the predominant hypotheses for the source of VF.

Reviewer 4:

This reviewer expressed a need to anxiously look forward to what authors have promised in Slides 10 and 12, to know if certain substitution atoms such as Mo or Cr will form Li_2MnO_3 - LiMO_2 phase, and if there are certain pathways to maximize the Mn-Ni interaction to prevent Mn atom migration.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said that the work is very relevant for narrowing down to a few compositions to mitigate VF.

Reviewer 2:

This reviewer observed that in the context of the project, the material studied is one of the optimal materials to achieve the EV cell performance goals.

Reviewer 3:

According to the reviewer, both the experimental and theoretical methods will be necessary to solve the problem of VF in LMR-NMC. This work contributes to the development of this promising cathode material, which will enable the next generation of high energy density Li-ion batteries.

Reviewer 4:

The reviewer stated that the theoretical research on LMR-NMC cathode VF will help the development of advanced batteries, and it is align with DOE's objectives to reduce dependence on petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer said yes to the resources.

Reviewer 2:

The reviewer stated that the funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 3:

The reviewer noted that further collaboration with associated project teams is encouraged.

Reviewer 4:

This reviewer had no comments, other than to get support for synthesis efforts from other ANL teams.

Addressing Voltage Fade: Synthesis and Characterization of Lithium- and Manganese-Rich Electrode Structures: Michael Thackeray (Argonne National Laboratory) - es194

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

According to the reviewer, the technical approach is logical, nicely described in the presentation, and exhibits novelty while remaining realistic and logical. While the VF issue still remains a challenge, the project team has made several relevant discoveries that can be attributed to their methodical methods and experimental approach.

Reviewer 2:

The reviewer stated that it was an innovative approach to synthesis LMR-NMC with integrated structure to attack the VF phenomenon.

Reviewer 3:

This reviewer noted that the approach sustained good program execution.

Reviewer 4:

The reviewer noted that various fundamental approaches have been demonstrated that could possibly overcome the barriers associated with LMR-NMC. These include incorporating a spinel component in the $\text{Li}_2\text{MnO}_3\text{-LiMO}_2$ structure, and making a certain composition Ni-rich as per the phase diagram analysis. The reviewer also said that these steps are all steps in the right direction.

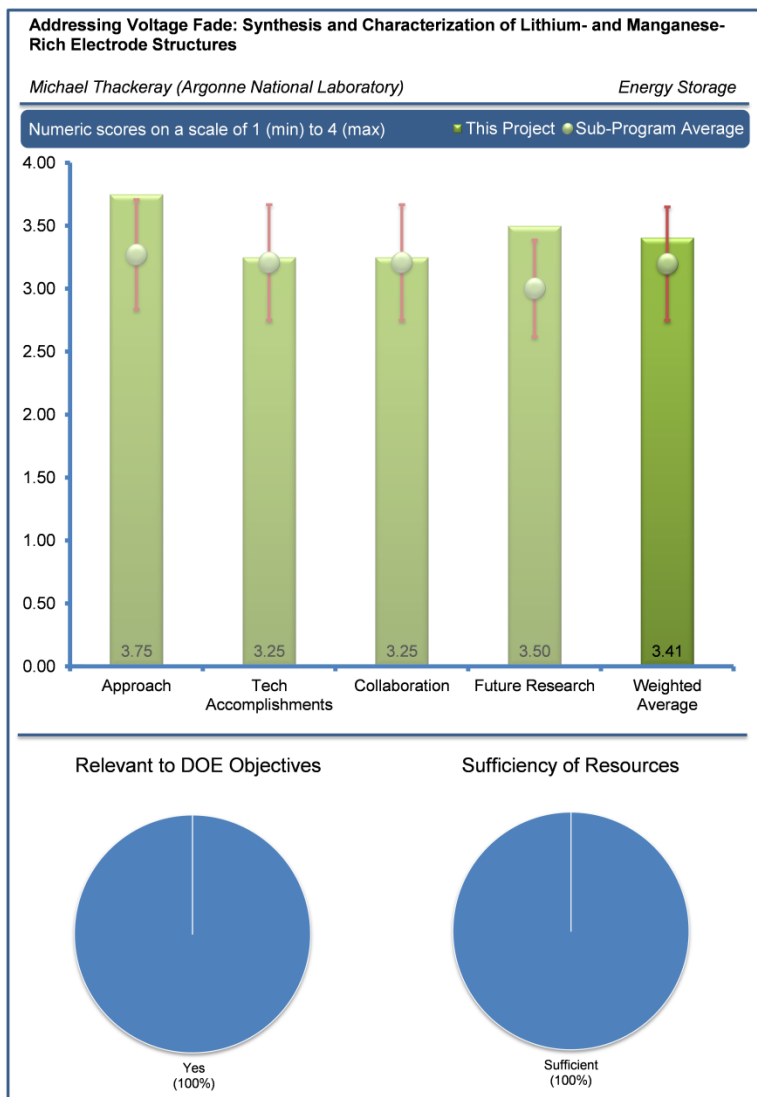
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that project team is developing the ability to control the synthesis of the material, although actual VF results were not shown within the presentation.

Reviewer 2:

This reviewer remarked that the completion of milestones is ongoing. However, significant technical progress has been made with both electrochemical analysis and materials characterization. The reviewer stated that the results are measured against appropriate metrics, and conclusions are made in a logical fashion and supported by a comprehensive data set. The reviewer added that the results presented nicely compliment other project elements and have relevance to the broader DOE objectives.



Reviewer 3:

According to the reviewer, the research appeared interesting. The reviewer added that the investigation indicated that a spinel component can reduce first cycle irreversible capacity loss, and may stabilize the layered-layered composite materials. The Ni content increases in high Co content and the layered-layered composites seemed that they can increase stability. The reviewer is not sure if the effect of the new approach on the true VF, without the IR contribution, had been investigated, or not.

Reviewer 4:

The reviewer noted that the proof of principle electrochemical cycling results are shown and discussed, but it is unclear if such approaches will any time soon address the limitation of LMR-NMC baseline chemistry. Any fundamental compositional changes need to go through the rigorous steps to make sure they meet the cycle and calendar life for automotive application.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer commented that the research team appears to have had good ongoing collaborations with other members of overall VF project and other academia and industry partners.

Reviewer 2:

The reviewer expressed that the team is good for addressing fundamental issues associated with LMR-NMC.

Reviewer 3:

This reviewer stated that the collaboration within ANL appears strong, but the project team could consider gaining feedback and interaction with industry partners.

Reviewer 4:

The reviewer noted that project team is utilizing commercial suppliers for research.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer remarked that a well-developed and defined plan is in place to continue the project, leveraging the conclusions from previous results. This reviewer also expressed that there are no recommendations for improvement.

Reviewer 2:

According to the reviewer, the future plan seemed to be a sound plan. The further study on composition optimization of the layered-layered-spinel cathodes has the potential reduce the VF of that type of materials.

Reviewer 3:

This reviewer said that the collaboration with other project teams should stay within the realm of the future work.

Reviewer 4:

The reviewer would like to know the exact or approximate composition of layered-spinel compounds that is proposed for the study. The fundamental studies proposed such as XAS, PDF analysis are important. The reviewer said that additionally, the PI should use Neutron PDF and diffraction methods to characterize the structure as well. Combining x-ray and neutron information is critical for such compounds.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer noted that in the context of the project, the material studied is one of the optimal materials to achieve the EV cell performance goals.

Reviewer 2:

According to the reviewer, the development of low cost, high-capacity cathode materials with good structural, electrochemical and thermal stability for PHEVs is aligned with DOE's objectives to reduce dependence on petroleum.

Reviewer 3:

This reviewer pointed out that the work is directed towards developing high energy batteries for PHEV and EV's.

Reviewer 4:

The reviewer stated that mitigating the VF of LMR-NMC is critical to enable the next generation of high energy density Li-ion batteries, which in turn supports the DOE objectives of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer said that the funding and resources available for this project appeared to be sufficient to conduct the research work.

Reviewer 2:

This reviewer noted that the resources are adequate.

Reviewer 3:

This reviewer stated that there were no comments.

Phase Relations and Voltage Fade Response in LMR-NMC Materials: Ira Bloom (Argonne National Laboratory) - es195

Reviewer Sample Size

A total of 4 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer noted the approach has combinatorial methodology with solid analysis.

Reviewer 2:

According to the reviewer, the project team has undertaken a well-defined experimental plan with clear objectives and deliverables. The team addresses the VF problem from both a compositional and electrochemical perspective, and is carefully analyzing the resulting data to define future work. The reviewer explained that generation of a common database for the ANL team and a common method for interpreting VF from voltage profiles [i.e., insulation resistance (IR) corrected average voltage (V)], are essential and will contribute to data integration across the project.

Reviewer 3:

This reviewer stated that the approach was innovative to synthesis LMR-NMC with integrated structure to attack the VF phenomenon.

Reviewer 4:

This reviewer noted that the combinatorial approach, guided by theory, should be the only way towards finalizing a new composition that has none or the least VF. This work should be closely tied with Chris Johnson's synthesis effort, so that ANL team can quickly converge on a new or modified high voltage cathode composition.

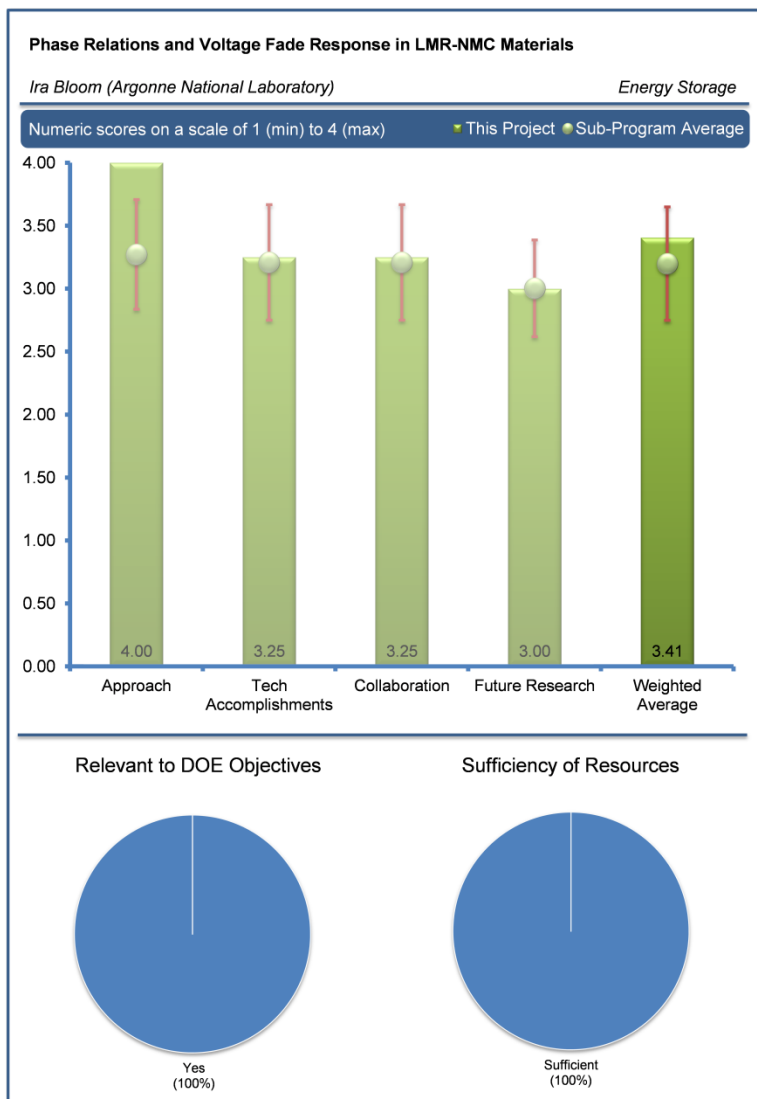
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer remarked that the development of a library for observations is excellent. It should be possible to simply expand the library, as more novel materials are investigated.

Reviewer 2:

The reviewer stated that the research appeared interesting. The investigation indicated a spinel component can reduce first cycle irreversible capacity loss, and may stabilize the layered-layered composite materials. The reviewer also noted that the Ni content



increases in high Co content. The layered-layered composites seemed to increase stability. The reviewer is not sure if the effect of the new approach on the true VF, without the IR contribution, had been investigated, or not.

Reviewer 3:

According to the reviewer, the progress and results presented suggest a path for overcoming the barrier of VF. Specifically, the evaluation of the kinetic factors associated with VF where this work indicates hot spots for compositions that will hopefully minimize or reduce the effect of VF. The reviewer added that the breadth of experimentation is impressive, as is the completeness of the data sets for the impact of the degree of activation and charging time.

Reviewer 4:

The reviewer commended the PI's approach towards standardizing the various efforts at ANL with respect to the LMR-NMC composition; phase, electrochemical results, and voltage fade analysis. This will help to summarize the results for cell suppliers, OEMS and others. The reviewer added that the kinetic model used for VF could be used a quick scan for evaluating the VF progression for new compositions. However, the reviewer is unsure of the limitations of this model, which looks like there are too many fitting parameters. The reviewer would like to know what are the constraints used in this project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer commented that collaboration is optimal at this stage.

Reviewer 2:

The reviewer said that the research team appears to have had good ongoing collaborations with other members of overall VF project and other academia and industry partners.

Reviewer 3:

This reviewer noted that the collaboration was suitable for this phase of the project.

Reviewer 4:

The reviewer stated that the collaboration is local to ANL and the project team could consider consolation with the likes of Ceder.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

According to the reviewer, the future plan seemed to be a sound plan. The further study on composition optimization of the layered-layered-spinel cathodes has the potential to reduce the VF of those types of materials.

Reviewer 2:

The reviewer observed that the team proposes a logical iterative approach to future work, which includes synthesizing materials relative to the predictions of the model, evaluating these materials, and using the results to fine tune the model. The team should consider defining decision points or triggers to determine when exiting the development loop is appropriate.

Reviewer 3:

This reviewer commented that the project is focused on data collection and analysis (characterization), and cautioned that expansion of this effort by related teams should be carefully evaluated.

Reviewer 4:

This reviewer would like to see tangible results from this with the help from synthesis PIs from ANL and elsewhere. Apparently the project team now has a solid framework to evaluate new compositions, and quickly converge on the right one, instead of spending years on one or two compositions.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer pointed out that project is very relevant, as the work is related to batteries for EV's.

Reviewer 2:

The reviewer commented that the development of low cost, high-capacity cathode materials with good structural, electrochemical, and thermal stability for PHEVs is aligned with DOE's objectives to reduce dependence on petroleum.

Reviewer 3:

This reviewer noted that in the context of the project, the material studied is one of the optimal materials to achieve the EV cell performance goals.

Reviewer 4:

According to the reviewer, that the project is consistent with DOE's objectives for petroleum displacement by advancing the development of high energy density Li-ion batteries that may find applications in EVs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the funding and resources available for this project appeared to be sufficient to conduct the research work.

Reviewer 2:

The reviewer said that the resources are adequate.

Reviewer 3:

This reviewer remarked that no recommendations are needed.

Reviewer 4:

This reviewer stated that there are no issues.

Impact of ALD Coating on Li/Mn-rich Cathode Materials: Shriram Santhanagopalan (National Renewable Energy Laboratory) - es196

Reviewer Sample Size

A total of 5 reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the approach of laying out a scaled up plan to allow the evaluation of ALD, as a potential coating technique, is clear and well thought out.

Reviewer 2:

The reviewer stated that the short term approach has been valuable in increasing confidence in the ALD methodology.

Reviewer 3:

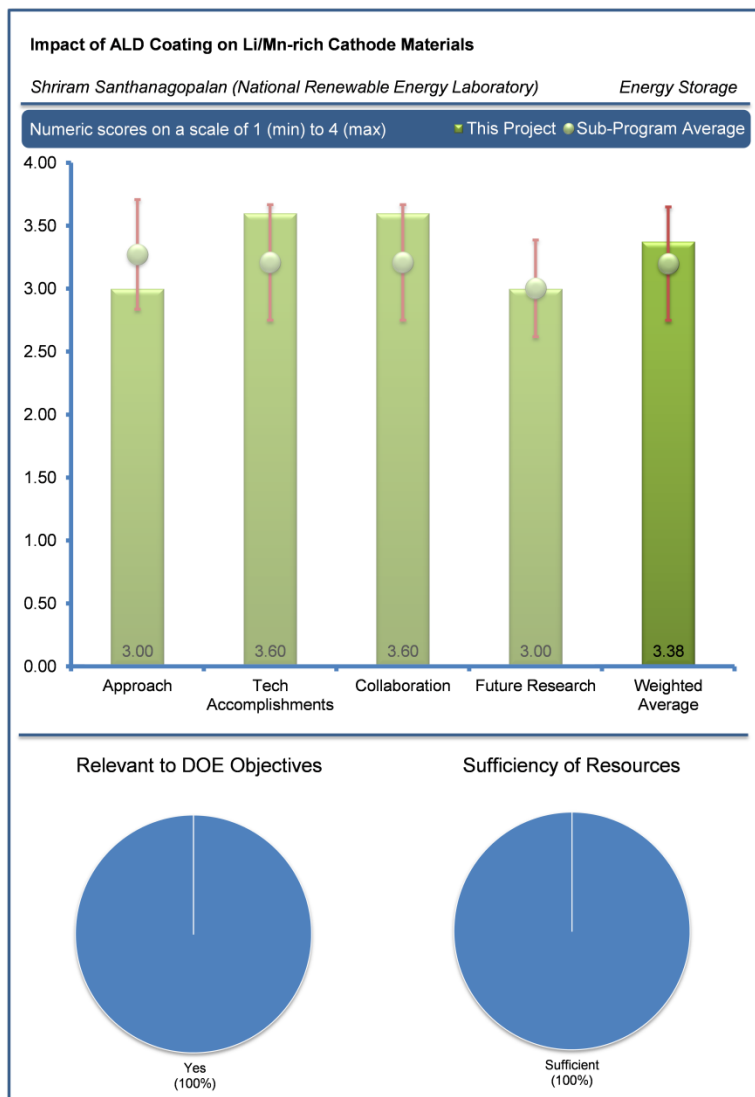
This reviewer remarked that this fast-track project is good.

Reviewer 4:

According to the reviewer, this quick hitting project is well focused, but addresses capacity fade and not voltage.

Reviewer 5:

This reviewer is unsure if the coating approach will really help with VF.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that there was impressive progress in a short period.

Reviewer 2:

The reviewer pointed out that three of the four milestones have been met with promising results, but would like to see some cost projections of utilizing ALD to manufacture these complex particles.

Reviewer 3:

This reviewer noted that this technical work appears solid, but it was hard to understand what was really done.

Reviewer 4:

The reviewer remarked that the technical accomplishments are not great, but consistent with the level of effort. If ALD can solve the capacity and VF problems, as well as allow high voltages to be applied to cathodes, the effort will be quite important.

Reviewer 5:

According to the reviewer, while the work in developing the process for the ALD coating process was well done, the issue of interpreting the impact of the results, as a justification for further work, is fairly weak. The small amount of results presented would not necessarily be compelling enough to justify continued work in this area, as these results were presented. The reviewer expressed a need to assume that the program ES162 takes this program forward and that this lack of results is a non-issue.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer affirmed that the collaboration is excellent, including a National Laboratory, small business, and university.

Reviewer 2:

The reviewer noted that the team is strong with an active, engaged industry partner.

Reviewer 3:

This reviewer noted that there is a high level of collaboration.

Reviewer 4:

The reviewer stated that the collaboration seemed appropriate for a short term, and that it is a fast track program.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer expressed that there is a need to see the work extended, especially in the direction of fluidized bed reactors.

Reviewer 2:

The reviewer stated that in this well-coordinated program, it appears that the milestones will be readily met.

Reviewer 3:

This reviewer remarked that given the existence and justification of Program ES162, this program would likely be at its logical conclusion.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer expressed that this fast track approach to generate data in support of ALD for electrode material applications is positive.

Reviewer 2:

This reviewer observed that high voltage cathodes are a key part of the program.

Reviewer 3:

According to the reviewer, coatings on cathodes are a viable approach to addressing some of the performance issues associated with various materials.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Acronyms and Abbreviations

Acronym	Definition
°C	Degrees Celsius
3D	Three Dimensional
ABR	Advanced Battery Research
Ah	Ampere-hour
ALD	Atomic Layer Deposition
AMR	Annual Merit Review
ANL	Argonne National Laboratory
AP	Atmospheric Processing
ARRA	American Recovery and Reinvestment Act
ASI	Area-specific Impedance
ATR	Attenuated Total Reflectance
B	Boron
BatPac	Battery Pack
BATT	Batteries for Advanced Transportation Technologies
BEV	Battery Electric Vehicle
BMS	Battery Management System
BNL	Brookhaven National Laboratory
BOL	Beginning of Life
BOM	Bill of Material
C	Carbon
CAEBAT	Computer-Aided Engineering of Batteries
CALPHAD	Computer Coupling of Phase Diagrams and Thermochemistry
CB	Carbon Black
CMC	Carboxymethyl Cellulose
CNT	Carbon Nanotubes
Co	Cobalt
Cr	Chromium
CTQ	Critical to Quality
Cu	Copper
DFT	Density Functional Theory
DOE	U.S. Department of Energy
DSC	Differential Scanning Calorimetry
EC	Ethylene Carbonate
EDS	Energy Dispersive X-ray Spectroscopy
EELS	Electron Energy Loss Spectroscopy
EIS	Electrochemical Impedance Spectroscopy
EMC	Ethyl Methyl Carbonate

Acronym	Definition
EOL	End of Life
EPR	Electron Paramagnetic Resonance
EV	Electric Vehicle
EXAFS	Extended X-ray Absorption Fine Structure
F	Fluorine
Fe	Iron
FRION	Flame Retardant Electrolyte Ions
FTIR	Fourier Transform Infrared Spectroscopy
FY	Fiscal Year
GM	General Motors
GBL	Gamma Butyrolactone
GVL	Ester Solvent
HCA	High-capacity Anode
HCC	High-capacity Cathode
HE	High Energy
HEV	Hybrid Electric Vehicle
HRSXRD	High-resolution Synchrotron X-ray Diffraction
HV	High Voltage
HVC	High Voltage Cathode
HVM	High-volume Manufacturing
ICE	Internal Combustion Engine
INL	Idaho National Laboratory
IR	Insulation Resistance
IREQ	Institut de Recherche d'Hydro-Québec
JCI	Johnson Controls, Inc.
LANL	Los Alamos National Laboratory
LBMP	Lithium-Bearing Mixed Polyanion
LBNL	Lawrence Berkeley National Laboratory
LEESS	Lower-Energy Energy Storage System
LFO	Lithium Iron Oxide
LFP	Lithium Iron Phosphate
Li	Lithium
LMO	Lithiated transition metal oxides
LiBF₄	Lithium tetrafluoroborate
LiBOB	Lithium bis(oxalato)borate
Li-ion	Lithium Ion
LiPF₆	Effective electrolyte salt for lithium-ion battery
LiPON	Lithium Phosphorous Oxynitride
LiTFSI	Lithium Bis(Trifluoromethanesulfonyl)Imide
LMNO	Ni-substituted manganese spinel oxides
LMR	Lithium Manganese Rich

Acronym	Definition
LT	Low Temperature
MA	Maleic Anhydride
MB	Methyl Butyrate
MERF	Materials Engineering Research Facility (Argonne National Laboratory)
MLD	Molecular Layer Deposition
Mn	Manganese
Mo	Molybdenum
MXene	Exfoliated MAX phases (2D structures)
NASA	National Aeronautics and Space Administration
NCA	Battery cathode material (nickel cobalt aluminum oxide)
NCM	Nickel Cobalt Manganese Oxide
NCSU	North Carolina State University
NDE	Non-Destructive Evaluation
NETL	National Energy Technology Laboratory
Ni	Nickel
NMC	Nickel Manganese Cobalt Oxide
NMP	N-Methylpyrrolidone
NMR	Nuclear Magnetic Resonance
NREL	National Renewable Energy Laboratory
O	Oxygen
OCV	Open Current Voltage
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
P	Phosphorous
PAN	Polyacrylonitrile
PDF	Pair Distribution Function
PEV	Plug-in Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
PHEV10	Plug-In Hybrid Electric Vehicle with a 10-mile range on a single charge
PHEV40	Plug-In Hybrid Electric Vehicle with a 40-mile range on a single charge
PI	Principal Investigator
PNNL	Pacific Northwest National Laboratory
PRC	People's Republic of China
PSU	Penn State University
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
ROI	Return on Investment
RT	Room Temperature
Ru	Ruthenium
S	Sulfur

Acronym	Definition
SBR	Styrene Butadiene Rubber (Copolymer)
SEI	Solid Electrolyte Interphase
SEM	Scanning Electron Microscope
Si	Silicon
SIC	Single Ion Conducting
SIMS	Secondary Ion Mass Spectrometry
SMOG	Si/MgO/Graphite
Sn	Tin
SNL	Sandia National Laboratory
SOA	State of the Art
SOC	State of Charge
SPEEK	Sulfonated Poly Ether Ether Ketone
SUNY	State University of New York
TEM	Transmission Electron Microscope
TFSI	Bis(trifluoromethane)sulfonimide [(CF ₃ SO ₂) ₂ N]
TGA	ThermoGravimetric Analyzer
Ti	Titanium
TM	Transition Metal
TMA	Tri Methyl Aluminum
USABC	US Advanced Battery Consortium
USCAR	U.S. Council for Automotive Research
UV	Ultra Violet
V	Volts
V	Vanadium
VC	Vinylene Carbonate
VF	Voltage Fade
VTO	Vehicle Technologies Office
XANES	X-ray Absorption Near Edge Spectroscopy
XAS	X-ray Absorption Spectroscopy
XPS	X-ray Photoelectron Spectroscopy
XRD	X-ray Diffraction (Crystallography)
XRF	X-ray Fluorescence

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3. Power Electronics and Electrical Machines Technologies

Because they are essential to electric drive vehicles, improvements in electric traction drives have the potential to significantly reduce petroleum consumption in the transportation sector as well as help meet national economic and energy security goals. Hybrid electric vehicles (HEVs) can reduce petroleum use compared to average conventional vehicles by as much as 50%, while plug-in electric vehicles (PEVs) extend these savings even further.

Achieving these goals will require cutting-edge research and development (R&D) in several areas including:

- wide bandgap (WBG) devices
- advanced motor designs to reduce or eliminate rare earth materials
- novel packaging
- improvements in heat transfer and thermal management
- integration of power electronics functions in advanced vehicle architectures

The U.S. Department of Energy (DOE) Vehicle Technologies Office's (VTO's) Advanced Power Electronics and Electric Motors subprogram works to improve electric drive systems to commercialize new technologies in this area and reach VTO's goals for electrifying transportation. These improvements will also help DOE meet the *EV Everywhere* Grand Challenge goal of making the U.S. the first nation in the world to produce PEVs that are as affordable for the average American family as today's gasoline-powered vehicles by 2022.

VTO pursues two major areas of research under this subprogram:

- power electronics
- electric motors

The Advanced Power Electronics and Electric Motors' long-term R&D strategy recognizes that lowering cost is essential for consumer acceptance and technology breakthroughs are necessary to achieve R&D goals. Because of these considerations, it focuses on traction drive system R&D that:

- Reduces cost, weight, and volume
- Improves performance, efficiency and reliability
- Develops modular and scalable designs
- Improves manufacturability to enable commercialization

This research builds upon decades of work that DOE has conducted in power electronics and electric motors. Research supported by VTO led to the first production facility for electric traction drive motors from a U.S.-based manufacturer (General Motors) and the first U.S. based high-volume automotive inverter production (Delphi).

The major goals of Advanced Power Electronics and Electric Motors subprogram are to reach these levels for traction drive systems by 2022:

- Reduce cost from \$30/kW in 2012 to \$8/kW
- Increase specific power from 1.1 kW/kg in 2012 to 1.4 kW/kg
- Increase specific volume from 2.6 kW/L in 2012 to 4 kW/L
- Increase efficiency from 90% in 2012 to 94%

In August 2009, the Department announced the selection of ten projects totaling \$495 million that will help accelerate the establishment of a globally competitive, domestic infrastructure for advanced electric drive vehicle manufacturing. American

Recovery and Reinvestment Act (ARRA)-funded Power Electronics and Electrical Machines Technologies activities support programs to enable production and commercialization of advanced electric drive vehicles, which help to reduce petroleum consumption. Activities include developing low-cost electric propulsion systems; supporting an increase in production capacities for electric drive components, manufacturing plants, and parallel hybrid propulsion systems; and supporting development of electric drive semiconductors. Additionally, AARA-funded activities that support commercialization include accelerating the launch of HEVs/PHEVs through efforts including localizing the design and production of transaxle systems, and developing a lower-cost, higher-control standardized platform.

Subprogram Feedback

DOE welcomed optional feedback on the overall technical subprogram areas presented during the 2013 AMR. Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area who volunteered to provide subprogram overview comments responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1: Was the subprogram area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Question 3: Does the subprogram area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Office's needs?

Question 4: Other Comments.

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc., as reviewer responses were optional.

Subprogram Overview Comments: Susan Rogers (U.S. Department of Energy) – ape00a

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer agreed that yes, the sub-program areas for power electronics and electric drive sub-systems had been covered well in the 2013 AMR presentations. In the program-summary presentation, the issues and challenges were clearly delineated from the program's point of view. The progress from the previous year was also clearly presented in several summary slides.

Reviewer 2:

The reviewer indicated that the sub-program understood the challenges well and was very focused on cost.

Reviewer 3:

The reviewer did not attend this sub-program session last year, but believed that Rogers had done a remarkable job bringing out relevant research questions and program definition, as well as selecting an excellent group of contract awardees who could apparently work together (or in lockstep).

Reviewer 4:

The reviewer reported that the sub-program area was adequately covered, and the most important challenge, which was cost reduction, had been identified. This reviewer added that the progress was documented with the commercialization activities in recent years and the key accomplishment in completed and ongoing projects.

Reviewer 5:

The reviewer concluded that the sub-program areas were adequately covered, the important issues and challenges had been identified, and the funded projects addressed them comprehensively.

Reviewer 6:

The reviewer stated yes.

Reviewer 7:

The reviewer voiced that the program needed a larger view of what constituted basic science. Investigators developing new technology needed to identify where the science that was developed fit into the broad goals of DOE. This reviewer added that it did no good for the DOE programs if the basic science was useless in reaching DOE's goals.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?**Reviewer 1:**

The reviewer indicated that plans were identified for addressing issues and challenges.

Reviewer 2:

The reviewer reported that plans had been identified and gaps were not observed.

Reviewer 3:

The reviewer highlighted that there was a need to have resources available to validate the new technology and carry out the preliminary investigations of its utility. This reviewer added that the new Hub concept placed the National Laboratories in the position of carrying out the basic process of proving the ability of new concepts to meet market needs. In this process, scientists and technicians were trained in critical technologies. This represented a move away from the concept that good fundamental science was carried out for its own sake to advance the basic understanding of phenomena. This has long been the operating principal of industrial laboratories such as General Electric, Dow, Exxon, and so forth.

Reviewer 4:

The reviewer concluded that the plans seemed to be shifting from a technology focus to a systems development and optimization focus.

Reviewer 5:

According to this reviewer, the most important issue was cost reduction for electric traction drive systems, and basically all current projects in the sub-program area addressed this issue as their main target. Even though there were no obvious gaps in the project portfolio, the focus for funding in the future should be shifted toward the funding of complete system project proposals, as these offered a higher potential for achieving an optimized system design (in terms of both cost and performance).

Reviewer 6:

The reviewer stated that meeting the industry-driven cost targets seemed daunting. It was possible that some summary judgments, such as mature manufacturing and minimal potential for improvement (as listed within the tabular description of induction motors)

might be overlooking some of the more radical induction motor designs. In particular, reconsideration of newer types of induction motors (such as greater-than-three-phase ones) might lead to the marked cost reductions that were sought in the program goals. The direction set was to focus on WBG power electronic semiconductors, which were high-cost alternatives (at least for the present). It was appropriate that DOE-funded work be out in front of the industry. Furthermore, developments in special thermal packaging of WBG devices might also be valuable in applications to vertical metal-oxide-semiconductor (MOS) silicon devices as nearer-term alternatives by industry.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:

The reviewer stated that the sub-program area was focused on the most important issue, which was cost reduction for electric drive systems. This reviewer added that it was well managed by the DOE representatives, who have the appropriate technical understanding and knowledge to evaluate and guide the projects in the sub-program area. It was effective in addressing DOE VTO needs.

Reviewer 2:

The reviewer felt that the sub-program area was focused and well managed, and that there was a good mix of fundamental-level and development work that would not be pursued as aggressively by the original equipment manufacturers (OEMs) without DOE support.

Reviewer 3:

The reviewer noted that the program appeared to be well focused on its stated needs. The program appeared to be well managed, with evident cross-discussions and peer-to-peer enthusiasm among the participants at the AMR meeting.

Reviewer 4:

The reviewer stated yes.

Reviewer 5:

The reviewer remarked that, for the common good, new technology should meet the needs of the country and assist in determining the ultimate value of that technology.

Reviewer 6:

According to this reviewer, the efforts at the labs seemed to be moving away from their strengths and were now more focused on architecture optimization and system development. While these areas were important, they typically did not lead to great breakthroughs in technology. This reviewer opined that the National Laboratories needed to be focused on technology development and not systems. The systems optimization and development were best left to industry, which was better prepared to make the appropriate tradeoffs in these systems while still meeting customer requirements.

Question 4: Other Comments

Reviewer 1:

The reviewer pointed out that, as the market accepted more and more electrical and electronic functions on vehicles and non-mobile systems, the investment in power electronics and electric drives seemed to be a sure-to-be-used technology. Whether the primary energy conversion system was an internal combustion engine (ICE) or a fuel cell (or a nuclear-powered utility charging a battery), the advanced developments in power electronics and electric drives would serve them all. Thus, funding for power electronics was a surer bet to be included in any eventual system, and seemed to justify greater investment in this multi-application technology area than in any one of the specific conversion/storage technologies.

Reviewer 2:

The reviewer observed that the APE program included an extensive collection of projects focusing on all aspects of electric machines and power electronics to meet DOE's 2020 targets. The projects focused on components as well as development of their key subsystems (capacitors, WBG and traditional silicon [Si] power modules, insulation materials, etc.). Many of the project presentations

did not reveal significant technical details relevant to the work, and this reviewer wanted to know if this was due to the projects being conducted with cost-sharing agreements. Projects fully funded, without an assertion of restrictions, would be delivered with unlimited rights to the government. In this case, the objective was not for the government to own all of the technological data, but rather to help the contractors develop key fuel-saving technologies to reduce dependence on imported oil and reduce pollution. The projects related to electric machines were particularly impressive. The reviewer asked if changing the name to include the electric-machines focus had been considered, and suggested Advanced Electric Machines and Power Electronics, Advanced Electric Drives, Advanced Electromechanical Systems, etc.

Reviewer 3:

The reviewer said that the industry-led projects were hard to evaluate, with the presenters invoking proprietary issues whenever asked technical questions. It would have been good to find a forum where the industry would have been more forthcoming with information so that the project progress could be properly evaluated. This reviewer added that, though a lot of universities were nominally participating in the research projects, the involvement of academia was relatively small in practice.

Reviewer 4:

The reviewer mentioned that systems work at the National Laboratories could lead to work that was no longer pre-competitive research and that would be difficult to move to industry. In a way, the labs appeared to be competing with industry solutions by creating their own optimized system solutions. This reviewer was not sure how or if those would ever move into the marketplace and actually help the DOE to achieve its goals.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, as well as numeric scoring responses (*on a scale of 1 to 4*). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Benchmarking State-of-the-Art Technologies	Tim Burress (Oak Ridge National Laboratory)	3-8	3.50	3.17	3.17	2.83	3.21
High Dielectric Constant Capacitors for Power Electronic Systems	Uthamalingam Balachandran (Argonne National Laboratory)	3-12	3.67	3.67	3.67	3.33	3.63
Improved High Temperature Polymer Film Capacitors	Cy Fujimoto (Sandia National Laboratories)	3-15	3.50	3.25	3.25	3.25	3.31
† Glass Ceramic Dielectrics for DC Bus Capacitors	Michael Lanagan (Pennsylvania State University)	3-18	3.25	3.25	3.25	2.75	3.19
High Temperature Inverter	Ralph Taylor (Delphi Corporation)	3-21	3.40	3.40	3.40	3.00	3.35
Permanent Magnet Development for Automotive Traction Motors	Iver Anderson (Ames)	3-25	3.86	4.00	4.00	3.43	3.89
Air Cooling R&D	Jason Lustbader (National Renewable Energy Laboratory)	3-30	3.50	3.00	3.00	3.00	3.13
Characterization, Modeling, and Reliability of Power Modules	Allen Hefner (National Institute of Standards and Technology)	3-32	2.33	3.33	3.33	2.00	2.92
Development of SiC Large Tapered Crystal Growth	Philip Neudeck (National Aeronautics and Space Administration)	3-34	2.75	3.25	3.25	3.00	3.09
Reliability of Bonded Interfaces	Doug DeVoto (National Renewable Energy Laboratory)	3-37	3.75	3.75	3.75	3.25	3.69
Electric Motor Thermal Management	Kevin Bennion (National Renewable Energy Laboratory)	3-40	3.33	3.00	3.00	3.17	3.10
Interim Update: Global Automotive Power Electronics R&D Relevant To DOE 2015 and 2020 Cost Targets	Christopher Whaling (Synthesis Partners)	3-44	3.40	3.20	3.20	3.20	3.25
† Reliability of Electrical Interconnects	Doug DeVoto (National Renewable Energy Laboratory)	3-47	3.33	3.00	3.00	3.00	3.08
† Two-Phase Cooling R&D	Gilbert Moreno (National Renewable Energy Laboratory)	3-49	3.25	3.00	3.00	3.25	3.09
† Advanced Liquid Cooling R&D	Sreekant Narumanchi (National Renewable Energy Laboratory)	3-51	3.60	3.40	3.40	3.60	3.48
Next Generation Inverter	Greg Smith (General Motors, Advanced Technology Center)	3-54	3.50	3.25	3.25	3.00	3.28
Unique Lanthide-Free Motor Construction	Jon Lutz (UQM Technologies)	3-57	3.33	3.67	3.67	3.33	3.54
Alternative High-Performance Motors with Non-Rare Earth Materials	Ayman El-Refaie (General Electric Global)	3-61	3.14	3.14	3.14	3.14	3.14

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Integrated Power Module Cooling	Kevin Bennion (National Renewable Energy Laboratory)	3-66	3.33	3.67	3.67	3.00	3.50
Traction Drive System Modeling	Burak Ozpineci (Oak Ridge National Laboratory)	3-69	3.00	2.40	2.40	3.00	2.63
WBG Inverter Packaging	Zhenxian Liang (Oak Ridge National Laboratory)	3-72	3.17	2.83	2.83	3.50	3.00
WBG Gate Drivers for Power Modules	Leon Tolbert (Oak Ridge National Laboratory)	3-75	4.00	3.33	3.33	3.67	3.54
Electric Motor R&D	John Miller (Oak Ridge National Laboratory)	3-78	3.17	3.50	3.50	3.17	3.38
Integrated Vehicle Thermal Management	John Rugh (National Renewable Energy Laboratory)	3-82	3.25	3.63	3.63	3.25	3.48
† Inverter R&D	Madhu Chinthavali (Oak Ridge National Laboratory)	3-87	3.00	3.33	3.33	2.83	3.19
† WBG Converters and Chargers	Gui-Jia Su (Oak Ridge National Laboratory)	3-90	3.40	3.40	3.40	3.20	3.38
† System Integration and Validation	Tim Burruss (Oak Ridge National Laboratory)	3-92	2.50	2.83	2.83	2.50	2.71
† Power Electronics Architecture R&D	Omer Onar (Oak Ridge National Laboratory)	3-95	3.00	3.50	3.50	3.17	3.33
† Electric Motor Architecture R&D	Curt Ayers (Oak Ridge National Laboratory)	3-97	3.33	2.67	2.67	2.67	2.83
† ‡ US Electric Drive Manufacturing Center	Judith Giesecking (General Motors)	3-99	3.75	2.50	2.50	3.67	2.96
† ‡ Low-Cost U.S. Manufacturing of Power Electronics for Electric Drive Vehicles	Greg Grant (Delphi Corporation)	3-102	3.25	3.25	3.25	3.33	3.26
† ‡ Electric Drive Component Manufacturing Facilities	Richard Thies (Allison Transmission, Inc.)	3-104	3.67	3.33	3.33	3.00	3.38
† ‡ U.S. Based HEV and PHEV Transaxle Program	Kevin Poet (Ford Motor Company)	3-106	3.67	2.33	2.33	3.00	2.75
† ‡ Providing Vehicle OEMs Flexible Scale to Accelerate Adoption of Electric Drive Vehicles	JJ Shives (Remy, Inc.)	3-109	3.25	3.50	3.50	3.25	3.41
† ‡ Electric Drive Component Manufacturing Facilities	Luke Bokas (UQM Technologies)	3-112	3.67	2.67	2.67	3.33	3.00
† ‡ Electric Drive Component Manufacturing: Magna E-Car Systems of America, Inc.	Brian Peaslee (Magna E-Car Systems of America, Inc.)	3-114	3.33	3.00	3.00	3.00	3.08
† ‡ DC Bus Capacitor Manufacturing Facility for Electric Drive Vehicles	Johnny Boan (Kemet)	3-116	4.00	3.67	3.67	3.33	3.71
Overall Average			3.35	3.22	3.22	3.12	3.24

† denotes poster presentations

‡ denotes ARRA funded projects

Benchmarking State-of-the-Art Technologies: Tim Burress (Oak Ridge National Laboratory) - ape006

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer described that this is a benchmarking project. The reviewer noted that the presented emphasized that it is good that it is consistent with the past year's approach: taking the units apart to identify the subcomponents, such as heat spreaders and lower cost insulators; and efficiency mapping/identifying peak efficiencies.

Reviewer 2:

The reviewer acknowledged that this project continues to provide valuable benchmarking results for electric vehicle (EV)/ PEV state-of-the-art motor, inverter, and converters that provide a foundation for determining the relevance and goals for the other power electronics and electric motors projects within the VTO. The reviewer expressed that the project could be expanded to provide more complete coverage of propulsion and charger product offerings and more rapid turn-around.

Reviewer 3:

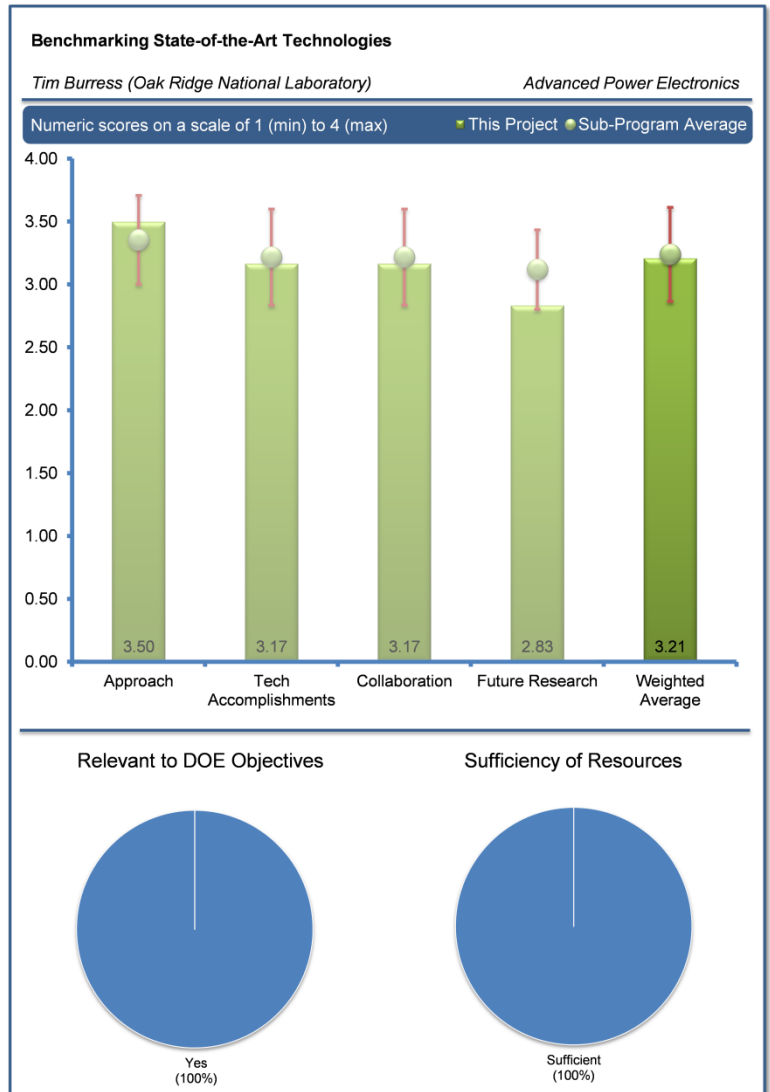
The reviewer expressed that the benchmarking effort is very important to the DOE mission. The reviewer cautioned, however, that because the team, on average, publishes one report every other year, it is a concern in terms of quick dissemination of the knowledge to researchers and industry. It was noted that the reviewers raised this concern previously.

Reviewer 4:

The reviewer described that this project has provided critical baseline information on the commercial electric drive vehicles in terms of current technology and cost. The information is important for developing advanced power inverter technologies to meet DOE's 2020 target.

Reviewer 5:

The reviewer affirmed that the project seems to be progressing very well and the approach for the tear downs and testing is very good. However, the reviewer did not see a clear use of the technical information within the presentation. It would have been helpful to have a data summary slide that showed the comparison of the Toyota and Nissan systems with Remy or other domestic power electronics manufacturers.



Reviewer 6:

The reviewer acknowledged that understanding the communication protocols of different manufacturer's products, to control their systems, can be a difficult task. The reviewer asked if this communication protocol is published and can be referenced. This work has been ongoing over the years, and the reviewer asked if it was possible to take the Toyota inverters and publish the advantages and disadvantages over design evolutions and describe what the enabling technologies are that provided those advantages.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer remarked that the project has made significant progress this year with accomplishments including the benchmarking of the Toyota Camry inverter, the Nissan LEAF inverter/motor and charger, and the Hyundai Sonata Hybrid starter/generator.

Reviewer 2:

The reviewer observed great technical accomplishments that were very well presented. It would be interesting to see a comparison, or evolution, of the power electronics in next year's presentation after all four vehicles have been analyzed.

Reviewer 3:

The reviewer noted that the project has made good progress, though it will be better if the test can be completed faster.

Reviewer 4:

The reviewer explained that a variety of parts from a variety of manufacturers had been taken and has provided useful information about their capabilities. The reviewer would refer to the evaluated systems as state-of-the-market, not state-of-the-art. The reviewer asked whether using vehicle simulators as opposed to dynamometer setups to speed up the work, had been considered.

Reviewer 5:

The reviewer noted that the project accomplishments are documented in a series of reports. The reviewer would have preferred a more technically-precise description of this this highly-detailed benchmarking work.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer expressed that there appears to be good coordination in working with materials analysts and with comparing to vendor efficiency plots. The reviewer acknowledged the good cooperation with those performing road-tests to better know how to mimic in-use conditions.

Reviewer 2:

The reviewer mentioned that in addition to the collaborations and coordination with Remy, the Argonne National Laboratory (ANL), and the National Renewable Energy Laboratory (NREL), this project provides a foundation for determining the relevance of and goals for the other power electronics and electric motor projects within the VTO.

Reviewer 3:

The reviewer pointed out that the team collaborated with ANL and other institutions to test the HEV and thermal management systems.

Reviewer 4:

The reviewer noted that it was good to see partnerships with private industry; however, the reviewer suggested that it would be better to have more private partners in this project to better compare where domestic suppliers stand compared to Nissan and Toyota suppliers.

Reviewer 5:

The reviewer suggested that a closer coordination with the OEMs may provide some of the information gathered in a more cost-effective manner. The reviewer observed that it was not clear what benefit the collaboration with Remy provides to the scope of the project. The reviewer added that the copper versus aluminum rotor issue is more of a research question.

Reviewer 6:

The reviewer pointed out that while the presenter provided information to NREL for thermal studies, the reviewer did not see any thermal study information in the presentation. The reviewer also mentioned that thermal stack information of the power stages would have been useful information.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer asserted that the project continues to select and benchmark cutting-edge technologies that are most relevant to the program and proposed future product selections seem appropriate. However, the reviewer suggested that it would be appropriate for the project to define a strategy of how it will advance its capabilities and throughput as technology advances and the number of product offerings continue to increase.

Reviewer 2:

The reviewer agreed that the plan is good; however, the reviewer added that it will be interesting to see the performance of a U.S.-brand electric drive vehicle. The reviewer noted that past analyses have primarily focused on foreign brands such as Toyota, Lexus, Honda, and Hyundai.

Reviewer 3:

The reviewer indicated that future plans were clearly presented, but expressed that it would have been helpful to see the comprehensive expectations of the project as a whole.

Reviewer 4:

The reviewer expressed that it will be interesting to see how aluminum compares to copper for rotors in the Remy work. Perhaps, continued this reviewer, this analysis can be extended to the thermal diffusivity vis-à-vis thermal conductivity as best for transient vav steady-state. The reviewer was not able to comment on the volume of proposed work to be done.

Reviewer 5:

The reviewer criticized that it is not clear what benefit the characterization of the Remy machine provides to the benchmarking effort, since the machine is not in any production vehicle. The reviewer observed that this characterization may fit better with another project. The reviewer also suggested that faster dissemination of results should be a focus in the coming year.

Reviewer 6:

The reviewer asked if there is any planned future work on the direct current (DC) converters that are state-of-the-market.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer asserted that knowing what others are doing sets the standards for which we (in the United States) need to exceed.

Reviewer 2:

The reviewer explained that learning from competitive tear-downs and testing is very valuable. This information learned will be very helpful for domestic suppliers to be competitive, and ultimately will decrease the costs of vehicle electrification.

Reviewer 3:

The reviewer reinforced that benchmarking the EV/PEV state-of-the-art motor, inverter, and converters is a core function required for relevance of the overall VTO. The reviewer added that continuity of this project will result in a consistent comparison of performance and technology development over time.

Reviewer 4:

The reviewer indicated that the project work is very important for DOE.

Reviewer 5:

The reviewer explained that electrification of vehicles tends to decrease the need for petroleum for powering those vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the project support is sufficient to benchmark key cutting edge product offerings today, but that more rapid turn-around of results and more broad market coverage might be achieved with more resources.

Reviewer 2:

The reviewer stated that it appears the project is sufficiently funded and has the resources necessary to meet its milestones.

Reviewer 3:

The reviewer asked if there were more resources, people, or equipment, and whether more assessments could be accomplished.

High Dielectric Constant Capacitors for Power Electronic Systems: Uthamalingam Balachandran (Argonne National Laboratory) - ape008

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that this project is focusing on the production process which will drive the cost down and result in a usable capacitor. The reviewer pointed out that early use of the capacitor in the Delphi project inverter enabled actual technical issues that were based on the in-circuit functionality to be discovered and addressed. The reviewer also highlighted that the volume reduction, ripple performance over-temperature, and thermal performance, in general, all look excellent.

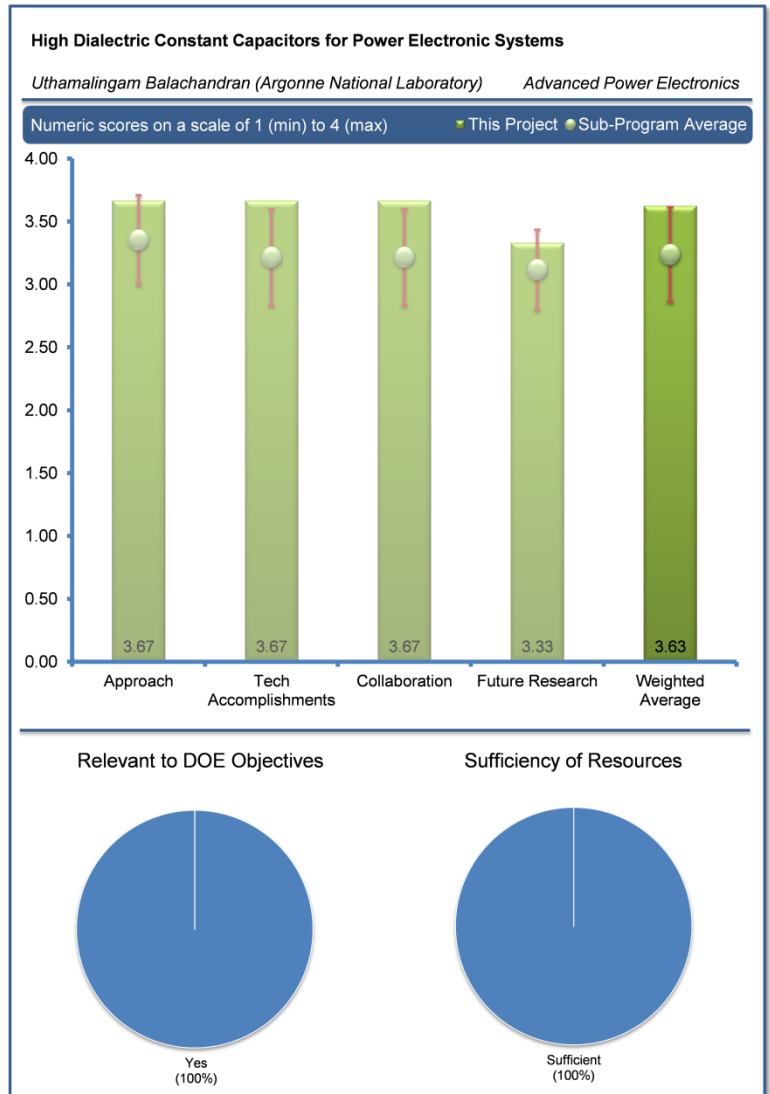
Reviewer 2:

The reviewer affirmed that the project has made significant progress since last year's presentation. The researchers effectively utilized Delphi and Penn State as partners. The reviewer commented that the aerosol application of the lead lanthanum zirconium titanate (PLZT) dielectric needs to be optimized. It is not yet a production-ready process, but shows promise. The reviewer indicated that the presenter acknowledged having a patent to identify and eliminate dielectric defects, but this was not explained. The reviewer confirmed that this is critical for the capacitor manufacture to have high yields. The reviewer also remarked that the presenter also acknowledged having a method to decouple shorted capacitors from the inverter bus, but this needs further explanation with end-of-life of PLZT capacitor defined as loss of 10% capacitance. The reviewer pointed out that film capacitors self-heal, but this PLZT technology would just short out catastrophically. Therefore, the solution of decoupling capacitor from the inverter bus needs to be explained.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed that the performance of the capacitor, as shown, is very good. The thermal performance over temperature was good, and the equivalent series resistance (ESR) projections were good. The reviewer emphasized that it was very good that the researchers are addressing thermal issues early. The project focused on production processes and how they impact cost and performance, which this reviewer described as outstanding.



Reviewer 2:

The reviewer stated that while they were unable to attend last year's Annual Merit Review (AMR) meeting, based on the previous year's presentation information, much work has been done this year. The reviewer was most interested in the possibility of using the vaporization process to increase the thickness of the PLZT, thus increasing the voltage.

Reviewer 3:

The reviewer indicated that the DOE target volume goal is 0.6 liter, and the calculated PLZT volume is 0.5 liter. The reviewer also pointed out that the presenter indicated that a target is to be a lower cost than the polypropylene (PP) film solution, and the projection is to hit the DOE target of \$30 for the DC link bus capacitor.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer applauded that the work with Delphi on the high-temperature inverter shows excellent cooperation. The use of the failure mode and effects analysis (FMEA), and root cause processes, should enable a solid corrective action plan and results. It appeared to the reviewer that the team was working well together based on the two presentations. The reviewer suggested that the researchers and Delphi need to update the FMEA after solving any technical issues, which will help in the transition to production.

Reviewer 2:

The reviewer simply stated that the researchers have worked very closely with Delphi and Penn State.

Reviewer 3:

The reviewer affirmed that utilizing Delphi as part of their partners is very good. The reviewer offered that the only thing that might be missing is a partner that is in the ceramic capacitor business.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer expressed that the next steps seem logical and typical for solving production process related issues. The reviewer suggested that the researchers continue to use and update the FMEA after the root causes for future issues are determined.

Reviewer 2:

The reviewer observed that development of sub-micron PLZT powders and optimizing the aerosol process are critical to this evolving into a production process. The reviewer expressed interest in seeing the mechanism of culling-out the defects in the sheets, as well as decoupling shorted out capacitors from the bus explained, as these are critical for the capacitor manufacturer, the end-use application, and passenger safety.

Reviewer 3:

The reviewer expressed interest in the possibility of using the vaporization process to increase the thickness of the PLZT, thus increasing the voltage.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer reinforced that DC bus capacitor operating temperature is one of the limitations of inverters; they are also a significant cost driver. The reviewer affirmed that this project addresses both of these.

Reviewer 2:

The reviewer explained that one of the major ideas for this project is to find a capacitor that can be implemented in higher temperature applications where polypropylene film is unable to reach. The reviewer confirmed that this project fits the bill and is proving to be a viable solution.

Reviewer 3:

The reviewer explained that bulk capacitors are the second most expensive, and typically the largest component, in a traction inverter and represent a significant percentage of the cost. The reviewer added that the form factor of the capacitor and its thermal requirements drive the packaging of the design, and that this project addresses these issues.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the level of funding appears to have been sufficient. However, the reviewer added, the project funding is going down this coming year, so it needs to be seen if this will impact the progress.

Reviewer 2:

The reviewer simply stated that, based on the progress reported, the resources are sufficient for this project.

Improved High Temperature Polymer Film Capacitors: Cy Fujimoto (Sandia National Laboratories) - ape009

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer affirmed that the project is addressing both technical and cost barriers as the researchers discover new issues. The reviewer noted that the team addresses both the advantages and disadvantages of potential issues as they are evaluated, including the cost and reliability impacts.

Reviewer 2:

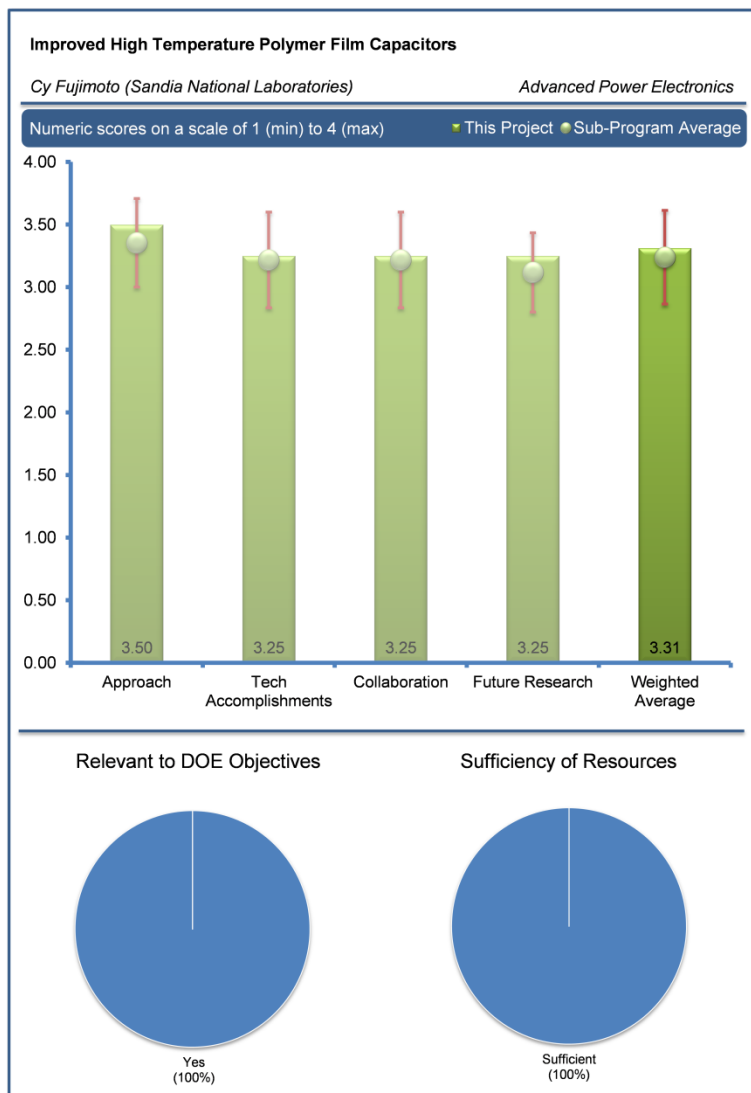
The reviewer summarized that the project has been developing a high-temperature polymer and film production process for high-temperature film capacitors. The reviewer described that different polymers have been developed and modified, and that both solvent casting and melt extrusion processes have been developed. The reviewer suggested that it would be great if the team can also develop an orientation process to improve the film performance, as commercial PP, polyethylene terephthalate (PET), and polyethylene naphthalate (PEN) films are produced with a biaxial orientation process.

Reviewer 3:

The reviewer stated that the researcher and team have approached this project methodically, and continue to do so with a forward path, and with production in mind. The reviewer indicated that the presenter claims that the material has a 150°C capability with higher K, at a cost of \$0.015/μF. The presenter claimed the material has almost double the energy density with the plasticizer and voltage stabilizer, and can be extruded and metalized, although not optimized. The reviewer questioned the \$0.015/μF claim, as this is lower than a polypropylene capacitor, and would welcome a capacitor manufacturer to validate the claim. The reviewer also explained that the researchers do not know if the material self-heals well. Although there are no studies planned for this self-healing, it still needs to be determined. The reviewer also reported that the researcher plans to increase the molecular weight in hopes to eliminate the need for the plasticizer, and explained that plasticizers are expensive and not suitable to oil immersion.

Reviewer 4:

The reviewer reported that the approach appears to be in order with the exception of one part; a cost analysis is missing.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer explained that the team has made progress to improve the temperature stability of the polymer, and that the film quality has been continuously improved.

Reviewer 2:

The reviewer commented that the researcher has made significant progress since last year.

Reviewer 3:

The biggest issue the reviewer observed, at the current state, is that the extruded film is cracking in larger windings. The reviewer explained that the researchers mentioned that this was primarily based on bad mechanical properties. The reviewer indicated that this is an important step, as it will allow for high capacitance values in larger windings. The reviewer looked forward to following this project.

Reviewer 4:

While significant progress has been made, the reviewer expressed that there are still issues that need to be overcome. The reviewer agreed that the goal of achieving a cost-competitive capacitor is great; however, the size projections are a concern, as the data indicate that the capacitor will be larger than the goal. The reviewer also cautioned that the performance of the capacitor at high temperatures and at typical bulk capacitance values remains to be seen.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer mentioned that the researchers have worked closely with Delphi, as well as Electronic Concepts, Inc. (ECI), Sandia National Laboratories (SNL), and Penn State.

Reviewer 2:

The reviewer highlighted that having a manufacturer of film capacitors as a resource, not only allows for increasing the technical ability, but it allows the utilization of the resource for testing purposes.

Reviewer 3:

The reviewer concluded that the collaboration among the team members appears to be very good and is working based on the results.

Reviewer 4:

The reviewer described that the Sandia team has been working with ANL, Penn State, and ECI during this project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer summarized the future research plans include the following: increasing molecular weight to hopefully eliminate plasticizers; and optimizing extrusion, metalization, winding, etc., for a production process. The reviewer identified the need to do two things: assess the self-healing ability; and have an independent capacitor manufacturer validate the cost claim, as it seemed too low.

Reviewer 2:

The reviewer stated that the plans were very basic in concept, but were still very important. The reviewer indicated that the researchers need to send material to ECI for building and testing prototypes; this important step is what will prove the process.

Reviewer 3:

The reviewer summarized that the future work will continue to expand the size of the devices, as well as address potential manufacturing issues. The reviewer observed that the team is addressing multiple issues in parallel, which is good, but may lead to difficulty if new issues pop up in trying to determine the root cause. The plan is appropriate for the project goal.

Reviewer 4:

The reviewer suggested that the future research should be focused more on film processing at a large scale.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer pointed out that higher temperature operation and higher K [with low dissipation factor (DF)] are needed to develop inverters that run hotter and that are smaller.

Reviewer 2:

The reviewer noted that high-temperature film capacitors are a critical component in electric drive vehicle (EDV) power inverters.

Reviewer 3:

The reviewer explained that one of the major ideas for the project is to find a capacitor that can be implemented in higher temperature applications that polypropylene film is unable to reach. The reviewer noted that this fits the bill, but still was unsure if it can be implemented in mass-production, or if it can meet the cost targets.

Reviewer 4:

The reviewer reinforced that bulk capacitors are significant issues in today's inverters in terms of size and cost, and are also limiting factors for high temperature use. The reviewer expressed that the proposed approach addresses most of the issues, with some concern that the size reduction will be significant enough, but acknowledging that any reduction is welcomed.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that resources appear to be sufficient, but may be on the light side. The reviewer expressed that there is significant progress to be made in the next few months. The goal is a 5-110 μF capacitor, which is achievable and sufficient to show viability of the film.

Reviewer 2:

The reviewer commented that availability of resources does not seem to be an issue for this project.

Glass Ceramic Dielectrics for DC Bus Capacitors: Michael Lanagan (Pennsylvania State University) - ape010

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer agreed with the presenter's evaluation of using glass as a dielectric for DC link capacitors is valid for a higher temperature operation. The reviewer also explained that the presenter has proven that the glass can be wound. The reviewer expressed that the researcher needs to find out if the glass can be vapor-deposited and metalized, and also if it can self-heal.

Reviewer 2:

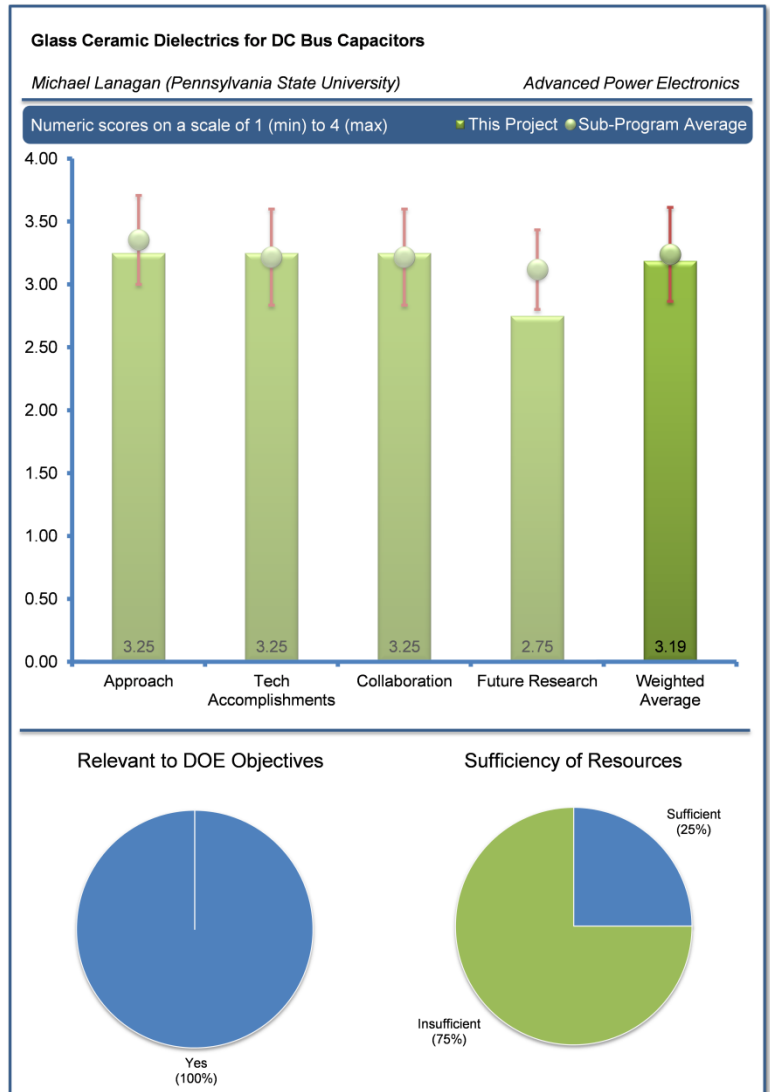
The reviewer commented that it was not clear from the presentation of the project's work, how the cost issue of capacitors is being addressed.

Reviewer 3:

The reviewer highlighted that leveraging suppliers of commodity available thin glass is an excellent approach for a PP replacement. The reviewer explained that the major barrier is how to get the suppliers of glass to provide thin enough material to compete with PP on a capacitance/volume basis. (Today the DC link suppliers are using 2.3-2.5 μm thick PP.) The reviewer described that using glass with a 200% improvement in permittivity, compared to PP, is possible. However, this reviewer asked whether the glass suppliers can provide a 6.6 μm thick glass to compete on a capacitance/volume basis with PP. The reviewer concluded by asking whether the supplied glass can provide a bend radius equal to that of PP.

Reviewer 4:

The reviewer applauded that it is outstanding that the researchers are taking advantage of the tremendous growth in flat panel displays to make a capacitor. The reviewer also thought that the approach of using Highly Accelerated Life Test (HALT) testing, to determine the viability, was extremely useful. The reviewer noted that the electrical performance potential is excellent. However, the mechanical performance has yet to be addressed. The reviewer noted that the flexibility of the glass has been shown, but not the ability to handle continuous vibration and shocks, such as are found in a vehicle. The reviewer expressed that this is not an insurmountable issue, but it will need to be addressed at some point.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that modest progress was made since last year due to minimal funding. The reviewer described that the project successes included: the materials passed the DC and alternating current (AC) electrical testing using painted palladium electrodes (replacing the previously used silver electrodes), and generated HALT data. The reviewer concluded by suggesting that the researchers need to migrate to vapor-deposited aluminum in order to be cost-effective.

Reviewer 2:

The reviewer commented that the pace is too leisurely, describing that the activities seem to have been done all serially, when they should have been done in parallel.

Reviewer 3:

The reviewer described that the work showed that a reliable glass-wound capacitor is possible. However, the reviewer suggested that it would be interesting to understand the compatibility issues of winding glass on the existing infrastructure used to wind PP. The reviewer asked several questions, including: whether the glass capacitor winding can be processed at the same rate as PP; whether there are handling issues that are unique to glass dielectric capacitors that could arise from the end spray or lead attachment process; whether clearing events cause other issues like fracturing the glass dielectric; and what rate of thermal shock can the glass based capacitors withstand.

Reviewer 4:

The reviewer reported that testing of the glass material for electrical performance and lifetime has shown the viability of the material as a high-voltage dielectric. The reviewer concluded that the results from the HALT testing indicate that the material choice was appropriate, and that it should become the choice for high-voltage/high-temperature dielectric material.

Reviewer 5:

Question 3: Collaboration and coordination with other institutions.

The reviewer explained that the collaboration plan is using the strengths of the team members. The reviewer believes that this team will meet the objectives of the project.

Reviewer 1:

The reviewer pointed out that the researchers are working with ANL, SNL, AVX, NEG, and Corning.

Reviewer 2:

The reviewer suggested that while there are a lot of capacitor industry partners, it may be beneficial to have an end-user partner to provide an end-user point of view. The reviewer also asserted that it would also seem reasonable that, with so many capacitor industry partners, the project team should be able to provide a relative cost for forming DC link capacitors made of glass, as opposed to PP and how that relative cost compares to the DOE 2020 targets. The reviewer asked whether that question has been asked of the partners.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that extrapolation of the life model to larger capacitors is critical. This reviewer also offered that understanding the impact of sodium impurity in glass on life is critical (sodium mobility). The reviewer explained that the investigation of the level of self-healing (if any) is very important for potential adoption of technology since the lack of self-healing will be a major obstacle. The reviewer concluded by stating that the researchers will likely will need to use vapor-deposited aluminum electrodes.

Reviewer 2:

The reviewer noted that technical understanding of this capacitor type is progressing, but indicated that other areas need to be worked in parallel; for example, cost understanding and manufacturing processes need to be explored.

Reviewer 3:

The reviewer observed that understanding the fundamental limitations of glass dielectric is important and needs to be done. If there is no fundamental limitation to the dielectric, the reviewer queried how the glass suppliers could be motivated to deliver a thin enough material to meet the cost, size, and performance targets set by the DOE.

Reviewer 4:

The reviewer stated that the researcher's future plans are appropriate; material life issues need to be identified and addressed and this is the plan.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer commented that high-temperature, low-DF dielectric will become critical should wide bandgap develop, since it operates at higher temperatures than insulated-gate bipolar transistors (IGBT). The reviewer expressed that glass is a viable potential solution if it can be shown to have self-healing capabilities, and can be adapted to high-volume manufacturing.

Reviewer 2:

The reviewer explained that the current PP DC link capacitors used in EDV power inverters are big, heavy, thermally challenged, and costly. As a result, finding a PP replacement will help to lower the cost of EDV inverters and help to enable the market for EDVs.

Reviewer 3:

The reviewer stated that the project addresses the least rate-able, largest, highest cost component in a high-temperature inverter.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that \$50,000 for Fiscal Year (FY) 2013 is only enough funding to cover one part-time resource.

Reviewer 2:

The reviewer remarked that no information was provided on the funding level of this project, but given the pace that the work is being done, it seems that funding must be very limited.

Reviewer 3:

The reviewer expressed that the funding level was insufficient, only because the major barrier is finding a supplier willing to supply glass thin enough to enable this technology.

Reviewer 4:

The reviewer commented that the progress is indicative of adequate resources, and that those listed are correct.

High Temperature Inverter: Ralph Taylor (Delphi Automotive Systems LLC) - ape012

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that this project is wrapping-up a very successful multi-year effort that involved requirements-based advanced technology development to fill critical gaps needed for high-temperature inverters. This involved high- and low-risk options that, for the most part, were realistic given the short time frame of the project.

Reviewer 2:

The reviewer commented that the project's basic approach is good; however, it is based on a two-sided cooling method. No data was presented that indicates that a two-sided cooling approach is more cost-effective than single-sided with more silicon (silicon is relatively cheap today). The reviewer described that the program was developing two capacitors for high temperature operation in reality, which provides backup in case of issues that are not solvable in the time frame. The reviewer pointed out that no mention was made of what had to be done to provide accurate current measurements across the current/temperature range. This reviewer concluded by asking what the efficiency of the unit was across the temperature range, and how much did it degrade at hot temperatures.

Reviewer 3:

The reviewer commented that there seems to be two approaches. One approach is a sequential process development (e.g., try one idea; see if it works; if not, try another; eventually, one reaches the target, or not). The other approach is a design-of-experiment, which presumes that everything can be held constant across the long-duration matrix. The reviewer asserted that both approaches are reasonable and that learning occurs in both, but only some few succeed.

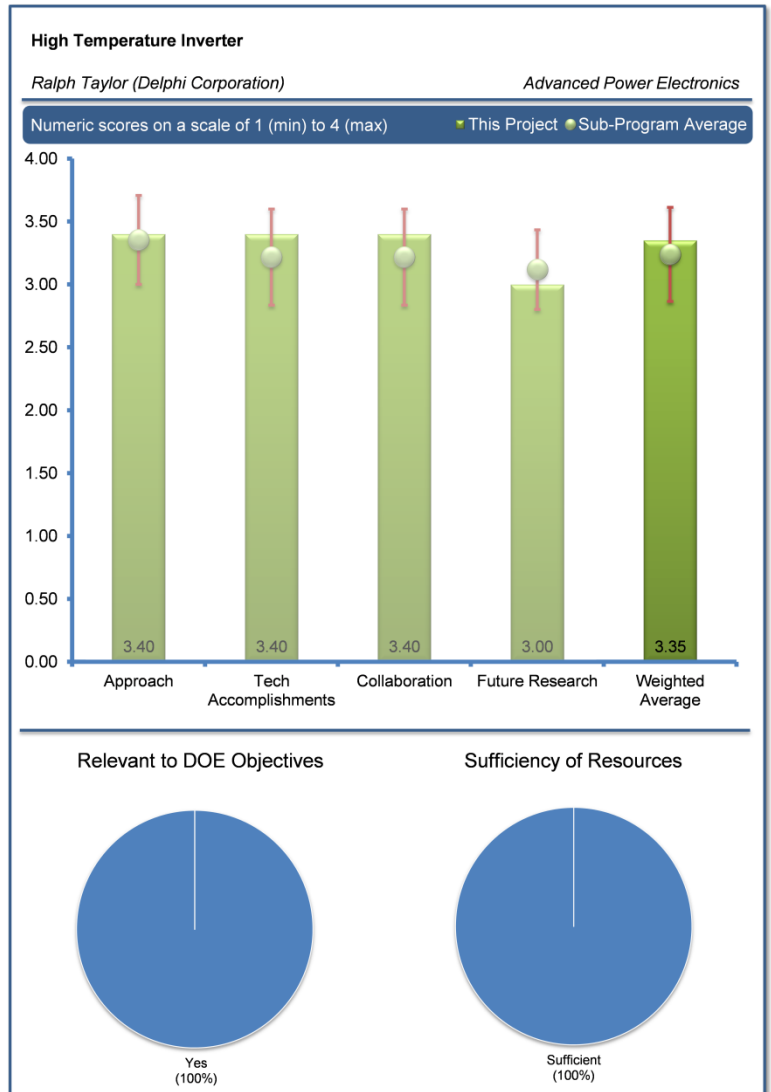
Reviewer 4:

The project has used different technologies to design and integrate high-temperature power inverters.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that the project has met the final milestone and delivered prototype power inverter to DOE.



Reviewer 2:

The reviewer applauded that the double-sided cooling package approach is outstanding and the project exceeded all expectations on this aspect. The reviewer explained that the silicon carbon (SiC)-on silicon (Si) wafers, proposed as a way to short-cut the time required to reduce cost of proven 4HN-SiC wafer manufacturing, is not viable. The reviewer understood that the project explored this route given the allure of the breakthrough performance that has been demonstrated with SiC and the frustration that many have with time-scale required to scale up manufacturing SiC material. The reviewer commented that the capacitor technology development has proven to be difficult, as expected, but the capacitor work represents significant technology advancement, with good probability of impacting high-temperature inverters. Ultimately, the reviewer concluded that the project has met its overall goal of developing a high-temperature inverter that meets DOE's targets.

Reviewer 3:

The reviewer provided a brief project work summary, stating that some ideas worked and some did not; some few parts passed; some of those are still working; overall, the cost or volume targets were not met; and the presenter stated the project team ran out of time. The presentation left the reviewer looking for conclusions. The presentation indicated the researcher did accomplish making a high-temperature inverter. The reviewer was unsure about the reproducibility when only some few worked, but acknowledged that this is in the early stage.

Reviewer 4:

The reviewer commented that, based on the presentation, the performance of the unit was demonstrated over temperature but the test conditions were not mentioned nor were performance numbers presented. The reviewer also expressed reliability concerns related to operating a board at 123°C with 125°C parts where there does not appear to be much of a margin. The reviewer explained that the team did work well together to resolve the technical issues that were faced. The reviewer also pointed out that the original schedule to complete the project in July 2011 was overly optimistic. The reviewer added that the project team realized that the presentation time is limited, but it would have been beneficial to see all of the required issues that had to be overcome (e.g., current sensors) to enable high temperature operations.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer offered that the project has collaborated with various component vendors and developers to identify the best suppliers.

Reviewer 2:

The reviewer indicated that the project performed very well in working with partners and collaborations in many areas including capacitors, cooling system technologies, and electrical and thermal modeling,

Reviewer 3:

The reviewer praised that the team did an outstanding job working together to solve technical issues, and that the use of failure analysis and process FMEA should prove very beneficial when transitioning to production. The reviewer reported that the process was used for both capacitor designs, as well as a Design of Experiments approach. The reviewer also stated that there was very good active teamwork.

Reviewer 4:

The reviewer commented that the project seems rather completely dependent on National Laboratories doing materials development of ceramic capacitors, which may be too research-focused for economic production.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the project will be completed this year.

Reviewer 2:

The reviewer indicated that, ultimately, the project has met its overall goals of developing high-temperature inverters that meet DOE targets by using alternate development pathways for each critical gap technology and appropriate down-selecting.

Reviewer 3:

The reviewer described that the development of the inverter was presented as complete, with the exception of the final report, but future work was described for the PLZT capacitor. The reviewer suggested that this should be moved to a separate project for that capacitor.

Reviewer 4:

The reviewer described that the future research plans include aerosol deposition with photonic sintering of PLZT materials; the reviewer cautioned that lots of novelty brings lots of risk.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the high-temperature power inverter is critical to the DOE VTO.

Reviewer 2:

The reviewer explained that high-temperature inverters will provide substantial system cost, weight, and volume benefits in HEV propulsion applications.

Reviewer 3:

The reviewer stated that high-temperature inverters have been discussed for a while, and this project demonstrated that such an inverter can be built. A complete cost tradeoff will be required (at the vehicle level) that clearly shows that this approach is viable in terms of cost and reliability, before it will be accepted by industry. The reviewer affirmed that this inverter can be used as a baseline for a high-temperature inverter, but that the cost of assembly needs to be included. This reviewer's opinion was that some of the solutions presented will be useful in a typical temperature range inverter to provide a lower cost solution through the use of these techniques to handle the thermal excursions from transient operation, while still requiring less Si for normal operation.

Reviewer 4:

The reviewer observed that electrification of vehicles tends to decrease the amount of petroleum and other fossil fuels used for transportation.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that work is ending.

Reviewer 2:

The reviewer believed that the resources were sufficient for the original plan, but due to the capacitor issues, the reviewer expressed that the resources were not sufficient to meet the original schedule. The reviewer highlighted that the fact remains that the goal of demonstrating a high-temperature inverter appears to have been met.

Reviewer 3:

The reviewer commented that the team has sufficient resources and partners to achieve the target.

Permanent Magnet Development for Automotive Traction Motors: Iver Anderson (Ames) - ape015

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the extensive effort reflects that the approach provides confidence, and that the technical barriers are being addressed extremely well.

Reviewer 2:

The reviewer explained that the project involves the development of new permanent magnet materials with reduced cost and improved performance. The first approach is the reduction of the most expensive component in rare-earth magnets (dysprosium) with a new single-stage hot deformation (SSHD) method to fabricate fully dense anisotropic magnets. The second general approach is the “Beyond Rare Earth Magnet” initiative in which AlNiCo materials are improved and completely new material compositions are synthesized. The reviewer indicated that the overall approach is very well-designed and could be extended, or changed, if necessary, depending on the intermediate results of the sub-projects.

Reviewer 3:

The reviewer reported that the researchers used a well-planned research approach that systematically dealt with a broad range of magnet types, covering near-term rare earth (RE) and non-RE magnets, as well as long-term non-RE. The reviewer pointed out that the project also uses theoretical modeling as well as experimental methods.

Reviewer 4:

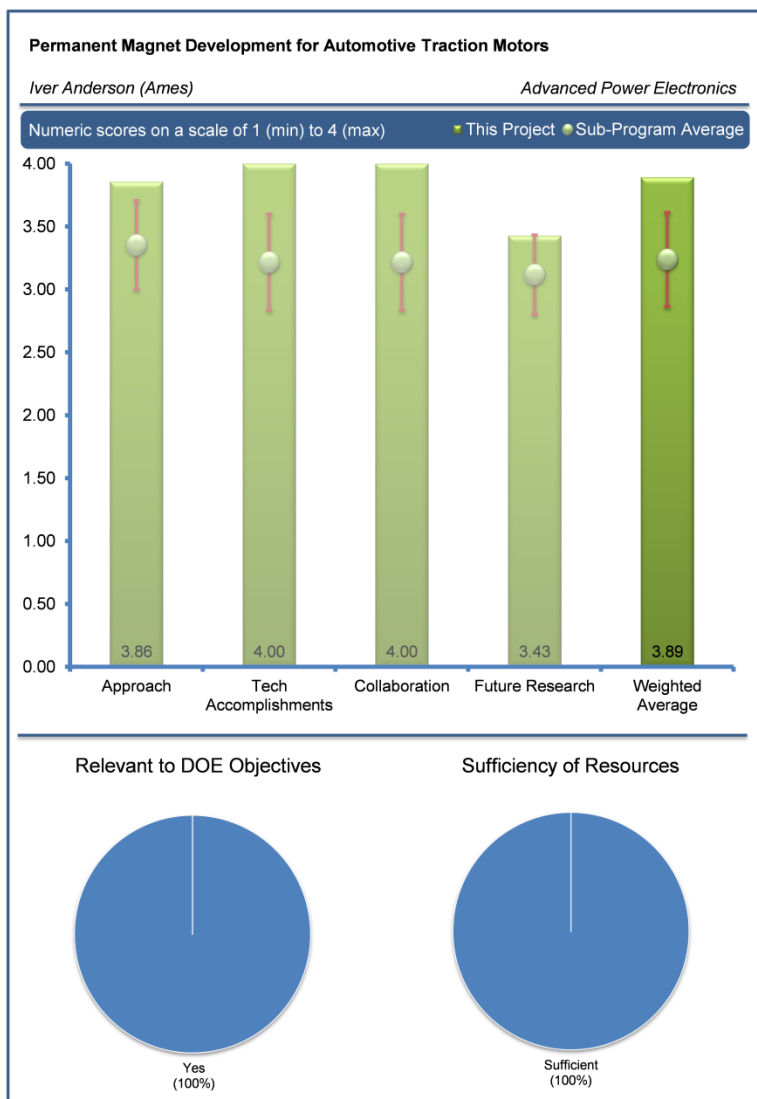
The reviewer indicated that, as could be said of all the motor development projects, the efforts are well-approached and seem to be highly collaborated by a select few. The reviewer also pointed out that the presenter is amazingly well-approached.

Reviewer 5:

The reviewer explained that reduced dysprosium and non-rare-earth work are both very important parts of this project. The reviewer applauded that the researchers have put much thought into the targets of the research to include the equivalent energy product (or flux density in the motor) at a relevant operating temperature.

Reviewer 6:

The reviewer summarized that the project approach is to develop new non-rare-earth, along with reduced-rare-earth, permanent magnet (PM) materials, which helps to ensure additional options in the near-term. The reviewer recounted that the reduction in



dysprosium, determined to be the most significant material in DOE's Critical Materials Strategy, is key to the reduced-rare-earth aspect of the project. The reviewer added that attention to both the material composition, as well as manufacturing steps, strengthens the approach.

Reviewer 7:

The reviewer warned that for the second milestone in September 2013, a more solid validation study is necessary before using Genetic Algorithm (GA) searching for the best structure based on computer simulations. The reviewer commented that the Principal Investigator (PI) showed a certain degree of agreement for a given structure from Slides 15 to 17; however, this does not mean the model is valid for exploring the new structure. As a consequence, the reviewer cautioned that the magnetic properties of the new selected Fe-Co-X alloys calculated from the model may mislead the material design.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that numerous publications have resulted from this work.

The reviewer asserted that significant work has been done with modeling, simulation, analysis, manufacturing, and other novel methods to improve the coercivity of AlNiCo, which will make it a viable alternative to rare earth magnets.

Reviewer 2:

The reviewer highlighted that a significant project achievement towards the improvement of rare-earth magnets is the development of a new single-stage hot deformation method to fabricate fully dense anisotropic magnets with reduced dysprosium. The reviewer described that this method could potentially replace the more expensive method, with two-stage hot deformation (hot press and die-upset forging) in commercial anisotropic magnets, to produce fully dense magnets. The reviewer suggested that, as a next step in this project, the potential cost savings should be quantified, if this is possible, at this point in time. The reviewer also reported that significant progress has been made in the "Beyond Rare Earth Magnet" initiative, with the improvement of AlNiCo magnet materials. Commercial AlNiCo materials have been characterized, and pathways for improvements in composition and manufacturing were determined. A first pre-alloyed AlNiCo8H gas atomized powder sample was produced and tested on a hysteresis graph, and it shows a lot of potential, even though the process is not optimized at this point in time. The collaboration with an electric machine supplier, which is developing a new AlNiCo PM machine concept, will guide the work on both sides in the right direction. Lastly, the reviewer mentioned that the theoretical and experimental investigation of Fe-Co systems shows some promise, but the research is still in an early stage.

Reviewer 3:

The reviewer reported that the presenter showed very good progress with understanding AlNiCo structure and mechanisms for improvement. Also, the reviewer indicated there was very good use of modeling to investigate the potentially high energy product of non-RE alloys.

Reviewer 4:

The reviewer explained that this program topic was initiated with great urgency because of rare earth material costs. The reviewer highlighted that even though rare earth material markets have stabilized, this program has continued on this aggressive path and has demonstrated a very real potential that will not be as dependent on rare earth material markets.

Reviewer 5:

The reviewer observed that the demonstration of higher coercivity is positive (reduced dysprosium magnets), although processes that improve performance across a wide temperature range are needed. The reviewer suggested that it would be helpful to concentrate more on accomplishments that can be understood by non-experts, even if it means oversimplifying the research details. The reviewer described that it was useful to see that structure and roles of the different elements are being closely scrutinized.

Reviewer 6:

The reviewer reinforced that there is sufficient information provided for assessing this project, and that the technical accomplishments and progress meet the overall project and DOE goals and objectives.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer explained that a number of research organizations and universities are collaborating on this project, with the Ames Laboratory as a lead. The reviewer reported that the assignment of the separate tasks seems to be based on the specific expertise of the research organizations and is thus well-coordinated. The reviewer concluded by mentioning that collaborations with electric machine suppliers are aiding with specific focus on the permanent magnet material improvement needed for the different electric machine design concepts.

Reviewer 2:

The reviewer described that the presentation showed a very good use of the collaboration partners to explore a wide range of topics, and in an organized manner.

Reviewer 3:

The reviewer described that, as was obvious just among the presenters, this topic is well-collaborated (which the reviewer will repeat over again); however, the Ames Laboratory is at the front and center (lead).

Reviewer 4:

The reviewer commented that the project collaboration is broad, and it included a variety of institutions and experts that looked at the research issues from different angles. The reviewer clearly observed that the researchers are acting upon input from the collaborators.

Reviewer 5:

The reviewer highlighted that this project has extensive collaboration with its academic and industrial partners. Several other DOE-sponsored projects that were presented during the review included the materials and emerging results from this work. The reviewer noted that new grades of AlNiCo are fostering new motor designs, which leverage their best properties.

Reviewer 6:

The reviewer indicated that sufficient detail was provided on what contributions are being made by each of the collaborators, and that there are no issues identified with any of the collaborators.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported that the project has well-defined milestones and that the plan for FY 2013 addresses the right issues. The reviewer expressed that the future research plans are based on the past progress, and that the barriers were identified as well as possible.

Reviewer 2:

The reviewer simply noted that the future work plan clearly builds on the success of the work to date.

Reviewer 3:

The reviewer acknowledged being unknowledgeable, perhaps, as to the needs that may remain.

Reviewer 4:

The reviewer expressed that the work is headed in the right direction, which bodes well for future research. The reviewer suggested that it would help to have more tangible goals (e.g., target magnet parameters) to allow industry to evaluate the impact of the new magnets may have on future motor designs. The reviewer suggested that even a rough idea of the possible improvements is helpful.

Reviewer 5:

The reviewer described that the further planned improvements in the coercivity of AlNiCo may make it a viable substitute to NdFeB magnets. The reviewer added that an ambitious plan was laid out for FY13.

Reviewer 6:

The reviewer observed that the proposed future work plan supports the project's objectives with adequate details.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer explained that the project supports the objective of petroleum displacement by developing non-rare earth magnet materials. The reviewer added that, if successful, these new materials would reduce the cost of PM machines, which would also enable a faster market introduction of HEVs and EVs.

Reviewer 2:

The reviewer affirmed that a sustainable supply of inexpensive, high energy product magnets is essential for low-cost, high-efficiency traction motors in HEV and EV applications.

Reviewer 3:

The reviewer expressed that reducing the reliance upon rare earth materials will allow for more stable electrified vehicle cost projections, thus allowing OEMs greater predictability of costs which will allow for market growth.

Reviewer 4:

The reviewer stated that alternatives to RE materials are important to the DOE's objectives, especially to those that retain the efficiency advantages of RE-PM motors.

Reviewer 5:

The reviewer summarized that the project will help reduce the cost of high-performance electric machines and ensure a steady supply of the included permanent magnets, while also reducing their price fluctuation. The reviewer emphasized that these machines are key components in HEVs which have demonstrated the capability to reduce fuel consumption. This work is especially critical to develop substitute non-rare-earth and reduced-rare-earth permanent magnet materials for future electric machines. The reviewer pointed out that this work is especially critical, considering the potential for supply disruption, cost fluctuation, and increased demand from new HEV and wind turbine applications.

Reviewer 6:

The reviewer indicated that statements in the presentation are positive that the work supports the overall DOE objectives of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer reported that the presenter did not comment on any difficulties on resources.

Reviewer 2:

The reviewer expressed that the project has sufficient resources for the defined tasks.

Reviewer 3:

The reviewer acknowledged a lack of knowledge in this area to comment.

Reviewer 4:

The reviewer expressed that the team that is working on this project, is appropriate and sufficiently diverse to create useful outcomes.

Reviewer 5:

The reviewer commented that the project is going very well; a lack of resources is not apparent from the presented material.

Air Cooling R&D: Jason Lustbader (National Renewable Energy Laboratory) - ape019

Reviewer Sample Size

A total of two reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer expressed that the approach determined feasibility before proceeding with the design and construction. The reviewer noted that this is a well thought out presentation.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer explained that the prototype data confirmed that air-cooled inverters were possible, and so the concept was proven to be feasible.

Reviewer 2:

Question 3: Collaboration and coordination with other institutions.

The reviewer indicated that this is a good team, but felt that a vehicle manufacturer should be added to the team to get industry input. This reviewer suggested that this would help the project to become easier to manufacture and get industry acceptance.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

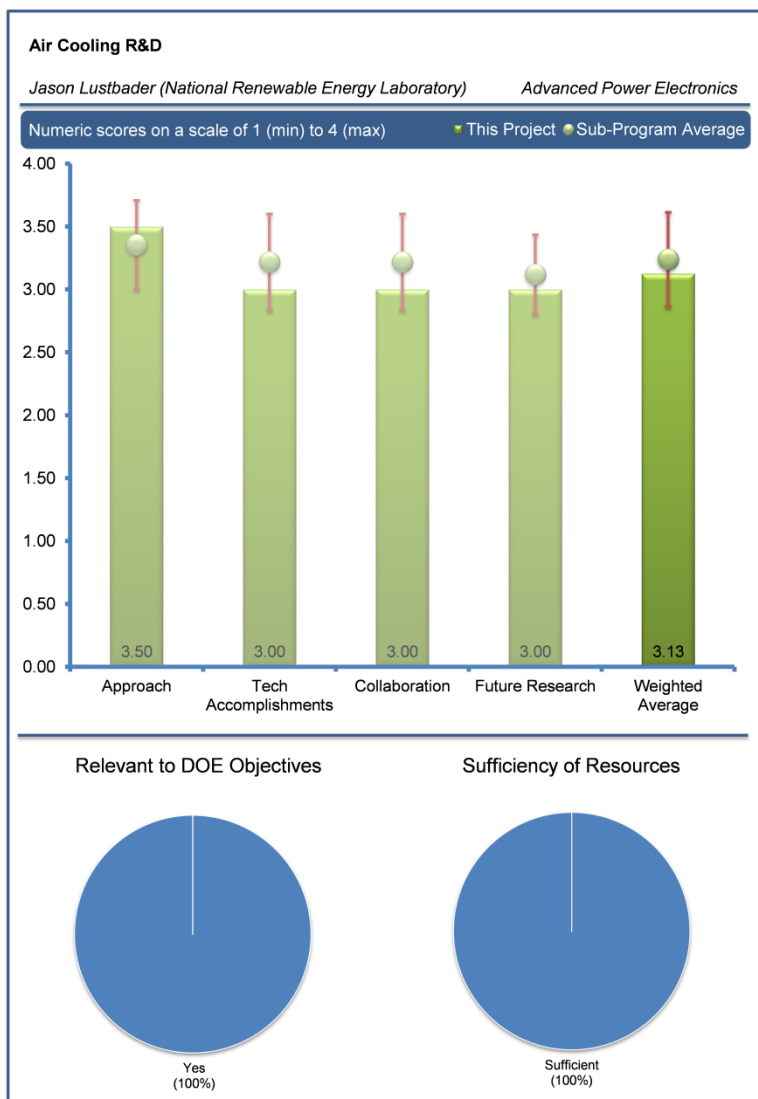
Reviewer 1:

The reviewer suggested that future work should produce a proof-of-concept of a working prototype and address practical application issues.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer observed that this project is very relevant to future wide-band applications because cooling requires significant energy that reduces the EV drive efficiency.



Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Characterization, Modeling, and Reliability of Power Modules: Allen Hefner (National Institute of Standards and Technology) - ape026

Reviewer Sample Size

A total of three reviewers evaluated this project.

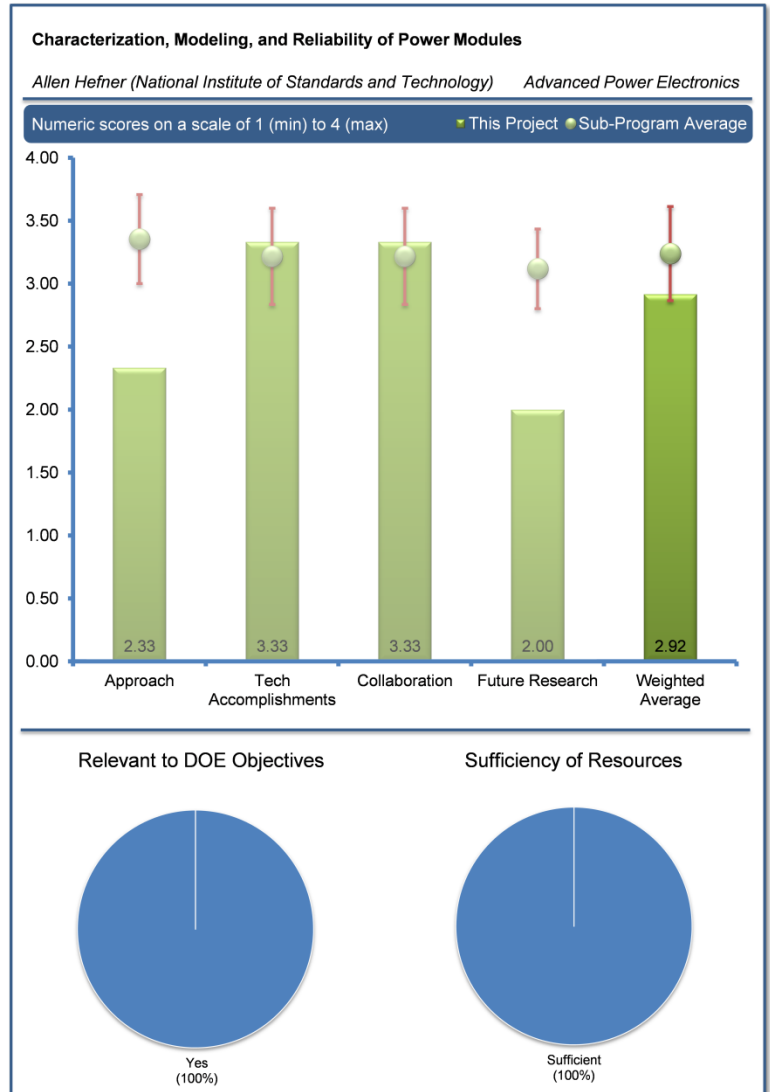
Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that certain items were deleted from original plan, and it was not clear why the items were deleted. The reviewer noted that the combination of making experimental test fixtures, and then modeling those fixtures, is desirable.

Reviewer 2:

The reviewer warned that the scope of the work seems to be too broad. The reviewer expressed a need to see a focus on identifying and understanding the vehicle thermal transient conditions effect on coolant temperature and ambient air. The reviewer also pointed out that component operating temperatures are dependent on the control strategy, which varies from vehicle to vehicle and from manufacturer to manufacturer.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the presenter had shown an interesting development for estimating the interior temperatures of metal–oxide–semiconductor field-effect transistors (MOSFET). The reviewer added that many parts of the simulation have come from other programs, so it was a little hard to detect which accomplishments are due to the present program. The reviewer admitted, however, that this is the nature of simulation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that the researchers have interfaced with other programs.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer cautioned that although the plans seem responsive to program needs, the plans seem broad and unfocused based on the presentation. The reviewer then noted relevant technologies included in the research plan, including the following: WBG; interconnect; electromagnetic interference; and bi-directional vehicle chargers.

Reviewer 2:

The reviewer cautioned that this work is too focused on specific devices, yet it was not clear to the reviewer that the simulation results will reflect real driving conditions. The reviewer suggested that understanding the physics of materials and packaging is more important than these particular applications. Also it seemed to the reviewer that several projects work that seems to be overlapping. The reviewer did not see was a clear understanding of what events during vehicle operation are creating stressful events for the electrification components and what the events characteristics look like.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer acknowledged that the electrification of vehicles will tend to decrease the use of petroleum for transportation.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Development of SiC Large Tapered Crystal Growth: Philip Neudeck (National Aeronautics and Space Administration) - ape027

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that this is deep-think work to address the very important problem of single crystals of 4H SiC. In spite of the many headaches, the reviewer found indications of the potential to operate. However, the timeframe of this project will not allow it to move far enough forward. Still, the reviewer acknowledged that the work is good and expected more in the basic funding area.

Reviewer 2:

The reviewer explained that the interest in the alternate SiC crystal growth method proposed, as a way to short-cut the time required to reduce the cost of proven 4HN-SiC wafer manufacturing, is understandable given the allure of the breakthrough performance that has been demonstrated with SiC. However, the reviewer cautioned that the new approach of this project is based on theoretical goals alone, without significant results that would indicate feasibility.

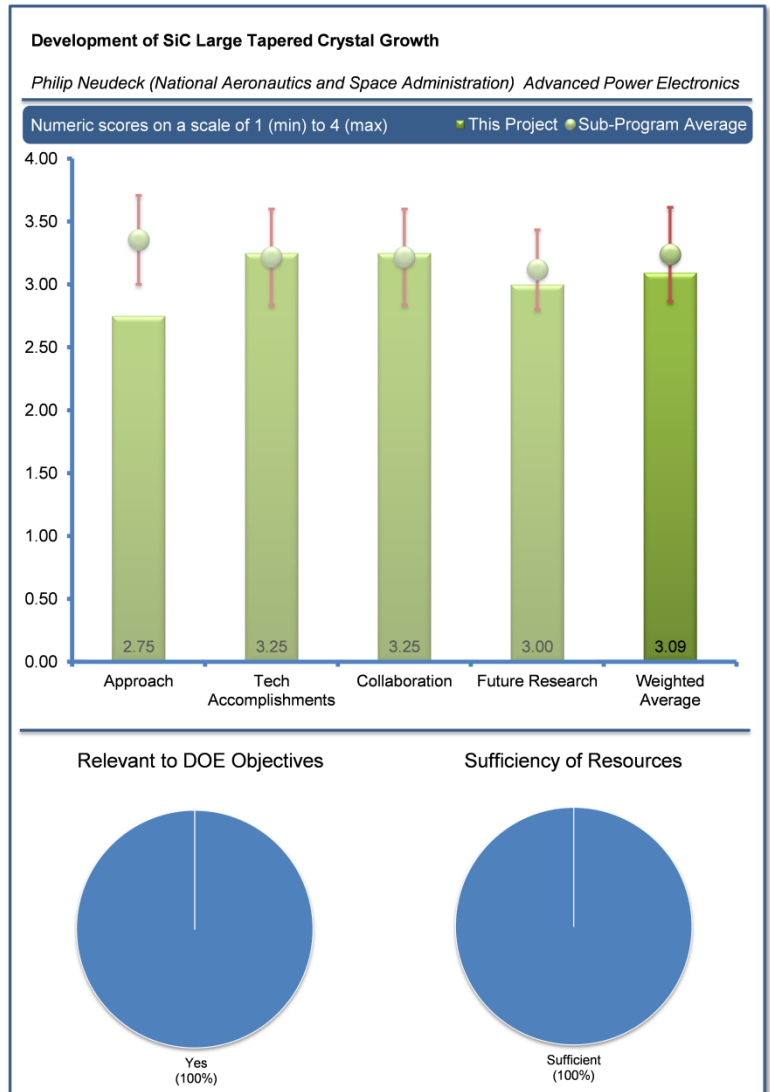
Reviewer 3:

The reviewer noted that the approach of this program seems to have morphed from the original objectives. The reviewer understood that this is a natural result of the research and development (R&D) results. The reviewer also expressed that the project is important and that the new approach supports the final longer-term objectives. However, the reviewer also opined that the project should re-evaluate what can be accomplished within the next seven months.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer praised that the project's technical accomplishments are great, and that it is nice to see progress on alternative development when the original accomplishments cannot be met. The reviewer expressed that progress will increase with the National Aeronautics and Space Administration (NASA) supporting it as a long-term project. However, the reviewer cautioned that there still need to be milestones and deliverable dates to avoid prolonging.



Reviewer 2:

The reviewer offered that it seems like a very reasonable amount of progress for a new critical materials development, but the work is not there yet, and the project is ending. The reviewer opined that the project objectives were idealistic, so falling short of meeting those objectives should not have been unexpected.

Reviewer 3:

The reviewer described that the project is growing some SiC crystals and is characterizing the material, but the reviewer criticized that the quality of the material is very poor and there is no indication that this will improve.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer remarked that the collaboration seems to be working well with analytical work in other laboratories.

Reviewer 2:

The reviewer asserted that the comprehensive team seems to be sufficient; however, the reviewer thought that it would be good to include more National Laboratories (if any are doing any of this kind of work). Also, the reviewer asked whether there are other companies, such as Dow, that could help with technical assistance and possibly funding.

Reviewer 3:

The reviewer affirmed that the project is coordinated with material scientists' need to characterize material, etc., but even if successful, the reviewer cautioned that this project would not have coordination points with other VTO projects for the foreseeable future.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer expressed that this research is poised to answer the feasibility of further development. The reviewer also expressed that the NASA funding seems likely to allow some future progress, but that this is a new front of development.

Reviewer 2:

The reviewer noted that the proposed future work is fine, but was confused as to which future work is going to be done through 2013 (through the DOE funding), and which work will be done independently (without DOE funding). The reviewer suggested that it would be beneficial to make that more clear, or to align them. The reviewer also suggested that adding years, when the project looks to accomplish future research, would be helpful.

Reviewer 3:

The reviewer reported that the project has multiple alternate methods to produce the fiber and the epitaxial growth. The reviewer added that the project continues to innovate, but also expressed that there was little indication that the project will be successful.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer commented that electrification of vehicles will decrease dependence on petroleum fuels, and that lower cost SiC will be helpful.

Reviewer 2:

The reviewer commented that, if successful in the long-term, this project has the potential to dramatically improve many of the crystal-affected industries, and not just the automotive industry.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the project team seems to have sufficient resources that may increase due to NASA money; however, the reviewer did not believe that the objectives will be met by the end of the program (2013).

Reliability of Bonded Interfaces: Doug DeVoto (National Renewable Energy Laboratory) - ape028

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that the interface, thermal interface material (TIM) or bonded interface material (BIM), between a power package and a heat sink is a limiting factor to the overall system thermal performance. As such, evaluating, TIMs or BIMs, to improve that interface performance, by testing and developing models that can predict their life, can be a valuable tool for the design of future EDV power electronics. The reviewer confirmed that the modeling holds the promise of shortening the testing time of materials, which can enable shorter time to market for EDV inverters and converters with improved thermal performance.

Reviewer 2:

The reviewer described that this project is addressing one of the barriers to developing a low-cost, reliable inverter for the transportation industry. The reviewer indicated that the method of attaching the die to substrates and to heat sinks is an important issue that must be solved for each application in a low-cost manner. The reviewer observed that this project is addressing the limitations of various types of bonding methods and that it should provide valuable insight into the strengths and weaknesses of each method, and hopefully help solve the weaknesses.

Reviewer 3:

The reviewer stated that the approach is logical and sound.

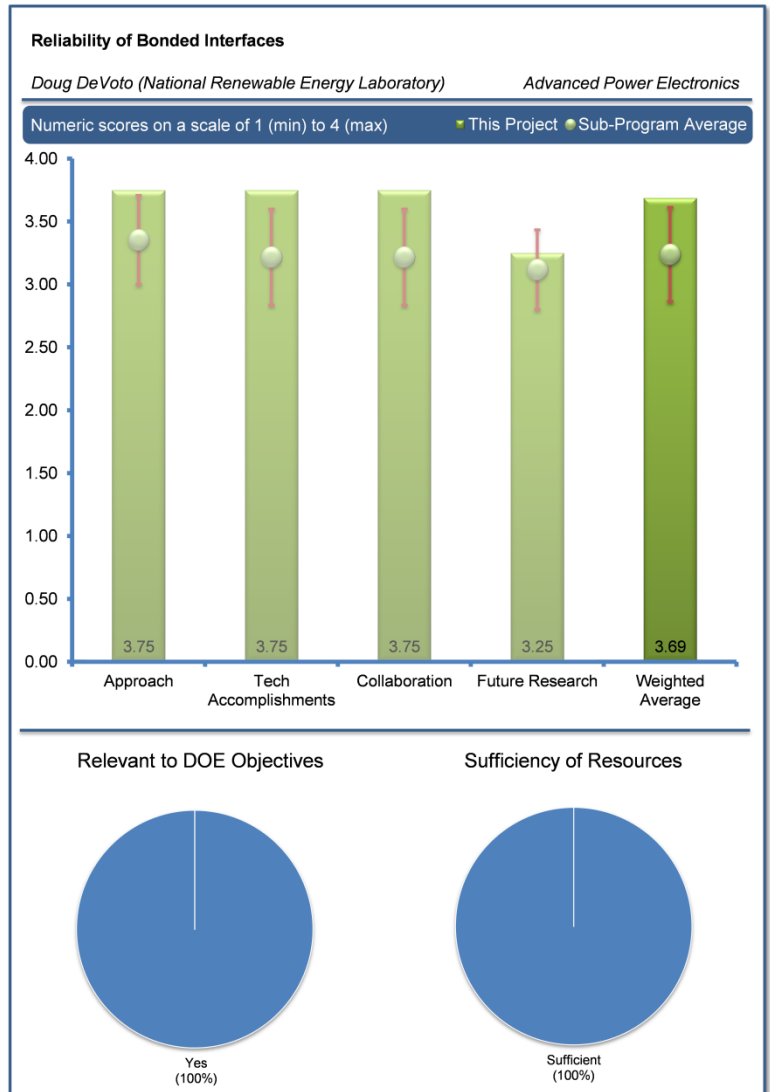
Reviewer 4:

The reviewer suggested the researchers need to look at other elements of creating a BIM.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer expressed that the progress towards understanding the manner in which the various bonding methods fail has been outstanding. The reviewer expressed that the use of modeling, followed by accelerated testing, is appropriate; defining failure limits up front was a requirement. The reviewer realized that lead-based solder is not acceptable now, but asked if it provides a good baseline to work from with years of use behind it. The reviewer concluded by stating that the choice for baseline was appropriate.



Reviewer 2:

The reviewer noted that the technical progress was good, but expressed that more comparisons were required to select the best bonding method.

Reviewer 3:

The reviewer stated that the modeling agrees with the tested results and is on track. The reviewer asked whether the researchers can take the next step and define the material properties for a BIM or TIM that will meet the stated performance targets.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer concluded that the collaboration was excellent with significant experts in the field being consulted.

Reviewer 2:

The reviewer simply noted that the project appears to be well-coordinated.

Reviewer 3:

The reviewer remarked that the project collaboration with team members appears to be very good to excellent; excellent regarding the involvement of team members assisting with the processes required to properly use their bonding material. It was not clear to the reviewer if the team members are being used to assist in identifying failure root causes for those that fail, but this reviewer would like to see the team members involved in this to improve their products.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer opined that this project is important in the future to determine the best bonding for high-temperature WBG applications.

Reviewer 2:

The reviewer reported that the future work is in-line with what is currently being done. The reviewer asked whether the work can be expanded such that, based on the BIM or TIM's material properties, the BIM or TIM will meet the stated performance targets. Restated another way, the reviewer asked whether the material properties can be defined to enable a BIM or TIM to meet the stated performance targets.

Reviewer 3:

The reviewer confirmed that the proposed plan for next year is a logical extension of the current program. The reviewer would like the research team to add tasks related to the required plating quality of the substrate/heat sink, and to develop a standard for what is good enough. The reviewer indicated that experience has shown that plating quality has a large impact on the reliability of the bond joint.

Reviewer 4:

The reviewer suggested that other areas that contribute to the quality of the BIM need to be investigated in greater detail. For example, the manufacturing process and plating are critical to yielding high quality joint, and therefore, these areas need greater understanding and definition.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer agreed that this is an important project because bonding significantly affects the reliability and acceptance of EVs and bonding is one of the major reasons for industry electrical failures.

Reviewer 2:

The reviewer explained that this project can provide a tool to help increase the bonded interface reliability while at the same time, improving performance. The reviewer commented that better thermal performance of the bonded interface between the power package and the heat sink can increase power device reliability, possibly enable a smaller silicon (lower cost), or allow the EDV power electronics to operate at higher coolant temperatures (no secondary coolant loop, possible lower cost). This lower cost and improved reliability will help to enable the market for EDVs and lower our dependence on foreign oil.

Reviewer 3:

The reviewer reinforced that every inverter has devices that require bonding, and this project is solving issue with the various bonding methods. The reviewer felt the project should result in lower costs overall.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer offered that there were adequate equipment and testing done for the scope of this project.

Reviewer 2:

The reviewer reported that the project results indicate that resources are sufficient to meet the program schedule.

Reviewer 3:

The reviewer noted that the team, with its partners, is well-coordinated and on track.

Electric Motor Thermal Management: Kevin Bennion (National Renewable Energy Laboratory) - ape030

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer described that the approach, as presented, provides sufficient detail identifying the degree to which the technical barriers are being addressed. The project is well-designed, feasible, and integrated with other efforts addressing the barriers.

Reviewer 2:

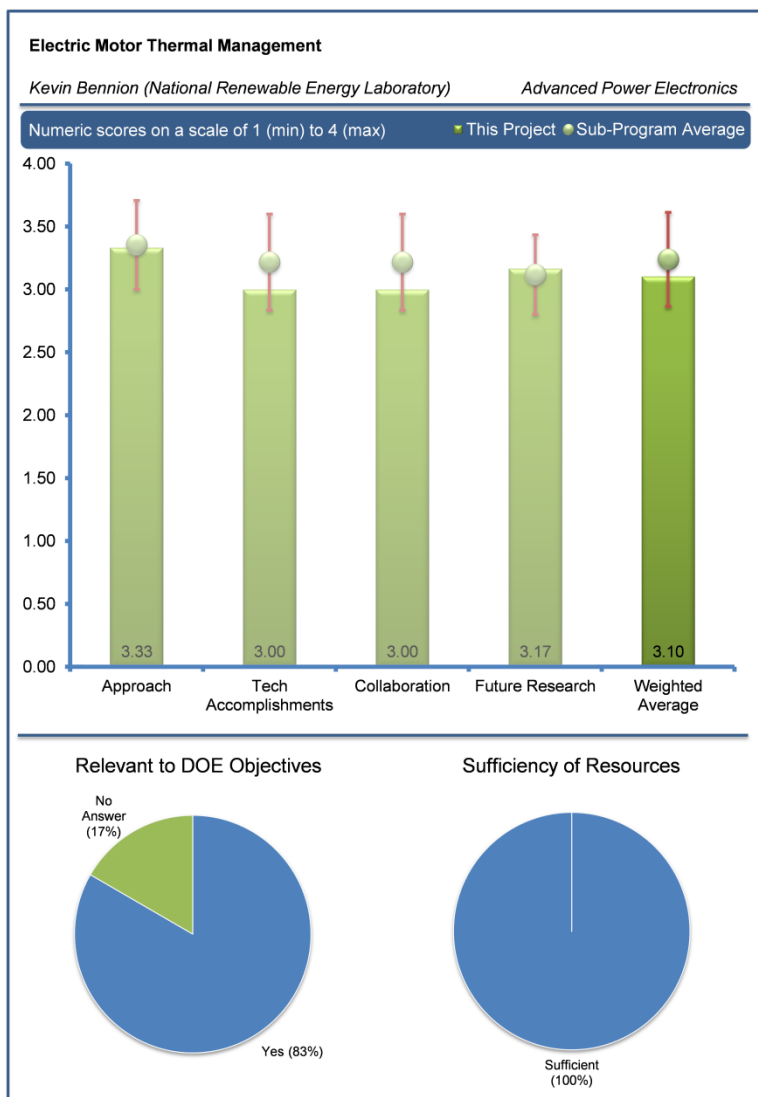
The reviewer explained that the project conducted a cooling parameter sensitivity analysis for electric machines, both with experiments and simulations. The approach consisted of thermal finite element analysis (FEA) modeling for concentrated winding PM machines, and will be extended to induction machines in collaboration with another National Laboratory. The reviewer mentioned that the research was extended within the last year to investigate oil impingement cooling which is a very effective means of active cooling that is used elsewhere in the automotive industry. Therefore, the reviewer felt that a better understanding of this cooling technique is of high interest for automotive applications. The reviewer agreed that the overall research approach is well-designed and the technical barriers and limitations of the simulations models and test procedures were identified.

Reviewer 3:

The reviewer described that as thermal management of motors is a very diverse topic, it is a challenge to cover it all. The reviewer observed that the plan for this project wisely does not try to address everything, but rather focuses on the motor and cooling topologies and winding types that are most relevant to HEV and EV traction motors. The reviewer expressed that the researchers have covered these selected topics systematically, using both modeling and experimental approaches. The reviewer appreciated the clear aim to assist machine designers with the outcome of this research.

Reviewer 4:

The reviewer expressed that one of the main keys of the advanced motor development is to reduce size and cost of motors and improve performance; this project addresses this key issue. The reviewer added that the project's passive thermal design elements are a unique enabler.



Reviewer 5:

The reviewer affirmed that passive cooling, stator cooling jackets, and oil impingement are all relevant cooling techniques. The reviewer observed that studying these baselines, and their implications, are useful for the analysis and ultimate selection of the best cooling techniques for a given motor.

Reviewer 6:

The reviewer opined that the PI did not address the objectives very well as listed in Slide 4. First, the reviewer asked how the researchers quantify opportunities for improving cooling technologies for electric motors. The reviewer criticized that this objective is very vague and left the reviewer unable to judge the accomplishment of this objective. Second, the reviewer asked how the thermal improvements were linked to their impact on the Advanced Power Electronics and Electric Motors (APEEM) program targets. The reviewer asserted that the PI does not clearly address this issue either qualitatively or quantitatively. The reviewer indicated that the third objective was to increase information related to motor thermal management in open literature. The reviewer asked whether this should be a natural by-product of the project, and suggested that it is not appropriate to be treated as an objective. Additionally, the reviewer reported that no validation experiment was reported in Slide 12, other than the finite element analysis, which makes the findings relatively weak.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that the technical accomplishments are good and the results are important for the improved design of electric machine cooling techniques. The reviewer reported that thermal sensitivity analyses were conducted for different PM machines and their passive thermal design elements (e.g., for contact interfaces between slot liner and copper wire and laminations). The reviewer also described that an experimental set-up was implemented for the evaluation of transmission oil impingement cooling, and initial tests have been conducted. The reviewer noted that this part of the work is still in an early stage but will hopefully lead to interesting results.

Reviewer 2:

The reviewer acknowledged that good progress was made on FEA thermal and loss models. The reviewer also noted that very useful data regarding thermal resistances in the motor and parametric sensitivities, particularly for cross-slot thermal conductivity, was collected. The reviewer applauded the excellent and very original work on experimental measurement of convection coefficient for oil cooling.

Reviewer 3:

The reviewer offered that the technical approach is based on sound FEA, and appears to be correct.

Reviewer 4:

The reviewer commented that the analysis and test setups are useful, and it will be important that the researchers work with motor design experts to check the manufacturing and motor loss assumptions. The reviewer observed that the tasks and accomplishments, thus far in the program, are on target relative to industry usefulness.

Reviewer 5:

The reviewer stated that the technical accomplishments and progress, as stated, meet the overall project and DOE goals and objectives.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer pointed out the good use of the University of Wisconsin-Madison for modeling efforts and industry collaboration, and to make sure the most relevant topics are addressed and deliverables are useful to designers.

Reviewer 2:

The reviewer remarked that like all of the other motor research programs, the researchers appear to be well-collaborated with other National Laboratories and universities (e.g., University of Wisconsin-Madison).

Reviewer 3:

The reviewer commented that there are no issues identified with any of the collaborators, and that sufficient detail was provided on what contributions are being made by each collaborator.

Reviewer 4:

The reviewer indicated that the project includes one university collaborator, but no industry collaborators, even though industry feedback is being used to influence the research activities.

Reviewer 5:

The reviewer indicated that the researchers are collaborating with another National Laboratory and a university on this project. The reviewer observed that the collaborators' contributions are mainly in the area of electric machine design support. The reviewer criticized that, although it was mentioned that there has been some discussion with automotive OEMs, it seems that this area is still a weak point for the project. In the end, the reviewer reinforced that the goal should be that the developed simulation tools and experimental results are used by the OEMs for the improvement of their electric machine designs.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the proposed future work plan is consistent with the project objectives, with adequate details and specificity in supporting this assessment. The reviewer suggested that the rectangular wire cross-section discussed on Slide 15 may offer opportunities for future research work.

Reviewer 2:

The reviewer stated that the project will be finished in FY 2013 and the milestones for this year are well-defined. The reviewer described that the extended project scope to oil-cooled machines is a very good choice, as this cooling technique is of great interest for the industry due to the significant machine performance improvement. The reviewer also mentioned that the collaboration with the Oak Ridge National Laboratory (ORNL) will be beneficial for both projects.

Reviewer 3:

The reviewer reported a logical plan to build on previous work, and add thermal interface resistance measurements.

Reviewer 4:

The reviewer expressed that in this case, it is more important to continue the research into the project depth, rather than spawning new areas.

Reviewer 5:

The reviewer suggested working with industry on the inputs to the analysis and test work. For example, selecting realistic wire fill factors for motors, understanding the loss effects of bar windings (e.g., skin effect and the increase in AC losses that are caused by large winding cross sections), and the reduced loss effects of twist windings due to balanced flux linkage across all conductors (especially applicable for concentrated winding motors). The reviewer suggested that all of these items are motor loss issues that may not be known by thermal researchers.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer explained that the project supports the objective of petroleum displacement by improving the thermal performance of electric machines. If successful, this improvement would result in smaller machines with higher power density, which would enable a faster market introduction of hybrid and electric vehicles.

Reviewer 2:

The reviewer explained that improved thermal management in motors reduces the need for dysprosium in RE magnet motors and provides higher continuous output power density; both contribute to the adoption of HEVs and EVs.

Reviewer 3:

The reviewer commented that any improvements in the marketable feasibility of the motors for EVs will improve their viability and market acceptance, thus displacing oil.

Reviewer 4:

The reviewer indicated that the statements in the presentation are positive, and that the work supports the overall DOE objectives of petroleum displacement.

Reviewer 5:

The reviewer noted that thermal management affects the performance and cost of electric propulsion motors.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer noted that the presenter did not comment on any difficulties on resources.

Reviewer 2:

The reviewer stated the project has sufficient resources for the defined tasks.

Reviewer 3:

The reviewer offered that the resources and logical progression of the program are on target to achieve program milestones.

Interim Update: Global Automotive Power Electronics R&D Relevant to DOE 2015 and 2020 Cost Targets: Christopher Whaling (Synthesis Partners) - ape032

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer highlighted that this work is critical for understanding the industry trends. The reviewer observed that the researchers have done a very good job in compiling the data.

Reviewer 2:

The reviewer described that this kind of evaluation is different from experimental presentations. The reviewer cautioned that opinions of the speaker are influenced by analogies to examples that are far afield from the immediate data collected. The reviewer described that there is some structure in the choice of (foreign) paired companies and single, vertically-integrated companies, for study, which is a good approach.

Reviewer 3:

The reviewer noted an understanding from the presentation that a standardization of requirements is needed to reduce overall costs. The reviewer inquired about recommendations for achieving standardization [e.g., Society of Automotive Engineers (SAE) committees], as well as what could motivate the OEMs to do such a thing.

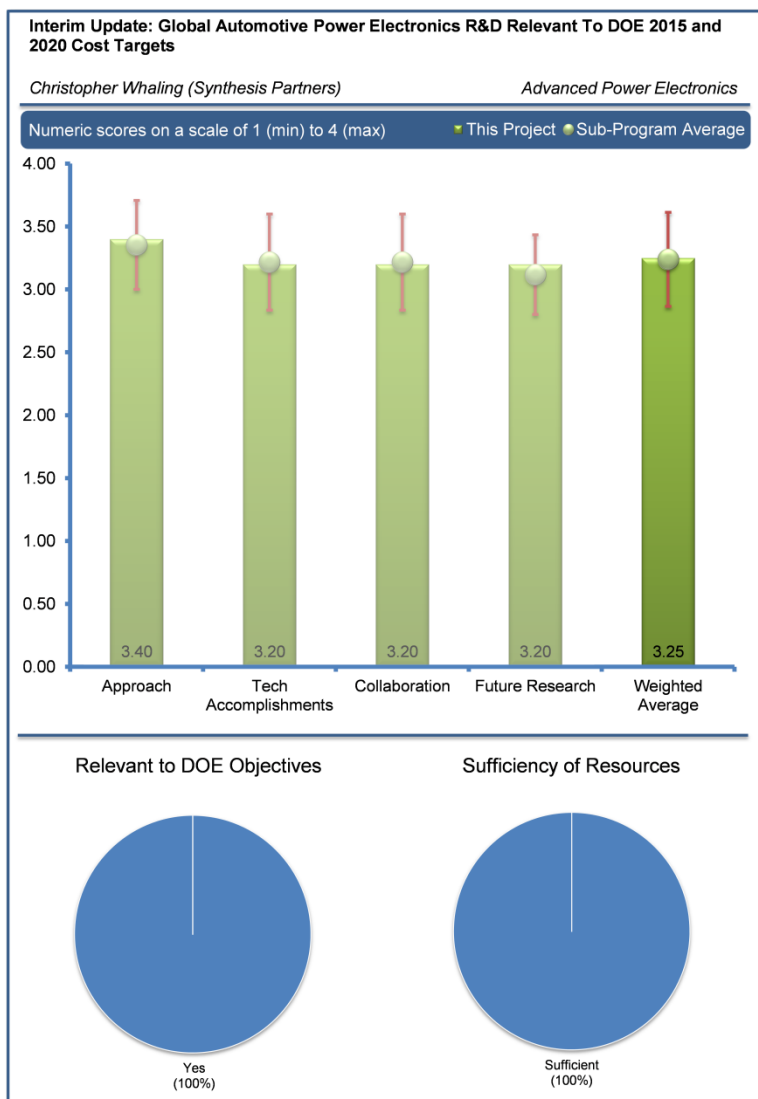
Reviewer 4:

The reviewer summarized that project has used several approaches to find and analyze, the information related to global automotive power electronics. The reviewer suggested that the project may invest more resources on other important components, such as switches and capacitors.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer explained that the project has gathered a lot of very useful information related to global automotive power electronics, and has provided a clear picture of the manufacturing and R&D.



Reviewer 2:

The reviewer described that the project accomplishments include data collection, which cannot be revealed due to licensing constraints placed by the information providers to the speaker. The reviewer also mentioned that the speaker reached some conclusions. For example, the DOE program cost goal will not be met without a radical change, presumably to some hub- or vertically-integrated structure.

Reviewer 3:

The reviewer asserted that it is very difficult to reduce thousands of pages of reports, timelines, technology road maps, business projections, etc. into a few relevant slides; but noted that the presenter made it work and interesting. However, the reviewer inquired as to who is responsible, or willing, to act upon the presented recommendations. The reviewer suggested that perhaps holding a workshop to bring OEMs together on EDV standards might be a starting point. The reviewer opined that from Slide 12 of the 2012 presentation (discussing technology road maps), if the road map does not support investment decisions, then it is not a good technology road map. From Slide 22 of the 2013 technology road map timeline, the reviewer did not see any investment decisions that enable the projected technologies. The reviewer also asked about the significance of the varying size and color boxes along the X-axis of the graph.

Reviewer 4:

The reviewer indicated that it was difficult to know the accuracy of the presented results. The reviewer, however, was not sure what else could be done to provide legitimacy to the findings.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer reported that many companies have contributed data for the study, which is evidence of collaboration. The reviewer explained that the information cannot be shared, which makes the product of the collaboration to be a bit obscure.

Reviewer 2:

The reviewer indicated that the researchers have talked to everybody, but suggested that perhaps the researchers should consider talking/working with the SAE to see how to establish standards committees.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the work will continue, and highlighted that more China input is going to be valuable.

Reviewer 2:

The reviewer commented that continuing what the researchers are doing regarding standards is informative and that the researchers suggesting what should be done is also interesting. However, finding a way to make it happen would be great.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer explained that vehicle electrification will tend to decrease the need for petroleum for transportation.

Reviewer 2:

The reviewer stated that the presentation provided a snapshot of time where the technology is, and possibly where it is going. These insights may allow others to see opportunities to displace others and enable lower cost, along with reliable solutions for EDV products. The reviewer added that these lower-cost, reliable products will help to enable the market for EDVs, which reduce the reliance on foreign oil.

Reviewer 3:

The reviewer emphasized that the information is critical for DOE to plan its future R&D efforts.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer thought the work seems to be progressing with the resources provided.

Reliability of Electrical Interconnects: Doug DeVoto (National Renewable Energy Laboratory) - ape036

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

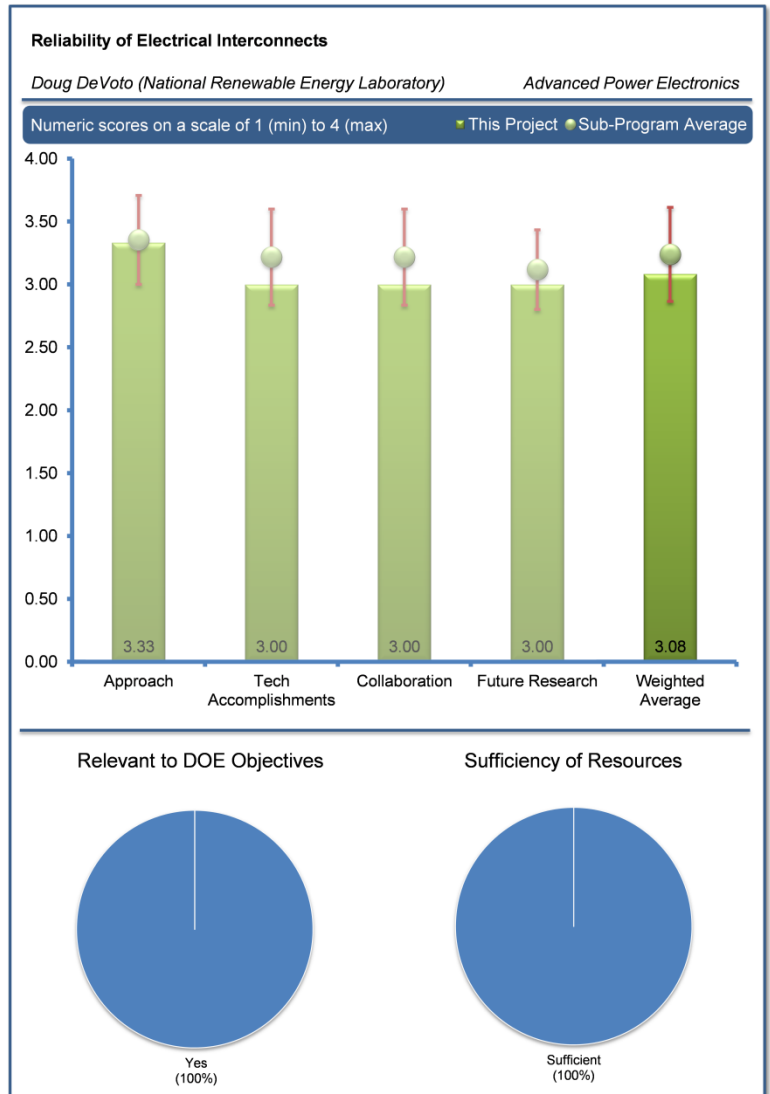
The reviewer commented that the objective to determine failure modes in interconnect technologies was developed well. The reviewer requested that the summary provide general observations and conclusions.

Reviewer 2:

The reviewer described that the project is focused on characterizing the failure modes of ribbon bonding, as compared to industry standard wire bonding.

Reviewer 3:

The reviewer expressed that this was very appropriate for high-power inverters which require low-inductance interconnects. The reviewer anticipated that project results should enable improvements in the performance of ribbon bonding with the end result of being able to accurately model this interconnect method should provide a reliable component when ribbon bonding is used.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer asserted that the progress to date is outstanding, and that the approach has shown to be viable and has produced encouraging results. The reviewer indicated that the outcome should be usable by industry.

Reviewer 2:

The reviewer reported that the pull tests were planned well and demonstrated that wire bonds weaken under high temperature and humidity. The reviewer added that one of the stated project targets was to help designers to improve cost, weight, and volume; however, it was unclear to the reviewer how ultrasonic ribbon bonding labor and new equipment costs compares to standard wire bonding.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer summarized that the project collaborated with three technical partners on wire and ribbon bonding. The reviewer suggested that in the future an EV component manufacturer might be added to the collaborators.

Reviewer 2:

The reviewer cautioned that the collaboration appears to be limited to supplying parts and performing bonding. The reviewer would like to see involvement with root causing of the failure mechanisms.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the future plans are a logical extension/progression of this project. The reviewer affirmed that industry will benefit if this plan is followed.

Reviewer 2:

The reviewer observed that making additional environmental testing of ribbon and wire bonds in the future is good, but suggested the project could also define the required temperature for WBG bonds and determine why higher temperature ribbon bonds are required.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer highlighted that this effort is an important part of the assembly of power modules, so it is imperative that it be correct.

Reviewer 2:

The reviewer offered that reliability and costs are relevant to acceptance of vehicle electrification.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer praised the excellent results and progress to date with the resources allocated.

Two-Phase Cooling R&D: Gilbert Moreno (National Renewable Energy Laboratory) - ape037

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the two-phase cooling design is a potential low-cost solution to automotive power electronics.

Reviewer 2:

The reviewer applauded the excellent and very creative approach. The reviewer pointed out that this concept has some special requirements, such as condenser location above the evaporator and in a location with adequate air flow for the fan. The reviewer cautioned that these physical requirements could cause interference with other components and increase the space required.

Reviewer 3:

The reviewer explained that the project is aimed at solving one of the issues with traction inverters, cooling the power switches; however, the reviewer was not sure that this approach will provide the optimum solution as it needs to address the packaging/serviceability of the inverter once it is installed in the vehicle. The reviewer opined that the approach is novel and the results do indicate that it is technically capable of cooling the switches. The reviewer recommended that more involvement with the overall packaging of the inverter and the cooling system is needed to provide a solution.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

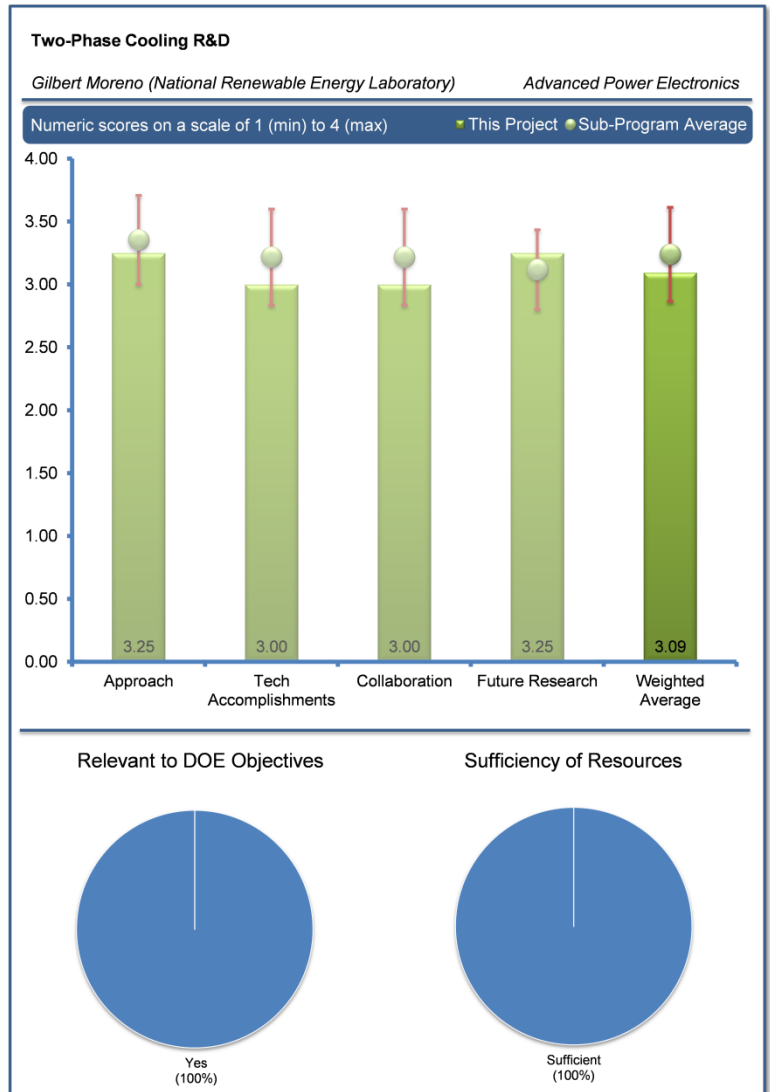
The reviewer pointed out that the accomplishments and progress has been very creative and the science has been well researched.

Reviewer 2:

The reviewer described that the presented technical data showed a design that on the bench, provided outstanding performance with the potential to do so in a small size. The reviewer stated that methods of further improving the performance were implemented, and are either under extended testing or are planned.

Reviewer 3:

The reviewer explained that the project has demonstrated the concept of the two-phase cooling in prototype device.



Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer observed that the team is good, but suggested it might be a good idea to add an automotive assembly team member.

Reviewer 2:

The reviewer observed that the team has done a good job to date of working to their strengths and providing the appropriate hardware. What is missing from the team, according to the reviewer, is a system integrator that can help with the physical requirements for mounting this system in a vehicle, and that can determine what it needs, to be a viable commercial product.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer stated the future plan was good, and that it includes the resolution of some practical issues.

Reviewer 2:

The reviewer remarked that the future plans are good to outstanding, depending upon the partner selected to assist in the demonstration. The reviewer pointed out the packaging issues related to the interface between the electronics and the cooling system, specifically the method of attaching the liquid supply and the vapor return lines. The reviewer highlighted that the orientation/method/location of the vapor return will be of interest as it may restrict the flexibility in allowable installation locations within the vehicle. The reviewer noted that the two-phase medium approach is good and should be reviewed with various OEMs to determine if a common fluid can be selected, or if multiple fluids need to be tested. The reviewer indicated that these issues are important, but are not overwhelming. The reviewer's biggest concern was the limitation of where the vapor return can be mounted and the cost of any disconnect method that may be required to support the installation.

Reviewer 3:

The reviewer asserted that the project will need to produce prototype for practical EDV power electronics.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer emphasized that cooling is a significant power loss and that this project has an interesting solution.

Reviewer 2:

The reviewer highlighted that cooling of power electronics is a big issue in vehicles, and that this method has the potential to reduce the volume required, as well as to provide an increase in performance.

Reviewer 3:

The reviewer observed that thermal management is critical for reliable low-cost power electronics in EDV.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that the resources are sufficient if an OEM is included.

Reviewer 2:

The reviewer said that resources have been sufficient to date as the results are impressive, but that vehicle level integration support is needed to move the project to the next level.

Advanced Liquid Cooling R&D: Sreekant Narumanchi (National Renewable Energy Laboratory) - ape039

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer summarized that the project will develop a single-phase liquid-cooled automotive inverter based on impinging jets, and enhances surfaces for improving thermal management for meeting the 2015 targets. The reviewer pointed out that the project will enable the use of high-temperature water-ethylene glycol coolant.

Reviewer 2:

The reviewer applauded that jet impingement was a great idea. This reviewer suggested that it would be interesting to compare adding channels to the plastic housing to direct the intake coolant toward the semiconductors. The reviewer also offered that the micro-surface and plastic container is a great idea.

Reviewer 3:

The reviewer commented that the submerged jet-cooling appears to be a means to reduce size of individual die and overall system, and that this was a good approach.

Reviewer 4:

The reviewer asked how this project impacts cost and added that no evidence was presented of what the cost is and could be with a new design.

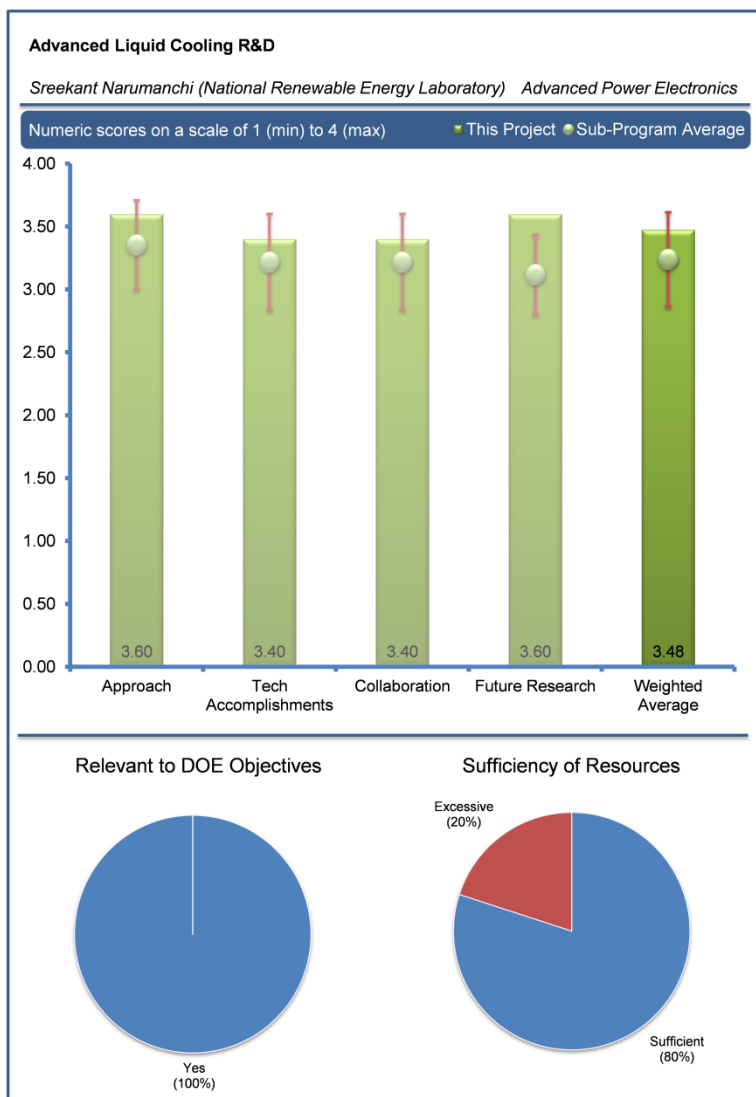
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the researchers had completed an initial design based on finite element analysis and modeling of three prototype designs. The reviewer also noted that the researchers had completed the design of the impinging jet configurations on a microfilm device.

Reviewer 2:

The reviewer summarized that the researchers demonstrated and imaged the cooling with the submerged jets.



Reviewer 3:

The reviewer simply noted that the project represented very good design and testing.

Reviewer 4:

The reviewer noted that the project is well-conducted, but criticized that the reliability characterization was weak. The reviewer expressed that no reliability modeling or system-level reliability testing is planned, which is crucial for demonstrating its real commercial value of this project.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer summarized that the collaborators included: UQM Industries (for inverter and power modules for dynamometer testing of the inverter); Delphi Electronics [for direct bonded copper (DBC) and DBA substrate for jet characterization]; and Wolverine Tube for micro-finned enhanced surface on a copper base plate and blocks.

Reviewer 2:

The reviewer agreed that this is a strong team for this phase of design and test, but emphasized that the next phase should include OEM vehicle input.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated the future research plans include characterization of the second and third prototype versions with jet impingement on a nickel-plated surface. The reviewer also mentioned that the research will address a cost comparison of mass production of the new heat exchanger as compared to the baseline aluminum heat exchanger.

Reviewer 2:

The reviewer reported that the plan to produce a prototype is excellent.

Reviewer 3:

The reviewer indicated that the future plans need to include a cost study that should include any cost impact to the entire system, if needed.

Reviewer 4:

The reviewer offered that the straight-through flow plan seems to have several benefits. The reviewer, however, asked whether it is possible that this positive in design may negatively affect the modularity of the overall system.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer explained that the EV battery will heat internally when used to power electric vehicles, so it will be necessary to provide cooling of the battery to prevent thermal runaway of the lithium-ion (Li-ion) battery and safe operation on public streets and highways

Reviewer 2:

The reviewer asserted that electrification of vehicles will lead to decreased use of petroleum, either through improved gasoline mileage, or through not using gasoline at all.

Reviewer 3:

The reviewer noted that this project could improve efficiency and reduce cost.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the funding was appropriate for this project

Reviewer 2:

The reviewer observed that the resources were adequate for this phase of the project.

Next Generation Inverter: Greg Smith (General Motors) - ape040

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that it seems appropriate that the focus is performance for the dollar, with commonality and worldwide manufacturing feasibility. The division into power modules, capacitors, gate drives, and control seemed appropriate to the reviewer. The reviewer applauded that the insight of the importance of cooling for cost reduction is leading the approach.

Reviewer 2:

The reviewer described that the strategy includes utilizing technologies that will be scalable to a wide range of vehicle applications, modular to enable cross-platform compatibility, and will be compatible with future technologies such as wide bandgap switches. The reviewer pointed out that the collaborations deep into the supply chain enable effective integration of advanced technologies. The reviewer noted that several collaborators for each key technical area (e.g., capacitors, gate drive, wide bandgaps, modules, and inverters) ensure that inverters can be specified consistently with multiple source supply chains

Reviewer 3:

The reviewer remarked that there is no doubt that General Motors (GM) has a practical approach to develop low-cost power inverter for commercial EDV, even though the project team can not disclose detailed technical information about the power inverter design.

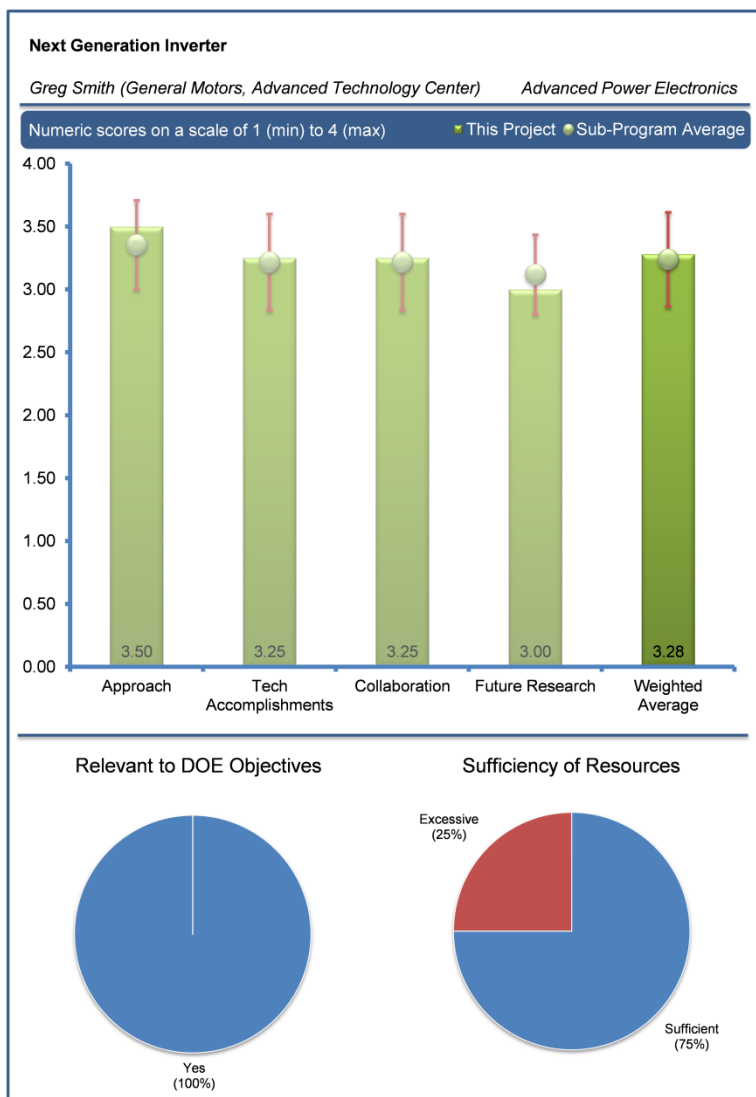
Reviewer 4:

The reviewer criticized that the presented work was very vague and shared very little information with the reviewers. The reviewer described that the presenter essentially summarized that the last two years were spent collecting data internally. The reviewer acknowledged that even though there is an understanding that there is a need for protecting confidential information, this does not give reviewers the impression that much was done.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that the program seems to be off to a good start, but with 2% done, it is too early to say much yet about accomplishments. The reviewer expected that significantly more will be accomplished by 2016.



Reviewer 2:

The reviewer summarized that a report on the technology and production cost was completed.

Reviewer 3:

The reviewer observed that GM has an integrated approach to achieve the target, though the details are not public.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer described that project collaborations deep into the supply chain, will enable effective integration of these advanced technologies. Several collaborators for each key technical area (e.g., capacitors, gate drive, wide bandgaps, modules, and inverters) ensure that inverter can be specified consistently with multiple source supply chains.

Reviewer 2:

The reviewer confirmed that GM has been working with various component suppliers.

Reviewer 3:

The reviewer noted that the list of vendor companies seems adequate.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer recounted that a quote from the oral presentation (i.e., stepping through every single piece) reflects the careful detailed approach that is being taken. The reviewer summarized that integration decision choices were described as best fit for the application, as the vendor reliability is seen as being good, and providing those many choices.

Reviewer 2:

The reviewer expressed that little information was provided about future tasks and milestones, so suggested that a concept design go/no-go review would ensure adequate project planning and oversight.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer noted that the electrification of vehicles helps to decrease the use of petroleum for vehicle propulsion.

Reviewer 2:

The reviewer explained that the project focuses on key VTO goals including cost, efficiency, performance and lifetime, and mass and volume to develop line of next generation propulsion inverters with a range of 55-110 kilowatt (kW).

Reviewer 3:

The reviewer asserted that GM is one of few companies that can develop integrated low-cost inverter technology and actually adapt it in a commercial EDV.

Reviewer 4:

The reviewer simply stated, yes, if successful.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer cautioned that it was unclear what has been done for the \$2 million spent so far, which goes beyond compiling the internally available data.

Unique Lanthide-Free Motor Construction: Jon Lutz (UQM Technologies, Inc.) - ape044

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the approach, as presented, provides sufficient detail to identify the degree to which the technical barriers are being addressed.

Reviewer 2:

The reviewer asserted that this project is another excellent example of motor development that does not rely on expensive rare earth materials.

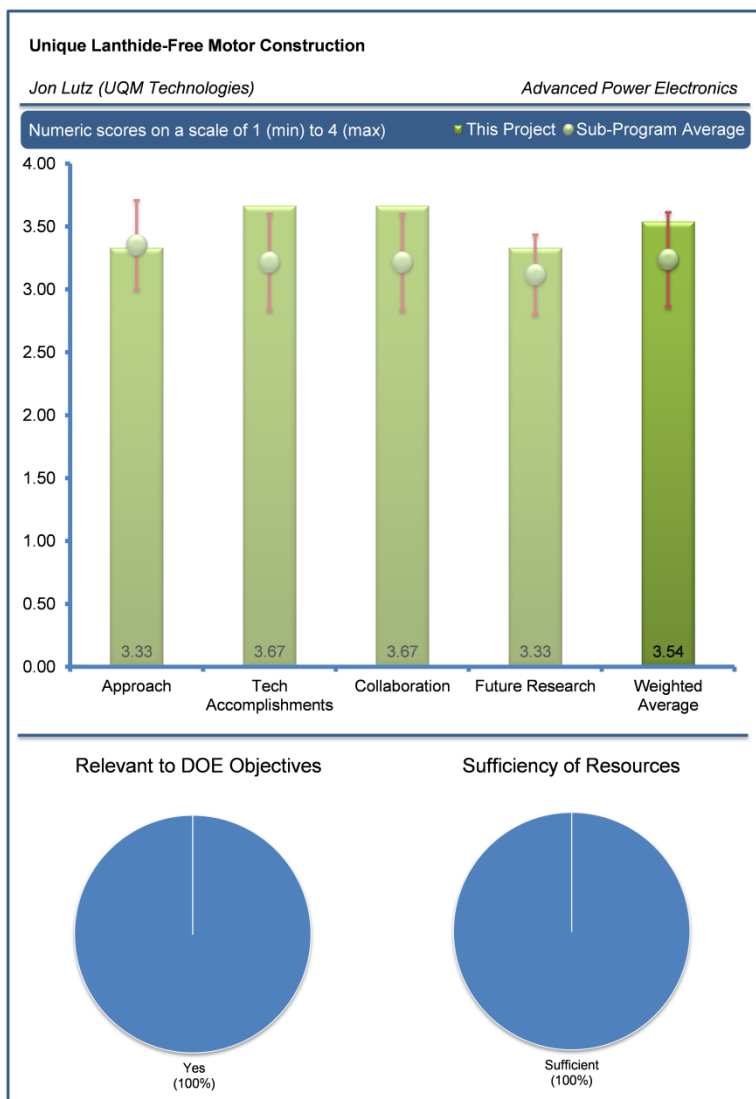
Reviewer 3:

The reviewer summarized that a new electric machine concept with AlNiCo magnets, instead of rare-earth magnets, is being developed in this project. The reviewer described the justification for the approach being that AlNiCo magnets are significantly cheaper than NdFeB magnets, at least as of today, and the prices have been stable for a long time. The reviewer reported that electromagnetic modeling of the machine confirmed that AlNiCo magnets are usable without a significant demagnetization (this has been the main issue with this magnet material in the past).

The overall approach is generally well-designed, according to this reviewer, and the technical barriers were identified. The reviewer pointed out that the milestones are well-defined and the manufacturing of prototype machines is coupled to go/no-go decisions based on simulation results.

Reviewer 4:

The reviewer observed that the research approach makes sense, focusing on a topology that results in large increase in permeance coefficient, and increasing coercivity of AlNiCo. However, the reviewer was concerned with the fact that, for PM machines, the design criteria for demagnetization was left to the discretion of the investigator. In the reviewer's opinion, this issue should be addressed in the DOE specifications for the project. The demagnetization criteria (current and temperature) can vary from normal operating currents at low temperature to transient 3-phase short circuit at high temperature. This has a significant effect on PM motor cost, as well as on feasibility of non-rare earth PMs. The reviewer asserted that whatever criterion is used by DOE, it should be applied consistently to all investigators. The reviewer cautioned that this issue is at the core of motor development using AlNiCo magnets, because demag is the Achilles' heel of this magnet type. The reviewer warned that UQM's self-imposed criteria of normal operating current level (the reviewer was not sure of what temperature) seems like a low standard.



Reviewer 5:

The reviewer explained that field weakening is not possible on this design, which requires an increase in voltage to meet the speed targets [750V required for 10,000 revolutions per minute (RPM)]. Current spikes are expected to demagnetize the edges of the permanent magnets (400A peak will result in approximately 2% demagnetization); so the only way to compensate for this loss is to increase the current to produce the same amount of torque, further increasing the demagnetization. The reviewer added that the loss of phase angle could result in more than 10% demagnetization. The reviewer noted that the approach was not described in sufficient detail during the presentation, adding that even a high-level discussion about the proposed rotor design was not included. The reviewer cautioned that the design has a high risk of not meeting the performance objectives due to demagnetization and the requirement for a variable DC bus voltage to meet the speed targets.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the technical accomplishments and progress, as stated, meet the objectives and goals, and the presentation provided sufficient detail to support this assessment.

Reviewer 2:

The reviewer applauded the excellent progress on concept development of AlNiCo usage.

Reviewer 3:

The reviewer expressed that given the high difficulty of basing the design on AlNiCo, the current design has reasonably good results so far (except for the demag criteria). It was not clear to the reviewer from the DOE specifications whether voltage-boosting was an allowable approach to meeting required performance. However, the reviewer admitted that this may just be the reviewer's misunderstanding of the specification. The reviewer added that good progress was shown by NREL and the Ames Laboratory on cooling and magnet improvement.

Reviewer 4:

The reviewer noted that the project is well-conducted, and also asked if the coercivity study results (Slide 13) were obtained from the simulation. If so, the reviewer indicated that an experimental validation study is necessary. In addition, the reviewer requested that the researchers please clarify how the results are related to the DOE requirements.

Reviewer 5:

The reviewer suggested that the reviewers may need to revisit current requirements since during the discussion it was revealed that some projects are targeting a 400 Arms system and UQM is targeting a 400A peak machine. The reviewer warned that the operative voltage range does not seem to be in compliance, despite a positive status on Slide 16. The reviewer noted that the magnetic, thermal, and controls analysis are helping to improve the machine design. The reviewer mentioned that no publications have resulted from the work to date.

Reviewer 6:

The reviewer observed that the technical accomplishments are generally good, detailing that the electromagnetic design simulations indicate that maximum torque and power is achieved within volume limits. However, the reviewer expressed that a drawback of this new machine concept is the fact that the machine cannot be field weakened. This fact leads to the need of including a boost converter traction system to obtain an only moderately high maximum speed (10,000 RPM) with a DC voltage of 750 volt (V). The reviewer reminded that this maximum speed is not even close to the DOE requirement of 14,000 RPM.

A second issue identified by the researchers is the significantly higher magnet mass in this type of machine (three times the mass of NdFeB magnets) for the same machine performance. The reviewer commented that it remains to be seen, if these drawbacks will increase the system cost significantly and may negate the cost savings with the AlNiCo magnets.

The reviewer noted also that researchers cannot reveal many details about the new machine concept at this point in time, as patent applications are pending, but hoped that this will be addressed in future review meetings.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that there are no issues addressed with any of the collaborators. The reviewer reported that sufficient detail was provided on what contributions are being made by each of the collaborators.

Reviewer 2:

The reviewer highlighted that the collaboration with Ames Laboratory for the development of improved AlNiCo magnets, is beneficial for the success of this project, as improved magnet materials can be implemented in the machine design when available. The reviewer also reported the other collaborations with NREL and ORNL will support the progress of the project.

Reviewer 3:

The reviewer commented that the work appears to be coordinated and that the researchers had used NREL well for thermal analysis and the Ames Laboratory for magnet improvements.

Reviewer 4:

The reviewer stated that, again, like most projects in this area, the project is very well-coordinated.

Reviewer 5:

The reviewer summarized that UQM has partnered with three government laboratories for aspects of the project, but that no relationships with academia or other industrial organizations were identified. The reviewer described that further improvements to AlNiCo coercivity in the Ames Laboratory research will have a significant positive impact on this development program.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the proposed future work plan is consistent with the project objectives with adequate details and specificity.

Reviewer 2:

The reviewer stated that the milestones in the project are well-defined and the barriers are identified as well as possible. The reviewer explained that the machine build, with standard off-the-shelf magnets, will be completed in October 2013, and subsequent testing will hopefully confirm the simulation results. In the next step, improved magnet materials will be implemented in the machine design, when available through the collaboration with the Ames Laboratory.

Reviewer 3:

The reviewer commented that the future plans seem logical and allow for multiple paths (e.g., oil- as well as water-cooling).

Reviewer 4:

The reviewer remarked that the next steps, of course, should be to integrate these various programs, especially the Ames Laboratory.

Reviewer 5:

The reviewer explained that UQM is working to reduce the required quantity of AlNiCo from three times to double the required rare-earth material required for similar power levels. End turn cooling is expected to improve thermal management performance compared to the existing water jacket design. The reviewer suggested that adding in the opportunity to refine/optimize the electromagnetic design of the machine after testing the first motor could strengthen the future plan. The reviewer asked if this will occur in Year 3.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer reported that statements in the presentation are positive and that the work supports the overall DOE objectives of petroleum displacement.

Reviewer 2:

The reviewer explained that the project supports the objective of petroleum displacement by developing a new motor concept without the use of expensive rare-earth magnet materials. If successful, the reviewer noted that these would result in cost savings for electric drive systems, which would enable a faster market introduction of HEVs and EVs.

Reviewer 3:

The reviewer described that the project addresses the inherent sustainability problem with motors that use current rare earth magnets and creates a possible path for sustainable, high-efficiency sand EV applications.

Reviewer 4:

The reviewer repeated the need to develop better motor technology, which will lead to more stable costs and acceptance for OEMs to develop.

Reviewer 5:

The reviewer explained that this project will help reduce the cost of high-performance electric machines due to the primary PM material being AlNiCo rather than traditional rare-earth materials. The reviewer pointed out that these machines are key components in HEVs, which have demonstrated the capability to reduce fuel consumption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that the presenter did not comment on any difficulties on resources.

Reviewer 2:

The reviewer indicated that the project has sufficient resources for the defined tasks.

Reviewer 3:

The reviewer stated there was good team selection.

Reviewer 4:

The reviewer stated that the project is on track and that a lack of resources is not apparent from the presented material.

Reviewer 5:

The reviewer asserted being unqualified to elaborate to detail.

Alternative High-Performance Motors with Non-Rare Earth Materials: Ayman El-Refaie (General Electric Global) - ape045

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the project is well-conducted and planned.

Reviewer 2:

The reviewer offered that trade studies on a variety of motor topologies is a good starting point, and when married with improved soft and hard magnetics, may result in overcoming barriers. The reviewer acknowledged that the organization and the PI are very familiar with the requirements and challenges of the DOE targets.

Reviewer 3:

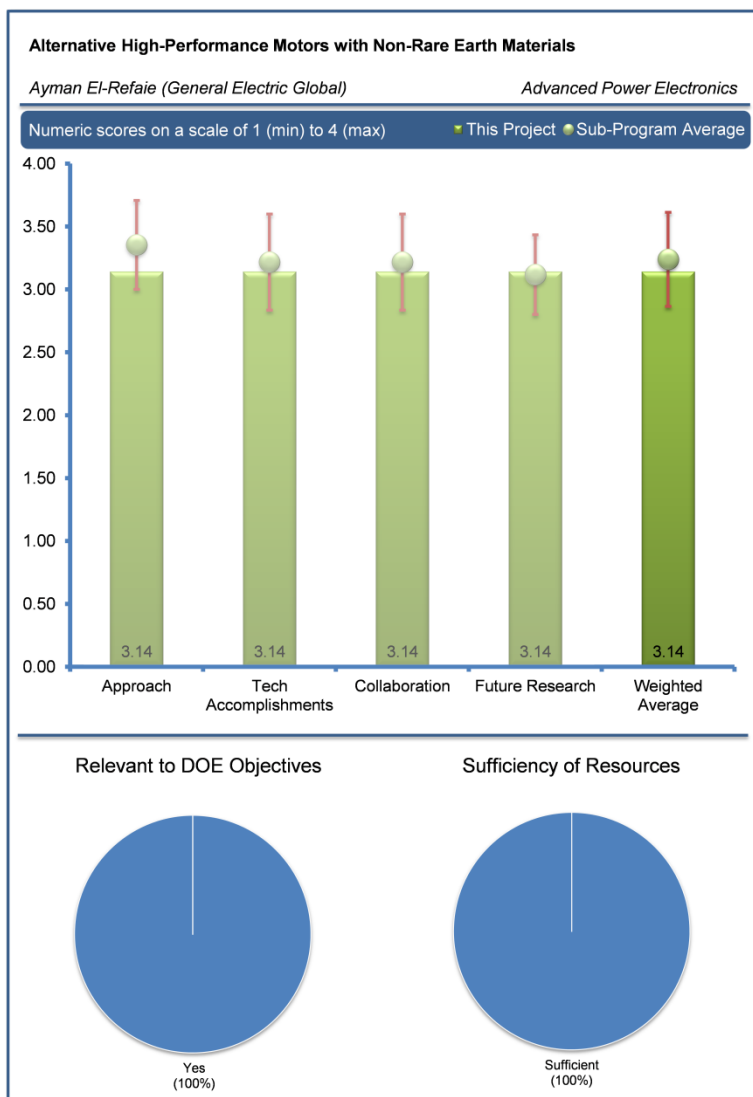
The reviewer explained that the main goal of the project is the development of new electric machine concepts with non-rare earth magnets, or with no magnets at all. The approach is to investigate 10 different motor topologies and to identify promising new materials. A downselection of three most promising machine concepts for further investigation and prototype build, will focus the project resources on the best candidate concepts. The reviewer reported that a weak aspect of the approach is that a cost model will be developed only for the final concept with the best performance. The reviewer explained that this approach somewhat ignores at first the main challenge for future electric traction motors, which is the high cost. For example the best concept in terms of performance might end up being the most expensive too.

Reviewer 4:

The reviewer stated that the research approach makes sense, with attention to improving machine topology and materials. However, the reviewer was concerned with the fact that, for PM machines, the design criteria for demagnetization was left to the discretion of the investigator. In this reviewer's opinion, this issue should be addressed in the DOE specifications for the project. The reviewer explained that the demag criteria (current and temperature) can vary from normal operating currents at low temperature to transient three-phase short circuit at high temperature; this has a significant effect on PM motor cost as well as on feasibility of non-rare earth PMs. The reviewer thought that General Electric (GE)'s self-imposed criteria of double the maximum operating current at 150°C seemed to be reasonable. Regardless, the reviewer thought that whatever criterion is used by DOE, it should be applied consistently to all investigators.

Reviewer 5:

The reviewer observed that the PI has a strong understanding of the project requirements; however, the approach was not described in sufficient detail during the presentation. The reviewer, however, warned that the approach leverages the use of an industrial motor



frame which may not represent the thermal performance of the machine integrated in its target automotive environment. The reviewer asked whether the use of reduced-rare-earth magnets in this project meets the DOE targets.

Reviewer 6:

The reviewer stated that the approach, as presented, lacks detail to identify the degree to which the technical barriers are being addressed. It was difficult for the reviewer to judge from the presentation if there is sharp focus on these technical barriers.

Reviewer 7:

The reviewer remarked that of the motor programs, this one seemed a bit less advanced or along the process.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer described that the evaluation of 10 motor topologies has been finished and a down-select of three most promising topologies has been done: one has reduced RE magnet content; one has no RE magnets; and one has no magnets at all. No further information was provided about the motor topologies, but the reviewer hoped this would change by the next annual review meeting. The reviewer also mentioned that, regarding the new material developments, new magnet materials are being evaluated and that new high tensile strength lamination steel shows promise. Finally, a new dielectric for use as insulation material at high temperatures has been developed. The reviewer summarized that all of the above are good technical accomplishments and the progress is significant compared to last year.

Reviewer 2:

The reviewer commented that the program is already building a prototype. Building hardware early is good; too many programs save hardware build until near the end of the program. The reviewer remarked that higher strength laminations have value for all motor topologies, so it is also positive that this activity occurs early in the program.

The reviewer believed that more details regarding the downselect process for the three motors would be helpful. Light load efficiency is very important (in this reviewer's opinion, perhaps more important than weight), so it would be useful to discuss why some of the heavier, yet more efficient, designs were eliminated from contention.

Reviewer 3:

The reviewer observed evidence of progress on all fronts, but not much detail given on accomplishments, and added that it was difficult to evaluate. The reviewer noted very little quantitative information about material developments. Topology downselection had some quantitative data, but sketchy about details. The reviewer expressed understanding that some of this may be necessary because of intellectual property (IP) pursuits, but it seems that non-proprietary designs/topologies (e.g., conventional induction, switched reluctance, IPM) could be shared in more detail. The reviewer inquired about why the locations of these conventional topologies on the efficiency and performance graphs, at least, were not shown. Reviewers do not even know if these conventional topologies were part of the evaluation (apart from induction, which was mentioned verbally as being evaluated, although no mention was made of which metrics corresponded to induction. The reviewer thought the balance between IP interests and accountability could be improved.

Reviewer 4:

The reviewer observed development of new soft magnetic lamination and insulation materials in addition to the permanent magnets and machine development helps further advance the state of art in motor technology. The reviewer asserted that the motor topologies were not described in the presentation. Topologies are being developed to minimize the likelihood of demagnetization. The reviewer believed that no publications were identified in the presentation material.

Reviewer 5:

The reviewer expressed that, when compared to the other similar projects, this one seems a bit behind.

Reviewer 6:

The reviewer commented that the technical accomplishments and progress, as stated in the presentation, meet the project objectives and goals. However, the reviewer explained that insufficient detail was provided as to how well and very little technical detail is provided beyond statements.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer commented that all of the programs are well-coordinated and compliments to DOE.

Reviewer 2:

The reviewer noted that this project has an extensive group of collaborators from universities and National Laboratories, along with an industrial partner for fabrication of the machine. In total, seven contracts are in place with the project partners.

Reviewer 3:

The reviewer acknowledged that a number of collaborations with universities were set up for the motor development. The reviewer also thought the collaboration with Ames Laboratory and Arnold Magnetics and their work on alternative magnet materials was a good choice. The reviewer added that it seems as if the researchers are doing a good job to assure that all modeling assumptions are the same for all different motor designs.

Reviewer 4:

The reviewer expressed that there is very good talent included in team, and that the teams made good use of the various material experts and a variety of machine design experts. It appeared to the reviewer that most parties are now actively engaged and it was encouraging to see that all of the legal contracts had been worked out. (It did not surprise the reviewer that this took a long time to do.) The reviewer wondered if it would be possible for DOE to establish a standard collaboration agreement that parties have to sign before being awarded a project, so that more time can be spent on collaborative research. Alternatively, DOE could make having a signed agreement (not necessarily DOE's) a condition for getting the award. The reviewer admitted that this may be overkill where the team consists of only a few parties, but it might make sense for projects like this with eight different groups that have to come to a legal agreement.

Reviewer 5:

The reviewer noted that the long list of partners is good, as long as the work is coordinated and each company's role is understood. The reviewer cautioned that the risk is fragmented work if the partners are not well-managed. The reviewer commented that how each partner contributed was not covered during the presentation, so it is difficult to assess how they are being managed.

Reviewer 6:

The reviewer reported that there are no issues addressed with collaborators. The reviewer also noted that there was very little detail on what contributions are being made by each of the collaborators and how well the coordination is working.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer explained that the future research plans include the completion of testing the proof-of-principle motors/materials. Moreover, the reviewer noted that final selection of motor topology/materials will be based on test results of the proof-of-principle motors, which will take place within the next year. The reviewer indicated that the project is well-coordinated regarding future plans, but as mentioned above, the implementation of cost models should not be postponed until the final, best performing motor topology is selected. This might lead to a great motor topology, which is far from meeting the cost target.

Reviewer 2:

The reviewer explained that the future research includes multiple builds, materials testing, and continued downselection, which are all appropriate. The reviewer emphasized that GE needs to be highly involved in the prototype build process, and that oversight of McCleer Power and the prototype challenges should be monitored closely.

Reviewer 3:

The reviewer described that the future activities include builds of two or three proof-of-principle motors and then a final motor that leverages the best aspects of the proof-of-principle designs along with scaled-up fabrication of new lamination and insulation materials.

Reviewer 4:

The reviewer remarked that, in general, the future work plan looks good; however, it was not clear to the reviewer how increased insulation temperature ratings would help attain the goals of this project. It seemed unlikely to the reviewer that operating with winding temperatures at 250°C will meet DOE's efficiency requirements.

Reviewer 5:

The reviewer noted that the proposed future work plan is the same as promised, but lacks details and specificity.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer indicated that statements in the presentation are positive that the work supports the overall DOE objectives of petroleum displacement.

Reviewer 2:

The reviewer explained that the project supports the objective of petroleum displacement by developing new motor concepts without the use of expensive rare-earth magnet materials. If successful, the reviewer believed that these would result in cost savings for electric drive systems, which would enable a faster market introduction of HEVs and EVs.

Reviewer 3:

The reviewer commented that this project addresses the sustainability problem of motors using current rare earth magnets, as well as evaluates machine, material, and control approaches that could reduce system cost for HEV and EV powertrains.

Reviewer 4:

The reviewer expressed not being qualified to make this judgment in this area.

Reviewer 5:

The reviewer affirmed that the PI understands the 2020 DOE objectives and their impact on petroleum displacement.

Reviewer 6:

The reviewer described that this project will help reduce the cost of high-performance electric machines through reduction/elimination of rare earth permanent magnets in the design. These machines are key components in HEV which have demonstrated the capability to reduce fuel consumption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that the presenter did not comment on any difficulties on resources.

Reviewer 2:

The reviewer thought the project has sufficient resources for the defined tasks.

Reviewer 3:

The reviewer expressed that the resources are certainly sufficient, but observed that the challenge may be organizing them to work together in a timely manner.

Reviewer 4:

The reviewer indicated that the resources appear to be sufficient and appropriate, as long as they are managed and understand their roles in the program. The reviewer highlighted that Program Management is key to this multi-faceted program.

Reviewer 5:

The reviewer reported that the project is on track, and that a lack of resources was not apparent from the presented material.

Integrated Power Module Cooling: Kevin Bennion (National Renewable Energy Laboratory) - ape047

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the objective was clear and well and understood and the approach was straight forward and effective.

Reviewer 2:

The reviewer commented that the use of an extruded heat sink for power modules is very good, noting low cost, small, and high performance. However, the reviewer expressed that it does not address the other components that require cooling such as current sensors and bulk capacitors. Additionally, heat sinks are also used as part of the chassis and for mounting other components, which may increase the size or at least add some constraints to allow for machining to support these needs. The reviewer stated that the basic approach is fine and can be expanded to include the complete inverter.

Reviewer 3:

The reviewer indicated that the extruded heat exchanger enables multidimensional heat transfer and under the project guidelines of doubling the heat flux this approach has potential. Extrusions are typically a low cost production process; it is not clear from the presentation what the cost of the extrusion would be.

One example the reviewer noted was that the planarity requirements of heat sinks could affect costs. Also, for a double sided cooled system, too much camber across the surface could require thicker BIMs, which reduce cooling performance and possibly offset the gains of the heat exchanger. The reviewer expressed that both costs and how planarity, flatness, and camber affect performance and cost need to be discussed.

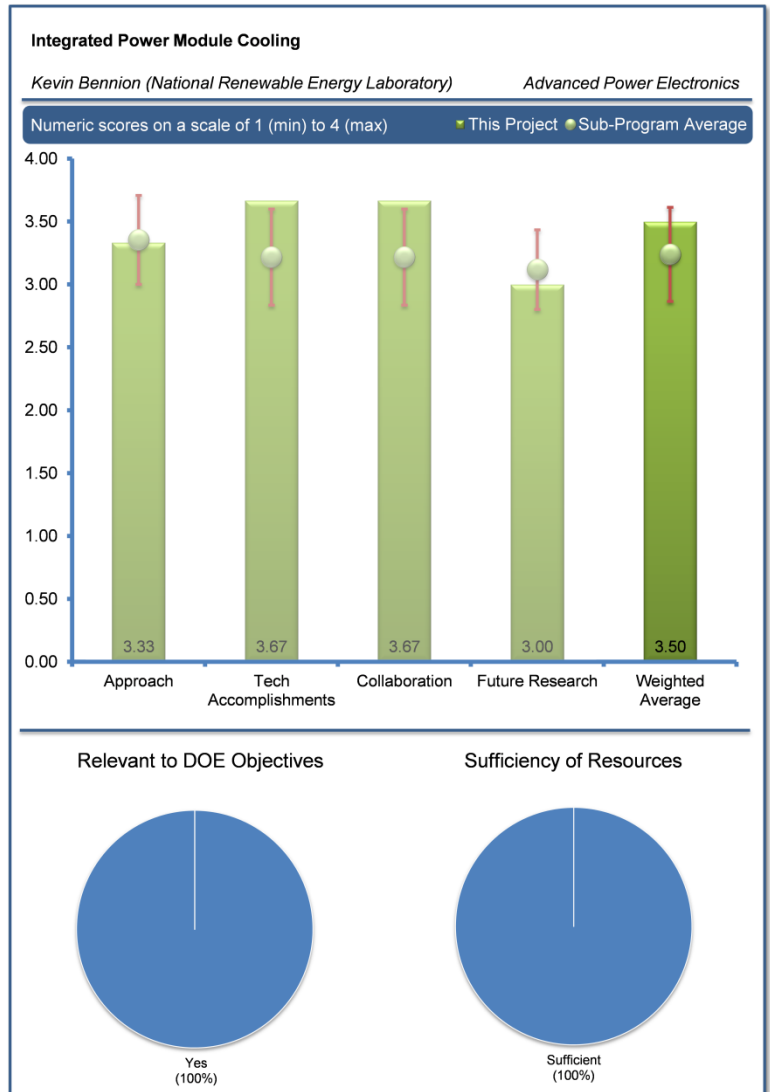
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that it was a good concept using low tech solution to get a significant gain in efficiency.

Reviewer 2:

The reviewer indicated that the initial test results of the heat exchanger are meeting or exceeding goals of the project.



Reviewer 3:

The reviewer opined that the accomplishments to date are outstanding. Performance modeling at typical flow rates is a very good approach because the potential performance can be seen based on the modeling results. It is very important that extrusion supplier design rules have been used. The reviewer liked the flexibility and scalability of the design to support additional modules and double sided cooling.

The reviewer indicated that there is a need to address the mounting of the heat sink within the inverter chassis and possible use as a part of the chassis; the heat sink's mass is also an important consideration because it would lead to using the extrusion as part of the chassis as opposed to mounting it in the chassis depending on the weight. The reviewer would like to see what the limit is for this design in terms of its ability to remove heat; specifically, at what point is the limiting factor the ability to spread the heat quickly enough from the die.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer commented that developing a design and having a commercial partner that can make the design is a very good approach.

Reviewer 2:

The reviewer indicated that collaboration with Sapa is excellent, suggesting that their knowledge could be used to provide design rules. The reviewer stressed the need to continue this type of collaboration with power switch/module industry partners in order to arrive at an optimal solution.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer felt that it is a good plan to apply this design to existing semiconductors.

Reviewer 2:

The reviewer expressed that the future plans are good but do not go far enough. There is a need to determine the limits of the heat sink's ability to dissipate heat and spread it from a small point source such as a die. The reviewer also suggested including performance with no flow, but with coolant, and then to investigate what happens with no coolant.

Reviewer 3:

The reviewer indicated that the future work should include looking at cost or stating tolerances required for fabrication that could allow this approach to be used in a double-sided cooled application and how these tolerances might affect cost.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer noted that effective cooling saves energy and improves reliability; with WBG comes products that run hotter and require better cooling. This project is very relevant to the success of electric vehicles.

Reviewer 2:

The reviewer indicated that the potential benefits of this heat exchanger are possibly smaller die size for an EDV inverter or higher inlet cooling temperatures for the EDV inverter; both results could lead to lower cost systems. This lower cost approach will help to enable the market for EDVs and lower our dependence on foreign oil.

Reviewer 3:

The reviewer commented that heat sinks are an important part of solving the cost/performance issue related to power electronics. A high performing low cost part is highly desirable.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that there is no mention of lack of resources or the need for more time to complete the project.

Reviewer 2:

The reviewer noted that the resources are sufficient to this point. The reviewer noted that there is a need to add industry team members to provide device/module expertise for future plans.

Traction Drive System Modeling: Burak Ozpineci (Oak Ridge National Laboratory) - ape048

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that a lot of work has been done considering that this is a new project. This work is very important, as it ties a number of other initiatives into a detailed system-level model.

Reviewer 2:

The reviewer noted that using a vehicle system model to determine the optimum traction drive parameters to refine the component performance requirements is a good approach. Getting an agreement from an OEM to use a combined drive cycle to specify component performance would be useful. The reviewer noted that it would be interesting to find out what the worst case conditions that drive component performance requirements are and if those worst case conditions are common to other combined drive cycles.

Reviewer 3:

The reviewer indicated that the approach and objectives of this project were clearly presented. The reviewer did feel that, for program tracking, it might be better to have more milestones defined.

Reviewer 4:

The reviewer expressed that it is not clear where this project is heading, what is unique, and why industry and the VTO needs ORNL to do this other than it is adding to modeling competency at ORNL.

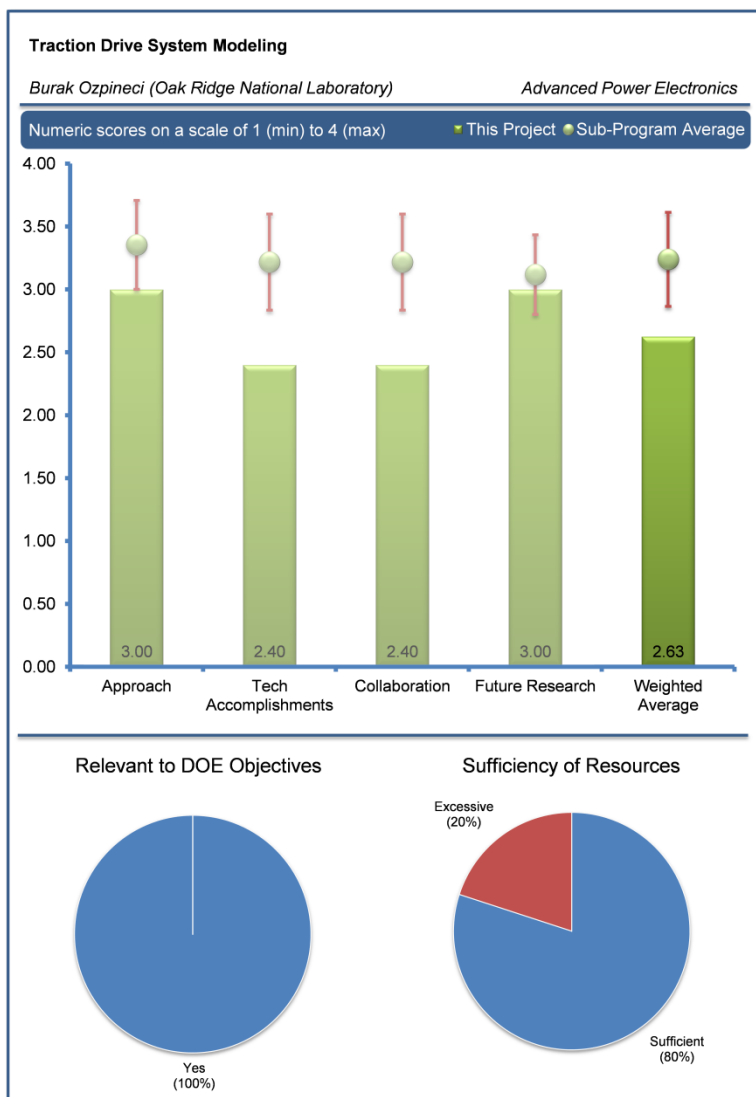
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the work is on track.

Reviewer 2:

The reviewer noted identifying regions of clustering to identify most common regions of operation. In many systems, the transient responses, rather than the steady state (most time spent) regions are most important to vehicle customer satisfaction, such as entering a highway. The reviewer opined that some steps should be taken to address the transient responses.



Reviewer 3:

The reviewer noted that there has been some progress toward analyzing what the best simulation operating points are to determine efficiency and cost optimization based on statistical analysis of driving cycles, development of simulation models collecting tools, and identifying trade-offs to study such as bus voltages and speed impact on efficiency and cost.

Reviewer 4:

The reviewer commented that the progress of this program is excellent, especially with the program just starting this year. The reviewer indicated looking forward to seeing more simulations throughout the program.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that the links are to other modelers and the links to experimental workers are often valuable to provide checking of model performance.

Reviewer 2:

The reviewer commented that there are some partners for models and software including ORNL, NREL thermal models, and ANL, but there does not yet seem to be sufficient partners to provide guidance on vehicle industry need.

Reviewer 3:

The reviewer indicated that, to do the modeling and the circuit simulations, the resources are there. The reviewer expressed that it would be interesting to have an OEM comment on the approach and results, as the program is progressing.

Reviewer 4:

The reviewer noted that this project does not have sufficient collaboration with private industry, especially as the future is looked at to work on optimizing cost.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the approach to the future work is logical and aggressive.

Reviewer 2:

The reviewer commented that the proposed future work for 2013 is good. The reviewer did indicate that it would have been helpful to see some details of future work and milestones beyond 2013.

Reviewer 3:

The reviewer expressed that asking of the audience for suggestions on what to do is diplomatic, but seems weak in form, from a presenter who is presenting himself as the expert.

Reviewer 4:

The reviewer commented that the future plan is not specific other than to do more of the same for other power electronic systems and components.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that electrification of vehicles tends to decrease need for petroleum and other fossil fuels.

Reviewer 2:

The reviewer commented that the project is on the topic areas that are important to meet DOE objectives, but it is unclear how the specifics of the project will lead to meaningful outcomes.

Reviewer 3:

The reviewer stated that a more efficient, lower cost propulsion system would help to enable the market for EDVs and lower our dependence on foreign oil.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that the team is very small, but based on the accomplishments for this first year, seems to have sufficient resources.

Reviewer 2:

The reviewer observed that the project is on track with the resources allocated.

Reviewer 3:

The reviewer commented that the resources seem high relative to other projects given the level of effort required to achieve the goals and apparent lack of planning and demonstrated need.

WBG Inverter Packaging: Zhenxian Liang (Oak Ridge National Laboratory) - ape049

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the approach of using a binary comparison of SiC MOSFET Schottky diode assembly with same assemblies in Si MOSFET and diodes seems likely to lead to a clear comparison.

Reviewer 2:

The reviewer commented that the approach to compare the Si and SiC as well as the cooling method is a well-balanced number of variables. The reviewer wanted to know if double sided cooling was planned for a future generation, and if there were plans to test this method of cooling in the future.

Reviewer 3:

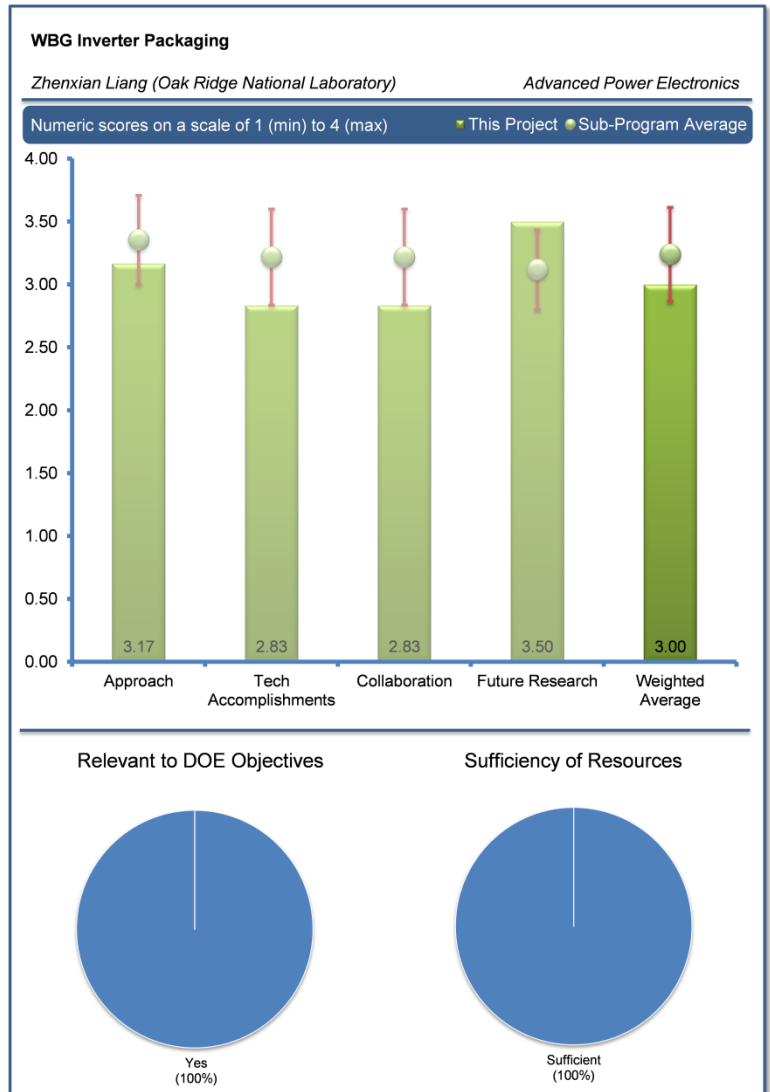
The reviewer commented that it was a very important goal to develop 100 Ampere (A)/1200 Volt (V) SiC and hybrid SiC/Si modules using mostly commercially available die and including both thermal grease baseplates and integrated cooling modules, and to compare the performance with silicon modules. However, there are published studies using dynamic electro-thermal analysis to size die in 10 kilovolt (kV) SiC half-bridge modules and 4.5 kV Si/SiC hybrid modules. The reviewer indicated that it would be a significant step backwards, and would provide meaningless results, to select the die sizes for modules based on what is optimal size for Silicon devices of a different type, rather than doing a proper analysis of optimal die size required to meet the same current and thermal performance as the silicon modules.

Reviewer 4:

The reviewer indicated that hard attachment, soldered, of the DBC substrate to the cold plate is very good from a thermal point of view as indicated on Slide 5. But the hard attach of the large area of the DBC with a low coefficient of thermal expansion (CTE) to the higher CTE copper base plate may not be a reliable solution. The reviewer noted that, if it is purported that this soldered hard attach approach is good for automotive – as Slide 6 indicated – data should be presented that shows the hard attach approach is also reliable. Additionally, the reviewer was interested in knowing the assumptions used for flow rate, pressure drop and convection coefficient for the heat exchangers used to determine allowed current density.

Reviewer 5:

The reviewer noted that the project develops packaging for WBG inverters for EDV and an integrated approach to improve the inverter performance. The WBG will improve the power density of EDV power inverter. However, the team may provide more information on the potential cost reduction with WBG switches.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that 55% reduction of die size was good progress, which may mean lower cost, with the more expensive material, SiC. The reviewer noted that it was seen as significant toward the program objectives; the technical accomplishments include 55% reduction in die size, 60% decrease in conduction power loss, and 20% in switching power loss.

Reviewer 2:

The reviewer indicated that the progress of this program is very good, especially at such an early stage of the program. The reviewer suggested it might be prudent to make sure that module prototypes are not over-designed, as this may increase costs of manufacturability and end up not being representative of real world components.

Reviewer 3:

The reviewer noted 50A/1200V SiC modules were developed, fabricated, and performance tested; 100A modules are underway.

Reviewer 4:

The reviewer stated that, within a short period of time, the project has produced various WBG switch packaging devices and performed systematic test on the performance.

Reviewer 5:

The reviewer commented that providing parts for testing in ORNL power electronics is on track. However, nothing in the slides suggests that any reliable work has been done or what the reliability targets are.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that the team has excellent collaboration with several suppliers, universities, and National Laboratories.

Reviewer 2:

The reviewer noted that many suppliers are working with the investigator.

Reviewer 3:

The reviewer reported that multiple device vendors and package partners are included, and that package assembly lead and partners are excellent. The reviewer noted that it would be best to include a partner to perform electro-thermal analysis of module optimal die size.

Reviewer 4:

The reviewer indicated that it was great to see collaboration with the University of Tennessee. However, it would be good to also include private industry partners in this program beyond simply sourcing materials.

Reviewer 5:

The reviewer commented that, from the collaborations, it looked like published work of others is incorporated but there is no industry or other DOE laboratory collaborators that are part of the team.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the goal of addressing high temperature capable package next year is a critical goal.

Reviewer 2:

The reviewer noted that the proposed future activities are very well explained and seem appropriately aggressive for the program timing and resources, while maintaining the leap frog objective.

Reviewer 3:

The reviewer remarked that the proposed future work approach looks reasonable.

Reviewer 4:

The reviewer commented that the project has a well-defined plan for future research.

Reviewer 5:

The reviewer noted that moving up to a specific size is representative of a clear direction in future work, but concerns about costs remain. While the smaller part will be less expensive than a larger one of the same material, the comparison here is for two different materials. It is possible that the larger of the lower cost material may be lower cost than smaller of the more expensive material. The reviewer observed that making this comparison clear would be helpful.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that electrification of vehicles is seen as decreasing the need for using petroleum based fuels for transportation.

Reviewer 2:

The reviewer indicated that assessing the benefits of SiC for vehicle propulsion inverters is very important, especially if high temperature capability is included in the study.

Reviewer 3:

The reviewer commented that the increase in power density appears to be on track and achievable in this project. This will dramatically assist the vehicle electrification goals of the DOE.

Reviewer 4:

The reviewer observed that helping to lower the cost of power electronics devices can enable the market for EDVs, which will lower our dependence on foreign oil.

Reviewer 5:

The reviewer indicated that WBG switches are critical for next generation EDV power electronics and packaging is important.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer did not observe on the presentation how much the total budget beyond 2013 was for, but for 2013, the resources and funding seemed to be sufficient, but on the low side for all of the future activities that the project team has planned.

Reviewer 2:

The reviewer indicated that, while the resources appear sufficient, there may be help available at NREL that has done work on bonded interfaces and their reliability. It may be better to expand on NREL's work than to start from scratch on another reliability assessment.

Reviewer 3:

The reviewer noted collaboration with the University of Tennessee.

WBG Gate Drivers for Power Modules: Leon Tolbert (Oak Ridge National Laboratory) - ape050

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that working to solve detailed level circuit issues, which may arise with the SiC substitution, with very fast switching seems appropriate.

Reviewer 2:

The reviewer observed that the goal and strategy of developing a highly integrated power module with integrated gate drive, input isolation, and integrated power supply in a high temperature package has significant potential to advance VTO goals.

Reviewer 3:

The reviewer noted that the availability of high performance gate drivers that are capable of operating at high temperatures is a key technology that needs development if the WBG devices are to be incorporated into vehicle power electronics. An impressive job has been done in the first year of the project.

Reviewer 4:

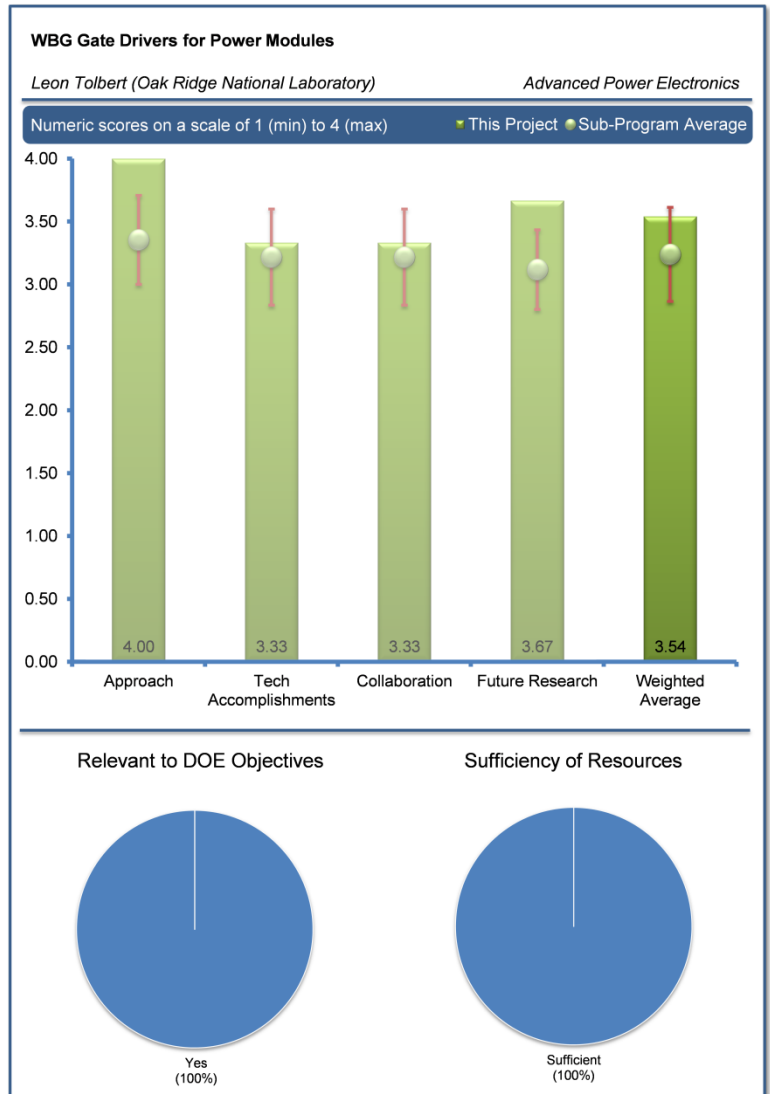
The reviewer indicated that the approach seems very comprehensive and runs in parallel paths with Zhenxian. The protecting factors for the fast switching are very important and will be very beneficial to the industry.

Reviewer 5:

The reviewer indicated that creating separate chips based on function is a low risk approach for evaluating new concepts. Having backup processes to evaluate process uncertainties also helps to increase the possibility of a successful first turn of chips. The reviewer added that it would be helpful to learn more details of the active current balance scheme. In particular, the reviewer was interested in the WBG chip requirements for making the balancing circuit work including current sense (i.e., what is the accuracy and repeatability, and number of additional pins required to perform the balancing).

Reviewer 6:

The reviewer commented that this project will develop a highly integrated power module incorporating WBG power electronic devices to reduce power density and cooling requirements by using high temperature packaging and components. The driver will include an integrated gate drive, isolation chip, power supply on a chip, and special protection features to enable fast switching of WBG devices.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that a great job of moving forward with the designs and simulation was done while awaiting Zhenxian's program deliverables to incorporate into the module. Getting all of those prototype designs out for fabrication by April was a great accomplishment.

Reviewer 2:

The reviewer noted that the project is on track and that barriers are being addressed.

Reviewer 3:

The reviewer noted that the interactions and choices are clearly being identified and potential issues are being addressed. The reviewer also noted that the project was able to reduce switching loss, which the reviewer expressed was good. In addition, the reviewer noted that, for paralleled SiC MOSFETs, experimental recognition of concern with variable threshold voltages led to simulation of a circuit to adjust the pulse width modulation (PWM) timing and, now more recently, confirming circuits with demonstrations in hardware.

Reviewer 4:

The reviewer commented that the input isolation device schematic and layout were designed, simulated, and submitted for fabrication in two technologies. Also, the power supply chip was designed and simulated. Additionally, the short circuit and overcurrent protection circuits were designed.

Reviewer 5:

The reviewer indicated that, in the first year, designing and sending the gate driver chips for fabrication was accomplished. Going forward, multiple fabrication techniques to mitigate the risk associated with the isolation requirements for the on-chip transformer are being looked at.

Reviewer 6:

The reviewer noted that circuit design has been completed, the circuit has been fabricated, and circuit modeling has been performed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that there was an outstanding team and collaborations.

Reviewer 2:

The reviewer observed that the project seems to be working well with vendors for integrated chip fabrication.

Reviewer 3:

The reviewer noted that the project has collaboration with several suppliers and other groups in DOE.

Reviewer 4:

The reviewer noted that there seems to be a strong collaboration within ORNL and the other programs. That is a great use of funding to piggyback on the different research programs. However, the reviewer observed that it would be beneficial to include private industry beyond just supplying components.

Reviewer 5:

The reviewer noted that another partner for the fabrication of the chips could be of use.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the reduced cross-talk and de-saturation protection seemed appropriate. The reviewer indicated that the plans to integrate and test the developed devices and circuits within the module are well defined. However, a simulation study of gate drive requirements for fast switching SiC and Insulated Gate Bipolar Transistors (IGBTs) in this module using physics-based power device models would be helpful in optimizing gate drive buffer. Simulation of electro-magnetic interference by including transmission line models for power module package interconnect parasitic would be helpful in eliminating the concern listed in the assumptions charts and evaluating the impact of parasitic capacitance of the gate isolation device.

Reviewer 2:

The reviewer indicated that the future research plans were well thought out, noting that the coming year would be challenging.

Reviewer 3:

The reviewer noted that the approach was logical and well stated.

Reviewer 4:

The reviewer commented that the project has a good plan to complete the driver design, modeling, and testing in the future.

Reviewer 5:

The reviewer noted that the explanation and amount of future activities for 2013 and 2014 was great. The future activities would have been more clear if more milestones were defined and if they were expanded beyond 2013.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that electrification of vehicles tends to lead to decrease in use of petroleum fuels.

Reviewer 2:

The reviewer commented that the goal and strategy of developing a highly integrated power module with integrated gate drive, input isolation, and integrated power supply in a high temperature package has significant potential to advance VTO goals.

Reviewer 3:

The reviewer indicated that, this, in combination with Zhenxian's project, will significantly improve the power electronics industry in both performance and cost goals.

Reviewer 4:

The reviewer noted that WBG devices may enable lower cost power electronics for EDVs. WBG devices will need a gate driver that can take advantage of their capability, and lowering the cost of the power electronics helps to enable the market for EDVs, which reduces our dependence on foreign oil.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the amount of resources and funding seems sufficient for this project. It is great that the University is also utilizing other funding sources to help this program and that it would be great to see that on other ORNL projects as well.

Reviewer 2:

The reviewer noted that the progress is on track with resources provided.

Electric Motor R&D: John Miller (Oak Ridge National Laboratory) - ape051

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the approach, as presented, provides sufficient detail identifying that the degree to which the technical barriers are being addressed. The reviewer noted that the project is well designed, feasible and integrated with other efforts to address the barriers.

Reviewer 2:

The reviewer observed that the project was well-conducted and planned.

Reviewer 3:

The reviewer noted that the project was a well-structured program with well-defined assessment criteria.

Reviewer 4:

The reviewer noted the appropriate focus on improved low loss steels and how to leverage these in non-RE topologies.

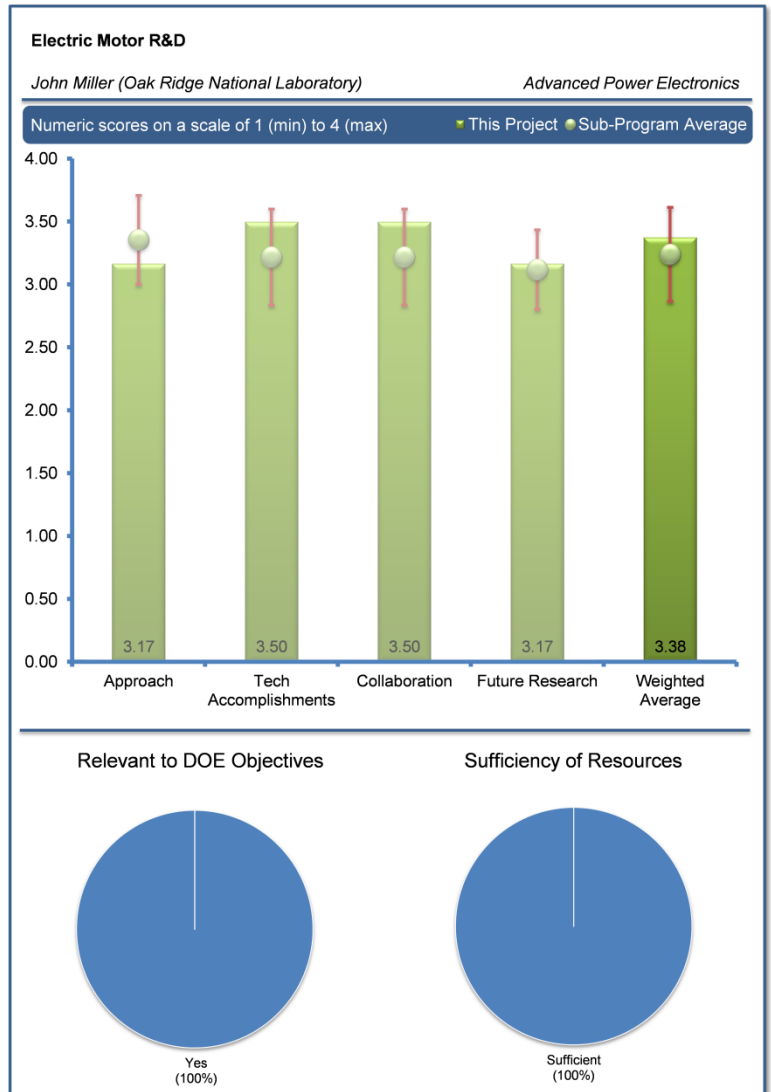
Reviewer 5:

The reviewer stated that the approach provides a good high-level view of baseline technologies, but higher speed has drawbacks that need to be honestly addressed to weigh the pros and cons. The approach pays little service to these issues, and glossing over them is the risk with this program. The reviewer noted that it will also be important to accurately quantify the costs of the various topologies: magnet costs, high speed bearing costs (also considering the typical tight tolerances required for other parts that drive up costs), high silicon lamination costs, etc.

Reviewer 6:

The reviewer commented that the main assumption for the approach in this project is that electric traction motors require a shift to a significantly higher maximum speed in order to meet the 2020 cost target. It was attempted to prove this assumption with a motor speed over time curve, which should describe the historical trend of automotive traction motor speed, as a surrogate for cost. The linear interpolation of the data points seems quite random and other interpolation curves are definitely valid, too; this could lead to a different conclusion like the curve is flattening over time. The reviewer also observed that the selection of the data points for interpolation was questionable. For example, the EV1 electric vehicle in the 1990s and all fuel cell vehicles from different manufactures over the last 8-10 years have maximum speeds around 10,000 to 12,000 RPM.

Additionally, the reviewer stated that, besides this general flaw in the approach, the other aspects of the project approach are well defined, as the selected motor topologies for investigation are valid choices and the improvement of materials for electric machines, especially in terms of loss reduction, and the improvement of thermal management are beneficial for any type of electric machine.



The reviewer also noted that the research in the area of high speed machines requires an evaluation of the complete drive system including transmission and inverter. This seems to be addressed with another new project.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the technical accomplishments and progress meet the overall project and DOE goals and objectives. The reviewer noted that sufficient information was provided in support of this assessment.

Reviewer 2:

The reviewer stated that the reasons for this work are sound, and exploring how fast is too fast is a worthwhile question. Documenting speed trends, the effect on motor size, and enabling technologies to push the speed envelope higher are all good research questions. The reviewer noted that the framework was set and it would be important to be thorough in evaluating all the implications of both low and high speed motors.

Reviewer 3:

The reviewer indicated that this was good progress, but the reviewer would have liked more detail on comparing specific motor performance curves under same conditions. The reviewer expressed concern that simply focusing on power density glosses over significant differences in speed range and efficiency. The reviewer was also not clear on what the rules of comparison were between benchmark motors and new topology designs.

Reviewer 4:

The reviewer observed that it was still too early to observe great gains in progress.

Reviewer 5:

The reviewer noted that the technical accomplishments are generally good, but not without flaws. The reviewer did feel that it was positive that suitable motor topologies have been selected for further investigation of high speed designs and the materials development has made progress, even though the latter topic needs more specific details about the obtained improvements. Also, the cost breakdown for the baseline permanent magnet (PM) motor from the Nissan LEAF was a very good accomplishment.

Additionally, the reviewer commented that a high speed induction machine has been designed and a cost breakdown has been derived, too. Unfortunately, this cost breakdown has errors. For example, the casting of the housing has been ignored and the cost assumptions for high speed bearings seem to be very optimistic.

Finally, the reviewer noted that that the high speed induction machine can easily meet the 2020 cost target was a very bold statement. Considering the mistakes in the cost breakdown and overly optimistic assumptions, the reviewer perceived that this statement was very questionable.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that, like all of these motor programs, there appeared to be great collaboration on this technical question.

Reviewer 2:

The reviewer commented that there are no issues identified with any of the collaborators; sufficient detail was provided on what contributions are being made by each of the collaborators.

Reviewer 3:

The reviewer noted collaborations with several divisions within ORNL and other National Laboratories are set up and seem to be working well, and the collaboration with material suppliers from the industry will surely benefit the project. The reviewer remarked

that it would be beneficial if collaboration with an electric machine OEM could be established in order to provide guidance for the project about what is of interest for the industry and how a high speed machine could be integrated into a transmission.

Reviewer 4:

The reviewer stated that the list of collaborators is good, but it would be outstanding to see a motor manufacturer on the list. A motor manufacturer, for example, may be the only type of collaborator that would be able to translate the tight tolerances required for high speed bearings into part costs.

Reviewer 5:

The reviewer indicated that collaboration is evident and well-coordinated with steel researchers. The reviewer expressed that it was not as clear if or how collaboration on thermal analysis is being done.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the proposed future work plan is consistent with the project objectives with adequate details and specificity supporting this assessment.

Reviewer 2:

The reviewer noted that, as this project scope goes through the 2015 fiscal year, there appears to be a great definition of future work and deliverables.

Reviewer 3:

The reviewer commented that a good approach was planned; the reviewer hoped to see more apples-to-apples performance curves and efficiency map comparisons going forward.

Reviewer 4:

The reviewer remarked that, overall, the milestones in the project are well defined. New developments in the material area will be integrated into the next iterations of the motor designs. The reviewer noted that this specific project has made many twists and turns in its approach and focus since it was started, even merging two other projects into one; the reviewer expressed hope that the researchers now have a clear plan for the remaining duration of the project.

Reviewer 5:

The reviewer listed some important questions to address in future presentations. Regarding low loss laminations, the reviewer was interested in the tradeoffs in costs and saturation flux density. For high speed motors, the reviewer would like to know the transmission implications. Regarding high speed bearing, this reviewer inquired about the cost implications for bearings, end bell tolerances, and shaft tolerances. For heat rejection, the reviewer noted that very high power density motors, especially induction motors, have real issues with heat rejection, which will also affect bearing performance and life. For motor life, the reviewer explained that service intervals and premature failures are almost always driven by bearings and seals, not insulation systems; as such, the reviewer suggested addressing bearing and rotating seal service and lifespan in the analysis. Finally, for magnets, the reviewer recommended an attempt to use real prevailing cost per pound numbers.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that the statements in the presentation are positive that the work supports the overall DOE objectives of petroleum displacement.

Reviewer 2:

The reviewer commented that the project supports the objective of petroleum displacement by developing new motor concepts without the use of expensive rare-earth magnet materials. If successful, these would result in cost savings for electric drive systems, which would enable a faster market introduction of Hybrid and Electric Vehicles.

Reviewer 3:

The reviewer stated that the project addresses inherent sustainability problem in motors that use current rare earth magnets and offers a potential path to sustainable, low cost, and high efficiency motors for HEV and EV applications.

Reviewer 4:

The reviewer noted that, by developing better motors that are less dependent on rare earth materials, the market can mature at a more stable rate.

Reviewer 5:

The reviewer stated that better motors for EVs and HEVs supports the objectives of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that the presentation does not comment on any difficulties on resources.

Reviewer 2:

The reviewer commented that the project has sufficient resources for the defined tasks.

Reviewer 3:

The reviewer opined that there was no way to qualify whether or not the resources were sufficient enough for the project to achieve the stated milestones in a timely fashion based upon the information received.

Reviewer 4:

The reviewer noted that the resources were sufficient, but there were additional details that had not been addressed that needed to be considered when performing design trade studies.

Integrated Vehicle Thermal Management: John Rugh (National Renewable Energy Laboratory) - ape052

Reviewer Sample Size

A total of eight reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the approach, as presented, provides sufficient detail identifying that the degree to which the technical barriers are being addressed. The project is well designed, feasible and integrated with other efforts to address the barriers. A system level look is the right approach for optimization.

Reviewer 2:

The reviewer noted that the approach in this project is to start with the implementation of thermal one-dimensional (1-D) models for all thermal components in an EV. In a second step, the most promising combined thermal management system concepts are selected and assessed in detail and tested on a bench test set-up.

The reviewer expressed that this is a very good approach and it will support the automotive industry in their effort to simplify the cooling systems for EVs and the collaboration with automotive manufacturers and suppliers on a vehicle-level should provide helpful insights in achieving this goal.

Reviewer 3:

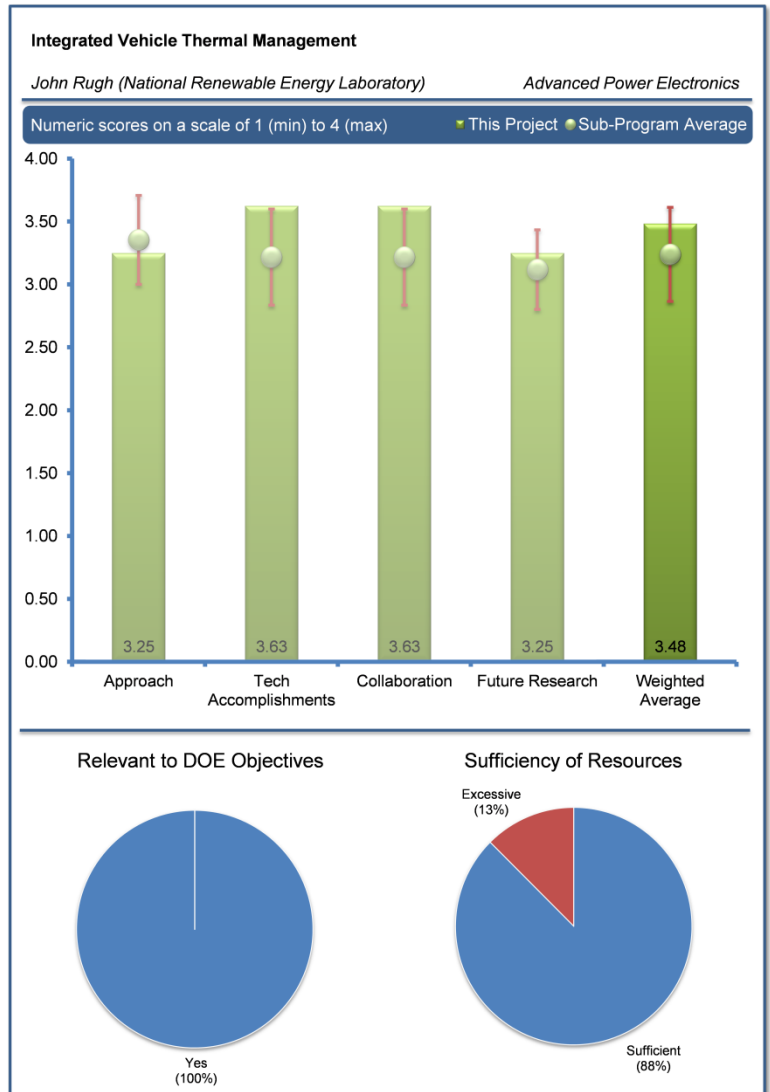
The reviewer commented that designing a cooling system based on all of the heat loads and optimizing it for optimum overall performance is a great objective. The reviewer opined that an important issue that remained to be addressed was how to convince the various separate design responsible entities to do this, but that issue was beyond the scope of the project. The reviewer thought that the combined approach is very good and would significantly reduce the overall cost and mass of the vehicle.

Reviewer 4:

The reviewer noted that the project includes the vehicle as a whole, including energy storage and the propulsion system, beginning with modeling and moving to bench testing. The reviewer noted that relevant scenarios, cooling combinations, and routing were addressed. The reviewer was surprised that vehicle OEMs are not designing thermal management from a vehicle systems standpoint; even if some are already doing so, this work will educate those who are not, and perhaps provide new ideas for those who are.

Reviewer 5:

The reviewer indicated that the project provides logical design and test approach, including complete system thermal/fluid model. Approach progresses from modeling, to bench tests, to vehicle level tests.



Reviewer 6:

The reviewer stated that the project is well conducted. The reviewer's only suggestion is to also include comparison of the cost, weight, and life to the baseline thermal management system if possible.

Reviewer 7:

The reviewer commented that thermal management synergies were another excellent DOE objective to working towards a fringe objective.

Reviewer 8:

The reviewer commented that there were many qualitative statements but nothing is quantified. The reviewer observed that, by stating combined cooling loops will save cost, the potential cost savings should have also been indicated, especially with so many suppliers involved in the project. The reviewer also did not feel that the barrier to be overcome was established.

The reviewer noted that modeling is performed. However, the modeling does not establish how much performance is taken from the individual cooling systems. The amount of performance lost through combining the systems was not noted.

The reviewer also indicated that the worst case cooling conditions that would establish the worst case heat transfer requirements that typically size the cooling systems were not established. Without that exercise, the reviewer was unsure how the combined cooling system is assured not to end up being a larger combined system that provides just a modest cost reduction.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that it was very good progress in adding or updating component thermal models, including inverter and battery. The reviewer also noted that the project demonstrated the benefit of utilizing waste heat of power electronics to reduce electric heater requirements and improve battery warm-up in cold conditions.

Reviewer 2:

The reviewer noted that the model and hardware tools were well defined and that the project brings a practicality to the solution.

Reviewer 3:

The reviewer commented that the technical accomplishments and progress, as stated, meet the overall project and DOE goals and objectives. The reviewer noted that there was sufficient information provided in support of this assessment. Additionally, the reviewer remarked that the results from a system level approach are encouraging.

Reviewer 4:

The reviewer noted that the baseline EV thermal systems models have been completed and combined cooling loop strategies have been investigated. The reviewer added that combining fluid loops can offer advantages, indicating that strategies have been identified to evaluate with bench testing.

The reviewer also expressed that it is very important to investigate the current DOE requirement of 105°C coolant temperature for the power electronics and electrical machine components in more detail. This requirement might make sense in hybrid vehicles with an existing cooling loop for the ICE, but in EVs without the legacy high temperature cooling loop, this might not be the best choice. The reviewer was hopeful that the project could help clarify the issue.

Reviewer 5:

The reviewer commented that the work to acquire the appropriate model inputs across many different groups is commendable. The work to create a realistic baseline was also time well spent. The reviewer indicated, relative to this research, the effects of combining systems were quantified for both power consumed and transient effects on the vehicle and passenger. Pros and cons are both disclosed as well.

Reviewer 6:

The reviewer indicated that the technical progress to date is very good; the data and models justify the approach and conclusions. The reviewer noted that there was probably need to determine the impact of the slightly higher energy storage system (ESS) temperatures mentioned on the performance of the battery (mostly life) to be able to answer questions from the battery responsible group. The reviewer queried whether the modeling took into account the length of coolant hoses due to various component locations with the vehicle.

Reviewer 7:

The reviewer commented that the technical accomplishments listed were weak. The listed accomplishments: completed baseline EV thermal systems model, investigated combined cooling loop strategies, identified advantages of combining fluid loops, and identified strategies for bench testing are very qualitative statements. The reviewer wondered, from a technical standpoint, what of the accomplishments was new.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated that sufficient detail is provided on what contributions are being made by each of the collaborators. There are no issues identified with any of the collaborators.

Reviewer 2:

The reviewer commented that the collaboration set-up with industry partners and the other VTO tasks is excellent.

Reviewer 3:

The reviewer observed that it is good to see industry involved and so it must have some value.

Reviewer 4:

The reviewer indicated that there was good use of industry collaboration including OEMs, component producers, and software.

Reviewer 5:

The reviewer expressed that it was very good to see Ford, Visteon, Magna, and VTO together, which will drive the practical solutions.

Reviewer 6:

The reviewer noted that the appropriate industry partners and groups within the VTO are included in the program. This looks like a well-organized program.

Reviewer 7:

The reviewer indicated that the collaboration among team members appears to be working well.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the proposed future research work plan is consistent with the project objectives with adequate details and specificity.

Reviewer 2:

The reviewer commented that the future research will mainly focus on the final bench test implementation and verification of the simulation models. The project is well planned and milestones will support the decision if vehicle level tests are necessary.

Reviewer 3:

The reviewer stated that the future work was a logical follow-up to modeling work, namely successively higher level verification of modeling through bench testing, and bench testing through vehicle testing.

Reviewer 4:

The reviewer commented that the future work for design, bench test, and vehicle level testing was good. The reviewer explained that it would have been useful to provide a little more detail on projected or desired outcome. The reviewer remarked that it was important to integrate cost impact into this program whether positive or negative. The reviewer expressed that a systems-level approach should have a net positive cost impact and it is important to highlight this during briefings.

Reviewer 5:

The reviewer found that the future work is logical for the next steps. However, the reviewer suggested adding some analysis investigating the life/reliability impacts of a single loop including failure mode and effects analysis (FMEA) for the system. The reviewer also wanted to know if the bench system will be able to vary the ambient conditions such as temperature, humidity, etc. and the various loads from the power electronics and ESS.

Reviewer 6:

The reviewer indicated that this project represents an incremental improvement. However, the reviewer did not see barriers overcome with this project and or any new technology being developed. The reviewer noted that Audi announced the e-Tron that will be released next year that will combine the battery and power electronics cooling loops. That will provide a nice incremental improvement, but it is hardly breaking down any barriers.

Additionally, this project is an integration effort; the reviewer observed that no technology has been defined that would warrant further involvement by the best minds at our National Laboratories. The reviewer stated that technology breakthroughs are needed by the laboratories, not integration efforts, and that integration should be left to industry to perform. Research would be better served to find new materials and/or more efficient heat transfer mechanisms that the supply base does not have the sufficient R&D capability to develop.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer commented that the research work supports the overall DOE objectives of petroleum displacement.

Reviewer 2:

The reviewer stated that the project supports the objective of petroleum displacement by improving the cooling systems of EVs. If successful, these improvements would result in reduced costs for the electric drive train, which would enable a faster market introduction of Hybrid and EVs.

Reviewer 3:

The reviewer indicated that the goals of project are to better utilize waste heat energy and common cooling loops to reduce mass, cost, and range of hybrid and EVs.

Reviewer 4:

The reviewer commented that looking at the entire vehicle relative to subsystem cooling is useful so that the appropriate synergies and tradeoffs are evaluated.

Reviewer 5:

The reviewer indicated that cooling is an integral part of the vehicle and reducing the number of separate loops should reduce vehicle mass and cost.

Reviewer 6:

The reviewer commented that, from the qualitative statements, it should support petroleum displacement, but the reviewer wanted to know how much displacement might occur. While it may be relevant, it may not be that significant.

Reviewer 7:

The reviewer expressed having no qualification for this question.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that there was no mention of difficulties on resources.

Reviewer 2:

The reviewer expressed that the project has sufficient resources for the defined tasks.

Reviewer 3:

The reviewer remarked that the resources for this program are appropriate and sufficient.

Reviewer 4:

The reviewer commented that the results indicate that resources are sufficient.

Reviewer 5:

The reviewer noted that the modeling effort to understand what is possible would be more than sufficient for the DOE to spend money. Spending additional money on testing and hardware is best left to industry partners. The reviewer commented that if value exists by doing this work, then industry will pay for the hardware and testing and did not see \$1.25 million worth of research that is showing how barriers are broken.

Inverter R&D: Madhu Chinthavali (Oak Ridge National Laboratory) - ape053

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that benchmarking is ongoing and that the work appears to be done in a detailed manner.

Reviewer 2:

The reviewer stated that the WBG device cost is mentioned and benefits of cost reduction on other subsystems is a focus but it is unclear that analysis cost break points have been determined.

Reviewer 3:

The reviewer stated that this is an important project for the DOE. It helps quantify the potential benefits of the emerging SiC devices. The reviewer noted that a lot of progress in the first year towards demonstrating the full scale system was reported. The reviewer noted that it would be interesting to quantify next year, once the 10kW system has been built, where the power density improvement comes from, as well as an efficiency comparison to the state of the art.

Reviewer 4:

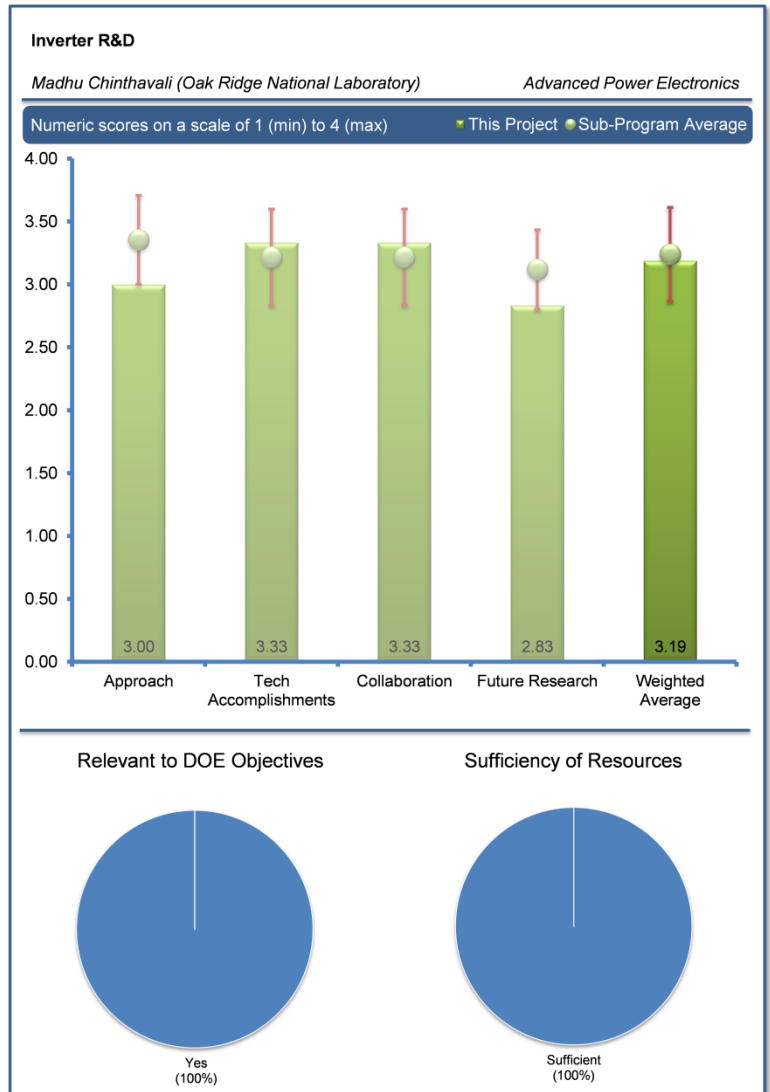
The reviewer remarked that the project presents a clear integrated approach on how to use WBG inverter to achieve the size, weight, and cost goals. Slides of particular note to the reviewer included Slide 6.

Reviewer 5:

The reviewer commented that the availability of WBG die in the voltage and current range needed for the application is a barrier. The reviewer indicated that working with the WBG supplier to understand their road maps to get an idea of costs and what is their plan for automotive qualifications for application specific devices will be necessary. Additionally, off the shelf WBG materials that would use all the capabilities of the in-house WBG gate driver may be even harder to get. For example, active current balance to share current evenly between paralleled devices may be difficult to find. From the design review in August, it would be useful to state the conditions under which the inverter could meet the 20/20 targets and what is included in that inverter design. The reviewer observed that this was a good first step to understand how WBG power devices can be used to meet the DOE 20/20 targets.

Reviewer 6:

The reviewer did not see a plan on how to accomplish the cost objectives. The reviewer commented there were no studies of cost trade-offs to determine how to balance the system cost.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer was glad to see a website to make the information about WBG transistors and diodes more widely available.

Reviewer 2:

The reviewer commented that the project has completed the initial design of a 10 kW inverter using commercial SiC 1200 V, 100 ampere (A) MOSFET modules. The project has also tested the power module in the Nissan LEAF as baseline. Additionally, the cooling design has been improved.

Reviewer 3:

The reviewer commented that there are quite a few subsystem development efforts each with alternate approaches but it is not clear how this will be pulled together to meet program goals.

Reviewer 4:

The reviewer noted that the designs are moving forward. The design review of the inverter will determine if there is a path to the 20/20 targets. At this time it is difficult to assess the progress toward objectives without more knowledge about the completed design.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted many connections with suppliers that are being benchmarked.

Reviewer 2:

The reviewer noted that the project has collaboration with several suppliers, power inverter companies, and several other groups in DOE.

Reviewer 3:

The reviewer remarked that, with regards to awareness of who to talk to in the industry about WBG materials, the project team is well covered. The reviewer noted that there was nothing mentioned about the project team's plans for capacitors, but there were three capacitor manufacturers listed as collaborators. The reviewer wanted to know if there was a custom capacitor that was part of the design or if it was just a repackaged PP capacitor.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted the ongoing nature of the benchmarking project.

Reviewer 2:

The reviewer commented that the project steps are reasonable, but a detailed cost study of what needs to be accomplished in the design to meet the 2020 goals and objectives is missing. The reviewer noted that good work is being done, but without focus on the cost issue it does not really provide any justification for using WBG technology in automotive applications.

Reviewer 3:

The reviewer expressed that it would be a very good thing if the project team can show a path to the 20/20 targets in August using WBG materials, but WBG may be one of many challenges needed to overcome to meet the targets. For example, if an air cooled WBG inverter is chosen to meet the 20/20 targets the costing should also include a fan and ducting. The reviewer asked what might happen if the fan and the inverter location required a twisted route to duct the air.

Reviewer 4:

The reviewer commented that the project has a clear path to 30 kW WBG power inverter with 55 kW peak power.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that electrification of vehicles tends to decrease petroleum use.

Reviewer 2:

The reviewer stated from efficiency only.

Reviewer 3:

The reviewer commented that, if the design can meet the 20/20 targets, this would enable the market for EDVs and reduce our reliance on foreign oil.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that, for where the project team is at today, the resources are sufficient.

WBG Converters and Chargers: Gui-Jia Su (Oak Ridge National Laboratory) - ape054

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the benefits from switching mode are becoming clearer.

Reviewer 2:

The reviewer stated that the strategy to utilize high frequency WBG on-board chargers and converters to reduce size, weight, and cost and increase efficiency is good. Bidirectional charger capability is also good, but roaming grid inverters face grid integration standard and regulatory changes which are being address by the Smart Grid Interoperability Panel (SGIP) Distributed Renewables, Generation & Storage (DRGS) and the Vehicle to Grid (V2G) Domain Expert Working Groups (DEWGS). The reviewer noted that ORNL and NREL are becoming members of SGIP so it might be appropriate for this project to monitor these efforts or to coordinate through National Institute of Standards and Technology (NIST).

Reviewer 3:

The reviewer commented that this project overcomes the limitations of present semiconductor and magnetic materials with WBG devices, advanced magnetic materials and novel control strategies to significantly increase power density, specific power and efficiency at lower cost. Additionally, the reviewer noted that the project can reduce the cost of the power inverter by using smaller capacitor.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

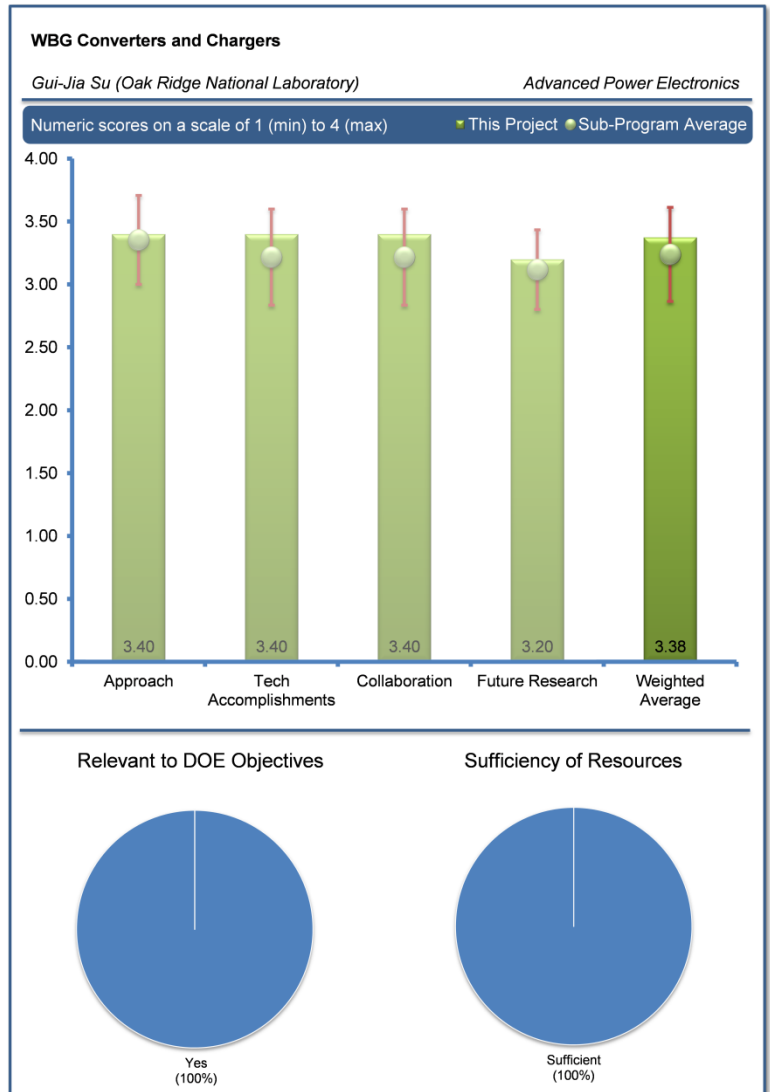
The reviewer noted that isolation converter architecture selection and design modeling was performed, and testing was performed using silicon devices. SiC and Gallium Nitride (GaN) switch for vehicle converter applications were also evaluated.

Reviewer 2:

The reviewer remarked that cost needs to be looked at and justify why this approach is better than a conventional solution.

Reviewer 3:

The reviewer commented that the team has done quite a bit of work in the first year. The reviewer observed that, though the new devices provide some interesting opportunities, a lot of work has been done on the topology tradeoff by others. It would be a good



idea to focus on the improvements that can be made with the conventional topologies using the new devices rather than spending too much effort on topologies tradeoff. The reviewer noted that it appeared that the goal was to complete the tradeoff analysis this year, but there was no indication which topology was chosen.

Reviewer 4:

The reviewer commented that the project has significant achievements up to now and several technical tasks have been performed. The project has simulated several converter architectures and developed a battery ripple current reduction control strategy for the isolation converter to reduce the bulky DC link capacitor. The project also identified one isolation converter candidate and completed testing of a 5kW Si-based integrated DC-DC converter and charger using the candidate. In addition, the project has completed DBC design for WBG switch phase-leg modules for CREE, Inc. SiC MOSFETs. The project also conducted tests of efficient power conversion (EPC) eGaN switches for possible use in the 14V DC-DC converter.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the industry WBG and magnetic material partners were outstanding. ORNL, NREL and the University of Tennessee were also listed as partners.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the detailed future plans seem reasonable.

Reviewer 2:

The reviewer indicated that the project has a clear plan to achieve the milestones in the future.

Reviewer 3:

The reviewer commented that a cost rational of how this lowers cost was needed.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that electrification of vehicles tends to decrease petroleum use.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

System Integration and Validation: Tim Burress (Oak Ridge National Laboratory) - ape055

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the system modeling seems appropriate.

Reviewer 2:

The reviewer remarked that this was an interesting project that will give the DOE capabilities to study the interactions between various electric driveline components.

Reviewer 3:

The reviewer commented that developing a vehicle hardware-in-the-loop (HIL) simulation system is an excellent approach to better quantify requirements as well as the possibility of shortening design cycles. Additionally, the reviewer noted that developing a universal controller with a dynamic control system and high speed data acquisition system should provide useful information on system behavior somewhat independent of hardware. However, the reviewer noted that a plan for incorporating the Glidcop material into an IM rotor was not addressed.

Reviewer 4:

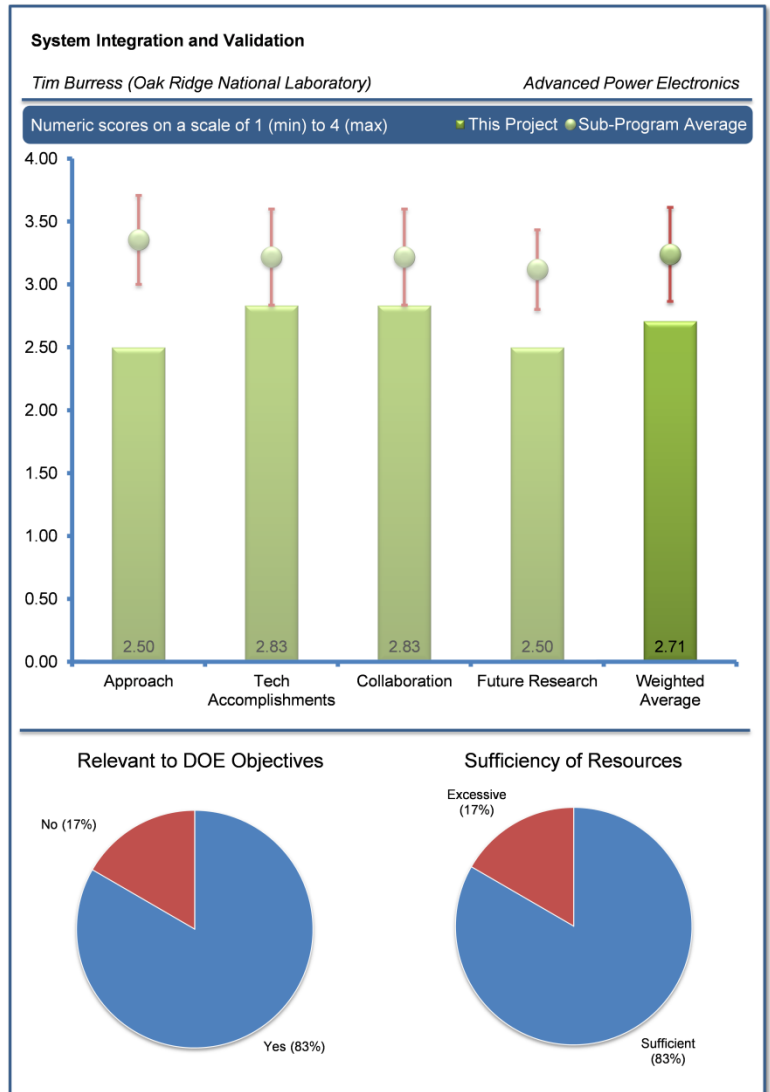
The reviewer commented that this project does not develop the technology to overcome barriers. The reviewer noted that this project is developing testing capabilities to perform verification work.

Reviewer 5:

The reviewer commented that the desire to test traction drive system performance is necessary, but wondered if the development of a facility to do this cost effective when compared to using existing facilities such as those that are available from AVL. The reviewer noted that the use of combined test profiles is very good and will provide usable data. An additional requirement to fully evaluate the system that was noted was to be able to test over temperature for the various components. The reviewer also wanted to know if the system will be able to test motors only or if it will be able to also test motor/gear boxes to determine the efficiency of the retransmission function.

Reviewer 6:

The reviewer commented that it was unclear why this was being done when it seemed to be more of an OEM task.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the system modeling work based on component-by-component simulation appears to be appropriate.

Reviewer 2:

The reviewer indicated that the development is on track from a hardware standpoint with barriers identified. However, some mention needs to be made about how the software development is going for the software that glues this system together and analyzes the results.

Reviewer 3:

The reviewer stated that the progress is very good in terms of supporting an in house HIL system capable of testing individual components from various suppliers. However, the reviewer noted that if the goal is to test only systems then these components might not be required and that the development of these components will support other uses such as motor testing and/or inverter only testing, if required. The reviewer asked if there is the capability/plan to test ESS subsystems in this facility.

Reviewer 4:

The reviewer stated that this project is not applicable to achieving the DOE goals. The reviewer indicated that this project is developing a HIL system in a dynamometer, building up ORNL to perform testing.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that it looks like a good team to develop the hardware in the loop vehicle simulation system.

Reviewer 2:

The reviewer noted that the collaborations with the DOE and the National Laboratories community are outstanding. The reviewer was interested in knowing if industry had been contacted to determine what facilities already exist and to find out what kind of issues and solutions that they have implemented.

Reviewer 3:

The reviewer commented that this project should not be an Advanced Power Electronics and Electrical Machines (APEEM) project, noting that this is a capital expenditure project to acquire test equipment.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that, in discussing future work, the year by year delineations are clear. The reviewer mused that perhaps it is only in modeling work that such precise plans can be formulated. The reviewer was heartened that the modeling in out-years will include hardware-in-the-loop.

Reviewer 2:

The reviewer noted that the hardware future development is well defined. More information about software development and how it plays into this development would be useful.

Reviewer 3:

The reviewer indicated that future plans are appropriate for the project as defined.

Reviewer 4:

The reviewer was unsure of how much value the data generated will be. Every vehicle's operating modes are different. It seemed to the reviewer that this project will not generate data that will be real.

Reviewer 5:

The reviewer stated that there is no research here.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer commented that the increased electrification of vehicles tends to decrease petroleum use.

Reviewer 2:

The reviewer noted that, if successful, there is potential for reducing design times and improving system efficiency and lowering system cost, all of which help to enable the market for EDVs, which in turn helps to lower our dependence on foreign oil.

Reviewer 3:

The reviewer stated that these functions are required to meet the DOE goals but wondered if this is the most cost effective method to achieve it. The reviewer stated that it might be, in the long run.

Reviewer 4:

The reviewer commented that this project is just a capital expenditure project.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer observed that the project is on track with resources defined.

Reviewer 2:

The reviewer commented that the resources are appropriate for the project as defined.

Reviewer 3:

The reviewer noted that hiring a company that specializes in dynamometers and HIL systems to deliver a turnkey system to the lab would be better. This project will be slow to develop, will be highly customized, and will have to walk through a long debug process to get up and running.

Power Electronics Architecture R&D: Omer Onar (Oak Ridge National Laboratory) - ape056

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that high voltage bi-directional conversions appear to be important to higher efficiency.

Reviewer 2:

The reviewer indicated that this is a new project, and the researchers have made good progress on meeting project goals.

Reviewer 3:

The reviewer stated that this project proposed a hybrid energy storage system with both batteries and ultra-capacitors. A modular and reconfigurable bi-directional buck/boost DC-DC converter will be designed and developed to be placed between the regenerative energy storage systems (RESS) and the DC link (traction drive inverter). The reviewer noted that the use of ultra-capacitors in the energy storage system may increase the vehicle energy storage cost as ultra-capacitors are more expensive than batteries.

Reviewer 4:

The reviewer commented that modeling many topologies for DC-DC converters, building one or two based upon the model results, and decoupling energy and power from the energy storage system is a good approach. Recognition that system cost could increase based on choices is an excellent observation. The reviewer noted that, if system cost increases, there needs to be a discussion on the expected system benefits that could justify the cost increase.

The reviewer indicated that the decision point on whether to proceed is not clear. It states change if the hybrid system outperforms the reconfigurable system, but it was unclear what would be changed if this occurred.

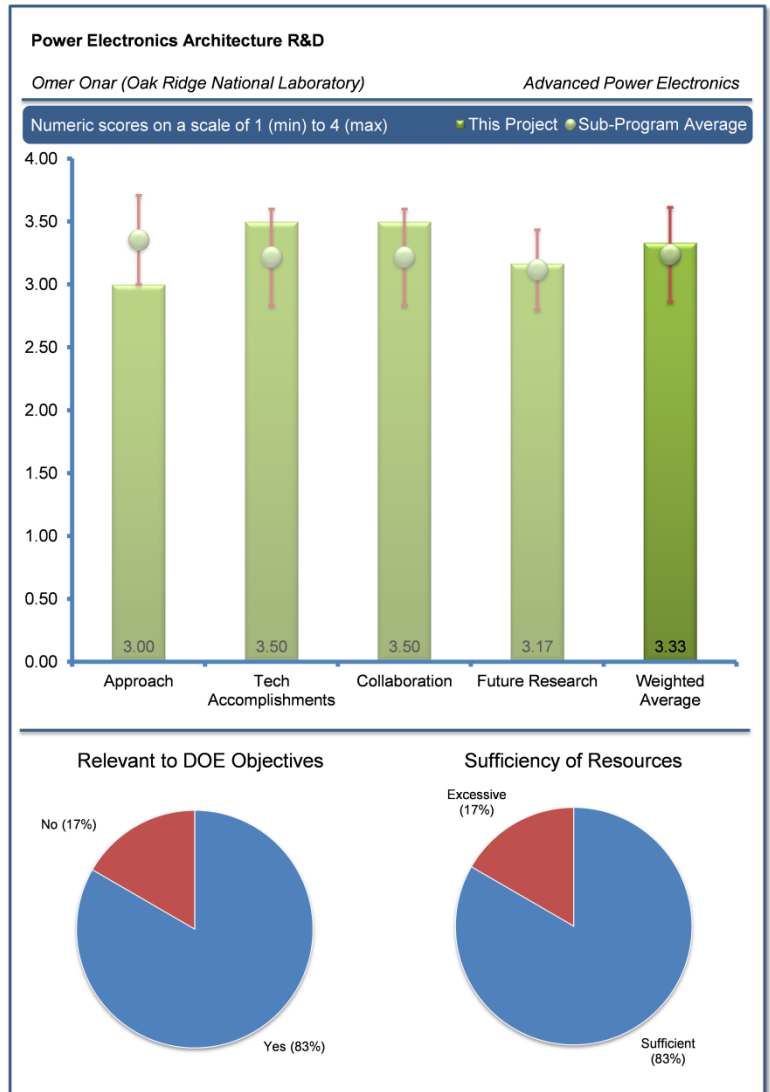
Reviewer 5:

The reviewer was not clear on why and how this work addresses the technical targets.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer believed that the work was still at an early stage, but the planning appears to be detailed.



Reviewer 2:

The reviewer commented that the project has a good start in analyzing architecture options.

Reviewer 3:

The reviewer stated that the progress is on track, noting that downselection of architecture needs to be finalized to see if costs are in line with DOE targets.

Reviewer 4:

The reviewer noted that the project has designed and modeled different designs.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer commented that the linkages with Maxwell and Chrysler were good.

Reviewer 2:

The reviewer stated that having Chrysler and the ultra-capacitor companies as collaborators with the ORNL team was positive.

Reviewer 3:

The reviewer noted that the project has collaborations with both energy storage experts and power electronics experts.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the plans seem clear and logical; first a test bed and then systems integration. The reviewer stated that this was good.

Reviewer 2:

The reviewer noted that the plans are based on progress; a decision point on cost versus performance needs to be included.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer indicated that electrification of vehicles tends to decrease petroleum use.

Reviewer 2:

The reviewer commented that the possibility of using active energy management to reduce the size and cost of power electronic converters helps to enable the market for EDVs, which decreases dependence on foreign oil.

Reviewer 3:

The reviewer commented that the hybrid energy storage system may balance the energy density and power density, and improve regenerative braking.

Reviewer 4:

The reviewer commented that it is not clear; system baseline performance and proposed system performance are not quantified.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer remarked that the project is on track with resources on hand.

Electric Motor Architecture R&D: Curt Ayers (Oak Ridge National Laboratory) - ape057

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the approach in this project supports the assumption from the Electric Motor R&D project, that electric motors need significantly higher maximum speed to meet the 2020 cost target. Although the validity of this assumption is questionable, the approach to include the transmission or gear box components into the overall system evaluation is good. Additionally, the reviewer noted that the evaluation of material limits regarding high speed operation is of interest for the automotive industry.

Reviewer 2:

The reviewer indicated that understanding current technology and utilizing information from other benchmarking and development programs is a good start to the approach. Analyzing these machines, their associated transmissions, and looking to address the issues found through these analyses are also appropriate. The reviewer noted that it will be important to understand not only the architecture, material, and component selection, but the tolerances and American Gear Manufacturers Association (AGMA) gear grades required for high speeds, as these affect cost.

Reviewer 3:

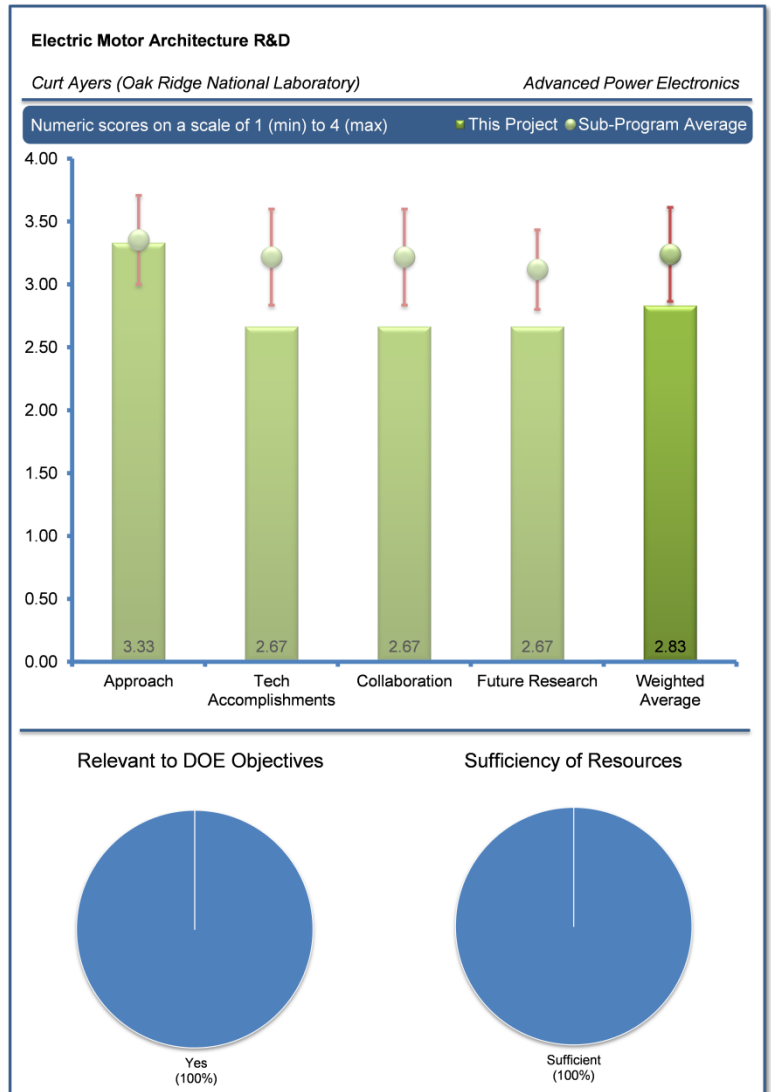
The reviewer indicated that the project is well conducted and planned.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the project was started in FY 2013. The initial accomplishments are good with the benchmarking of existing traction systems.

The reviewer was unclear on the benefits of the investigation of starter motor designs for high power traction drive systems. The usage profile and thus the requirements for a starter motor are very different compared to a traction motor. The reviewer thought that future accomplishments might make the benefits of investigating starter motors more obvious.



Reviewer 2:

The reviewer indicated that this is a relatively new program. The technology teardown, technology evaluation, and FEA modal analysis are good early accomplishments. The reviewer commented that motors are designed for their speed of operation, and suggested not to conclude that higher speeds are limited by copper bar or magnet retention because retention systems can be improved by trading off performance, which is why retention systems are not highly over designed.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that collaboration with an industrial motor supplier is in an early stage, but will hopefully lead to good results. The reviewer commented that the involvement of transmission suppliers or automotive OEMs would strengthen the project focus.

Reviewer 2:

The reviewer noted that Regal-Beloit Corporation is an industrial motor supplier. The reviewer questioned their knowledge regarding traction systems for transportation.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that analyzing possible gear solutions for high speed motors, complementing other ORNL work, is worthwhile. It will be important to look at gearing cost (materials, grades, and tolerances), gearing and bearing losses at high speeds, and total traction system specific power and power density. Most of these issues were already noted, leading the reviewer to believe there was a good understanding of what needs to be analyzed.

Reviewer 2:

The reviewer commented that the future research plans are not very detailed at this point in time. The reviewer hoped that the planned benchmarking activity will support the future definition of more specific plans.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer indicated that the project supports the objective of petroleum displacement by investigating driveline components with the focus on higher speed. If successful, this could result in cost savings for electric drive systems, which would enable a faster market introduction of Hybrid and EVs.

Reviewer 2:

The reviewer commented that better electric propulsion systems support the DOE objectives of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer remarked that the project has sufficient resources for the defined tasks.

Reviewer 2:

The reviewer indicated that resources at ORNL are appropriate and there is industry involvement in this program.

US Electric Drive Manufacturing Center: Judith Giesecking (General Motors) - arravt021

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that GM has built the first U.S. factory for electric motors in Maryland. The facility also makes electric drivetrains. Both components will be part of the Spark EV. The equipment for both components has been installed and validated. The factory began making electric motor units in May 2013.

The reviewer indicated that the aims are to develop domestic electric motor design, engineering, and manufacturing capabilities, as most key electric drive components are currently built in East Asia. GM reported that prototype and production builds of both motors and electric drive units were delivered on time, with hundreds of units of both parts built through the first quarter of 2013.

Reviewer 2:

The reviewer commented that creating more jobs and building a new factory to make EV motors in three years is very good.

Reviewer 3:

The reviewer indicated that the program was responsive to the requirement of adding production capacity for electric motors and drives.

Reviewer 4:

The reviewer noted that the facility is up, running, and producing parts.

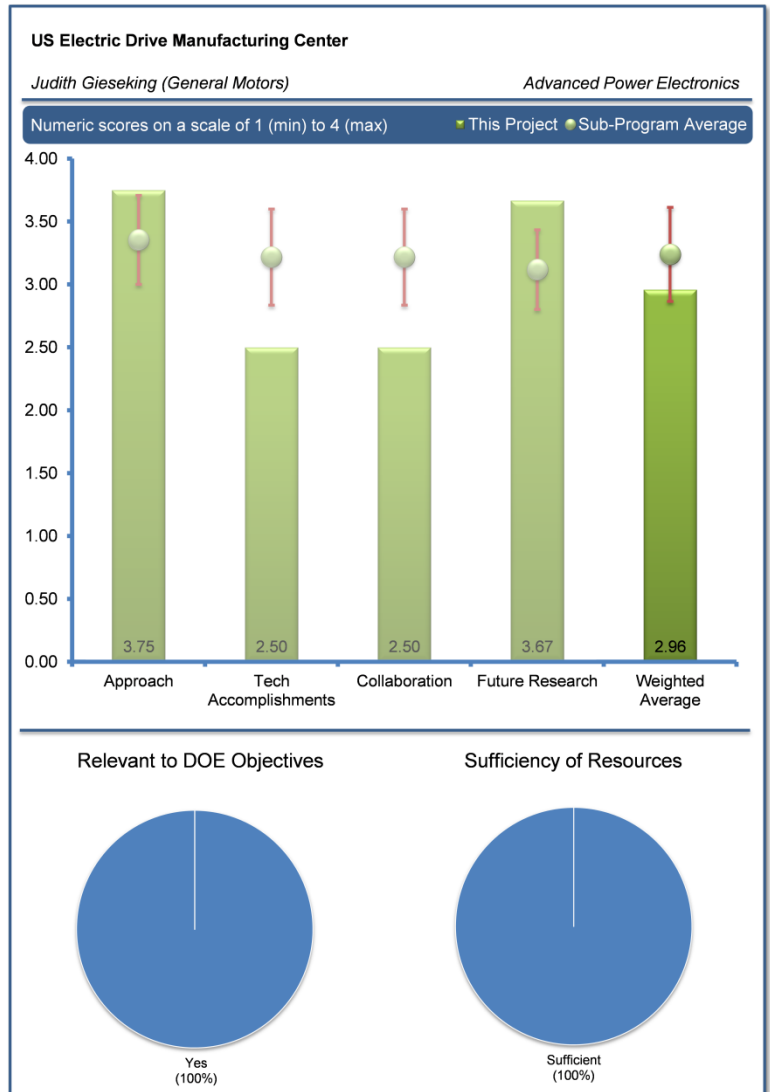
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the equipment for both components has been installed and validated. The factory began making electric motor units in May 2013.

Reviewer 2:

The reviewer noted that the project made good use of automation and technology.



Reviewer 3:

The reviewer stated that production in the facility has been launched. The production line strategy and the product qualification were provided. However, there was little detail regarding the system being manufactured.

Reviewer 4:

The reviewer noted that consumer acceptance is the last barrier that needs to be overcome. The market for EDVs is growing and GM is well positioned to capitalize on that expanding market.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated that GM reported that there were no external collaborations beyond the DOE assistance. The reviewer presumed that construction contractors were involved at some point.

Reviewer 2:

The reviewer noted that GM used in-house expertise.

Reviewer 3:

The reviewer stated that no collaboration on this program is noted. The reviewer indicated that little collaboration for this type of program is required.

Reviewer 4:

The reviewer indicated that there are no other partners.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer expressed that it was great that plant production in 2013 was on budget and on schedule.

Reviewer 2:

The reviewer noted that the program is concluding, so there is no future work to evaluate.

Reviewer 3:

The reviewer stated that the project is on track for close out.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer commented that GM's new factory supports the manufacture of PEVs in the U.S. This will make it easier for GM to deliver PEVs to U.S. consumers, who can then drive these vehicles instead of conventional ICE vehicles that run exclusively on petroleum-based fuel.

Reviewer 2:

The reviewer indicated that the project gives the United States a leadership position in electrifying vehicles into the future.

Reviewer 3:

The reviewer stated that manufacturing infrastructure is a key element in the sale of electrified vehicles.

Reviewer 4:

The reviewer noted that the project enables the U.S. manufacturing of EDV powertrains and creates and retains U.S.-based manufacturing jobs. The reviewer noted that 29 advanced manufacturing jobs were created at the new facility. The reviewer was unclear regarding the number of jobs that were retained at the facility.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the project was completed with the resources provided by DOE and GM.

Reviewer 2:

The reviewer stated that GM has the resources to execute this program.

Reviewer 3:

The reviewer commented that the project is heading to closure with the resources available.

Low-Cost U.S. Manufacturing of Power Electronics for Electric Drive Vehicles: Greg Grant (Delphi Automotive Systems LLC) - arravt022

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

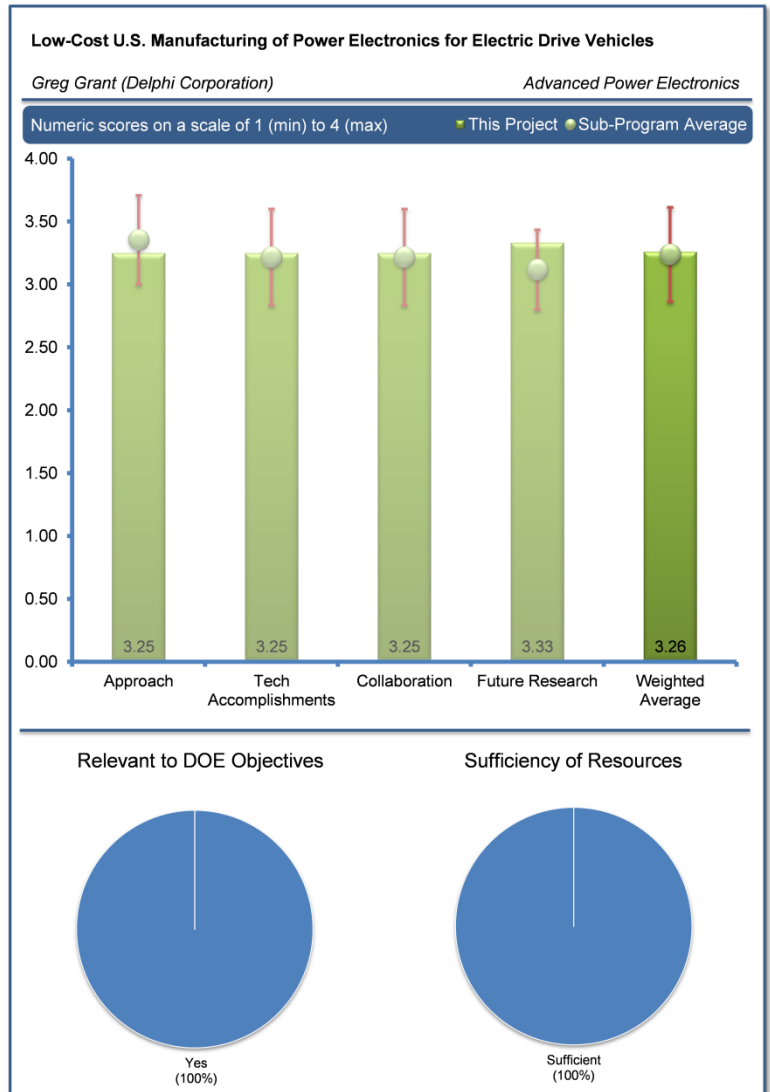
The reviewer indicated that robust power management of power electronics is critical for the success of electric vehicles. The approach here is based on the considerable background available at Delphi.

Reviewer 2:

The reviewer noted that the work seemed to be concluding with some measure of success.

Reviewer 3:

The reviewer commented that the goal to develop low cost manufacturing and produce a trained workforce in this country for manufacturing electric vehicle components was achieved. Over 900 jobs were created and electric components were developed.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that a model system was developed and tested that meets the needs of electric vehicles. It is ready for distribution.

Reviewer 2:

The reviewer remarked that Delphi seemed to have made reasonably good use of ARRA funding to make inventions necessary for high volume manufacturing of power electronics.

Reviewer 3:

The reviewer indicated that the project created technology and manufacturing facilities for electric vehicles which can supply the industry for many years. The reviewer noted that increasing acceptance of EVs requires low cost and efficient manufacturing.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that collaborators included several car manufacturers and the State of Indiana.

Reviewer 2:

The reviewer commented that the level of collaboration and coordination was appropriate for manufacturing work.

Reviewer 3:

The reviewer noted that the collaborators included several industry leading companies.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the various electrical devices, inverters, chargers, control algorithms, etc., have been created. New job creation goals were also met.

Reviewer 2:

The reviewer hoped that the project effect will live on in future Delphi products.

Reviewer 3:

The reviewer noted that the project is nearly complete.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that power electronics are the base for electric vehicle propulsion. Electric vehicles use electrical energy to power the system. The demands on power electronics range from milliwatts to megawatts for the various systems, especially to deliver the high power essential for vehicle operation. The reviewer noted that electric vehicles are a key element in meeting the goals for petroleum displacement.

Reviewer 2:

The reviewer commented that the project was relevant to create an incentive for manufacturing EV equipment.

Reviewer 3:

The reviewer noted that vehicle electrification will decrease petroleum use in transportation.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that sufficient resources were available.

Reviewer 2:

The reviewer noted that the resources were sufficient to achieve the goals.

Electric Drive Component Manufacturing Facilities: Richard Thies (Allison Transmission, Inc.) - arravt023

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that ARRA dollars were directed to setting up manufacturing of utility vehicle hybrid motor transmissions.

Reviewer 2:

The reviewer stated that the goal to produce a hybrid commercial drive for buses, trucks, emergency vehicles, and motor homes was well understood. The project was planned with schedule milestones and it was completed on schedule.

Reviewer 3:

The reviewer commented that Allison has been able to mitigate schedule and technical risk due to their integration experience and controls and communication background. The reviewer noted that Allison has a separate program with Office of Naval Research (ONR), which packages a generator inside a modified bell housing around the torque converter, maintaining the same driveline length. The reviewer remarked that that system is ideal for retrofit applications assuming no interference with the additional radial diameter and no need for power take off (PTO), and wanted to know if this packaging approach was considered for this project.

Also, the reviewer added that providing more detail on the need for the engine disconnect clutch and when it is used would be helpful.

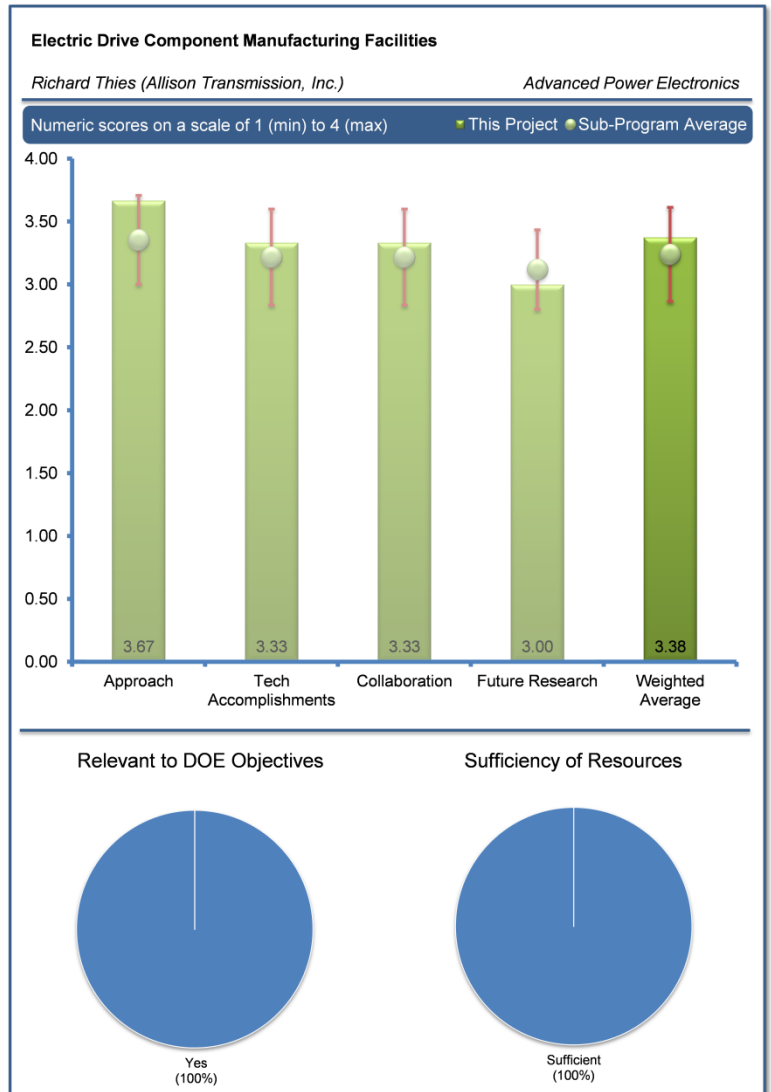
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the manufacturing line was set up and products are now in mass production. The reviewer exclaimed that this was the best kind of success for a manufacturing project.

Reviewer 2:

The reviewer stated that this was an excellent achievement to design and build a commercial grade hybrid drive train for large vehicles.



Reviewer 3:

The reviewer indicated that, due to the high overall budget, a high-level breakdown of significant subcontracts and costs would be helpful in the project assessment. The reviewer noted that the accomplishments were excellent leading toward the start of production (SOP) in October 2013, including low rate initial production (LRIP) in November 2012.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer commented that the collaboration with Delphi Electronics (a power electronics and energy storage system company) and Remy, Inc. (a motor-generator company) was outstanding.

Reviewer 2:

The reviewer expressed that the collaboration and coordination was appropriate for a manufacturing type project.

Reviewer 3:

The reviewer noted that several other companies collaborated on the project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the ARRA work is concluding, and the product is already being sold. The reviewer commented that future research may be in directing other power needs to such successes, probably in other projects.

Reviewer 2:

The reviewer indicated that the goal is be able to produce 20,000 units by the end of this year and the project is on schedule.

Reviewer 3:

The reviewer commented that the future plans were not specified in detail; however, the timeline from Slide 17 indicates that SOP is scheduled for October 2013 for the H3000-based system and continuation of the design validation (DV) for the H4000-based system.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer observed that the project is very relevant because savings are estimated to be 29 million gallons of fuel and 291 tons of Carbon Dioxide (CO₂) eliminated.

Reviewer 2:

The reviewer noted that the electrification of vehicles will tend to decrease petroleum use.

Reviewer 3:

The reviewer stated that Allison's existing fleet of H 40/50 hybrid transit busses has saved more than 29 million gallons of fuel over more than 553 million miles. The reviewer noted that the project has a 25-35% fuel economy improvement goal.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer commented that the resources were adequate for the project to complete the scheduled milestones.

Reviewer 2:

The reviewer stated that the project is on track. A lack of resources was not apparent.

U.S. Based HEV and PHEV Transaxle Program: Kevin Poet (Ford Motor Company) - arravt024

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the goal to build a U.S.-based transaxle was broken down into four phases with milestone completion dates and the project was completed on time. The reviewer commented that this was a job well done.

Reviewer 2:

The reviewer indicated that the program is responsive to the requirement of adding production capacity for components. In this case, the production capacity was for a transaxle system for HEVs and PHEVs.

Reviewer 3:

The reviewer noted that Ford's new facility was built to make the HF35 transaxle, which is its first one to be internally manufactured. Its cost is mitigated by using components that are common to other Ford transaxle products. The HF35 is made by Ford's first transaxle assembly process that offers flexibility for tailoring the unit for each of several models of vehicle that Ford makes or will introduce. The reviewer commented that lessons learned through prototype testing and simultaneous engineering were applied to the design leading into Phase IV and ultimately the production launch of the product.

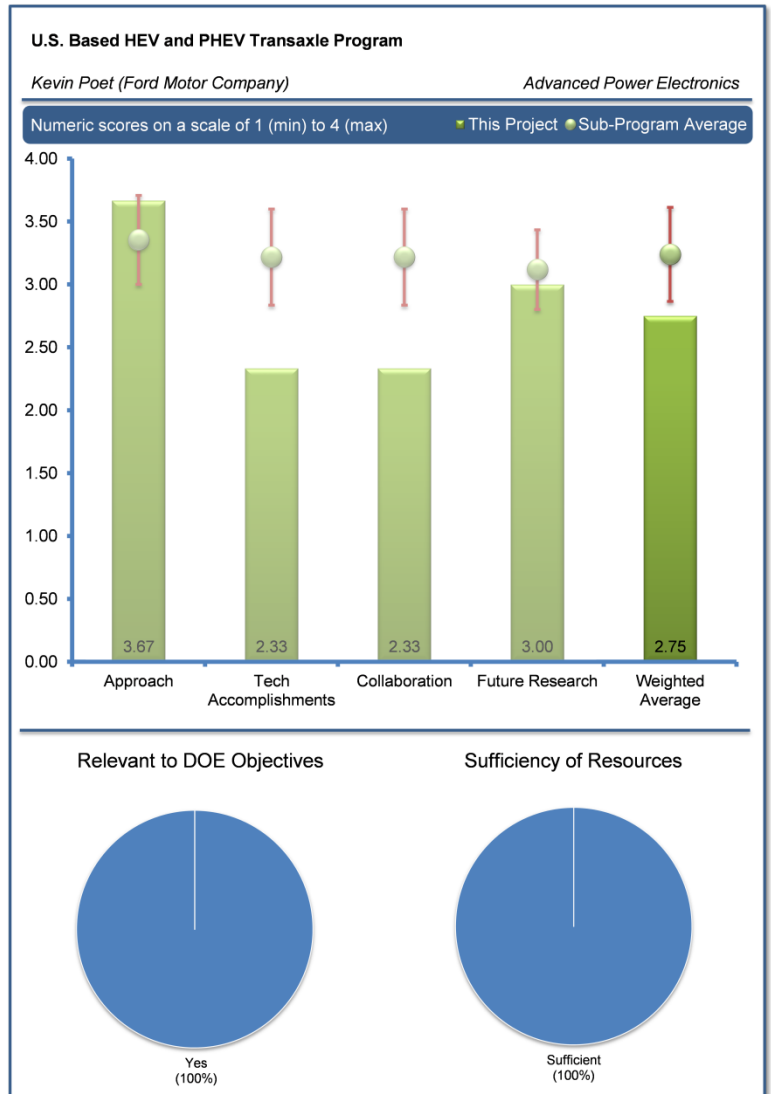
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the project was executed over four phases, with various go/no go decision points. Each of those phases was completed, and the production line is almost completely ready. Some automation on the assembly line is still being completed. However, it is anticipated that these will be complete by the end of August 2013, which is the official end of the project. The reviewer also noted that the HF35 transmission is in full production.

Reviewer 2:

The reviewer stated that the project produced the first Ford transaxle manufactured by Ford and is compatible with other Ford drive components. This enabled PHEV and HEV vehicles to be made on the same assembly line with other Ford vehicles. The transaxle was extensively tested during Phase IV.



Reviewer 3:

The reviewer noted that production in the facility has been launched. The details regarding the development process, phased project plan, and installed equipment shows that the program has been successful.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that Ford identified no partners, but contractors were used in the process of constructing and outfitting its facility. Ford also credited partners in the community, machine tool suppliers, and production component suppliers in achieving its goals here.

Reviewer 2:

The reviewer indicated that this project did not officially have collaborators but Ford worked with several other companies and experts to complete the project.

Reviewer 3:

The reviewer noted that little collaboration was required for this program.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the project was near completion.

Reviewer 2:

The reviewer noted that the program is concluding and Ford will react to market demand going forward.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the plant is in full production of the HF 35 transaxle. The reviewer remarked that the project is a real success story for fuel saving hybrid vehicles already on the road. This project has already had a major impact on reducing petroleum production.

Reviewer 2:

The reviewer indicated that the facility enables the mass customization of electric drive vehicles, which do not yet appeal to a broad enough market to enable large-scale series production. Plug-in electric vehicles appeal to a variety of niche markets, and if Ford can meet the needs of each of these niche markets, it is likely to sell more vehicles than if it chooses just one model and ramps up to volume manufacturing. The more PEVs on the road, the fewer vehicle miles traveled (VMT) on petroleum; the reviewer concludes that this project supports the DOE objective of petroleum displacement.

Reviewer 3:

The reviewer noted that manufacturing infrastructure is a key component to selling electrified vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the funding was sufficient to build this facility that enables Ford to have the capability of mass customization for its EDVs.

Reviewer 2:

The reviewer indicated that there was sufficient funding for the project goals to be achieved since Ford contributed half of the funding.

Reviewer 3:

The reviewer observed that Ford has the resources to execute this program.

Providing Vehicle OEMs Flexible Scale to Accelerate Adoption of Electric Drive Vehicles: JJ Shives (Remy, Inc.) - arravt025

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that developing a standard, scalable platform for EDV motors and controls has been demonstrated. The barriers of market acceptance are based on performance and cost of their product. The reviewer noted that Remy and Phoenix are well positioned to capitalize on the expanding market for EDVs.

Reviewer 2:

The reviewer commented that the idea of providing a cost effective source of scalable electric drive traction systems is attractive. The reviewer indicated that the main question is when the market will be able to support multiple sources. The approach of improving existing facilities first is good and then building new facilities for high rate production is logical, but the reviewer needed more information regarding the definition of high rate and the limits of an improved facility.

Reviewer 3:

The reviewer stated that the approach to make non-OEM-specific and high-voltage variants of the motors will help reduce cost and promote wider adoption. The torque curves on Slides 11-12 show the continuous and peak torque curves for both the HVH410 and HVH250. For the HVH410, the continuous torque and peak torque are nearly the same, while for the HVH250 they have a difference of approximately 50 Newton-meters (Nm) of torque. The reviewer wanted to know if the continuous torque and peak torque ratings for the HVH410 motor were the same.

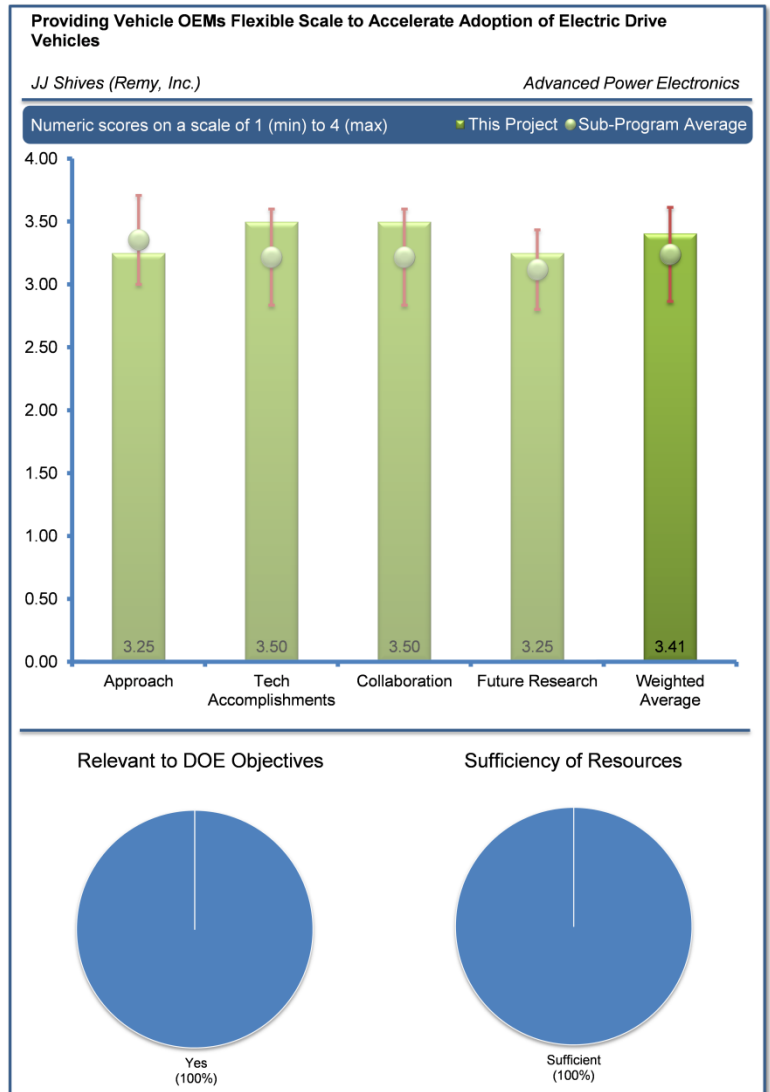
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer expressed that the accomplishments were excellent. These included the completion of the Phase 1 production facility for both the electric machines (Remy) and inverters (Phoenix). This work also facilitated commercialization of multiple variants of the HVH250 and HVH410 motor families, including oil and water cooled variants with multiple lengths and winding patterns.

Reviewer 2:

The reviewer noted that products have been developed, can be manufactured, and are for sale.



Reviewer 3:

The reviewer commented that the plan to provide a matched set of inverter and motor is very good. The use of the same facility to recycle the parts is also good. The reviewer believed that both of the partners are capable of delivering working production parts, but had concerns that market could provide enough demand for them to be successful.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated that the team members are doing a great job of collaborating on the plan and the requirements from their customers. If the market supports the project team, the reviewer believes that the project team will be successful.

Reviewer 2:

The reviewer indicated that it appears that Remy and Phoenix are working well together.

Reviewer 3:

The reviewer noted close collaboration with Phoenix on the associated power electronics as well as collaboration with multiple customers.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that basing expansion on market demand is outstanding and recommended not to spend money unless it was needed.

Reviewer 2:

The reviewer noted that a second manufacturing site in Indiana is presently under investigation. However, Remy is waiting on additional booked business prior to moving forward.

Reviewer 3:

The reviewer indicated that implementing phase two of the program based on increasing demand is a good approach. The reviewer wanted to know if market demand, at this time, does not necessitate the increased capacity does the program end in December 2013 or does something else occur.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer noted that low cost EDV powertrains help to enable the market for EDVs which, in turn, lowers our dependence on foreign oil.

Reviewer 2:

The reviewer commented that the project supports the DOE goal of developing U.S. suppliers which, if cost effective, should support the overall goal of displacing petroleum.

Reviewer 3:

The reviewer commented that this project will help reduce the cost of high-performance electric machines and power electronics through production at high-volume manufacturing facilities supporting multiple OEMs. These electric drives are key components in hybrid electric vehicles, which have demonstrated the capability to reduce fuel consumption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the project is on track. A lack of resources is not apparent.

Reviewer 2:

The reviewer noted that the product developed with the available resources, and that resources and money appear to be available for the facilities. The reviewer noted that there still remains a question as to the need for increased manufacturing.

Reviewer 3:

The reviewer commented that it remains to be seen if the market will justify the expense of upgrading the facilities.

Electric Drive Component Manufacturing Facilities: Luke Bokas (UQM Technologies, Inc.) - arravt026

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

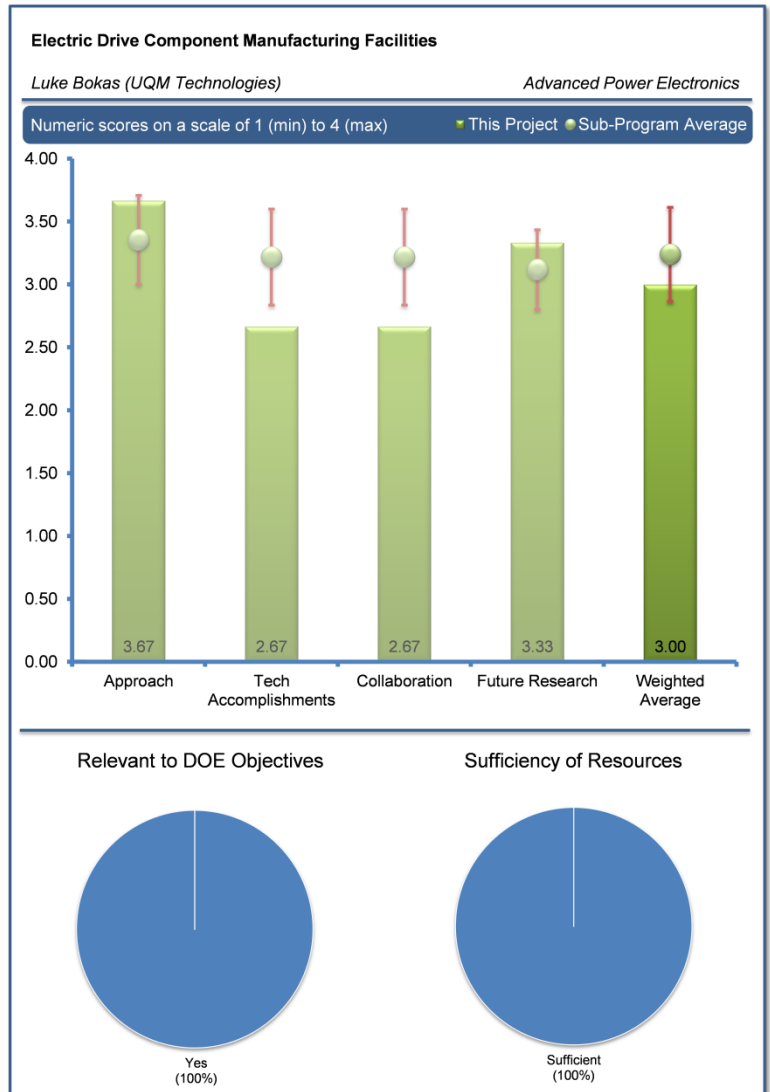
The reviewer noted that the project is directly addressing the issue to reduce costs in manufacturing.

Reviewer 2:

The reviewer indicated that the approach addresses high volume manufacturing of electric machines and power electronic components for both passenger and heavy duty vehicle markets. This will help reduce the cost of these components.

Reviewer 3:

The reviewer commented that the project produced a new manufacturing plant and improved electric components for bus, truck and car electrification.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer remarked that the results were great, including motors produced and passed to meet automotive standards.

Reviewer 2:

The reviewer commented that the project improved plant automation and increased the plant's capacity to produce more components. Components were improved in numerous ways including reducing weight, volume and cost.

Reviewer 3:

The reviewer noted that the project supported relocation to a larger 140,000 square foot facility. New controller and motor lines have been established and are operational at the new site, capable of 20,000 units annually. Components from the new assembly line have completed automotive qualification. Additionally, a second generation interior permanent magnet (IPM) motor of 100kW and a new heavy-duty motor of 220kW have been developed under this effort. The reviewer noted that a next generation motor controller which is 50% of the size of the original has been developed. Finally, over 1,000 units have been manufactured on the new production lines.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer remarked that the project was well-coordinated, with capable suppliers for both product and production.

Reviewer 2:

The reviewer noted that UQM Technologies collaborated with customers.

Reviewer 3:

The reviewer indicated that no collaborative arrangements were identified.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer indicated that there were plans to increase product capabilities to improve production line utilization.

Reviewer 2:

The reviewer noted that most of the milestones are complete except for final validation of some automotive system components.

Reviewer 3:

The reviewer commented that new variations of the heavy-duty motor are planned, including a high-torque, low-speed variant and a high-voltage variant. UQM Technologies is still working to leverage the additional capacity through higher volume production contracts.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer noted that UQM Technologies understands the fundamental issue very well and is attacking the problem with improved manufacturing and customer acceptance which will lead to petroleum displacement.

Reviewer 2:

The reviewer commented that efficient, high production manufacturing is required to produce low cost, reliable electric and hybrid vehicles which will reduce the use of petroleum.

Reviewer 3:

The reviewer indicated that this project will help reduce the cost of high-performance electric machines and power electronics through production at high-volume manufacturing facilities supporting multiple OEMs. These electric drives are key components in hybrid electric vehicles which have demonstrated the capability to reduce fuel consumption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer commented that the objectives were achieved on schedule with the available resources.

Reviewer 2:

The reviewer noted that the project is on track. A lack of resources was not apparent.

Electric Drive Component Manufacturing: Magna E-Car Systems of America, Inc.: Brian Peaslee (Magna E-Car Systems of America, Inc.) - arravt027

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

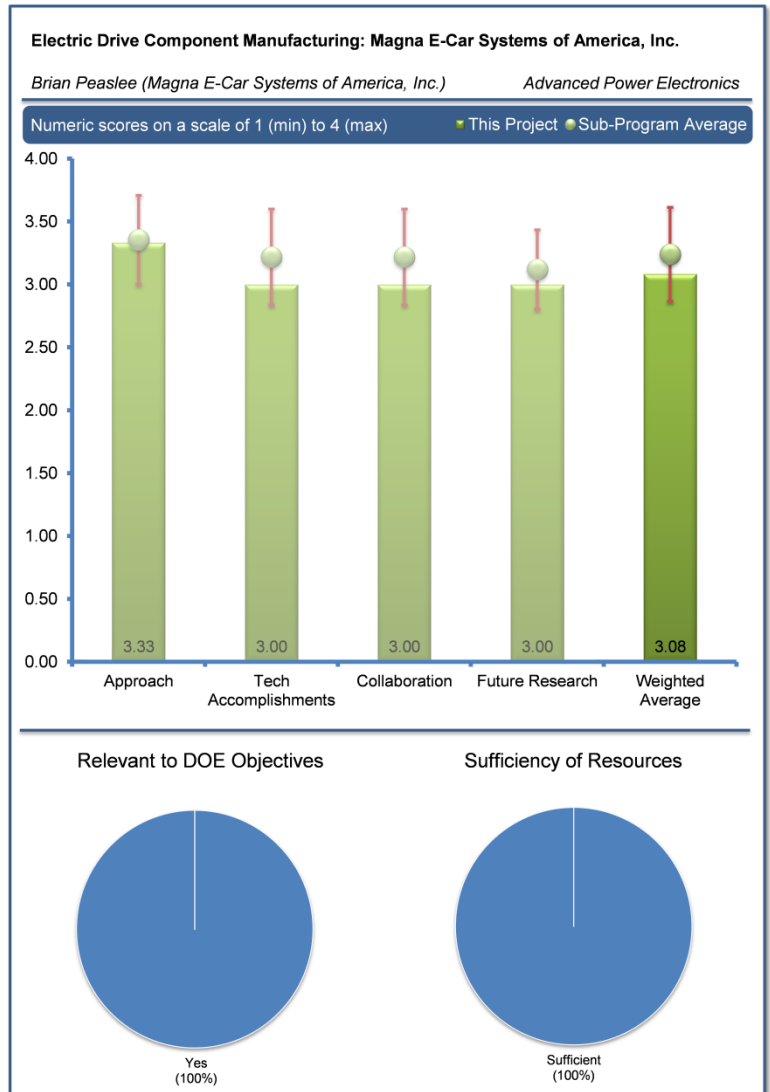
The reviewer noted that this project produced an efficient manufacturing plant to produce electric vehicle components.

Reviewer 2:

The reviewer observed that the program is responsive to the requirement of adding production capacity for components.

Reviewer 3:

The reviewer indicated that the project is well designed to meet the goal of increasing U.S. production of electric drive system components as it relates to this project. The facility supports a variety of components by sharing resources. The reviewer expressed uncertainty surrounding market demand being acceptable enough to be profitable.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the manufacturing plant was designed to be highly efficient using the latest in technology in robotics and automation. The plant also included a laboratory and test areas.

Reviewer 2:

The reviewer remarked that the program is ambitious in terms of the number of different products that are being released to production. The reviewer noted that most of the large systems have been production launched, and the small control modules will be launched within the next year.

Reviewer 3:

The reviewer observed that the technical accomplishments are good, but the volume is relatively large compared to DOE specifications. The performance is very good and supports the upper end of the DOE range of 75 kW to 150 kW.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that in-company collaboration was used.

Reviewer 2:

The reviewer stated that no collaboration is mentioned; the reviewer expressed that collaboration was not likely to be required for this type of program.

Reviewer 3:

The reviewer expressed that collaborations among the various divisions of the company should be good and it appears that they are.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer noted that the project is nearly complete except for final testing and evaluation.

Reviewer 2:

The reviewer expressed that the program has reasonable time left to complete the launch of the remaining products.

Reviewer 3:

The reviewer commented that future plans are based on meeting viable milestones.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer opined that the project is relevant because reducing cost and improving quality are required to get public acceptance of electric and hybrid vehicles. This project achieves both reduced cost and improved quality and testing.

Reviewer 2:

The reviewer indicated that manufacturing infrastructure is a key component to selling electrified vehicles.

Reviewer 3:

The reviewer commented that there is a need for U.S. based suppliers. The reviewer expressed that the market needs to expand to support this.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that the resources were adequate to meet the schedule milestones.

Reviewer 2:

The reviewer remarked that Magna has the resources to execute this program.

Reviewer 3:

The reviewer stated that the resources appear sufficient to date.

DC Bus Capacitor Manufacturing Facility for Electric Drive Vehicles: Johnny Boan (KEMET Corporation) - arravt028

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the goal is to produce a plant for high volume capacitors in electric vehicles. KEMET upgraded an existing facility with additional automated equipment. The project team made a decision to make soft wound film capacitors based on customer input.

Reviewer 2:

The reviewer commented that KEMET is one of the largest capacitor manufacturers with products from capacitor film metallization, capacitor winding/stacking machining, and finished capacitors for various applications.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

KEMET will build and equip a factory to manufacture DC buss capacitors for 100,000 EVs. The reviewer noted that the factory made its first shipment of DC bus capacitors and will support about 110 new jobs. The project is 29% complete.

Reviewer 2:

The reviewer indicated that the project is 32% complete. Machines and equipment for the first of three lines necessary to increase production have been purchased. More people have been hired and DC bus capacitors have already been shipped. The reviewer believes that the project will be completed on time.

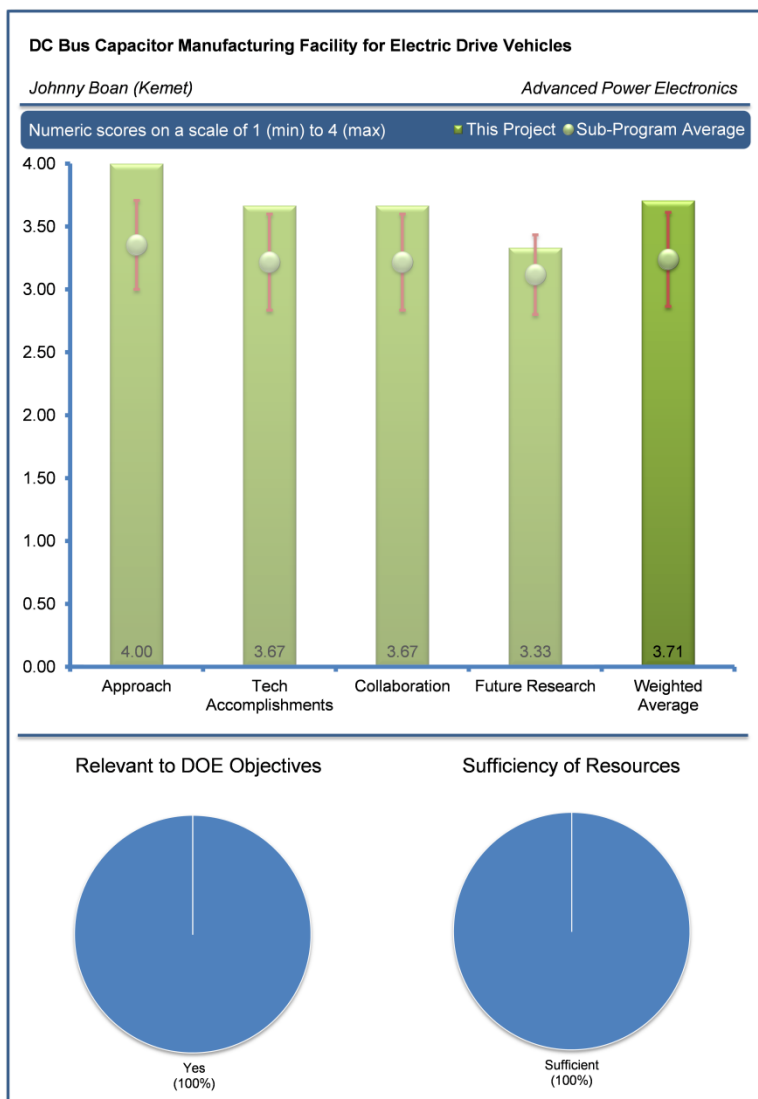
Reviewer 3:

The reviewer noted that film capacitor manufacturing facilities have been set up in the United States, even though the current EDV market is affecting their project plan due to business issues.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that participants in the project and project monitors were adequately informed.



Reviewer 2:

The reviewer noted that collaboration was in-house.

Reviewer 3:

The reviewer indicated that the project has close collaboration with various customers and the project is also discussing with potential future dielectric materials.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the project completes in 2015 and the project will install two more high volume lines.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that high volume production and automation will reduce the cost of the electrification of vehicles.

Reviewer 2:

The reviewer commented that a DC bus capacitor is one critical component in EDV power electronics. The film capacitor manufacturing is mainly related to polypropylene capacitors. The reviewer noted that some high temperature capacitor products may also be explored to achieve the 140°C target.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that adequate resources are available.

Reviewer 2:

The reviewer observed that the resources have been adequate for KEMET to meet scheduled milestones.

Reviewer 3:

The reviewer commented that KEMET has all the resources for EDV film capacitor manufacturing and marketing.

Acronyms and Abbreviations

Acronym	Definition
1-D	One-Dimensional
°C	Degrees Celsius
A	Ampere
AC	Alternating Current
AGMA	American Gear Manufacturers Association
ANL	Argonne National Laboratory
APEEM	Advanced Power Electronics and Electrical Machines
ARRA	American Recovery and Reinvestment Act
BIM	Bonded Interface Material
CO₂	Carbon Dioxide
CTE	Coefficient of Thermal Expansion
DBA	Direct Bonded Aluminum
DBC	Direct Bonded Copper
DC	Direct Current
DEWGS	Domain Expert Working Groups
DF	Dissipation Factor
DOE	U.S. Department of Energy
DRGS	Distributed Renewables, Generation & Storage
DV	Design Validation
ECI	Electronic Concepts, Inc.
EDV	Electric Drive Vehicle
EPC	Efficient Power Conversion
ESR	Equivalent Series Resistance
ESS	Energy Storage System
EV	Electric Vehicle
FEA	Finite Element Analysis
FEMA	Failure Mode and Effects Analysis
FY	Fiscal Year
GA	Genetic Algorithm
GaN	Gallium Nitride
GE	General Electric
GM	General Motors
HALT	Highly Accelerated Life Test
HEV	Hybrid Electric Vehicle
HIL	Hardware-in-the-loop
ICE	Internal Combustion Engine
IP	Intellectual Property
IPM	Interior Permanent Magnet

Acronym	Definition
IGBT	Insulated Gate Bipolar Transistor
kW	Kilowatt
kV	Kilovolt
Li-ion	Lithium Ion
LRIP	Low Rate Initial Production
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
NASA	National Aeronautics and Space Administration
NIST	National Institute of Standards and Technology
Nm	Newton-meters
NREL	National Renewable Energy Laboratory
OEM	Original Equipment Manufacturer
ONR	Office of Naval Research
ORNL	Oak Ridge National Laboratory
PEN	Polyethylene Naphthalate
PET	Polyethylene Terephthalate
PEV	Plug-in Electric Vehicle
PI	Principal Investigator
PLZT	Lead Zirconium Titanate
PM	Permanent Magnet
PP	Polypropylene
PTO	Power Take Off
PWM	Pulse Width Modulation
R&D	Research and Development
RE	Rare Earth
RESS	Regenerative Energy Storage System
RPM	Revolutions Per Minute
SAE	Society of Automotive Engineers
SGIP	Smart Grid Interoperability Panel
Si	Silicon
SiC	Silicon Carbon
SNL	Sandia National Laboratories
SOP	Start of Production
SSHD	Single-Stage Hot Deformation
TIM	Thermal Interface Material
U.S.	United States of America
V	Volt
V2G	Vehicle to Grid
VMT	Vehicle Miles Traveled
VTO	Vehicle Technologies Office
WBG	Wide Band Gap

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4. Advanced Combustion Engine Technologies

Improving the efficiency of internal combustion engines is one of the most promising and cost-effective near- to mid-term approaches to increasing highway vehicles' fuel economy. The Vehicle Technologies Office's (VTO) research and development activities address critical barriers to commercializing higher efficiency, very low emissions advanced internal combustion engines for passenger and commercial vehicles. This technology has great potential to reduce U.S. petroleum consumption, resulting in greater economic, environmental, and energy security.

Already offering outstanding drivability and reliability to over 230 million passenger vehicles, internal combustion engines have the potential to become substantially more efficient. Initial results from laboratory engine tests indicate that passenger vehicle fuel economy can be improved by more than up to 50%, and some vehicle simulation models estimate potential improvements of up to 75%. Advanced combustion engines can utilize renewable, and when combined with hybrid electric powertrains could have even further reductions in fuel consumption. As the EIA reference case forecasts that by 2035, more than 99% of light- and heavy-duty vehicles sold will still have internal combustion engines, the potential fuel savings is tremendous.

The VTO undertakes research and development activities to improve the efficiency of engines for both light and heavy-duty highway vehicles, whether they run on petroleum-based (gasoline and diesel) or alternative fuels. We support every type of research in these areas, from fundamental science to prototype demonstration. The research focuses on improving engine efficiency while meeting future federal and state emissions regulations. It does this through four main approaches:

- Improving the understanding of advanced combustion processes, including how fuel properties affect combustion and emissions. Researchers then use this knowledge to refine combustion strategies and associated processes that minimize the formation of emissions within engine cylinders. In this area, we also research cost-effective aftertreatment technologies that further reduce exhaust emissions.
- Recovering energy from engine waste heat

Commercialization of these advanced combustion engine technologies could allow the U.S. to cut its transportation fuel use and corresponding greenhouse gas emissions by as much as 20 to 40%.

Research and development is done in collaboration with industry, National Laboratories, other federal agencies [such as the National Science Foundation (NSF)] and universities, as well as through government/industry partnerships:

- the U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability (U.S. DRIVE) Partnership focusing on light-duty vehicles
- the 21st Century Truck Partnership, focusing on heavy-duty vehicles

The major goals of the Advanced Combustion Engine R&D subprogram are:

- By 2015, increase the efficiency of internal combustion engines for passenger vehicles resulting in fuel economy improvements of 25% for gasoline vehicles and 40% for diesel vehicles, compared to 2010 gasoline vehicles. By 2020, improve the fuel economy of gasoline vehicles by 35% and diesel vehicles by 50%, compared to 2010 gasoline vehicles.
- By 2015, increase the efficiency of internal combustion engines for commercial vehicles from 42% (2010 baseline) to 50% (a 20% improvement). This goal is part of the overall SuperTruck initiative to increase Class 8 truck freight hauling efficiency by more than 50% by 2015. By 2020, further improve engine efficiency to 55% (a 30% improvement) with demonstrations on commercial vehicle platforms.
- By 2015, increase the fuel economy of passenger vehicles by at least 5% using thermoelectric generators that convert energy from engine waste heat to electricity.

Subprogram Feedback

DOE welcomed optional feedback on the overall technical subprogram areas presented during the 2013 AMR. Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area who volunteered to provide subprogram overview comments responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1: Was the subprogram area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Question 3: Does the subprogram area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Office's needs?

Question 4: Other Comments.

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc., as reviewer responses were optional.

Subprogram Overview Comments: Gurpreet Singh (U.S. Department of Energy) – ace00a

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer stated that the sub-program area was covered fairly well. It took the realistic view that internal combustion engines (ICEs) would be around for a long time and mentioned that improving efficiency and reducing emissions were important goals. The presenter spoke about low temperature combustion challenges. The presenter also mentioned progress in modeling [both large eddy simulation (LES) and the conceptual flame model] as well as the reactivity-controlled-compression-ignition (RCCI) engine test work at Oak Ridge National Laboratory (ORNL).

Reviewer 2:

The reviewer noted that the sub-program was well described given the time slot. This reviewer would have enjoyed a longer presentation from the presenter with more details, as this reviewer thought this was a very important area with significant challenges and issues identified. Progress from the previous year was clearly identified and the challenges facing the current year and future years were also highlighted.

Reviewer 3:

The reviewer felt that the sub-program was adequately covered, adding that more effort could be spent in identifying and articulating challenges with advanced combustion concepts, such as transient control issues. While the programs were described in generic terms, progress in comparison to the previous year was not clearly presented.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?**Reviewer 1:**

The reviewer remarked that the presenter mentioned the programs in the Advanced Combustion and Emissions Control (ACEC) research and development (R&D) that had been established to address issues.

Reviewer 2:

The reviewer acknowledged that plans for addressing many traditional issues and challenges with low temperature combustion had been identified. This person added that more emphasis could be placed on addressing the transient control issues with low temperature combustion.

Reviewer 3:

The reviewer commented that the plans for addressing the challenges, specifically bridging the fundamental research to the applied, were discussed. The one gap in the portfolio this reviewer saw was in incorporating university research into the program.

The NSF/DOE collaboration was a fantastic opportunity, but was only able to fund a very small number of projects. This reviewer added that a downside of this was that some of the traditional powerhouse universities in engine research (who have had long programs with DOE) were not funded in this mechanism, and the ability to leverage previous DOE investments was lost. Another issue with this call was that the reviewer felt that it was a little misleading in terms of the scope of the resources available per project. It was this reviewer's belief that projects that went for close to the maximum (large-scope, large-team projects) were at a disadvantage in the review process due to their size.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?**Reviewer 1:**

The reviewer observed that this sub-program was very well focused, well managed, and had been very effective in addressing the DOE VTO goals.

Reviewer 2:

According to this reviewer, the area did seem to be focused and set up to address DOE goals and needs, and it seemed to be well managed.

Reviewer 3:

The reviewer asserted that the program was well focused and managed, and funding levels in the appropriate areas were properly balanced. However, with regard to the light-duty vehicle awards, this reviewer commented that management should continue to encourage progress in the primary areas of focus, which were advanced combustion strategies, aftertreatment technologies, and waste heat recovery (WHR). Without that watchful eye, this reviewer felt that the programs could be tempted to give up on the above challenging areas and instead focus on non-engine, non-combustion areas like vehicle- and chassis-level friction reduction (as one example).

Question 4: Other Comments

No comments were received in response to this question.

Subprogram Overview Comments: Ken Howden (U.S. Department of Energy) – ace00b

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer asserted that the emissions control program was very well covered. This reviewer added that the direction of developing integrated (with combustion) aftertreatment systems that minimized both emissions and the fuel penalty associated with aftertreatment was a very important issue. The challenge of hitting near-zero emissions was well defined. The progress from the last year was clear and healthy, despite the budgetary issues. This was a very important area, which this reviewer felt should have been the first one to receive additional funding if DOE got the requested budgetary increase.

Reviewer 2:

The reviewer expressed that yes, the sub-program was adequately covered and important issues had been identified. However, this reviewer added that progress in comparison to the previous year had not been clearly made.

Reviewer 3:

The reviewer affirmed that yes, the sub-program area had been appropriately covered and important challenges had been identified and addressed. However, this reviewer added that although individual catalyst technologies were in focus, combined technologies were not. Addressing combined catalyst technologies might be an important area of research to meet the aftertreatment needs of highly efficient engine and aftertreatment systems. This person added that the presenter had identified the correct barriers. The inclusion of low temperature aftertreatment research and development activities was critical to enabling highly efficient engines to enter the U.S. automotive market.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Reviewer 1:

The reviewer indicated that plans had been identified for addressing issues and challenges with the low exhaust temperatures that resulted from improving the efficiency of the internal combustion engine.

Reviewer 2:

The reviewer reported that, in general, plans appeared to cover the emerging combustion and aftertreatment needs of the automotive industry to meet very challenging fuel economy and emissions regulations. The reviewer added that the inclusion of low temperature catalysis was very consistent with this need. However, addressing natural gas as a fuel (as well as renewable fuels) might not be sufficiently covered.

Reviewer 3:

The reviewer highlighted that the particulate matter (PM) section of the portfolio was a little light. The characterization of gasoline direct injection (GDI) or other novel combustion strategies (chemical as well as physical), especially with regard to fuel effects (such as for ethanol and methanol), would be necessary to deal with these emissions.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:

The reviewer concluded that yes, overwhelmingly, the activities and programs were consistent with the industry need for more efficient engines and their associated aftertreatment systems. Acknowledging the need for low temperature aftertreatment as an area that must be explored more intensely was important for enabling efficient powertrains.

Reviewer 2:

The reviewer indicated that the program was focused and well managed.

Reviewer 3:

The reviewer noted that the program seemed to be very well and attentively managed. This reviewer added that perhaps more integration with the fuels team would be a useful way to leverage funding.

Question 4: Other Comments**Reviewer 1:**

The reviewer offered that the Cross-Cut Lean Exhaust Emission Reduction Simulation (CLEERS) activity was certainly one of the gems in this portfolio, and noted the integration of industry, National Laboratories, and academia, on both a national and international platform.

Reviewer 2:

The reviewer indicated that the cooperative and supportive efforts of the DOE to enhance the competitiveness of U.S. automotive manufacturers were an essential element to OEM success. However, this reviewer added that the government electrification efforts should not come at the expense of liquid-fuel-based powertrain system R&D. This person went on to say that increasingly efficient and clean gasoline and diesel powertrains would represent the vast majority of transportation vehicles for many years and would help enable and support electrification efforts such as hybrid vehicles, which would act as the stepping stone to the eventual transition to a predominantly electric fleet in the coming decades.

Subprogram Overview Comments: Roland Gravel (U.S. Department of Energy) – ace00c

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer indicated that this sub-program bridged the research realm to the applied realm. It leveraged all of the fundamental work in the other areas of the VTO program to advance real-world applications and was the front line of technology deployment.

Reviewer 2:

The reviewer reported that this was generally well covered. The slides were rather dense and this reviewer could not read fast enough to see everything on the slides. This person added that, if the information was needed, time should have been spent to say it. If not, it should have been left off of the slide.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Reviewer 1:

The reviewer highlighted that the portfolio looked pretty complete and the projects were addressing the issues that seemed to need work.

Reviewer 2:

The reviewer stated it was a very thorough portfolio.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:

The reviewer stated yes.

Reviewer 2:

The reviewer summarized that this was one of the most exciting areas in the VTO.

Question 4: Other Comments**Reviewer 1:**

The reviewer stated that surprisingly good results were being shown.

Subprogram Overview Comments: John Fairbanks (U.S. Department of Energy) – ace00e

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer stated that Fairbanks had done an excellent job of identifying a valuable niche for thermoelectrics for WHR. In many ways, this project could not fail because the energy recovered was free and otherwise wasted to the environment. The key to successful transition was cost, and the performers on Fairbanks' program had identified that as a key.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Reviewer 1:

The reviewer stated that the presenter seemed to have a great grasp on the materials, the device, the thermal management, and the systems analysis. If there was a gap, it could be manufacturability and cost. This reviewer thought that Fairbanks had been looking into new approaches for low-cost manufacturing and that this would be an extremely valuable addition to his portfolio. This person strongly emphasized that the presenter needed support for that.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:

The reviewer asserted that the sub-program areas were well focused and the critical/key technologies were receiving adequate focus.

Question 4: Other Comments**Reviewer 1:**

The reviewer believed that the presenter's programs would have an extremely important impact on the energy needs of the consumer. Even though the energy savings were marginal on a per-unit basis, if one amortized the results over time and averaged over the immense number of units, there would be a significant energy benefit to mankind.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (*on a scale of 1 to 4*). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling	Mark Musculus (Sandia National Laboratories)	4-11	3.50	3.00	3.00	3.00	3.13
Low-Temperature Automotive Diesel Combustion	Paul Miles (Sandia National Laboratories)	4-15	3.57	3.57	3.57	3.29	3.54
HCCI and Stratified-Charge CI Engine Combustion Research	John Dec (Sandia National Laboratories)	4-19	3.20	3.80	3.80	3.20	3.58
Spray Combustion Cross-Cut Engine Research	Lyle Pickett (Sandia National Laboratories)	4-22	3.50	3.50	3.50	3.00	3.44
Automotive HCCI Engine Research	Richard Steeper (Sandia National Laboratories)	4-26	3.00	3.17	3.17	3.00	3.10
Large Eddy Simulation (LES) Applied to Advanced Engine Combustion Research	Joe Oefelein (Sandia National Laboratories)	4-29	3.67	3.17	3.17	2.83	3.25
Free-Piston Engine	Terry Johnson (Sandia National Laboratories)	4-33	2.43	2.14	2.14	2.43	2.25
Fuel Injection and Spray Research Using X-Ray Diagnostics	Christopher Powell (Argonne National Laboratory)	4-38	3.50	3.67	3.67	3.17	3.56
Use of Low Cetane Fuel to Enable Low Temperature Combustion	Steve Ciatti (Argonne National Laboratory)	4-41	3.00	3.00	3.00	2.75	2.97
Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines	Dan Flowers (Lawrence Livermore National Laboratory)	4-44	3.33	3.67	3.67	3.17	3.52
Chemical Kinetic Models for Advanced Engine Combustion	Bill Pitz (Lawrence Livermore National Laboratory)	4-47	4.00	3.00	3.00	3.33	3.29
2012 KIVA-Development	David Carrington (Los Alamos National Laboratory)	4-50	3.33	3.00	3.00	2.33	3.00
Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes	Stuart Daw (Oak Ridge National Laboratory)	4-53	3.40	3.50	3.50	3.00	3.41
High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines	Scott Curran (Oak Ridge National Laboratory)	4-56	3.67	3.50	3.50	3.33	3.52
Accelerating Predictive Simulation of IC Engines with High Performance Computing	Dean Edwards (Oak Ridge National Laboratory)	4-59	3.29	3.14	3.14	3.29	3.20
A University Consortium on Efficient and Clean High-Pressure, Lean Burn (HPLB) Engines	Margaret Wooldridge (University of Michigan)	4-63	3.00	3.20	3.20	2.60	3.08
Flex Fuel Optimized SI and HCCI Engine	Gouming Zhu (Michigan State University)	4-66	2.17	2.50	2.50	2.83	2.46
CLEERS Coordination & Joint Development of Benchmark Kinetics for LNT & SCR	Stuart Daw (Oak Ridge National Laboratory)	4-70	3.71	3.71	3.71	3.43	3.68
CLEERS Aftertreatment Modeling and Analysis	George Muntean (Pacific Northwest National Laboratory)	4-75	3.00	3.50	3.50	3.00	3.31

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Development of Advanced Particulate Filters	Kyeong Lee (Argonne National Laboratory)	4-78	2.00	2.67	2.67	2.00	2.42
Enhanced High Temperature Performance of NOx Storage/Reduction (NSR) Materials	Chuck Peden (Pacific Northwest National Laboratory)	4-83	3.00	3.00	3.00	3.00	3.00
Development of Optimal Catalyst Designs and Operating Strategies for Lean NOx Reduction in Coupled LNT-SCR Systems	Michael Harold (University of Houston)	4-86	3.40	3.50	3.50	3.00	3.41
Cummins/ORNL-FEERC CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines	Bill Partridge (Oak Ridge National Laboratory)	4-89	3.33	3.50	3.50	3.17	3.42
Emissions Control for Lean Gasoline Engines	Jim Parks (Oak Ridge National Laboratory)	4-93	3.80	3.40	3.40	3.20	3.48
Advanced Collaborative Emissions Study (ACES)	Dan Greenbaum (Health Effects Institute)	4-96	3.40	4.00	4.00	3.00	3.73
Thermoelectric HVAC and Thermal Comfort Enablers for Light-Duty Vehicle Applications	Clay Maranville (Ford Motor Company)	4-99	3.50	3.75	3.75	3.50	3.66
Energy Efficient HVAC System for Distributed Cooling/Heating with Thermoelectric Devices	Jeffrey Bozeman (General Motors Corporation)	4-102	3.00	3.20	3.20	2.60	3.08
Neutron Imaging of Advanced Engine Technologies	Todd Toops (Oak Ridge National Laboratory)	4-107	3.43	3.29	3.29	3.29	3.32
Collaborative Combustion Research with BES	Scott Goldsborough (Argonne National Laboratory)	4-111	2.80	3.20	3.20	2.80	3.05
Deactivation Mechanisms of Base Metal/Zeolite Urea Selective Catalytic Reduction Materials, and Development of Zeolite-Based Hydrocarbon Adsorber Materials	Chuck Peden (Pacific Northwest National Laboratory)	4-114	3.40	3.40	3.40	2.80	3.33
Fuel-Neutral Studies of Particulate Matter Transport Emissions	Mark Stewart (Pacific Northwest National Laboratory)	4-117	3.50	3.00	3.00	3.25	3.16
Cummins SuperTruck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks	David Koeberlein (Cummins)	4-120	3.80	3.60	3.60	3.40	3.63
SuperTruck - Improving Transportation Efficiency through Integrated Vehicle, Engine and Powertrain Research	Kevin Siskin (Detroit Diesel)	4-124	3.00	3.20	3.20	3.20	3.15
SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer	William de Ojeda (Navistar International Corp.)	4-128	2.80	2.60	2.60	2.40	2.63
Volvo SuperTruck - Powertrain Technologies for Efficiency Improvement	Pascal Amar (Volvo Trucks)	4-132	3.60	3.20	3.20	3.20	3.30
ATP-LD: Cummins Next Generation Tier 2 Bin 2 Diesel Engine	Michael Ruth (Cummins)	4-135	3.40	3.20	3.20	3.40	3.28
A MultiAir / MultiFuel Approach to Enhancing Engine System Efficiency	Ron Reese (Chrysler LLC)	4-138	3.29	2.71	2.71	3.29	2.93

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Lean Gasoline System Development for Fuel Efficient Small Car	Stuart Smith (General Motors)	4-142	3.57	3.00	3.00	3.00	3.14
Gasoline Ultra Fuel Efficient Vehicle	Keith Confer (Delphi Automotive Systems)	4-146	3.50	3.67	3.67	3.33	3.58
Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development	Corey Weaver (Ford Motor Company)	4-150	3.00	2.57	2.57	3.43	2.79
Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles	Hakan Yilmaz (Robert Bosch)	4-154	3.50	3.50	3.50	3.00	3.44
Thermoelectrics Partnership: Automotive Thermoelectric Modules with Scalable Thermo- and Electro-Mechanical Interfaces	Kenneth Goodson (Stanford University)	4-157	3.50	3.00	3.00	3.50	3.19
DOE/NSF Thermoelectric Partnership Project SEEBECK Saving Energy Effectively By Engaging in Collaborative Research and Sharing Knowledge	Joseph Heremans (Ohio State University)	4-161	3.25	3.25	3.25	3.00	3.22
Advancement in Fuel Spray and Combustion Modeling for Compression Ignition Engine Applications	Sibendu Som (Argonne National Laboratory)	4-165	3.25	2.75	2.75	2.67	2.86
Improved Solvers for Advanced Engine Combustion Simulation	Matthew McNenly (Lawrence Livermore National Laboratory)	4-168	3.33	3.67	3.67	3.50	3.56
CRADA with Cummins on Characterization and Reduction of Combustion Variations	Bill Partridge (Oak Ridge National Laboratory)	4-171	3.25	3.50	3.50	3.25	3.41
Investigation of Mixed Oxide Catalysts for NO Oxidation	George Muntean (Pacific Northwest National Laboratory)	4-174	3.20	3.00	3.00	2.80	3.03
Robust Nitrogen Oxide/Ammonia Sensors for Vehicle On-board Emissions Control	Rangachary Mukundan (Los Alamos National Laboratory)	4-177	3.20	3.25	3.25	2.75	3.18
Thermoelectric Waste Heat Recovery Program for Passenger Vehicles	John LaGrandeur (Amerigon)	4-180	4.00	4.00	4.00	3.50	3.94
Development of Cost-Competitive Advanced Thermoelectric Generators for Direct Conversion of Vehicle Waste Heat into Useful Electrical Power	Greg Meisner (General Motors)	4-183	3.20	3.40	3.40	3.25	3.33
Nanostructured High-Temperature Bulk Thermoelectric Energy Conversion for Efficient Automotive Waste Heat Recovery	Chris Caylor (GMZ Energy Inc.)	4-188	2.75	3.00	3.00	3.00	2.94
High Efficiency GDI Engine Research, with Emphasis on Ignition Systems	Thomas Wallner (Argonne National Laboratory)	4-192	2.17	2.33	2.33	2.17	2.27
Low Temperature Emission Control	Todd Toops (Oak Ridge National Laboratory)	4-196	3.20	3.20	3.20	3.20	3.20
High Energy Ignition and Boosting/Mixing Technology	Edward Keating (General Motors)	4-199	2.75	2.25	2.25	2.25	2.38
Next-generation Ultra-Lean Burn Powertrain	Hugh Blaxill (MAHLE Powertrain LLC)	4-202	2.57	3.14	3.14	2.57	2.93

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Heavy Duty Roots Expander for Waste Heat Energy Recovery	Dale Stretch (Eaton)	4-207	2.86	3.14	3.14	3.00	3.05
Radio Frequency Diesel Particulate Filter Sensor and Controls for Advanced Low-Pressure Drop Systems to Reduce Engine Fuel Consumption	Alexander Sappok (Filter Sensing Technologies, Inc.)	4-212	2.60	3.40	3.40	2.80	3.13
Overall Average			3.22	3.21	3.21	3.01	3.19

Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling: Mark Musculus (Sandia National Laboratories) - ace001

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the use of an optical engine with a variety of different techniques (high-speed luminosity, laser-induced incandescence, and multi-laser sheets) seemed like an excellent approach for elucidating and developing a fundamental understanding of in-cylinder soot processes. Although the results were likely affected by the specific hardware and cylinder geometry of the optical engine used, they helped advance fundamental understanding. The reviewer added that it was also very good that the experimental results were coupled with computational-fluid-dynamics (CFD) modeling.

Reviewer 2:

The reviewer emphasized the sharp focus on science base for spray, combustion, and pollutant formation for low-temperature combustion (LTC) and compression ignition (CI).

Reviewer 3:

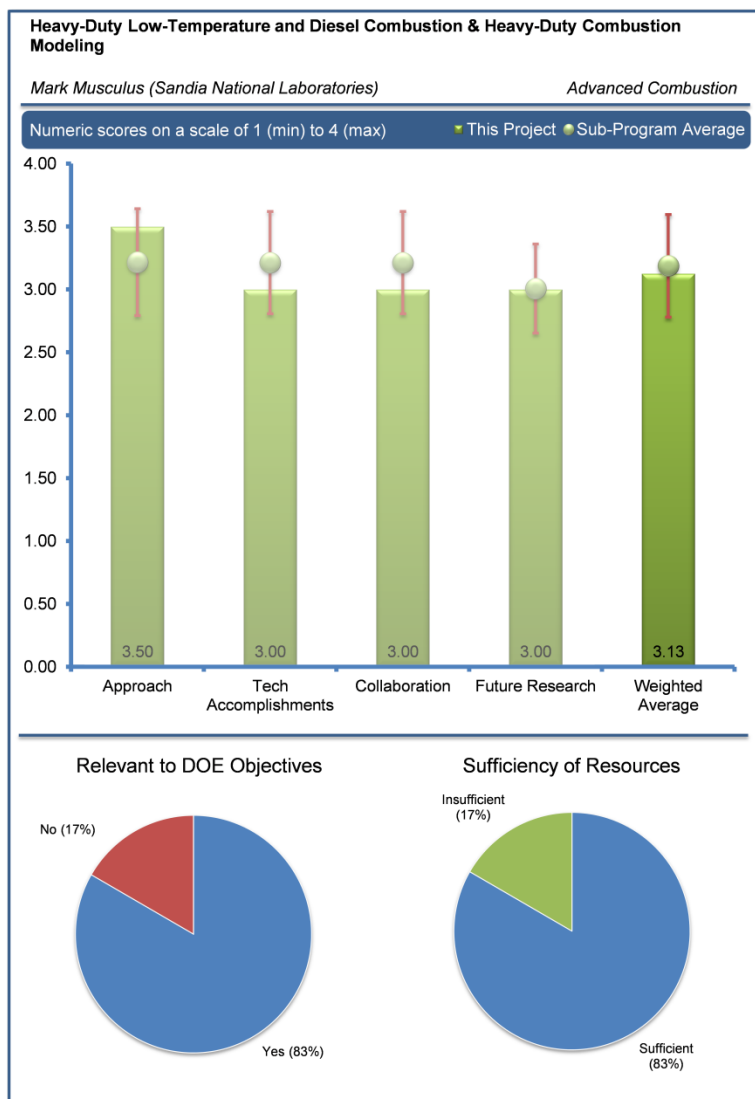
The reviewer noted a good combination of diagnostic techniques to help provide insight into soot reduction with post- injection.

Reviewer 4:

The reviewer commented that the approach was a very good combination of experimental work and three-dimensional (3D) simulation. There had been quite a bit of input from reviewers in the past, which was addressed in this project within the limits of time and cost. The reviewer added that this work was valuable in suggesting potential strategies for reducing PM while maintaining the indicated specific fuel consumption (ISFC) in a large-bore diesel. Possible areas of future work that could be helpful include the impact of fuel injection pressure on post-injection mixing, the influence of nozzle hole size on mixing (over-leaning), and any clever nozzle/injection control strategies that could address various piston geometry impacts on observed performance.

Reviewer 5:

The reviewer stated it was both appropriate and critical to improve the fundamental understanding of combustion processes, and that multiple injection was a natural area to extend that model. Multiple injections include both post-injection and pilot injection, and the reviewer added that the expansion to post-injection was an excellent place to start. The study appeared to be well-thought out to



separate the different effects. This reviewer also suggested that it might be possible to more fully leverage CFD modeling to assist in the understanding of the physical processes in the future.

Reviewer 6:

The reviewer acknowledged that there was an excellent use of experimental techniques with interesting results, but added that the modeling seemed to need more focus to explain and predict results.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that excellent progress had been made and that the development of an LTC spray/combustion model was a significant accomplishment. This reviewer also noted very good progress in elucidating the influence of post-injection on soot formation.

Reviewer 2:

The reviewer commented that the principal investigator (PI) made very good progress this year exploring post-injection timing on PM reduction under LTC-type conditions, adding that there was still quite a bit of work that needed to occur, including injection control parameters, nozzle design, and piston design on post-injection strategy. This reviewer also felt that it would have been helpful to see more discussion on the ISFC impact of post-injection strategies.

Reviewer 3:

The reviewer noted significant post-injection diagnostics and planar-soot-laser-induced-incandescence (LII) that was simultaneous with high-speed luminosity, and further noted that the project moved to multi-planar soot and hydroxide (OH) diagnostics. The reviewer asked what injection pressure(s) were investigated, and what was the effect with injection pressure.

Reviewer 4:

The reviewer summarized that this work was getting started, such that some preliminary hypotheses had been formed but not yet fully vetted. This reviewer looked forward to future conclusions.

Reviewer 5:

The reviewer emphasized that good progress was made in generating a significant dataset, but went on to say that it was not so clear that a unifying theory would emerge that could be used to generalize the results.

Reviewer 6:

The reviewer suggested that the project needed some way to evaluate the tradeoffs and dependencies between soot and engine efficiency, adding that soot reduction was certainly important, but that engine efficiency tradeoffs must also be considered.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the PI is heavily leveraging the University of Wisconsin (UW) Engine Research Center's (ERC's) expertise in 3D simulation, which is valuable and will continue to be valuable in understanding the physics associated with the impact of post-injection mixing on PM at LTC-type conditions.

Reviewer 2:

The reviewer noted that the emphasis of the project work was experimental. While there is a connection to UW, there may be an opportunity to gain greater understanding to strengthen and expand that workstream. This reviewer also highlighted the interaction with the industry through the Advanced Engine Combustion (AEC) Memorandum of Understanding (MOU) and consultation as the study was developed; however, the reviewer added that there may be opportunities to strengthen that interaction.

Reviewer 3:

The reviewer felt that the list of collaborators was impressive, but it was not clear that there were appropriate supports and interaction.

Reviewer 4:

The reviewer remarked that the collaboration seemed to mainly be with UW in the area of CFD modeling and with Delphi. Interactions with the industrial members of the AEC MOU meeting were mentioned, but no specifics were given; such that this reviewer was uncertain whether the interactions were restricted to the two presentations that Mark made at those meetings or whether the interactions with members extended beyond that.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer asserted that the plans seemed reasonable to continue to obtain the information needed to further develop the conceptual models and link them to CFD simulation models.

Reviewer 2:

The reviewer indicated that all the proposed pathways were valid. This person's only suggestion was to include fuel injection pressure, nozzle design, and (possibly) piston design effects.

Reviewer 3:

The reviewer emphasized that the continuation of this study and expansion to different geometries would be interesting. The development of a conceptual model of post-injection would be very interesting. In the long term, the reviewer suggested that the PI might also want to expand to pilot injections. Pilot injections are used on almost every engine in the market today, this reviewer added, but the physical processes dictating why the quantity and timing optimize the way they do to improve hydrocarbon (HC), carbon monoxide (CO), and noise emissions are not well-understood.

Reviewer 4:

The reviewer said to continue building a conceptual model understanding. This person brought up how combustion design affected heat transfer and efficiency, and suggested stronger emphasis in this area. This reviewer also indicated that more LTC work was needed (earlier injection).

Reviewer 5:

The reviewer indicated that the plan addressed the key open issues, but added that it was not clear how much could actually be achieved. This reviewer would like to see more focus on efficiency impacts.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer claimed that this project explicitly targeted strategies for reducing PM in heavy-duty (HD) diesels while maintaining ISFC and therefore supported the Department of Energy (DOE) objectives in the HD area.

Reviewer 2:

The reviewer stated that fundamental understanding of in-cylinder combustion processes should generate ideas on how to improve combustion efficiency (and thereby reduce fuel consumption) and reduce emissions, which is in line with DOE objectives.

Reviewer 3:

The reviewer reported that the project was investigating efficiency and emission challenges.

Reviewer 4:

The reviewer noted that, although the work was addressing soot formation, it was not clear how this work supported the goals of lower fuel consumption.

Reviewer 5:

The reviewer cautioned that the project was focused on soot emissions reduction without a means to evaluate the potential impact on engine efficiency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer suggested that the expansion of the CFD activity connected to this project (if it is only at a low level) might be appropriate.

Reviewer 2:

The reviewer voiced that it looked like there was good progress versus the planned milestones, such that the resources seemed sufficient.

Reviewer 3:

The reviewer summarized that the funding appeared to be pretty consistent throughout the last few years and was adequate to address the various objectives of this project.

Low-Temperature Automotive Diesel Combustion: Paul Miles (Sandia National Laboratories) - ace002

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer emphasized that this was outstanding work. The investigator was developing a fundamental understanding of the interaction of in-cylinder processes such as in-cylinder mixing, with emission and engine performance. The fundamental processes were being examined relative to changes in bulk engine control parameters like injection pressure and swirl. The work encompassed rigorous and detailed experiments, with comparison to 3D simulation. This reviewer added that the analysis used quantification from the experiments and was supported with explanations using detailed chemical kinetic evaluations; the work was very comprehensive.

Reviewer 2:

The reviewer explained that the project provided fundamental research to support the development of advanced light-duty (LD) diesel engines. The authors sought to develop a fundamental understanding of the combustion process by aligning the Sandia National Laboratories (SNL) optical engine with simulations carried out at the University of Wisconsin-Milwaukee (UWM). The reviewer remarked that the approach was clearly described.

Reviewer 3:

The reviewer offered that the project addressed the lack of fundamental understanding and accurate CFD models, adding that the project aided in the development of such models. This person also indicated that understanding mixture formation impacted combustion, and hence, thermal efficiency.

Reviewer 4:

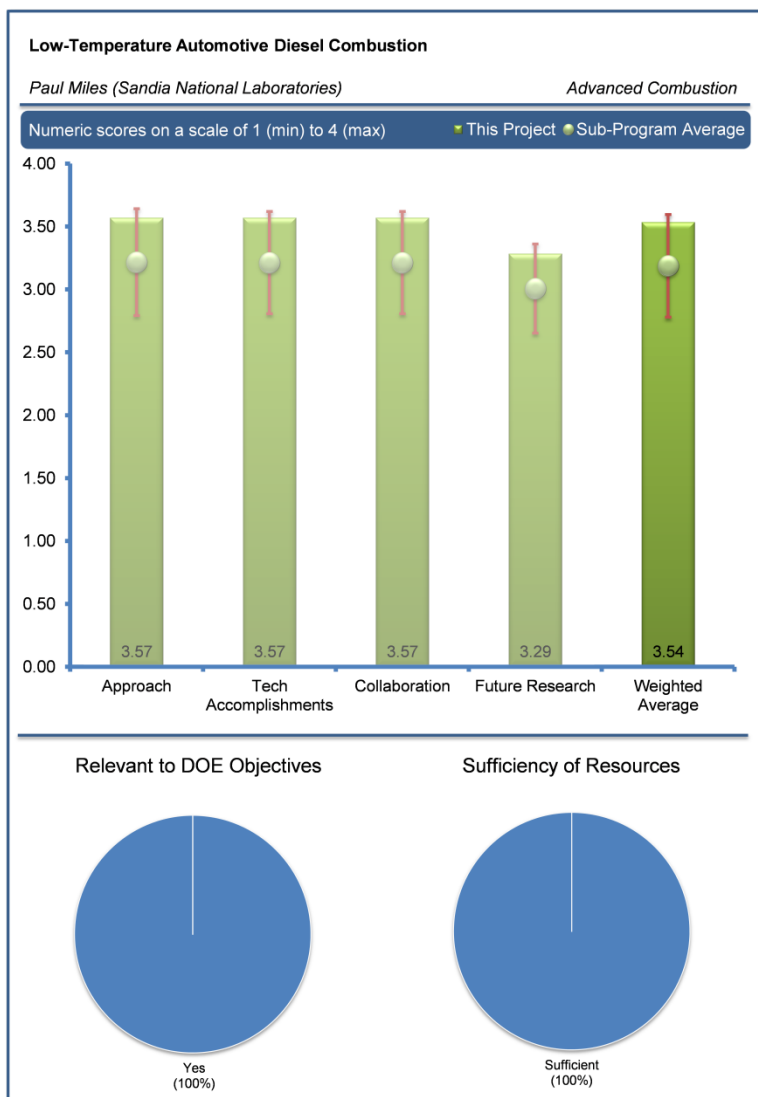
The reviewer highlighted that carefully building a comprehensive quantitative data set under LTC conditions was very useful, not only for understanding in-cylinder processes and validating models.

Reviewer 5:

The reviewer stated that it was good to see production-type combustion system geometries being used.

Reviewer 6:

The reviewer voiced that the general approach of optical experiments coupled with simulation was good. At the moment, this reviewer added, LD diesel was not a large fraction of the U.S. market, but a few new offerings were entering the market. If this project is



successful in meeting the 40% fuel-economy (FE) and Tier 2 Bin 2 emissions goals, the number of diesel offerings (and number of sales) would likely increase.

Reviewer 7:

The reviewer noted that the structure of the project was well set. The collaboration of an optical engine with CFD modeling, along with input from industry, was an effective means to understand the fundamentals of current clean LD diesel combustion. This person added that, given the interdependences of many variables, some form of design of experiment (DoE) should have been implemented to reduce the number of test/simulation points.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted a very nice connection between the experimental results, simulation comparisons, and changes in emissions from the engine when typical operating parameters (e.g., swirl, injection pressure, and multiple injections) were manipulated. The reviewer added that the new understanding of lean and rich CO and HC emission phenomena were important additions to the knowledge base.

Reviewer 2:

The reviewer remarked that the lab had been updated for improved diagnostics capability and scope of experiments, and that good progress had been made on correlating the equivalence ratio with CO and unburned hydrocarbon (UHC) emissions. This person added that the effect of reverse squish flow needed to be investigated, and that it looked like many of the effects of swirl and injection timing could also be explained by the timing and strength of the reverse squish flow, and the relative timing of injection.

Reviewer 3:

The reviewer acknowledged that good progress had been made against the milestone, the sweeps of some variables yielded meaningful information, and the images were impressive. Additionally, the correlation between test and modeling was well-presented, and the directions for improvement had been well-sought out. The large crevice volume of the optical engine was a concern with regard to UHC/CO. This person further commented that, while it was not practical to modify the engine itself, some additional modeling work might be helpful. It was necessary, in the reviewer's opinion, to make sure that this difference from the production engine would not alter the outcome of this research.

Reviewer 4:

The reviewer pointed out that comprehensive data sets had been developed for one geometry and had contributed to the development of the conceptual model in LTC. The modeling work showed differences, but the source of those differences was not well-understood. This reviewer added that it was important at this point to focus on interaction with the modeling effort to identify the source of the discrepancy.

Reviewer 5:

The reviewer mentioned very interesting findings, but added that there was no direct way to gauge the impact or significance of these findings back to the stated targets of efficiency, emissions, and cost.

Reviewer 6:

The reviewer indicated that the authors did a good job capturing last year's Annual Merit Review (AMR) status and bringing the reviewers up to date on this year's activities. The authors had been focusing on the importance of the mixture formation process and its impact on soot and oxides of nitrogen (NO_x), HC, and CO emissions. This work helped lay out an optimal combustion strategy approach to controlling and lowering emissions, which could provide the foundation for future in-cylinder and aftertreatment combinations. This reviewer added that the impact of injection pressure on HC and CO was demonstrated in detailed images across three planes within the combustion chamber. A similar study with resulting observations was given for varying swirl ratio and injection timing. The injection timing particularly highlighted the balance between the mixture formation and kinetics of oxidation. This person went on to say that the comparisons with the modeling studies revealed significant discrepancies. The comparison

revealed serious disconnects in key parameters such as underpredicting the spray penetration, swirl velocity, and turbulent diffusion. The authors proposed to examine the gas-jet model performance and expand the simulation to the full 360-degree combustion chamber; the reviewer felt that this may be indeed necessary. At this stage of the work, the reviewer continued, the simulation fidelity should be much better. It may be worthwhile to re-evaluate the team and see if there is a better platform for the modeling work. Further, the accomplishment section closed with a description of the pilot injection tests. The data reported offered only broad responses based on CO and HC, but the reviewer indicated that this data is readily available from metal engines. The reviewer stated that the authors should focus on providing unique insight to such strategies.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported very good engagement with and leverage of the UW ERC for modeling work, as well as a strong interaction with General Motors Corporation (GM) and Ford.

Reviewer 2:

The reviewer confirmed that there was good representation comprised of many industrial partners, including heavy-duty manufacturers. This person added that the project was also connected with several AEC/DOE-sponsored projects.

Reviewer 3:

The reviewer noted that very good collaborations existed with industry partners (GM and Ford) and UW.

Reviewer 4:

The reviewer felt the project had good synergy with other institutions and a close collaboration with the industry.

Reviewer 5:

The reviewer remarked that the AEC MOU was a good framework for extending the collaboration beyond that of the principle participants.

Reviewer 6:

The reviewer acknowledged that there were good collaborations with universities, but added that it was not clear to what extent the original-equipment-manufacturer (OEM) collaborations influenced or benefited from this work.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the future work was a good extension of the current work.

Reviewer 2:

The reviewer observed that the plan was a good continuation of current research, adding that the choice of piston bowl went hand in hand with injector design/protrusions, injection pressure, and operating strategy. The reviewer stated that, if Ford had already considered those issues, then great; otherwise, an injector with a different geometry should be considered. This reviewer added that DoE should be performed to reduce the number of test/modeling points and thus speed up the progress. It would also be helpful to put more emphasis on the cold start conditions, which are critical to meeting the Tier 2 Bin 2 emissions goal.

Reviewer 3:

The reviewer said that work would expand to other piston geometries (stepped-lip bowls) and higher loads, and added that modeling work might need to look closer at the injector characteristics.

Reviewer 4:

The reviewer mentioned that the squish flow should be measured and characterized, and correlated to CO and HC emissions.

Reviewer 5:

The reviewer asked if, given the discrepancies found in the simulation, there was a need for metal engine experiments. This person suggested this might be another collaborative opportunity, either with a university or an OEM, and added that this might also be a way to roll up all the progress every year and thereby show the net progress toward the stated targets.

Reviewer 6:

This reviewer looked forward to seeing the comparison of different bowl geometries, which would contribute to the data set. It was important to get these data sets to validate models with different bowl geometries, since that is how the models are used in the industry. This person added that the post-injection study plans were not well-defined and encouraged the PI to discuss this with industrial partners in AEC.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer asserted that this program was very strong and very valuable. It was making good progress in identifying and understanding the fundamental processes occurring in-cylinder and how they were impacted by changes in engine operation. This reviewer added that, to achieve the pending fuel-economy and emission standards, it would be critical to affect the manipulation of these in-cylinder phenomena.

Reviewer 2:

The reviewer emphasized that the project was relevant and uniquely focused on the LD diesel challenges.

Reviewer 3:

The reviewer affirmed that the project increased the potential to meet engine-efficiency targets by providing fundamental understanding of combustion and emissions formation processes in the cylinder.

Reviewer 4:

The reviewer explained that engine-out HC was clearly a barrier to fuel efficiency due to the negative impacts of calibration and aftertreatment actions.

Reviewer 5:

The reviewer agreed that this research would enhance the understanding of LD clean diesel combustion, which could potentially help to expand the use of high-efficiency and low-emissions diesel engines, which would in turn help reduce fuel consumption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer affirmed that there was no clear need to increase funding.

Reviewer 2:

The reviewer suggested that it might be important to evaluate what additional diagnostics could be applied to fully characterize the injector to help with model validation. The data set was meant to validate models, this reviewer continued, but the spray was critical to the model, so the better that spray was characterized, the better. This should be done soon, this person added, while the injector hardware was fully functional.

HCCI and Stratified-Charge CI Engine Combustion Research: John Dec (Sandia National Laboratories) - ace004

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer summarized that the work combined metal, optical, and computational approaches and was a good way to provide meaningful and realistic data for homogeneous-charge-compression-ignition (HCCI) combustion.

Reviewer 2:

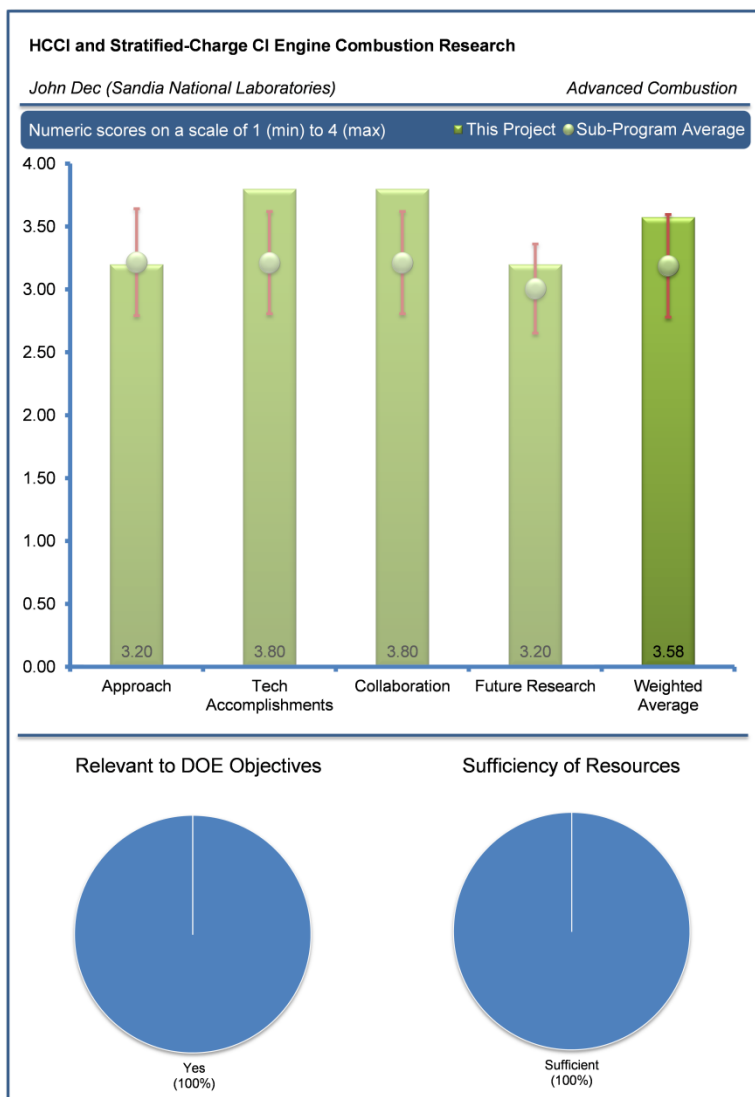
The reviewer confirmed that a significant portion of this project addressed the DOE goals of improving engine thermal efficiency while ensuring engine-out emission levels were near regulated limits. In particular, a key focus area was the impact of fuel reactivity on the ability to push HCCI-like combustion to high loads within the limits of blending ethanol and gasoline. This effort showed the reactivity limits of gasoline under the speed and load conditions of this study, including the particular engine geometry. This person added that, though the results were limited to this particular engine, the project provided evidence concerning the impact of fuel reactivity on the ability to balance pressure rise rate, exhaust-gas-recirculation (EGR) level, and injection timing strategy on engine load limits.

Reviewer 3:

The reviewer stated that the project addressed barriers to high efficiency on a medium-duty engine.

Reviewer 4:

The reviewer noted that this was a good study of fuel reactivity on HCCI that was trying to isolate the influence of ethanol. This reviewer added that this was a good start looking at combustion noise, and that it confirmed that ringing intensity (RI) and combustion noise measured different things (i.e., knock versus noise). The next step should be to understand the sensitivity of efficiency to the noise. This reviewer went on to say that there may be an opportunity to better account for air path using an air path model to define appropriate exhaust pressure given the boost and exhaust temperatures.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that there was good progress towards understanding the effects of fuel reactivity, and added that the definition of the desirable fuel properties for HCCI appeared to be closer due to this work. The reviewer also thought that implementation of the noise calculation was a great step forward.

Reviewer 2:

The reviewer felt that the PI had done an outstanding job performing various parametric studies, including reactivity effects, boost effects, and some intake manifold temperature effects. This person added that one possible further parametric study could be a large intake manifold temperature sweep within vehicle design limits, not only at 1,200 revolutions per minute (RPM), but also at other key speed points.

Reviewer 3:

The reviewer remarked that the results provided a significant contribution to understanding HCCI combustion and efficiency potential. However, this person added that there was a need for a better understanding of why the indicated thermal efficiency (ITE) was so much lower than the results from some other HCCI research. This was a fundamental question as to the potential for HCCI to reach higher efficiency targets.

Reviewer 4:

The reviewer acknowledged the very impressive results in terms of efficiency and compression ignition load range, but went on to say that the results suggested significant implementation challenges regarding the boost system and engine control outside of a laboratory setting. This reviewer added that an estimate of brake thermal efficiency (BTE) or test results from a multi-cylinder engine would provide an assessment of the impact of the boosting system requirement on the overall engine efficiency.

Reviewer 5:

The reviewer commented that additional background on the tests, such as determining which exhaust backpressure and temperatures simulated the turbocharger, would have been helpful. This person suggested that, since the intake port was suspected for the fairly low peak efficiency, it might make sense to either slightly modify the flow field (to evaluate this possibility) or work with an outside partner for a complete revision.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that there was good collaboration.

Reviewer 2:

The reviewer noted participation in AEC and added that the combustion noise information provided was improved relative to previous years.

Reviewer 3:

The reviewer said there was a good list of collaborators and went on to suggest that the PI might try to connect to Dan Haworth at Penn State, as he is doing interesting work on LTC combustion modeling.

Reviewer 4:

The reviewer mentioned that, although the PI ran out of time to discuss portions of their collaborations, it appeared that this element was present in the project. In particular, Cummins had been a key collaborator along with Lawrence Livermore National Laboratory (LLNL) in the chemical kinetics area.

Reviewer 5:

The reviewer affirmed that there was good interaction with the industry and good leverage of utilizing LLNL and universities for modeling work, but this person added that it was not clear how well-coordinated those activities were.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer emphasized the project's good focus on efficiency evaluation and improvement.

Reviewer 2:

The reviewer agreed that the overall plan made sense, but asked about the compression ratio (CR) study and whether it was truly necessary to spend the money to design and install a new piston for high-load testing when one could simulate these conditions by properly choosing the intake manifold thermodynamic condition. This reviewer added that it was recognized that mixing could be a little different between the two cases, but a straightforward experiment with simulated conditions at higher CR could indicate the initial effects of such a change on the compression event.

Reviewer 3:

The reviewer warned that the current approach was to set combustion phasing based on knock limit, but that this might not be acceptable for noise. This reviewer added that it would be useful to look at the sensitivity of noise to combustion phasing and other things, as well as the sensitivity of efficiency to noise. The reviewer felt that this was as important as looking at the 16:1 CR and early direct injection (DI).

Reviewer 4:

The reviewer indicated that greater definition of the plans for Miller-cycle spark-assisted compression ignition (SACI) versus spark ignition (SI) would be helpful. This reviewer also asked about the lack of intake port revision plans.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer concluded that this project directly addressed thermal efficiency goals by exploring the limits of fuel reactivity over a broad range of operations under HCCI-like conditions and at ISFCs higher than today's engines. This person went on to say that the latter ISFC results had been a little disappointing, but nevertheless established insight into the limits of this type of combustion strategy.

Reviewer 2:

The reviewer reported that this work should help to answer the fundamental question of whether HCCI can lead to substantial efficiency gains over conventional diesel combustion. However, this reviewer added that there was a need to understand the differences with other work in this field.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that this project has been well-funded for many years.

Reviewer 2:

The reviewer simply noted \$740, 000 in 2013.

Spray Combustion Cross-Cut Engine Research: Lyle Pickett (Sandia National Laboratories) - ace005

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer summarized that this type of research was critical to developing fundamental knowledge to enable predictive spray simulations. A simple, well-controlled environment, as the PI had in his combustion vessel, was a good approach for this type of work. This reviewer added that the approach of engaging and aligning like work from various research institutions from around the world were also good.

Reviewer 2:

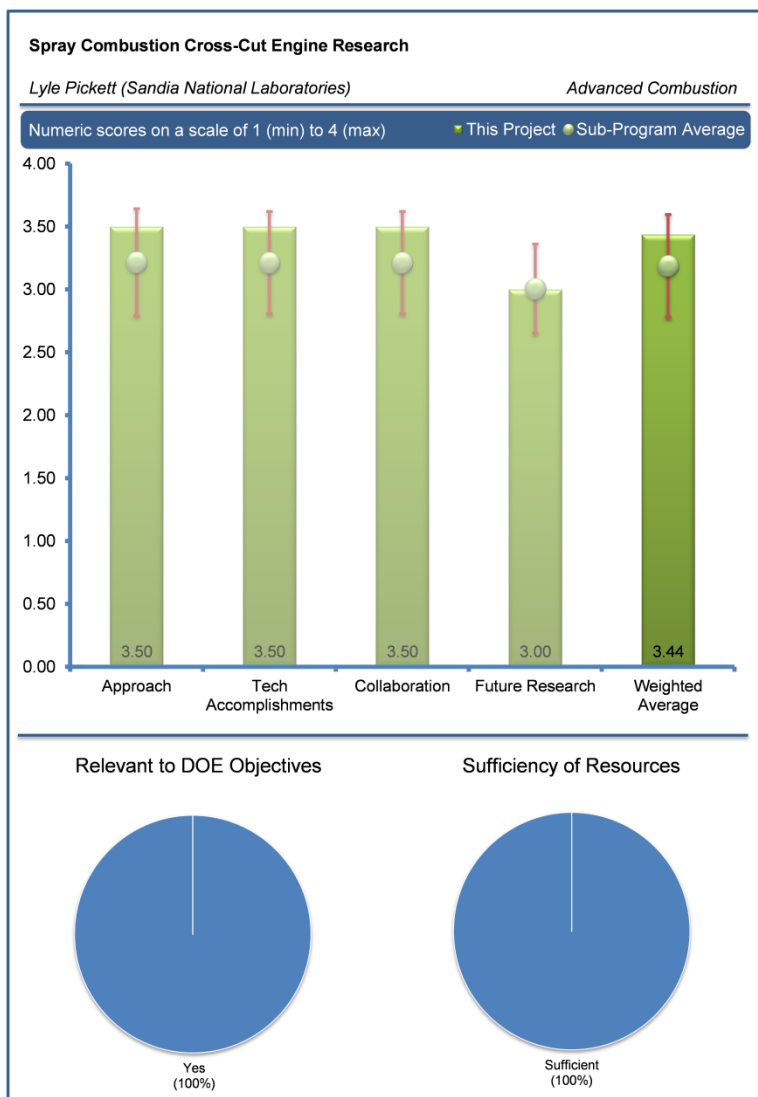
The reviewer confirmed that the project provided fundamental research to support the development of advanced engines and related technologies, and that the work identified the need to capture the interactions among spray, mixing, and chemistry for better future engine designs. The physics described here was to be integrated with better simulation tools. This person added that the experimental work proceeded with a well-controlled, constant-volume chamber, with consistent benchmarks across various facilities. The reviewer went on to say that this report had shifted the focus to gasoline-like systems, and asked if there were plans to continue with the diesel development. It might be worth capturing the impact the earlier diesel work had had on the capability to deliver more efficient systems. The impression of this reviewer was that there was much work that needed closure in the diesel world.

Reviewer 3:

The reviewer stated that it was good to see expansion into GDI, but asked how the injector-to-injector variability had been captured. In the images that were shown for the GDI analysis, the PI highlighted the asymmetry. The reviewer asked if this was characteristic of that injector or that family of injectors, as well as how the issue of injector-to-injector variability was captured by the Engine Combustion Network (ECN).

Reviewer 4:

The reviewer felt that this project was a good compliment to the optical engine test and modeling work, and that it offered a fundamental description of the spray behavior relatively undisturbed by other variables. This reviewer also acknowledged that, because things were not injected into real flow/temperature/pressure environments, the results were valuable only in close collaboration with other two-system approaches, which seemed to be happening.



Reviewer 5:

The reviewer noted that DI sprays would be a critical component of achieving enhanced performance of ICEs, yet they were still not well-understood. The work described here was an important contribution to advancing our understanding of combusting sprays, and the ECN was a good way to engage the international spray community in a focused effort. The comparison between the unified sets of spray data and simulation was a great way to advance the model development. This reviewer added that it would be interesting to ask the modelers to extend their predictions to an environment in which the pressure (and temperature) was (were) changing, as it did during engine expansion. It was known that predicting a fuel's ignition delay in a shock tube or rapid compression machine did not necessarily validate the kinetic scheme for predicting auto-ignition of the fuel in an engine. This reviewer inquired whether if it was possible that the thermodynamic state history that the spray experiences in the constant-volume vessels used in the ECN, masked phenomena that influenced spray combustion in an engine. This reviewer emphasized that extrapolating the model predictions to include an expansion process might highlight important differences among the different models, and identify important subtleties associated with spray combustion during engine expansion.

Reviewer 6:

The reviewer acknowledged that high-temperature/high-pressure chambers provided good optical access and mimicked certain static conditions in the engine, thus providing a good flexibility to study fundamental phenomena. However, this reviewer added, it did have some limitations as well, and that a greater balance between diesel and gasoline work should be encouraged. This person noted that the ECN provided a good forum for experimentalists and spray modelers to collaborate to improve spray models.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the PI's work was very well done, and that the PI was able to draw valuable insights from his work. This person added that it was good to see the incorporation of GDI into this project.

Reviewer 2:

The reviewer felt that the inclusion of GDI sprays was a very good addition, as was the focus on particulates. This person also mentioned that the application of the array of diagnostics was very impressive.

Reviewer 3:

The reviewer noted great progress on adding GDI.

Reviewer 4:

The reviewer remarked that the optical diagnostics to date were providing excellent insights into spray behavior. The plotting of spray collapse with the use of plume plotting vectors was very interesting and visually very informative. The understanding provided regarding asymmetry among the plumes was very useful. This reviewer added that the outlet of GDI injectors should have been imaged to verify that the jet plume was or was not contacting the outer stepped hole, as it would greatly affect the downstream spray.

Reviewer 5:

The reviewer acknowledged that progress had been made with regard to Spray-A conditions in collaboration through the ECN. Liquid and vapor visualization provided insightful information. This reviewer also noted that the shot-to-shot variation in vapor penetration and plume interaction were good examples, adding that it would have been helpful to show the injector-to-injector variations. Testing some (if not all) of the 12 Delphi injectors could have provided a valuable data set on the scope of variability among production injectors. This reviewer added that such information could then be used by the testing and modeling community to study the impact of injector variability on the combustion process.

Reviewer 6:

The reviewer stated that, for the Spray-A DI, the present work highlighted significant differences in current models (as noted in errors in lift-off length and ignition delay, and sprays with similar lift-off lengths but very different OH profiles across the spray). This

person added that the work had provided a new technique to quantify soot concentration based on high-speed extinction imaging, and it might have been of interest to explain how this could be integrated in the modeling efforts (such as soot formation and the location of the lift-off flame). This person asserted that the work had taken a deep look at specific challenges seen in GDI sprays, such as plume interactions, ignition in stratified environments, and injection-to-injection variability. The reviewer added that the work was very dependent on hardware (such as in the nozzle step geometry) and that it was difficult to understand how universal these findings might be, especially when the experiments were performed in a combustion vessel that differed greatly from the engine environment.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that the ECN was an excellent forum that maximized the group's ability to participate and share in this activity. It also represented a tremendous leverage of resources.

Reviewer 2:

The reviewer mentioned that the ECN was proving to be very productive and useful. Many institutions were participating and many measurements were being made. This reviewer further noted that appropriate connections with the industry existed to ensure that the relevant hardware and operating conditions were being selected.

Reviewer 3:

The reviewer affirmed that there was good representation comprised of multiple industrial partners, and multiple experimental and modeling capabilities through the ECN. The interactions have increased over the years, covering more technical ground across the combustion research front. This provided for the identification of future work areas.

Reviewer 4:

The reviewer emphasized that the ECN collaboration, with its over 100 participants, was outstanding, and further noted that the 26 types of experiments at Spray-A conditions across 10 different international institutions was an excellent example of coordination. A summary of the outcome would have been helpful, this reviewer added.

Reviewer 5:

The reviewer suggested that while the collaboration was good, the coordination appeared to be lacking. The reviewer asked about the types of information needed, the plan for getting there, and how progress was being measured. The reviewer also questioned if all the involved researchers were being utilized to their fullest potential, and if, once the various research institutions around the world had shown good agreement, it was possible to then coordinate each to look at different parts of the problem. The reviewer felt that it would be good to see this work occur at a faster pace, and asked about the limitations of going faster.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that this was important work and that the plans for the future were good.

Reviewer 2:

The reviewer reported that the future work plan was sound and reflected the growing interest in the GDI engine and its challenges.

Reviewer 3:

The reviewer suggested that the gasoline spray measurements should be accelerated.

Reviewer 4:

The reviewer stated that the GDI injector performance could (and likely would) be different for each injector manufacturer, and asked how this would be addressed. The reviewer asserted that it was good to see Delphi involved. This reviewer asked whether other

suppliers had been approached and if they were willing to supply multiple samples of their latest (best) injector design. The reviewer also asked how large the part-to-part and shot-to-shot variations for GDI were, how the injector design details impacted GDI performance, and how multiple GDI injections influenced the bulk spray. It would be good to see these types of results next year.

Reviewer 5:

The reviewer noted that the scope of work could be extended beyond LTC and HCCI to systems representative of current products that tended more toward hot-temperature combustion. This person added that the work could also explore kinetics of SI, flame-front propagation, and stratification.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer felt that this work was fundamental and pre-competitive, and addressed important phenomena that would be important for improved engine performance.

Reviewer 2:

The reviewer remarked that the project provided robust spray data for the development of spray models that were needed to analyze and design high-efficiency advanced combustion engines.

Reviewer 3:

The reviewer commented that findings from this project would enhance the understanding of fuel spray and guide the design of efficient combustion systems for both diesel and gasoline engines, which would reduce fuel consumption.

Reviewer 4:

The reviewer pointed out that the fundamental understanding of sprays was clearly critical to our understanding of combustion and our ability to model it. This person went on to say that it would be helpful to better understand the true long-term objective of this project, so the project could be measured and tracked; this would help to ensure it remains relevant. This reviewer asked if the long-term objective was to establish the important performance characteristics of injectors, improve their design, or improve our ability to model them. If the goal was to improve the modeling, this person added, some evidence as to progress in this area should have been included in the presentation and work plan.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that there were nice facilities. As far as this reviewer could tell, the resources appeared sufficient.

Automotive HCCI Engine Research: Richard Steeper (Sandia National Laboratories) - ace006

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that this project had a very interesting approach to characterizing products of negative valve overlap (NVO) reactions.

Reviewer 2:

The reviewer pointed out that the new sampling valve test setup provided some interesting insight into the NVO chemistry.

Reviewer 3:

The reviewer said that coupling optical engine tests with in-cylinder sampling and computer modeling seemed to be a reasonable approach. This reviewer added that the in-cylinder sampling device and method that were developed seemed to provide a way to relate engine performance to in-situ chemical species and (potentially) chemistry effects.

Reviewer 4:

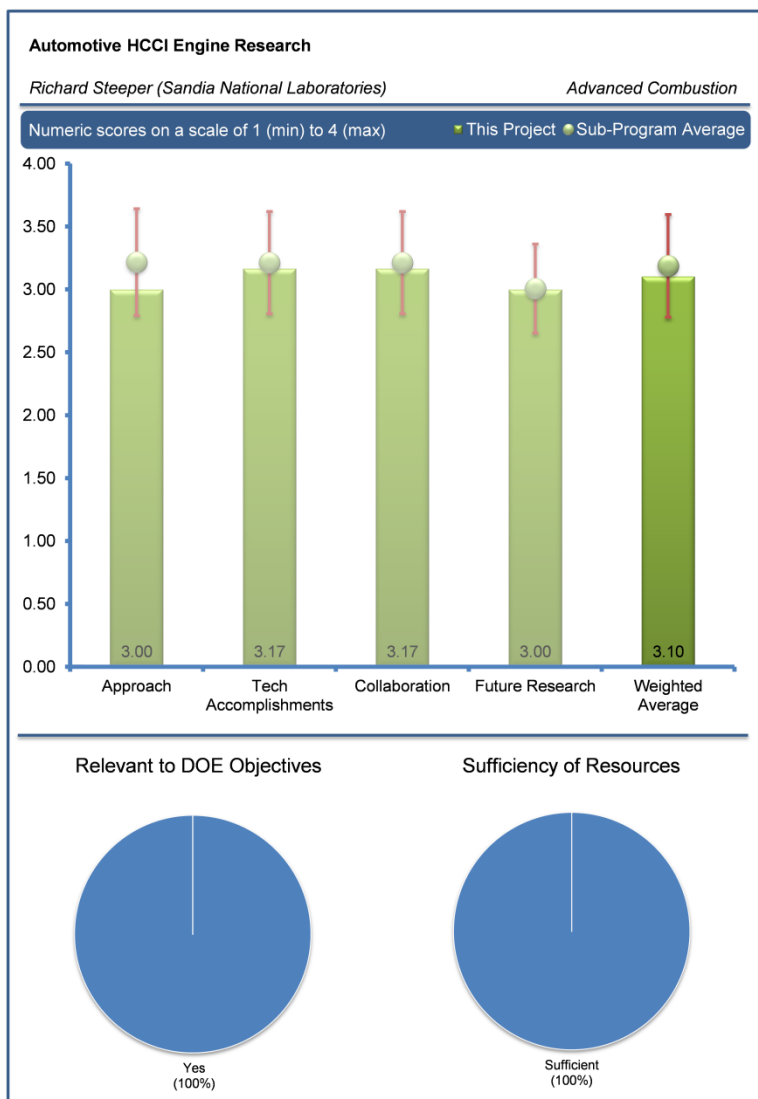
According to this reviewer, this project studied NVO species' influence on HCCI combustion, connecting NVO injection experiments with previous experiments in which trace species were introduced. This reviewer thought this was a very good use of a sampling system to characterize trace species and understand which species were most critical, and suggested expanding the focus to higher load conditions. The condition chosen was very low load (almost like an idle condition), which might become less relevant as engines are downsized and stop-start is introduced.

Reviewer 5:

The reviewer expressed that, even though it was not the focus of the work, NVO HCCI load challenges were not addressed, and it would have been nice to mention them.

Reviewer 6:

The reviewer affirmed that the work to date had been very good in assessing the impact of NVO fuel timing on combustion system response. However, the impact of ISFC was not clear to the reviewer, and thus more attention could have been paid to this detail. Also, mixing effects and reactivity effects could potentially be addressed at some point if it has not already been addressed sufficiently in the past.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer emphasized that great progress on the sampling system appeared to be providing good information for understanding what was happening and what species were driving the process.

Reviewer 2:

The reviewer noticed good progress in both experimental and computational aspects.

Reviewer 3:

The reviewer cited the completion of the acetylene seeding study, a gas-sampling system for probing the chemistry of NVO, and model application. This reviewer also mentioned the nice isolation of chemical versus thermal effects on combustion phasing.

Reviewer 4:

The reviewer explained that the progress and accomplishments were good, but the timing and quantity were not outstanding. This reviewer added that the development and validation of the in-cylinder sampling method had enhanced the ability to determine fuel chemistry effects. This reviewer also noted interesting results on the impacts of the acetylene species on combustion phasing.

Reviewer 5:

The reviewer indicated that much effort had been spent this last year making sure good speciation measurements could be taken as well as studying the impact of NVO timing on combustion system performance. This reviewer added that it would have been nice to see the corresponding impact on ISFC through the various experiments.

Reviewer 6:

The reviewer cautioned that it was not clear how the CHEMKIN modeling could impact the conclusions or direction when the correlation to measured results was so poor.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer highlighted that there looked to be a very good collaboration set up with two automobile companies (Ford and, especially, GM) as well as with two National Laboratories (ORNL on parallel engine tests with NVO, and LLNL for the kinetic modeling).

Reviewer 2:

According to this reviewer, strong collaboration was apparent with GM, ORNL, and LLNL.

Reviewer 3:

The reviewer reported wide AEC participation.

Reviewer 4:

The reviewer noted that there was a strong connection to GM but not with the other OEMs. This reviewer also acknowledged interactions with ORNL and LLNL, but added that the extent and level of coordination were not clear.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that the PI intended to extend the operating range of the engine under NVO timing. This person added that it would have been helpful to see more details concerning targeted loads, possible fuel injection strategies, and any fuel reactivity studies. It is possible that these details had been developed and were simply not presented.

Reviewer 2:

The reviewer commented that the plans included a lot of activity. It would be interesting to explore how to enhance acetylene formation during NVO combustion. Also, it was not clear if the work was done with gasoline only or a 10% ethanol blend with gasoline (E10). E10 and higher ethanol blends should be more meaningful for high-output SI engines.

Reviewer 3:

The reviewer acknowledged that the plans to complete the work on elucidating chemistry effects during NVO seemed reasonable. The plans to shift the study to advanced ignition effects seemed a bit broad, with its focus on a large number of techniques (including cool plasma, microwave, and laser). This reviewer suggested some prioritization of techniques was needed there.

Reviewer 4:

The reviewer suggested a narrow focus on a short list of ignition technologies working specifically on spark-assisted HCCI. Otherwise, the ignition work area will be too broad for a meaningful deep dive. This person also suggested further collaboration with other DOE projects regarding the gas-sampling hardware and approach. The observed piston wetting and pool fires during NVO were likely drawbacks. This reviewer asked if there were other spray orientations (e.g., different injector) to assess reduced piston wetting.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer observed that expanding the fundamental understanding of LTC processes would lead to more efficient engines and thus better fuel economy, in turn displacing some petroleum.

Reviewer 2:

The reviewer said that, since high-output gasoline engines predominantly run at light load and low efficiency, this work should help to improve overall vehicle efficiency.

Reviewer 3:

The reviewer mentioned that this project did address DOE's goal of improving the thermal efficiency of advanced gasoline engines. While progress to date had shown clear improvement in ISFC, there was potential for progress with the NVO fuel injection approach.

Reviewer 4:

The reviewer asserted that more work was needed at higher load regions of HCCI (5–10+ bar indicated mean effective pressure [IMEP]).

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the resources seemed sufficient, and cited that there was no indication that milestones were being missed due to a lack thereof.

Reviewer 2:

The reviewer indicated that the funding was very reasonable for this effort both in this fiscal year (FY) and in the past.

Large Eddy Simulation (LES) Applied to Advanced Engine Combustion Research: Joe Oefelein (Sandia National Laboratories) - ace007

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer affirmed that the three basic objectives of the project were well-aligned with the stated technical barriers, and that the high fidelity models would provide a useful tool to validate engineering models and the code used in the industry. This reviewer added that the validation of the model with the experiment was also very important and valuable.

Reviewer 2:

The reviewer expressed that it was hard to fault the approach.

Reviewer 3:

The reviewer rated the approach as very good, adding that the work was very fundamental and addressed the very essence of what was going on in fuel sprays. Consequently, it was very focused on important technical barriers to future developments. The interface with the ECN was an excellent and important collaboration. The reason this reviewer did not rate the approach as outstanding was that it was not clear what the pathway was for migrating this understanding into engineering-type models, or if this was being addressed. If this deficiency were due to the reviewer's lack of understanding, then this person would rate the approach as outstanding overall. This reviewer added that including GDI in the portfolio of topics was an important addition.

Reviewer 4:

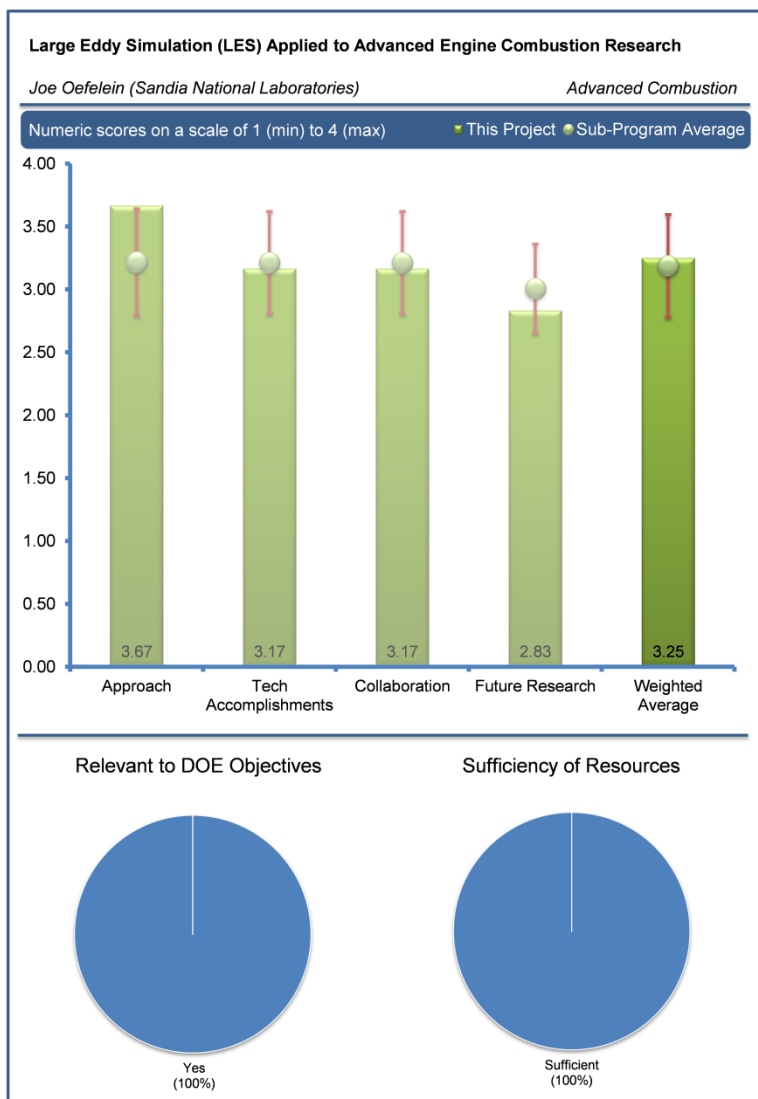
According to this reviewer, LES appeared to be the only way that the industry could truly understand in detail the stochastic nature of combustion.

Reviewer 5:

The reviewer explained that the project used unique, powerful computational capabilities and advanced physical models like LES to evaluate spray and combustion calculations in advanced, high-efficiency engines.

Reviewer 6:

The reviewer indicated that the project focused on improved simulation capabilities using LES. The team had unique access to very powerful parallel codes and DOE computers to make this work possible. The work attempted to maintain a link between basic science and applied research, and promoted model development using thermodynamic principles with close coupling of experiments. This reviewer added that the project applied unique, high-fidelity simulation capabilities that complemented development of engineering



models and codes. The main focus was the detailed simulation and analysis of direct injection processes with an emphasis on ECN experiments with target sprays of n-Heptane and n-Dodecane. The work included liquid-injection at high-pressure conditions.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that progress had been made on computing n-Heptane at supercritical conditions.

Reviewer 2:

The reviewer highlighted that the three focus points had progressed well. The emphasis on modeling of ECN experiments was important, as it was for the HCCI engine project work presented by Dec, et al. The LES simulations matched fairly well with Pickett's optical spray experiments (which was a good validation), and the quantitative description of high-pressure interface dynamics was impressive. The reviewer added that the high-fidelity models required long computation time. It was desirable to see this method be used to validate some simpler engineering models the automotive industry uses.

Reviewer 3:

The reviewer confirmed that the work continued to make progress towards a better understanding of the high-pressure fuel injection process. The project distinguished between low- and high-pressure environments, and it was impressive to see the correlations of simulations with experimental data. The work comprised unique descriptions of the spray interface. The reviewer added that the work yielded predictive diagrams separating the classical atomization and spraying regime from the diffusion-dominated mixing regime, with overlaid classical diesel injection. This reviewer went on to say that there could have been a better effort to represent and further explain the conditions modeled. It will be important to at some point tie the improvements in understanding these physical regimes to the capability of predicting combustion processes and what advantages these bring to applied teams.

Reviewer 4:

The reviewer confirmed that very good progress was shown, adding that it would be good to understand the nearness to an engineering-level LES solution, the path to get there, and the measurements of progress along that path.

Reviewer 5:

The reviewer noted that the enhanced understanding of the fundamental changes occurring at the liquid/vapor interface with changes in pressure and temperature [Knudsen number (Kn) and mean free path] was an important contribution to the knowledge base of the injection/spray community. It was not clear to this reviewer how this was being transitioned into an engineering analysis of the sprays.

Reviewer 6:

The reviewer felt that there had been great progress in leveraging the ECN results, and added that it would have been nice to see a prediction of when this type of computing could be used by the OEMs to develop combustion systems. This reviewer asked if, given that a certain level of detail is required to accurately represent the spray, the simulation cost or time would ever be low enough for it to be used by OEMs to develop combustion systems.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the work with the ECN seemed to be strong, adding that building a connection between DOE Basic Energy Sciences (BES), EERE, and industry stakeholders appeared to be in place as well.

Reviewer 2:

The reviewer pointed out that the presenter was making good use of the data generated through the ECN. This reviewer asked if there were additional data that the presenter needed to move faster and/or to further improve his models.

Reviewer 3:

The reviewer acknowledged good representation from National Laboratories and universities. This person added that the input from engine OEMs could bring very valued input, particularly to corroborate the value added to the modeling capability.

Reviewer 4:

The reviewer observed that there were significant collaborations within DOE labs, ECN, and university partners. However, this reviewer mentioned that direct collaborations with industry partners seemed to be lacking.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer affirmed that the plans for the continuation of the research appeared to be very good.

Reviewer 2:

The reviewer emphasized that it was good to see GDI coming into the scope, as Lyle had done. This reviewer hoped to see more GDI detailed analyses (e.g., multiple GDI injections, shot-to-shot variability) next year from the PI. It would be good to see the PI influencing the types of tests run in the ECN to make sure the PI is getting the information the PI needs.

Reviewer 3:

According to this reviewer, the scope of work could be extended beyond LTC and HCCI to systems representative of current products that tend more towards hot-temperature combustion. This reviewer added that the work could also explore kinetics of SI, flame-front propagation, and stratification.

Reviewer 4:

This reviewer suggested that more gasoline sprays under GDI-like conditions should be calculated.

Reviewer 5:

This reviewer explained that continuation of the current three aspects was proper, but added that more emphasis on direct-injection-spark-ignited (DISI) injection would be timely and that more direct collaboration with industry partners would be desirable.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer claimed that the findings from this project would enhance understanding of fuel spray and guide the design of efficient combustion systems, which would in turn reduce fuel consumption.

Reviewer 2:

The reviewer indicated that the project aided in the predictive simulation of combustion in high-efficiency, advanced-combustion engines.

Reviewer 3:

The reviewer concluded that the project was relevant to developing the fundamental understanding of combustion, but noted the need to also be working toward an engineering LES solution if it is truly desired to impact the product being sold in the United States.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the PI made great use of a modest amount of funding (relative to other projects).

Reviewer 2:

The reviewer stated that the resources appeared to be sufficient. This person assumed that the investigators were getting the computational access they needed.

Free-Piston Engine: Terry Johnson (Sandia National Laboratories) - ace008

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer asked if the plan was reasonable or too aggressive. It appeared that a parallel long-stroke mechanical solution combined with the free-piston engine (FPE) would be a powerful approach (versus FPE only).

Reviewer 2:

The reviewer stated that, while one could question the wisdom of an opposed-piston project, the presenter had a methodical approach to the execution of the concept.

Reviewer 3:

The reviewer remarked that, while the unique approach did not guarantee that the efficiency results would be better, a different approach was the first step toward realizing a different result.

Reviewer 4:

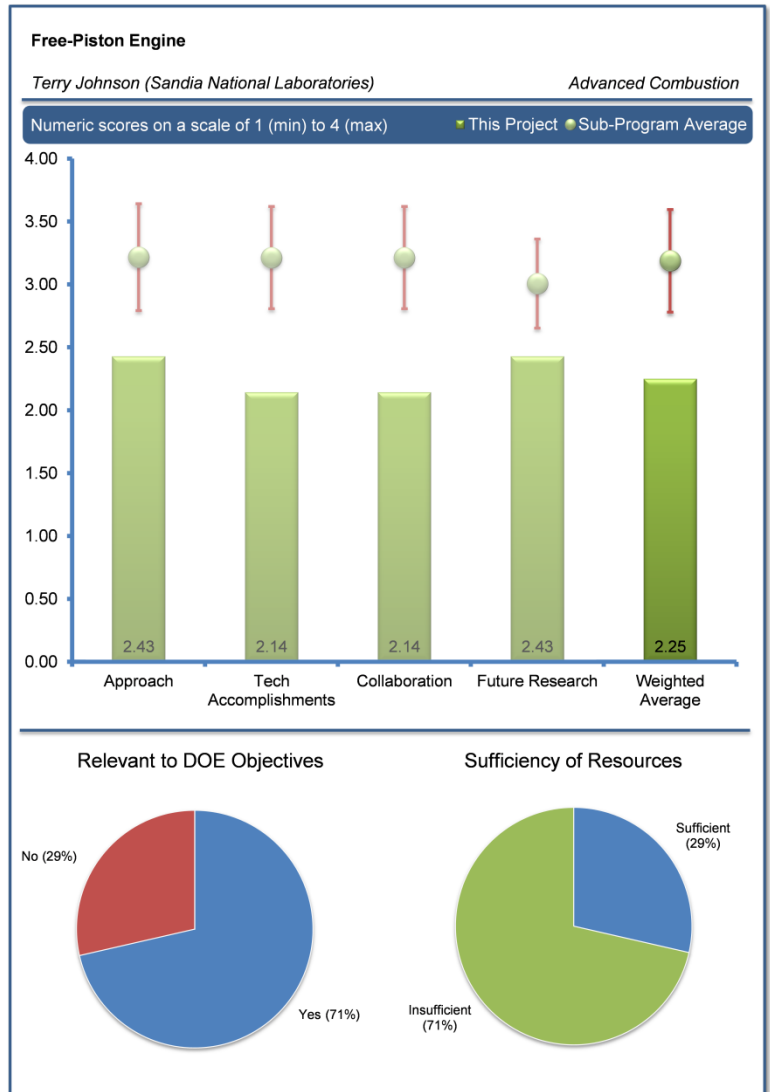
According to this reviewer, this project fell into the category of new engine concepts with the potential for improved efficiency and lower emissions. This reviewer added that, until this point, these characteristics have not been proven for this engine. The probability of success for such projects was likely to be low according to the reviewer, but it is important to investigate this with government funding. The lack of success in successfully proving the concepts in these types of projects is often not related or due to the approach taken.

Reviewer 5:

The reviewer commented that this project had made very slow progress throughout the last five years. The experiments were constrained and seemed to be transient-type versus steady-state experiments (e.g., the operating time was short and only one fuel was included [hydrogen]). The reviewer recognized that funding warranted only a part-time effort, but the limit on fuel type could be preventing further progress on this research project.

Reviewer 6:

Comments regarding the approach and scope of this project had been made over several years by this reviewer. The scope of this project has always been too large. As a result, progress toward goals has been less than satisfactory. Too many advanced features were combined altogether at once, which has clearly proven to be a huge challenge to make progress.



Reviewer 7:

The reviewer pointed out that this project was based on the concept that a very high compression ratio (20:1–40:1) was better for efficiency. The focus of the work had been to develop the engine, but the first step should be to verify the underlying hypothesis of the benefit of compression ratio. The reviewer asserted that this question should be answered before any more resources are put into anything else in this project.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed that it was good to finally see some firing results and looked forward to additional tests.

Reviewer 2:

This reviewer was glad to see combustion data from the project before it closed, and added that estimates of the overall efficiency (including what energy was required to operate the bounce chambers, etc.) would be a good addition.

Reviewer 3:

The reviewer said that, compared to the progress made over the last six years, the progress made last year was commendable. Challenges to motoring the engine had been identified and were being fixed so motoring times could be extended. Also, some of the first useful firing tests had been conducted.

Reviewer 4:

The reviewer mentioned that there was significant progress on many subsystems, but added that it was not clear how much remained (in the high-level plan).

Reviewer 5:

The reviewer emphasized that, based on the projected 2012 Merit Review Future Work, the main effort of this year was to be on combustion studies. However, the reviewer indicated that only a few of these experiments had been conducted. The reviewer eagerly awaited additional experiments to determine if the efficiency made this approach worth pursuing.

Reviewer 6:

The reviewer explained that the rate of progress had historically been very slow. Even over the previous year, much of the work had focused on modifying the engine and setup in an attempt to reduce friction losses and improve the amount of time that the engine could be run before the motion was damped out (current run time was about 10-13 seconds, which seemed very short). The reviewer described that at the present time, the next step was to evaluate the success of a new piston design to significantly reduce friction losses so as to increase engine efficiency. The reviewer indicated that the slow progress was likely not due to poor performance of the PI, but rather the technical challenges of getting the FPE concept to work.

Reviewer 7:

The reviewer noted that one big accomplishment was having a running engine (although its operational capability was limited at this time), and appreciated that just ensuring the gas bounce system would work satisfactorily was an accomplishment in and of itself. Nevertheless, there was hope that more experimental work would have been completed by this time. The few experiments running very lean hydrogen were barely scratching the surface about what might be possible with this type of combustion system arrangement.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that the University of Michigan (UM) and GM had been added as collaborators. This person suggested OEM industry input on design details, especially on candidate piston and ring details.

Reviewer 2:

The reviewer reported that this project appeared to have included collaboration with UM in the overall modeling of the engine flows, but noted that the collaboration with GM was not clear.

Reviewer 3:

The reviewer concluded that the degree of collaboration seemed to be limited to Los Alamos National Laboratory (LANL) and GM/UM. It had been mentioned that the latter was set up in 2009 to help with modeling work in MATLAB/Simulink. It was unclear to the reviewer how effective that collaboration had been. This reviewer added that perhaps the modeling work could not be effective until a good quantity of experimental data was obtained.

Reviewer 4:

The reviewer confirmed that some collaboration existed. In retrospect, this person added that experts in the area of FPEs, hydrogen (H₂) combustion, and linear alternators (admittedly rare) should have been sought out early in the project.

Reviewer 5:

The reviewer voiced that there appeared to be a little collaboration with GM and UM, but it appeared to be minimal and it was not clear how it fit into the overall project.

Reviewer 6:

The reviewer stated that there was minimal collaboration.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer felt that it would be good to fully characterize the performance of the engine given the investment to build it.

Reviewer 2:

The reviewer remarked that a combustion study (to answer the question about the premise of the study) should be the priority for the next year followed by a decision on whether to continue the project.

Reviewer 3:

The reviewer asked that the PI please mention the money needed for the various stages.

Reviewer 4:

The reviewer acknowledged that a lot of work remained if the project was to be completed in mid-2013.

Reviewer 5:

The reviewer commented that two key issues still had to be addressed: the ability to run the engine for more than 10 seconds before motion was damped out, and the reduction in friction losses to increase the engine efficiency. The latter issue depended on whether the new piston design successfully reduced friction losses. The reviewer asserted that if those two issues could not be addressed, the other proposed plans were not particularly relevant.

Reviewer 6:

The reviewer said that the proposed research plan was too vague, adding that little experimental progress had been made to date and that any future work needed a closer focus studying the combustion process with specific fuels and boundary conditions.

Reviewer 7:

The reviewer expressed that, in the time remaining, work should largely be focused on understanding efficiency potential and not on understanding any emissions characteristics. Work should focus on firing the engine repeatedly enough to be confident about the data

so that efficiency estimates can be robustly made. This reviewer added that the project should be terminated this year and not continued unless totally rescoped.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer affirmed that this was actually a very relevant project, because it had very stretch goals for efficiency gains while using a very unique concept. This person added that this was just the kind of high-risk/high-reward work that a National Laboratory should be doing.

Reviewer 2:

The reviewer explained that if this concept were to be successful and an FPE having high thermal efficiencies could be commercialized, then the quantitative demand for fuel would be reduced. Also, this person added, the fuel could potentially be non-petroleum based.

Reviewer 3:

The reviewer suggested rescoping the project to include a mechanical approach to help accelerate the combustion portion of the project (thereby determining efficiency).

Reviewer 4:

The reviewer warned that the likelihood that this project would be successful in ultimately lowering petroleum consumption was low. This project provided a new engine architecture that takes advantage of hydrogen and HCCI. The reviewer indicated that there is a risk that both of these approaches might not succeed, and further that the new engine architecture would fail to be adopted.

Reviewer 5:

According to this reviewer, the experimental results showed that the concept engine had little chance of making progress towards meeting the DOE objectives focused on high efficiency engines. The reviewer explained that there were significant challenges in the alternator portion of the engine and in the potential ISFC capabilities of the engine using automotive-relevant fuels such as gasoline or diesel fuel (work to date has focused on lean-burn hydrogen).

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer acknowledged that the project needed minimal additional funding to complete testing and characterize the performance of the engine.

Reviewer 2:

The reviewer pointed out that there had been only \$100,000 in funding in 2013. While this was certainly not sufficient, progress had been quite slow even in prior years with larger funding. This reviewer added that it was not clear where this project was headed, and that the PI had mentioned that Stage 3's financial need would be about \$200,000.

Reviewer 3:

The reviewer said that the project should be funded just enough to focus on getting robust firing-efficiency numbers.

Reviewer 4:

The reviewer noted that the presenter had indicated that the funds allocated to the project in 2013 were insufficient for the proposed plans (especially Stage 3, which included broader emissions analysis). Specifically, the presenter estimated that an additional \$150,000 to \$200,000 would be needed. However, this reviewer added that given the state of the project, it was hard to justify the allocation of those additional funds.

Reviewer 5:

The reviewer expressed that it was apparent that the lower funding level had slowed down progress, but added that this project had very high risk, such that reduced or nil funding would be adequate in this case.

Fuel Injection and Spray Research Using X-Ray Diagnostics: Christopher Powell (Argonne National Laboratory) - ace010

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the project had well-considered the use of X-rays in an appropriate application area.

Reviewer 2:

According to this reviewer, the use of X-rays to elucidate the fundamental spray structure and characteristics in the near-nozzle region was proving to be a very good approach.

Reviewer 3:

The reviewer felt that the development of a technique to measure cavitating flows would provide key information that were previously unknown. Citing the unique capability at Argonne National Laboratory (ANL), this reviewer added that it was important to continue active involvement in the ECN.

Reviewer 4:

The reviewer remarked that the PI and his predecessor had done a great job during the past decade to bring X-ray spray measurement from concept to reality. This reviewer added that the combination of modeling support and experimental evaluation of various nozzles had been very helpful throughout the years. The one area of weakness this person noted was the limited operating temperature for taking spray measurements, which made any evaporation effects difficult to assess.

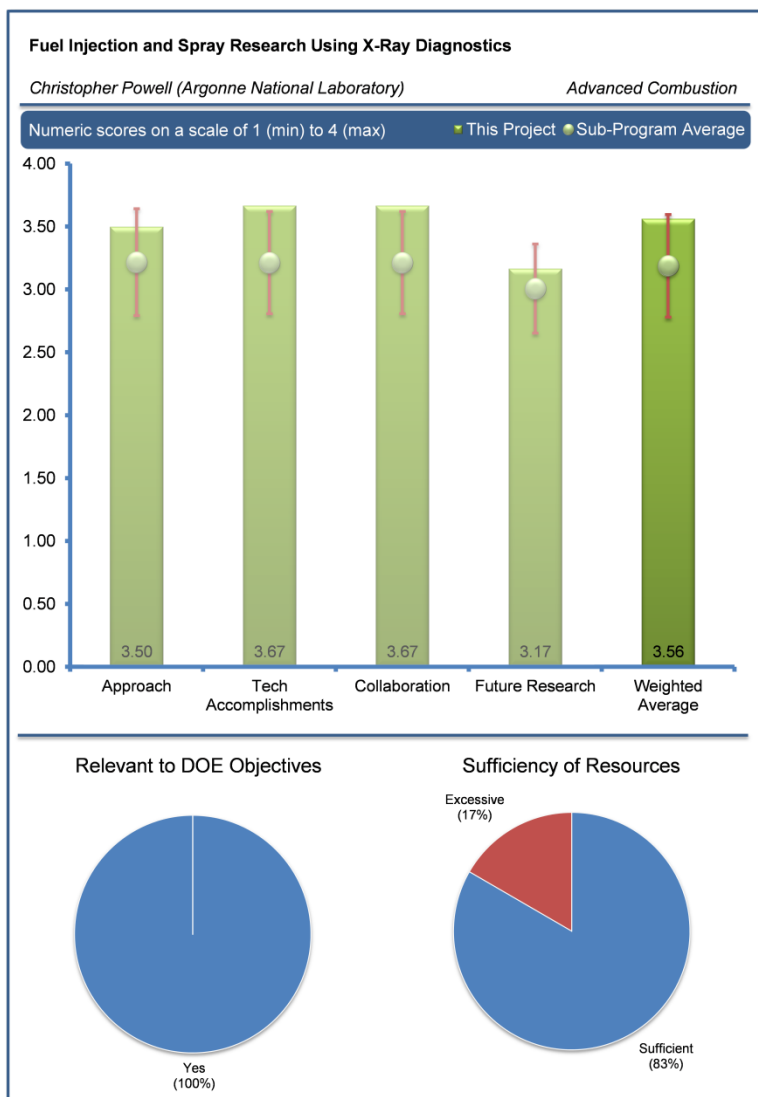
Reviewer 5:

The reviewer acknowledged that the X-ray absorption technique, while capable of providing very useful information for certain types of problems, had the limitation of being limited to room-temperature conditions and only producing ensemble-average data.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that there had been great progress developing the technique for measuring cavitation, in both plastic tubes and injectors.



Reviewer 2:

The reviewer pointed out that there looked to be good progress in using the X-rays to view fuel flow near the nozzle. The project had seen the formation of bubbles near the nozzle, which are entrained back into the nozzle when closed and contribute to cavitation.

Reviewer 3:

The reviewer observed that new data on cavitation had been produced that will help understand the phenomena. The reviewer explained that different nozzle entrance effects had been studied, and droplet size data for gasoline sprays had been obtained.

Reviewer 4:

The reviewer said that it was good to see a better understanding of injector control and noise factors that influence spray. This person was looking forward to seeing how these factors influenced (or did not influence) spray and, ultimately, combustion.

Reviewer 5:

The reviewer mentioned the experimental cavitation results.

Reviewer 6:

The reviewer asserted that the recent work on cavitation was quite interesting and would be helpful for fuel suppliers in addressing methods for either minimizing the cavitation in a nozzle or exploring design changes to ensure that nozzles can withstand such conditions in future advanced designs. This person added that this tool would be very helpful for both fuel injector suppliers and engine companies in exploring spray formation phenomena, including cavitation in the combustion system designs. This reviewer concluded that the one downside of this technique was the temperature limit, which did not sufficiently include real-world evaporation effects.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer expressed that there looked to be a good number of collaborations with industry partners (including Delphi D, Infineum, and Chrysler) as well as the National Laboratories and universities (including via the ECN).

Reviewer 2:

The reviewer affirmed that it was good to see that various OEMs and suppliers were using this resource to better understand their products.

Reviewer 3:

The reviewer listed ECN and Chrysler.

Reviewer 4:

The reviewer reported that the project was leveraging simulations at ANL and the University of Massachusetts–Amherst to understand cavitating flows and suggest experimental improvements. This reviewer added that engagement with fuel-system suppliers would be useful.

Reviewer 5:

The reviewer reinforced that the existing collaborations were good, but encouraged more collaborations with the industry fuel-injector suppliers.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer highlighted that the plan to address the temperature and pressure limitations would be a good step. This reviewer looked forward to the results of future application of cavitation diagnostics and continued involvement with the ECN.

Reviewer 2:

The reviewer summarized that the proposal to continue work on near-nozzle sprays with X-rays with various nozzles seemed reasonable.

Reviewer 3:

The reviewer confirmed that, generally speaking, the approach was logical and would yield further insight concerning two-phase flow in nozzles. This person added that it would be helpful if the PI could explore the possibility of increasing the chamber temperature to levels closer to reality in DI engines.

Reviewer 4:

The reviewer voiced that the move to diamond windows should be accelerated so that high-temperature measurements could be made. This reviewer asked whether something could be done to improve the X-ray flux to enable single-cycle imaging rather than ensemble-average.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that an improved understanding of the fundamentals of fuel injection and sprays, along with improved models, should lead to better designs and better engine efficiency. This in turn would lead to lower emissions and petroleum use.

Reviewer 2:

The reviewer noted that the trend toward high K-factor nozzles with lower cavitation indicated the importance of this phenomenon. This reviewer added that the importance was likely to increase with higher injection pressure.

Reviewer 3:

This reviewer remarked that the project provided fundamental data for understanding sprays and injector behavior.

Reviewer 4:

The reviewer acknowledged that this project provided others with a tool to explore various combustion modes through an improved understanding of intra-injector and near-injector nozzle outlet spray formation.

Reviewer 5:

The reviewer commented that cavitation diagnostics were more useful at very high pressures.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the budget was very large for this project. This reviewer was not sure if the funding was excessive or not.

Use of Low Cetane Fuel to Enable Low Temperature Combustion: Steve Ciatti (Argonne National Laboratory) - ace011

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer pointed out that there was excellent practical work with a clear focus and goals.

Reviewer 2:

The reviewer observed that the project was a good study of the potential for pushing up LTC operation to high loads using gasoline-like fuels.

Reviewer 3:

The reviewer mentioned that the approach taken was based on experimental work with the support of simulation, both from CFD (for in-cylinder operations) and Autonomie (for real-world impacts). Further, the presenter mentioned the supporting role of Argonne's Advanced Photon Source (APS) facility for injector performance characterization, as well as its rapid compression machine (RCM) for examination of ignition parameters. The latter two, however, had not yet been introduced to the project (the RCM may be part of another project). This reviewer additionally noted that the studies focused on gasoline-like fuels, combustion controls of ignition, and high power density. The low-octane and high-volatility fuels provided an increased ignition delay.

Reviewer 4:

The reviewer noted that this project addressed two of the three technical barriers directly (namely, the mechanism to control LTC timing and LTC high-load/high-speed operation). However, this person added that the approaches taken thus far had yet to show that true LTC had been achieved.

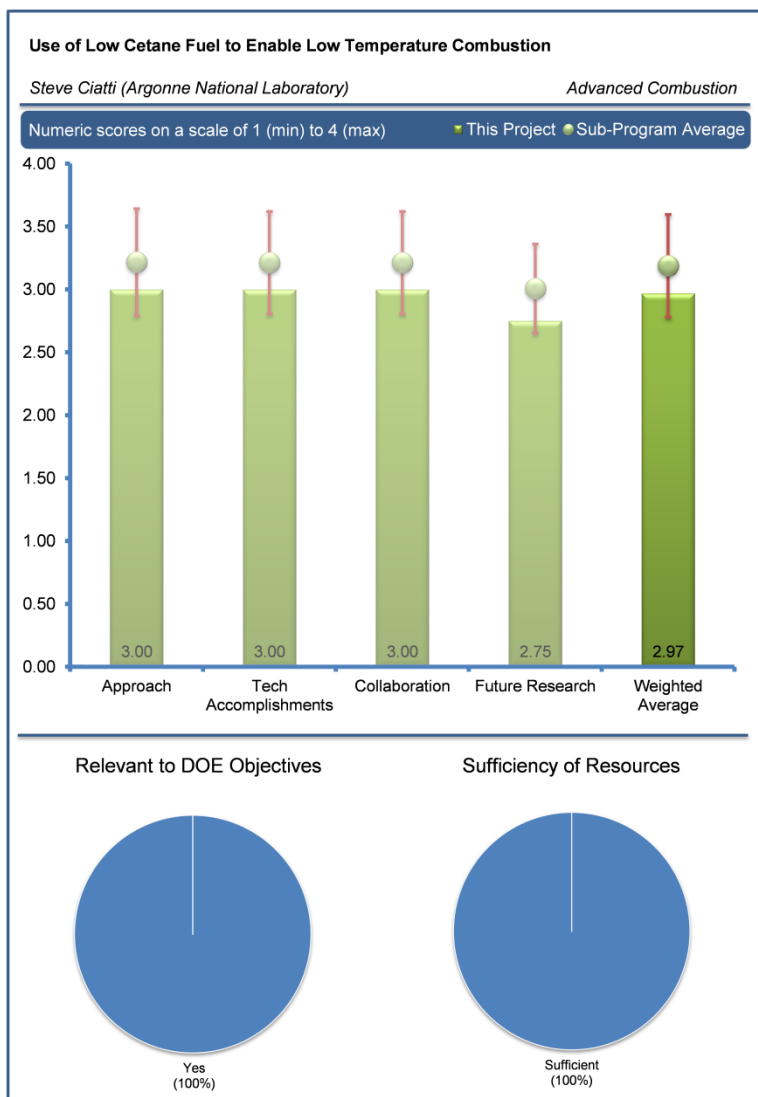
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer applauded the project's impressive progress toward low-load operation and low-emissions/high-efficiency operation.

Reviewer 2:

The reviewer emphasized that there was good progress demonstrating operation across the load range (going down to 1.5 bar brake mean effective pressure [BMEP]). This reviewer added that favorable fuel consumption compared to gasoline was good, but asked how this compared with a diesel engine (which was likely to be closer to the cost of this type of engine).



Reviewer 3:

According to this reviewer, the accomplished results were quite impressive, especially the power density (approximately 20 bar) and combustion stability (with a center of variation of IMEP less than 3%). However, this reviewer added that the NO_x level was still too high, which indicated that true LTC had not been achieved.

Reviewer 4:

The reviewer indicated that the work presented was a good step forward from last year's presentation. The project spanned a wide range of fuels at various operating conditions, and the load range that was run was very impressive. This reviewer added that it was not clear that the Autonomie selection of points was relevant at the present stage. It was disconcerting to the reviewer that the presentation provided fuel economy performance benchmarks with respect to the baseline hardware. The comparison should have been done at a much deeper level, taking into account the emissions levels, exhaust temperatures, exhaust makeup, and impact on aftertreatment. Other constraining factors would be important, such as pressure rise rate limits and coefficient of variation, and a consideration of steady state points was not sufficient for this type of engine. This reviewer went on to say that data of brake specific fuel consumption (BSFC) versus brake specific NO_x (BSNO_x) at fixed load would have better represented the trends, rather than overlying all the data at once across the load range. This reviewer asked what the expectation was from the KIVA work. The CFD work lacked direction and appeared as an afterthought to the experimental work. This tool should have been used to explore conditions beyond the experiments and provided useful direction to the project. The reviewer mentioned that the presentation emphasized the variation across cylinders as a major issue and that the tool should not be used in this context, but rather as directionally showing how the combustion system might be exercised for increased efficiency.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer reported that there were good collaborations with other institutions, and that the modeling collaboration with UW showed good synergy. This reviewer added that coordination with other DOE labs that have a similar LTC engine test program would be desirable (as indicated in the future work).

Reviewer 2:

The reviewer summarized that the work overlapped many other efforts currently taking place in industry and academia. The uniqueness of the work was running a multi-cylinder engine demonstrator. This person added that it might be good to frame the present work with the available reference data to illustrate the new ground gained from working with low octane number fuels.

Reviewer 3:

The reviewer noted that the project was working with UW for simulations, but that it was not clear how the modeling was being leveraged to further the goals of the project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer felt that the planned future work covered all the areas, but added that the major focus should have been to demonstrate that low BSFC/BSNO_x was achievable with the proposed operating strategy. If not, then the transient study ought not to be performed.

Reviewer 2:

The reviewer remarked that it would have been useful to have identified all the issues that must be solved to provide a viable vehicle engine along with the work needed to address each.

Reviewer 3:

According to this reviewer, the project should continue to push toward low load and define what was needed to enable idle operation. Low emissions were critical to providing a cost benefit to this approach relative to diesel. The reviewer added that it was good to connect the work with John Dec's fundamental work. The noise (90-95 decibel [dB]) was high for LD. This reviewer further stated to explore LD as well as the tradeoff between efficiency and noise, trying to match the noise of the base diesel engine.

Reviewer 4:

The reviewer pointed out that last year's presentation had indicated the use of an endoscope, but this had not been carried out. The RCM work was also noted, but nothing had been reported. This reviewer added that caution must be taken to avoid this type of planning. It would be important to verify the feasibility to expand the low load limit with 93 Research Octane Number (RON) fuel. It would also be good to prove-out the feasibility and robustness of transients.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer observed that the work was clearly aimed at fuel savings for light-duty engines.

Reviewer 2:

The reviewer mentioned that low-cetane fuel could be one of the enablers for HCCI engines, which could reduce fuel consumption. Thus, this project supported the DOE objectives of using less petroleum.

Reviewer 3:

The reviewer explained that the project was working on improving efficiency with gasoline-like fuels running high-load LTC.

Reviewer 4:

The reviewer agreed that this project was relevant to the impact of fuel composition on future engine architectures and efficiency targets.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines: Dan Flowers (Lawrence Livermore National Laboratory) - ace012

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the project objectives were very well-aligned to the needs of the industry to thereby impact engine design.

Reviewer 2:

The reviewer reported that the approach taken to develop faster, more efficient computational combustion tools appeared to be reaping sizable benefits. This reviewer indicated not being an expert in this area and thus was unable to fully judge whether the approach and tools being used were the very best possible (i.e., outstanding, outstanding) or not.

Reviewer 3:

The reviewer summarized that the approach was to make CFD simulations of advanced combustion concepts available to the desktop computer. The approach was to validate new multi-zone schemes and advanced graphics-processing-unit (GPU) solvers, and incorporate enhanced features into commercial codes.

Reviewer 4:

The reviewer recommended investigating the sensitivity to various combustion system variables.

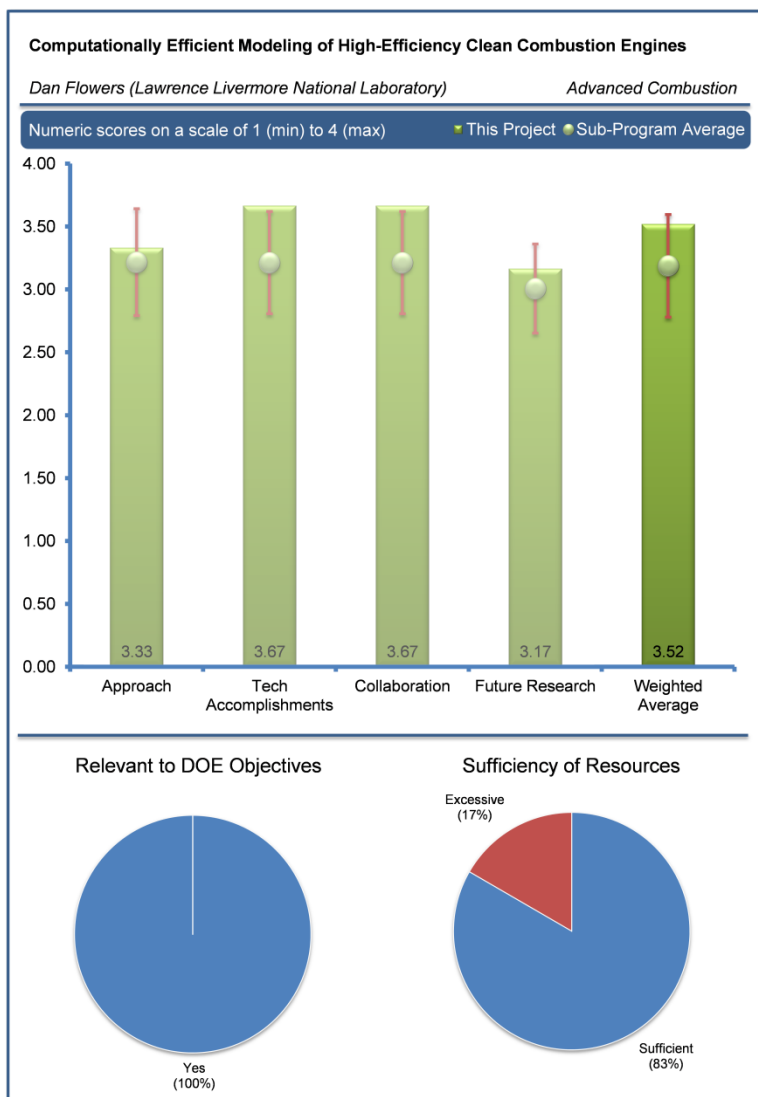
Reviewer 5:

The reviewer voiced that this ongoing project had demonstrated good progress in improving computational efficiency and time throughout the years, adding that this approach had included exploration in multi-zone modeling, techniques for performing chemistry calculations, and methods for speeding up processing time. The missing ingredient, according to the reviewer, is a lack of validation for engine operating conditions. The reviewer added that showing good results at one operating condition was not adequate.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted lots of significant progress in a number of areas, including: validation of a new multi-zone scheme demonstration of a CFD multi-zone model for GDI SI and premixed charge compression ignition (PCCI) operation; a reduction by a factor of 25 in



the chemistry computational time for multi-zone engine simulation with the latest LLNL solver; and the licensing of simulators to various companies.

Reviewer 2:

The reviewer acknowledged an amazing improvement in simulation runtime.

Reviewer 3:

The reviewer commented that the non-premixed reactor validation work was well-considered.

Reviewer 4:

The reviewer observed that the multi-zone scheme was working well and that orders-of-magnitude reductions in simulation runtime had been achieved with the advanced GPU-solvers. The new enhancements had been validated for a PCCI test case. This reviewer added that it seemed like progress on applying the models to real-world problems and the evaluation of models could be faster. This project had been ongoing for several years.

Reviewer 5:

The reviewer mentioned that there had been very good progress throughout the years improving computational efficiency and reducing simulation runtime, but the validation for engine use was really lacking within this project. It would have been very helpful to broadly compare predictions with numerous operating conditions, including single and multiple injections, varying intake conditions, and various nozzle sizes.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer asserted that there appeared to be lots of interactions with OEMs (including Cummins, Ford, Volvo, Bosch, Delphi, and General Electric Turbines), National Laboratories (SNL and ORNL), and universities (University of California–Berkeley, UW, and UM). It looked like the project team was serious about getting their simulation models/tools in the hands of end-users.

Reviewer 2:

The reviewer expressed that the collaborations with academia and industrial partners was great and helped advance the analysis tools.

Reviewer 3:

The reviewer affirmed that this project had supported many researchers throughout the country. The best collaborations had led to improved CFD codes and the use of specific solvers/models for internal use by different industry partners.

Reviewer 4:

The reviewer explained that several relevant collaborations existed with commercial code suppliers, industry, other labs, and academia.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that there were excellent plans proposed to continue the work and to make further improvements to reducing the computational time for conventional-diesel and advanced combustion.

Reviewer 2:

The reviewer reported that parallel CFD with chemistry with a very large number of reactions was planned, and that multiple-operating-point simulations were also planned.

Reviewer 3:

The reviewer noted the diesel fuel model includes nine species.

Reviewer 4:

The reviewer summarized that the proposed approach was fair, but really needed to focus on much more detailed validation.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer confirmed that improving the accuracy and reducing the computational time of engine simulations should lead to the design of engines with improved efficiency and lower emissions; this was in alignment with DOE goals.

Reviewer 2:

The reviewer voiced that improved engine simulation tools would help the industry design engines with improved efficiency for the marketplace.

Reviewer 3:

The reviewer stated that this was another project that provided others with tools for pursuing combustion system approaches that address DOE objectives.

Reviewer 4:

The reviewer noted that the project aimed to make high-fidelity CFD available to engine designers by reducing simulation time without sacrificing accuracy.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer reported that the funding was very high for a software-focused effort, and this person was not sure where all the money was being spent.

Chemical Kinetic Models for Advanced Engine Combustion: Bill Pitz (Lawrence Livermore National Laboratory) - ace013

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the scope was very clearly laid out in four steps, covering detailed mechanisms for diesel and gasoline components, and two-component mechanisms for diesel engine simulation tools. The reviewer thought the approach was comprehensive, transitioning between detailed individual components, combined mechanisms, and reduced mechanisms (for more practical use).

Reviewer 2:

The reviewer acknowledged that the approach was sound, and the end deliverable of reduced and accurate mechanisms for use in engine design would enable new, more efficient engines.

Reviewer 3:

The reviewer felt that the project's approach was well-considered, especially the validation process. This person added that it might be time consuming, but it was well worth doing it right. The chemical kinetic models established from this research would be very valuable to the research community as well as the industry.

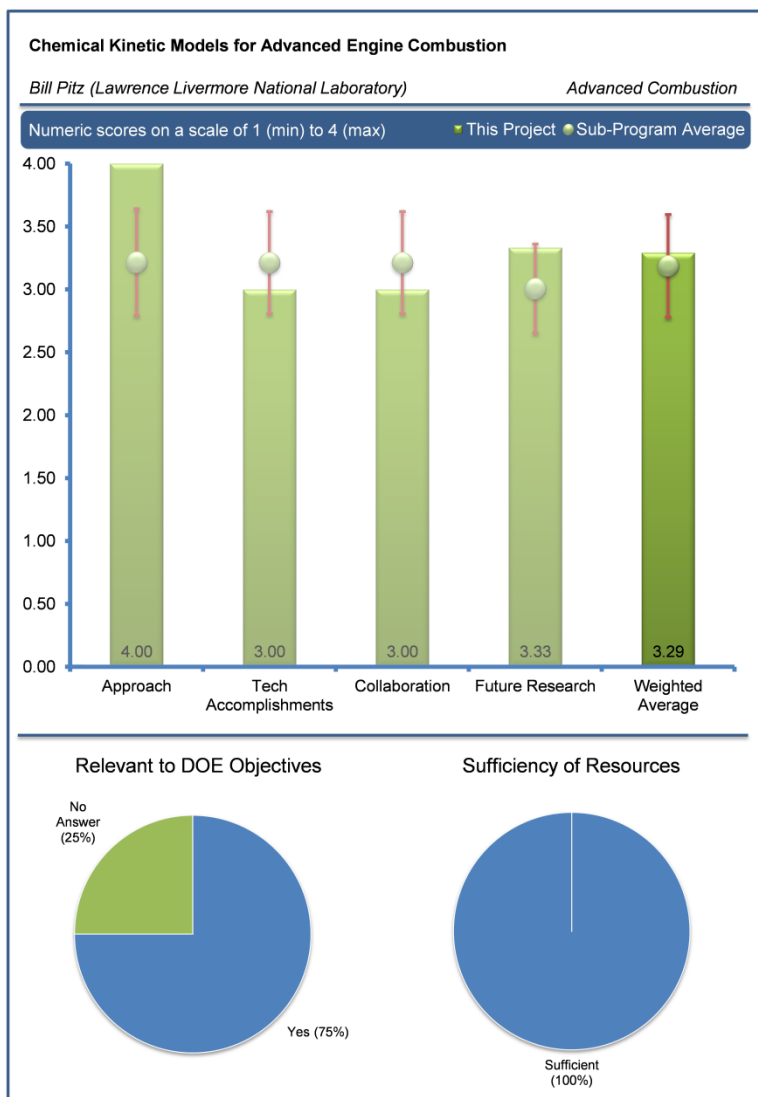
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer pointed out that there was an excellent agreement between the bench tests and modeled results. This reviewer was looking forward to the gasoline/EGR validation that had been mentioned as proposed work in the project's 2012 presentation. Unfortunately, this reviewer did not see it in the 2013 presentation but hoped that it would be there in 2014.

Reviewer 2:

The reviewer observed that the presentation outlined four objectives clearly and that the numerical work was accompanied by experimental results. Objective 1 on the diesel side covered N-propyl and N-butyl benzenes in ranges covering shot-tube and RCM experiments. There was a good spread of pressure ranges between one and 50 atmospheres at an equivalence ratio (EQR) of 1.0 and 2.0. Objective 1 showed flame speeds for alkyl benzene and intermediate species for alpha-methylnaphthalene. Objective 2 revealed the maturity of the gasoline surrogate from LLNL and expanded this to gasoline-ethanol mixtures. Models were to be exported for comparison with single cylinder test engine (SCTE) data. Flame speeds were benchmarked with experimental data. Objective 3



considered large alkyl-cyclohexanes. The updated methlcyclohexane (MCH) mechanisms satisfied experimental species profiles in low-pressure flame experiments. Finally, Objective 4 outlined the reduction effort for the two-component diesel surrogate made out of m-xylene and n-dodecane. This reviewer would have liked the authors to have provided a picture, specifically arising from Objective 4, regarding the effectiveness of the work in the real applications. This might come from collaborations with academic or industrial partners.

Reviewer 3:

The reviewer commented that the objectives set out for the FY were mostly accomplished. The models were validated with results from experiments by other researchers on a fundamental level. Most comparisons yielded excellent results, except some cases with MCH, which deserved some further review. This reviewer added that it would be interesting to see the models perform in the actual engine modeling.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer affirmed an excellent lineup of resources, encompassing experienced numerical and experimental teams.

Reviewer 2:

The reviewer expressed that the collaboration and coordination with other institutions were well-handled.

Reviewer 3:

The reviewer affirmed good collaboration with other researchers. This person added that it would have been interesting to see a more tangible link to the industry, either by demonstrated use of the presenter's work or incorporation into commercial tools.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the authors had set up an aggressive schedule to transition to a nine-component palette for diesel as well as the development of models for five Fuels for Advanced Combustion Engines (FACE) gasoline fuels. This reviewer looked forward to the results of these efforts.

Reviewer 2:

The reviewer agreed that the plan to finish modeling the rest of the three components was proper. This person added that the remainder of the two action items was also valuable.

Reviewer 3:

As for most other projects, this reviewer would like to see more work on gasoline. This reviewer asked about the long-term roadmap for the further development of gasoline surrogates, and whether the models had been fully validated over a range of equivalence ratios and EGR concentrations. This person went on to say that it was also not clear how the work was prioritized (e.g., which molecule was next, and why).

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that the development of kinetic mechanisms was essential to modeling advanced efficient combustion engines, which would in turn lead to reductions in fuel consumption.

Reviewer 2:

This reviewer summarized that the work was very relevant and that fuel surrogate models for gasoline and diesel fuels enabled accurate engine simulations with fuel effects.

Reviewer 3:

The reviewer confirmed that simulation of advanced combustion concepts would not be possible without this type of work.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer concluded that it was not clear how more funding, if it were available, would serve to expedite or expand this work.

2012 KIVA-Development: David Carrington (Los Alamos National Laboratory) - ace014

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the project was developing robust, accurate algorithms, and added that modular object-oriented code was a sound approach. Many aggressive goals were set. This reviewer went on to say that improving the KIVA's accuracy was very important for all of the users in the industry. The large number of KIVA licensees showed the general acceptance by the engine community.

Reviewer 2:

The reviewer confirmed that the work being done appeared to be addressing some of the shortcomings of the prior version of KIVA.

Reviewer 3:

The reviewer stated that the author emphasized the robustness and accuracy of simulation, based on a development process that emphasized physical modeling as well as validation and verification. The key was to provide modular object-oriented code. This reviewer added that the practical software improvements included a long list of wants, including faster grid generation, higher-order accuracy, and better turbulent modeling (Eulerian versus k-e). This reviewer noted that the author contended that this could be done with a new discretization and algorithms. The presentation seemed to lack depth on the verification side, especially in terms of real-world problems.

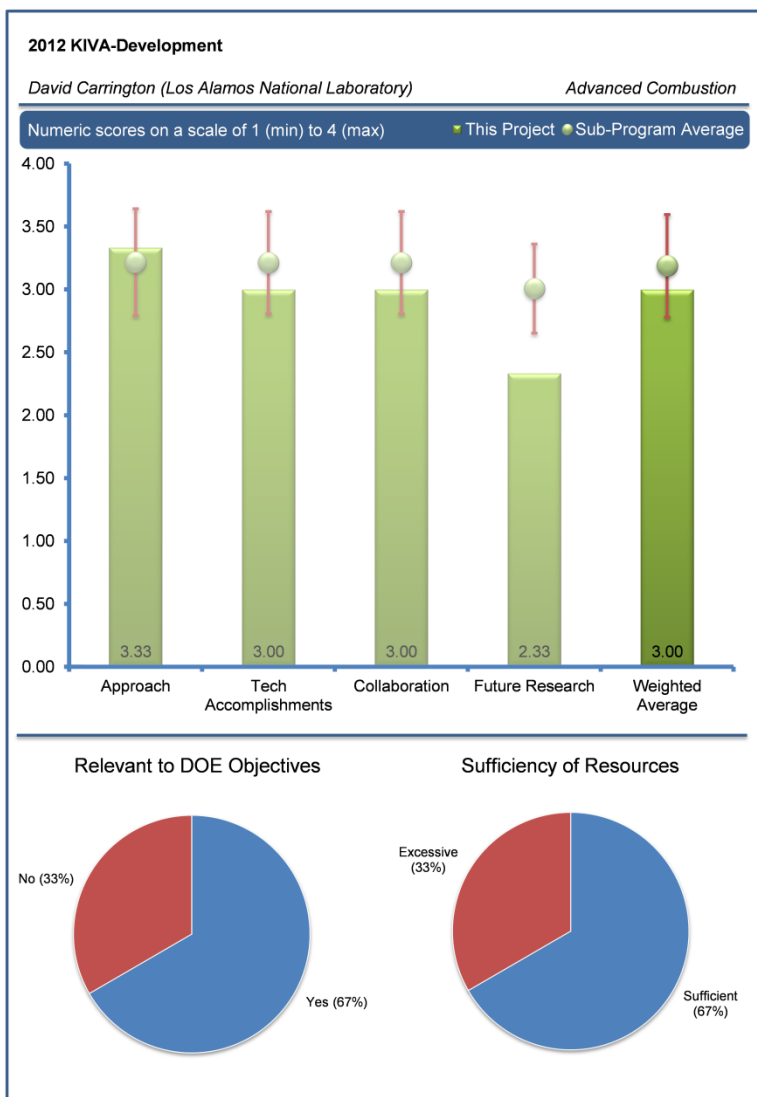
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the project went well against the objective and research plan. It was mostly going in the right direction, and there were good efforts in piece-by-piece validation. This reviewer went on to say that some of tests were just beginning, and that it would be interesting to see how the new KIVA would be proven to be more accurate in applications by the research community and industry.

Reviewer 2:

According to this reviewer, the author covered a wide range of material, focusing on numerical methods (finite element methods) and modeling approaches (e.g., k-omega and k-epsilon). This reviewer added that this was applied to airfoil geometries in subsonic flow regimes, boundary layer separation, and shock wave detachment. The present effort would have been more appreciated by this



reviewer if the work presented here were incorporated into the simulation of an internal combustion engine where the present KIVA was being used to see the benefits of both modeling and numerical techniques. If this was already happening, the reviewer asked when it would take place and whether any issues were foreseen on valve pockets, recessed seat geometries, and so forth. This person also asked how the present effort compared with the work being carried out in other institutions, one example of which was the work being done by SNL and Convergent Science.

Reviewer 3:

The reviewer remarked that accomplishments were shown, but it was not clear how significant they were. This reviewer wanted to know whether the progress was ahead of or behind schedule.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the collaboration and coordination with other institutions were excellent, with contractors contributing 40% of the funding for this study and a significant number of KIVA licensees.

Reviewer 2:

The reviewer asked if this project would benefit from a broader partnership, particularly in the area of verification in industrial-like problems. This person further inquired about how this work related to that of SNL with Convergent, whether the effort should be plugged in with SNL, and how KIVA compared with Convergent over the short and long term.

Reviewer 3:

The reviewer pointed out that the collaboration appeared to be limited to three universities and LANL. This was surprising to this reviewer, who expected to see more universities involved given that KIVA was said to have many users and that its open source enabled researchers to make code improvements.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed that the tasks planned for this project were quite aggressive. Since a modular approach was taken, prioritizing the tasks was necessary.

Reviewer 2:

The reviewer said that the work proposed was piecemeal but was scheduled to roll out to the public in a year or so.

Reviewer 3:

The reviewer criticized that it was not clear what tasks remained and when this activity would be done. This person would have liked to see a clear (and independent) comparison of the features and capabilities in KIVA and how they compared to commercial codes available today.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer asserted that KIVA was widely used in the auto industry for developing new high-efficiency engines that would reduce fuel consumption.

Reviewer 2:

The reviewer expressed that it was important to upgrade a long-standing tool used in combustion development.

Reviewer 3:

This reviewer questioned the relevance of KIVA the more time went on. Because this person had to pick between yes and no, this reviewer picked no to make a point. This reviewer asked how many true users there were. This should be tracked annually, and not as a flat list of licensees since the beginning of this work. If the list of users were significant, this reviewer would change the relevance rating to yes. Given the fact that other researchers were partnering with commercial code providers, this reviewer asked if there was a similar opportunity here, and whether any of the commercial code providers would be willing to grant free licenses to universities and open up their system to enable code enhancements. This reviewer further asked whether DOE had approached them, as this would be a more direct, quicker way to get the code improvements into the hands of the OEMs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes: Stuart Daw (Oak Ridge National Laboratory) - ace015

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

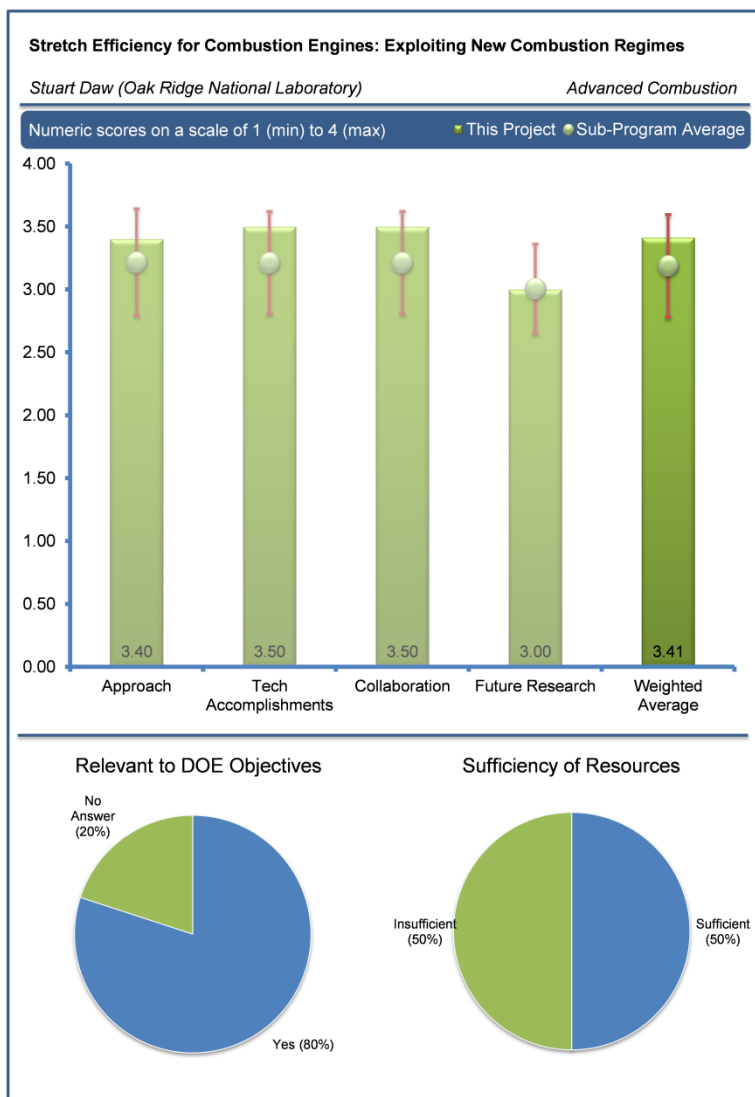
The reviewer noted that the project pursued thermodynamic strategies and technologies that could provide an increase in efficiency that would be revolutionary rather than evolutionary. The project focused on high-risk, high-reward technologies that could have a real-world impact over a longer-term timeframe. Thermochemical recuperation was the lead technology pursued. It is an attractive path to exhaust heat recovery (using one conversion device), where reforming may increase the lower heating value and exergy of fuel through endothermic reactions, driven by exhaust heat. This was evaluated via two pathways. The first was in-cylinder non-catalytic, for which the authors were considering the feasibility of the in-cylinder process via a six-cycle process. The second was catalytic reforming in an EGR loop. The reviewer indicated that here, the authors were identifying catalysts with sufficient activity and durability for future engine experiments and were building on work previously carried out at the Gas Technology Institute (GTI).

Reviewer 2:

The reviewer stated that this was exactly the type of project that the DOE should be supporting, as it had a high risk of failure but also a potentially high reward if successful.

Reviewer 3:

The reviewer remarked that this project was a result of previous years' brainstorming sessions on aggressive, high-risk strategies to noticeably improve LD engine thermal efficiency. This was an exploratory research project and there were many unanswered questions concerning whether reforming in some manner could dramatically impact thermal efficiency. This research will evolve as the research team learns on a day-to-day basis. There were many unknowns with this project and thus the direction will evolve with time.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer acknowledged very interesting results regarding speciation of NVO products.

Reviewer 2:

The reviewer commented that most of the work focused on the first path (non-catalytic). The authors provided an organized report based on the experimental investigation of in-cylinder thermochemical recuperation with iso-octane, methanol, ethanol, iso-butanol, and hydrous ethanol, across various NVO durations and timings. The work was dependent on NVO settings, injection timing and oxygen (O₂) concentration, and fuel type. This was well-documented in the work published here. The reviewer added that H₂ and co-trends were shown for the fuels tested, which, when combined with fuel timing, were the main drivers. The conversion of fuel carbon to CO and shorter-chain hydrocarbons was recorded and did not compare well with the kinetic mechanisms used in the modeling exercises. The H₂ production was predicted more accurately by a temperature integral method. The reviewer explained that the authors needed further work to confirm if thermochemical recuperation was feasible, that is, that the fuel energy that resulted was greater than the input fuel energy. This reviewer also noted that work along the second path (catalytic) encompassed comparisons between fresh and used catalysts. Here, sulfur appeared to be the likely cause of the shift recorded in the experiments.

Reviewer 3:

The reviewer pointed out that much effort had been spent setting up and performing initial experiments in a single-cylinder engine (SCE). These initial experiments confirmed that reformation was possible, at least, but much work needed to be done to show the pros and cons of this approach. This reviewer reemphasized that much work still needed to be done.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that the project leveraged a good team, including SNL, GTI, Cummins, Sturman Industries, and various universities. The work was being shared through the U.S. Council for Automotive Research (USCAR) colloquium.

Reviewer 2:

The reviewer mentioned that the history of this project had included various researchers at multiple National Laboratories and universities, as well as industry input. This reviewer added that this project connected well with Dick Steeper's work.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the work of in-cylinder and EGR reforming would continue. The present work indicated that the effort might be successful. It was viewed as a good idea to extend the work from the single- to multi-cylinder engine platform.

Reviewer 2:

The reviewer indicated that the comparison between different reforming approaches would be interesting.

Reviewer 3:

According to this reviewer, the proposed future work was very general. The reviewer explained that it would be helpful to have seen a more detailed plan, including any work that might focus on using reformation to enable combustion modes that had shown promise toward improving engine thermal efficiency. The reviewer recognized that there was initial upfront work required to ensure the reformation process was somewhat optimal and worked well within an engine system, but that eventually other portions of this research effort needed exploration.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reinforced that this project was a result of a DOE-supported effort to explore ways to theoretically improve engine efficiency. From its inception, it had been addressing DOE fuel-economy objectives.

Reviewer 2:

The reviewer noted that the effort was high risk but also high reward if successful at improving engine efficiency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer suggested that, given the range of interesting ideas presented, it seemed like more work could be done to evaluate them and understand the opportunities and tradeoffs.

Reviewer 2:

The reviewer explained that the budget could become insufficient depending on how the reformation experiments progressed toward exploring that possibility (leading to advanced combustion strategies that have shown promise for improving engine thermal efficiency). For example, this reviewer added that if the PI needed to modify the engine setup, then the budget could become insufficient.

High Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines: Scott Curran (Oak Ridge National Laboratory) - ace016

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the data and analysis generated in this project had been needed for a few years. It pointed out the pros and cons of dual-fuel combustion systems for practical automotive use. This reviewer added that the combination of engine testing and zero-dim vehicle analysis was very fruitful for this project.

Reviewer 2:

The reviewer felt that this project provided an understanding of RCCI combustion on a more real-world multi-cylinder engine. This project was a critical step in providing efficiency and emissions data so that the barriers to advanced combustion modes could be better understood and therefore better addressed.

Reviewer 3:

The reviewer remarked that the valuation of the RCCI technology in a multi-cylinder engine with real aftertreatment was critically important to determine the commercial feasibility of the RCCI approach.

Reviewer 4:

The reviewer acknowledged that it was a good idea to investigate the potential vehicle-level fuel economy impact of the RCCI approach.

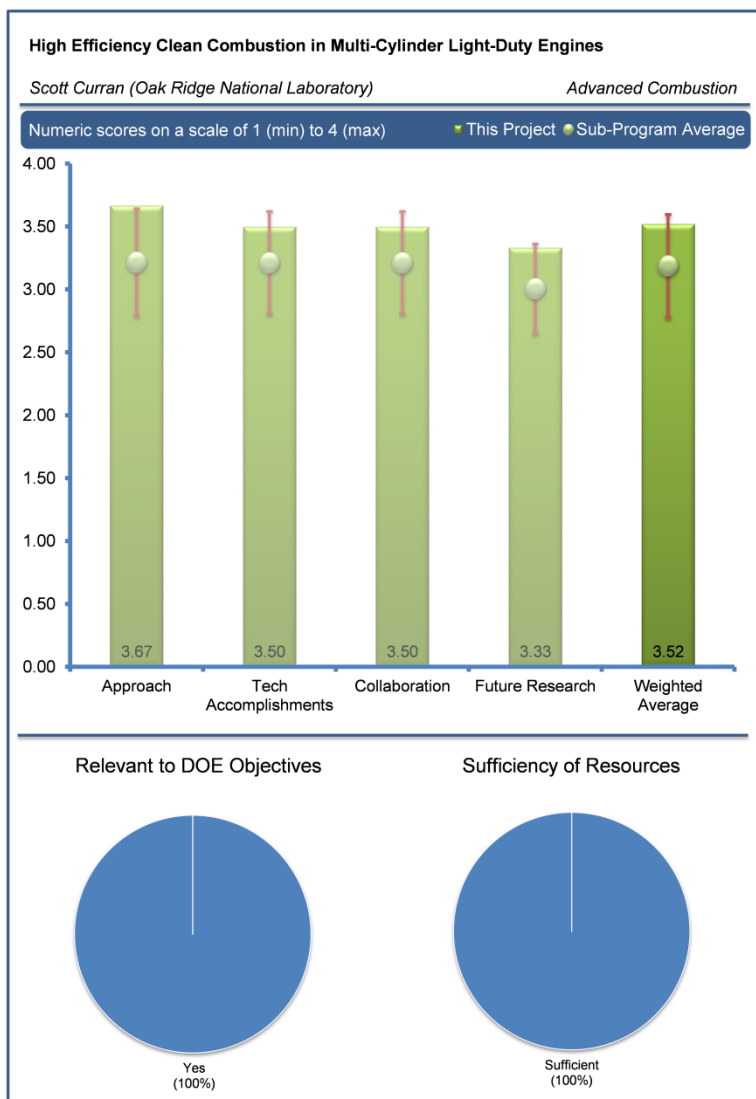
Reviewer 5:

The reviewer commented that it was good to see a systems-level project in the portfolio. This reviewer added that dynamometer measurements of efficiency could easily be lost when implemented on a vehicle.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer pointed out that there was excellent progress in assessing the benefits and challenges of RCCI technology in real multi-cylinder engines with real aftertreatment systems. The project had mapped the performance of RCCI as well as validated the high efficiency and low NO_x and smoke emissions on the multi-cylinder platform. This reviewer added that the project had identified several challenges, which included high HC and CO emissions coupled with low engine-out temperatures, which made the current



aftertreatment systems ineffective. The project had also extended the engine maps to the Urban Dynamometer Driving Schedule (UDDS) drive cycle.

Reviewer 2:

According to this reviewer, excellent progress had been made. Within the limitations of the stock turbo, the multi-cylinder engine had been mapped and BSFC and emissions data had been obtained, providing a much clearer picture of the potential of RCCI. Further, the map had been used in Autonomie predictions and compared to some baselines to get an idea of the potential on the Federal Test Procedure (FTP) cycle.

Reviewer 3:

The reviewer observed that there was very good work to date demonstrating the capability of RCCI in a practical multi-cylinder engine. The vehicle analysis work was also very good and at least provided the community with a feel for what sort of fuel economy gains were reasonable with RCCI engines.

Reviewer 4:

The reviewer said that there was great progress. The project addressed many important aspects of implementing an LTC strategy. The PI should attempt to estimate the cumulative TP emissions to see how close the project was to a Tier 2-Bin 2 or partial-zero-emissions-vehicle (PZEV) TP emissions standard. By the early part of the next decade, OEM fleet averages will need to be at these levels. If their standard catalysis is not an option, then alternatives such as HC traps will be required.

Reviewer 5:

The reviewer noted the Quarter Three Milestone (high-efficiency RCCI mapping) and Quarter Four Milestone (drive-cycle evaluation).

Reviewer 6:

The reviewer asserted that the project needed to compare vehicle fuel economy on an equivalent performance basis. It was not fair to compare fuel economy for an 8-bar BMEP engine with an 18-bar BMEP engine because vehicle performance would be so different.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer expressed that very good collaborations with very relevant organizations over several areas existed. These collaborations would ensure that the relevant data and results were obtained to understand the potential of RCCI combustion.

Reviewer 2:

The reviewer affirmed that the project showed good collaboration between the PI, UW, GM, and other minor partners in both performing experiments on the small diesel and modeling the RCCI combustion events.

Reviewer 3:

The reviewer explained that a number of collaborations were mentioned, including those with MAHLE, GM, MECA, CLEERS, Diesel Engine Research Consortium (DERC), and UW.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that there were very reasonable plans to continue to assess the benefits and challenges of RCCI technology (including transient performance) as well as aftertreatment integration options to address the challenges of high HC and CO emissions coupled with low engine-out temperatures.

Reviewer 2:

The reviewer reported that the project proposed to replace the stock turbocharger with a bigger one (and perhaps a supercharger as well) to enable the completion of the RCCI map at higher loads and speeds. This person added that this was a very appropriate next step.

Reviewer 3:

The reviewer reinforced that, overall, the objectives for FY 2014 were solid. This person's only suggestion was to also work on transient response during load transition, especially within the RCCI operating regime.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer claimed that this work directly supported the DOE's objectives of improving vehicle fuel economy, adding that this project had shown the potential of one type of engine combustion strategy at steady-state conditions to improve over diesel and port-fuel-injection (PFI) type technology.

Reviewer 2:

The reviewer summarized that this was exactly the kind of work that was needed to bridge fundamental single-cylinder research in the area of advanced low-temperature combustion to more real-world-like multi-cylinder evaluations.

Reviewer 3:

The reviewer voiced that RCCI was an advanced combustion approach that had the potential for higher efficiency, lower fuel consumption, and lower NO_x and soot emissions than current engines. The ORNL project was assessing what the technical benefits and challenges of this technology were in realistic engine and vehicle system setups.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the milestones were being met, so it appeared that resources were sufficient.

Reviewer 2:

The reviewer reported that the project had been supported for years at consistent funding levels and continued to produce useful results.

Accelerating Predictive Simulation of IC Engines with High Performance Computing: Dean Edwards (Oak Ridge National Laboratory) - ace017

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the project was very focused in two areas of interest to OEMs: combustion stability and GDI injector design optimization. This looked like a very useful approach of using meta-models to greatly speed up the simulation.

Reviewer 2:

The reviewer noted that the lack of fundamental knowledge of advanced engine combustion regimes, and the lack of modeling capability for combustion and emission control, were cited as the technical barriers this project tried to address. The approach this project had taken was in general alignment with the goals by reducing the computing time. The methods were innovative and seemed feasible. The two cases where the methods were applied were very important to the industry. The ultimate validation of the method would be the degree to which that predication matched the test results, as the authors recognized (here the reviewer referenced page 22).

Reviewer 3:

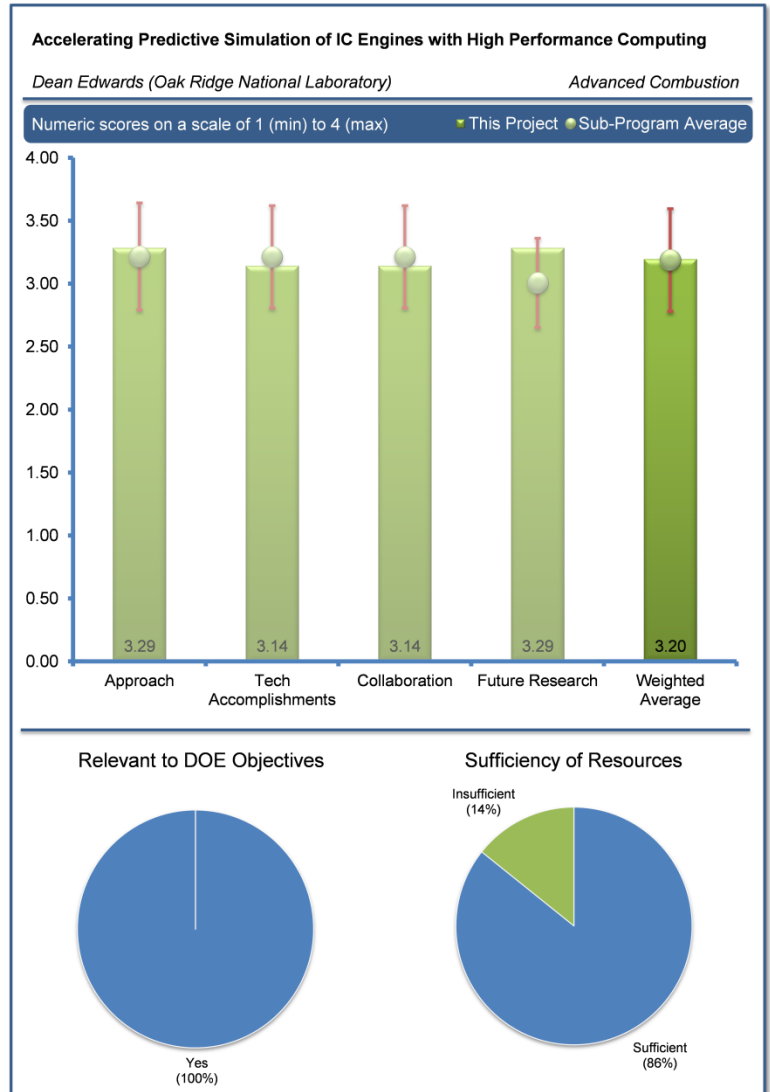
The reviewer remarked that the project aimed to reduce engine design and simulation time from months to weeks. This person added that high-performance computing schemes and meta-models (models of models) were being used to optimize and speed up calculations. Two real-life applications were being studied as test cases.

Reviewer 4:

The reviewer commented that, for the injector spray optimization, it would have helped to provide the measures of success for optimizing. This reviewer assumed one measure was the set of control factors that provided a minimum in the response variables. The other would be robustness to noise factors (such as injector-to-injector spray variability).

Reviewer 5:

According to this reviewer, the approach to make use of large-scale computing was good. This reviewer was not sure if the meta-model approach being used for the Ford project would work. Given the approach to closely partner with two OEMs, this reviewer asked if all of the details of the approach would be open and publicly available, since it was being developed with public funds.



Reviewer 6:

The reviewer observed that this was a potentially valuable project. Using the most current simulation models and the massive computing power of Titan, the researchers were exploring the extent to which processes currently viewed as stochastic might actually be deterministic. If successful, it would shed light on the extent of current understanding of the details of phenomena that ultimately controls ability to maximize engine efficiency with reduced emissions. The second part of the reported effort involved using the extensive computing power of Titan to implement a very comprehensive injection system optimization. It was not clear what the new knowledge would be if this aspect of the work were successful. This reviewer concluded that it seemed that this part of the work was more the use of impressive computing capability to develop a more comprehensive optimization process.

Reviewer 7:

The reviewer said that CFD modeling was an excellent approach to studying the issues with the combustion system. Specifically, this reviewer thought that using CFD in an optimization loop was an excellent step forward in how injector design could be better optimized and matched to the engine's combustion system. This reviewer was admittedly not convinced that there was good value to studying cycle-to-cycle combustion variation in CFD, as it was not clear what could be done with this information. This person added that some explanation or theory on how understanding cycle-to-cycle variations could be used to improve overall engine efficiency would have been helpful.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer mentioned that getting the codes ported and running was a significant accomplishment.

Reviewer 2:

The reviewer asserted that there looked to be good initial progress in setting up the meta-models and initial validation/calibration runs.

Reviewer 3:

The reviewer emphasized that the work was in its early stages and the results were basically the establishment of techniques and approaches. This reviewer went on to say that good progress had been made in doing this.

Reviewer 4:

The reviewer explained that the progress on this program seemed good, with most of the progress being made on the combustion-stability task.

Reviewer 5:

The reviewer asked, for the DI injector spray optimization, how some of the findings from Chris Powell and Lyle Pickett (on the asymmetries that existed in fuel sprays and their influence on the mixing) would be incorporated.

Reviewer 6:

The reviewer agreed that some progress had been made on both fronts. For the Ford study, the meta-model approach had been demonstrated with simple model and LES simulations in progress. For the GM study, the automation and optimization framework had been developed. This person added that it would be beneficial to verify the model prediction at an early stage with some test results from industry partners.

Reviewer 7:

The reviewer indicated that the project was in its first year, but the concept had been demonstrated to some extent and the framework had been established. It seemed like this was yet another project on using supercomputers to model mixing and combustion. This reviewer went on to add that every effort should be made to test the models on real-world industrial applications to prove its worth.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project was working very closely with Ford on the real-life combustion stability test case and with GM on the real-life injector pattern optimization.

Reviewer 2:

The reviewer reported that there appeared to be close collaboration with GM, Ford, and Convergent Science, as well as collaboration with other groups within ORNL. This person added that hopefully the results and tools that were developed were not only beneficial to GM and Ford, but also useful and made available to the other OEMs (and ultimately would result in interactions with them as well).

Reviewer 3:

The reviewer concluded that there was good collaboration among the stakeholders, and that the stakeholders would also be significant beneficiaries if the work were successful.

Reviewer 4:

The reviewer confirmed that both ongoing efforts had direct industry involvement. This reviewer added, however, that coordination with institutions and labs outside of ORNL seemed to be lacking.

Reviewer 5:

The reviewer voiced that the collaboration with only two OEMs appeared to be limited.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the plans for upcoming work were good.

Reviewer 2:

The reviewer felt that the plans to complete validation of the various model components and then running the full models were important and reasonable.

Reviewer 3:

The reviewer stated that the work on matching injector design and optimizing this to the combustion system was an outstanding objective, and the work in this area should have value to many in the industry and represented a good step forward in state-of-the-art combustion CFD. (This reviewer added that this was assuming this could be done in a good, linked manner, ideally including an automated optimization method.)

Reviewer 4:

The reviewer remarked that, given the approach, the future work appeared to be reasonable.

Reviewer 5:

The reviewer commented that the final results that would prove out the concept and approach were to be expected in the next phase of the work.

Reviewer 6:

The reviewer observed that the proposals were fine in their general direction. This reviewer pointed to an item that the authors have recognized (model validation with experimental data is vital during each phase) and added that this task was not defined in future work.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer said that this project had the potential to accelerate advanced GDI engine development to meet future efficiency and emissions goals, which supported the objective of the DOE in reducing petroleum consumption.

Reviewer 2:

The reviewer observed that this project focused on the development of tools to reduce the time it took to run simulations and thus presumably decrease the time for design and commercialization of advanced combustion equipment and technologies. These support the DOE goals of high-efficiency, cleaner-combustion engines.

Reviewer 3:

The reviewer mentioned that this work was designed to help optimize engine combustion system design, which was directly relevant to improving engine performance.

Reviewer 4:

The reviewer expressed that advanced combustion concepts needed to be tried and tested via simulation and that, currently, the computing time was prohibitively large. Concepts and approaches like this were needed to hasten the development of advanced combustion concepts.

Reviewer 5:

The reviewer asserted that making use of high-power computing to impact engine design was very relevant. This person added that the time to run simulations needed to be short enough so they could be used in real product development cycles where time is finite and limited.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer voiced that it would be good to see this work expanded.

Reviewer 2:

The reviewer summarized that it appeared that milestones were being met, which would suggest that resources were sufficient.

Reviewer 3:

The reviewer confirmed that the resources appeared sufficient for the proposed scope of work.

A University Consortium on Efficient and Clean High-Pressure, Lean Burn (HPLB) Engines: Margaret Wooldridge (University of Michigan) - ace019

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that there was excellent work to collaboratively develop significant data sets and to characterize opportunities with advanced combustion modes.

Reviewer 2:

According to this reviewer, there had been quite a bit of fundamental combustion research within this project exploring the intricacies of SACI and partially homogeneous spark-assisted modes. The modeling portions of this effort, especially in the multi-dim arena, were developing as more data was generated from optical engine experiments to further refine the UM flamelet model. The piece missing in this work revolved around integrating new knowledge gained about these lean-burn combustion modes into either a thermodynamic engine simulation and/or a simple vehicle model to project the potential fuel-economy/thermal-efficiency gains.

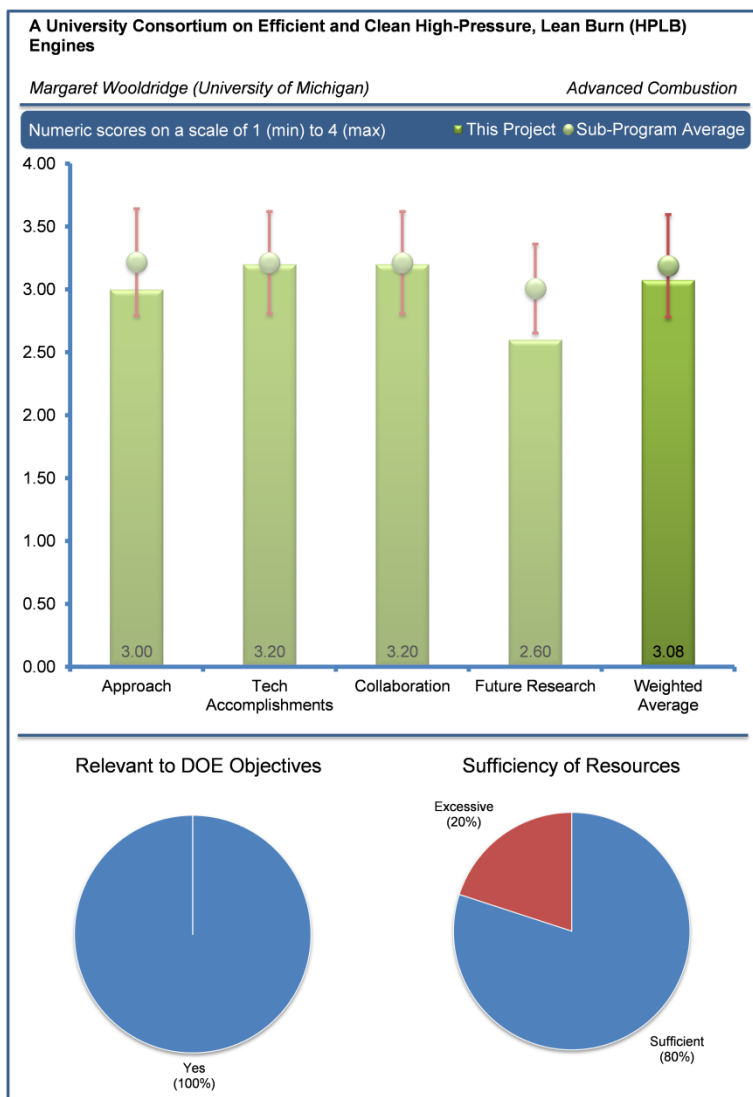
Reviewer 3:

The reviewer remarked that this project provided a comprehensive approach to exploring the advancement of dilute, high-pressure combustion for LD gasoline engines. It proposed to focus on four areas: the development of analytical tools to link engine and vehicle fuel economy; stratification; SACI; and novel fuel properties. This person added that, whereas the approach proposed was clearly identified, the presentation failed to show how these areas impacted the goal to attain the 45% engine efficiency. In fact, it was unclear if this goal would be realized.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer acknowledged that the key goals had been achieved as the project was now near completion.



Reviewer 2:

The reviewer commented that the key technical accomplishments have occurred at a fundamental level in assisting the physics associated with various facets of lean-burn, spark-assisted-combustion modes. This person added that this knowledge must eventually be integrated into a form that could be used to assess fuel economy gains and thus address DOE goals in this technical area.

Reviewer 3:

The reviewer asked how stratification impacted efficiency and emissions, what power level and input power were used for the microwave system, and if there were any results for engine-out emissions. This reviewer further noted interesting rapid compression machine results where SI was included.

Reviewer 4:

This reviewer wanted to know why it was not shown why load extension was critical to minimizing the friction-mean-effective-pressure (FMEP) percentage of BMEP, and added that the FE results versus the base SI engine were not shown.

Reviewer 5:

The reviewer pointed out that the work was near completion, but felt that the presentation could have provided a better comprehensive review of their overall efforts and success in achieving the goals proposed here. Task 1 addressed the overall fuel efficiency goal of the project (only one slide was dedicated to it). This was done via the development of a quasi-D model that combined multiple combustion modes (SI, HCCI). This reviewer added that no dynamometer demonstration was provided. Task 2 pursued the impact of stratification, which can be used to mitigate high-pressure rise rates. The work reported improvements of an integrated spray-interactive flamelet (SIF) model over the simpler Reynolds-Averaged Navier-Stokes (RANS) model. This was explained by turbulent fluctuations affecting the heat release under stratified conditions. Mitigation of pressure rise rates was explored by adjusting the timing of the direct injection gasoline. Additionally, the authors embarked on interesting tests with SACI in Task 3. New work included KIVA-3V predictions, with temperature distributions accompanying earlier heat release traces. The task then added the contributions of EGR across a wide range of O₂ ratios. The dilution method affected the tradeoff between flame heat release and ignition delay, and could be used to manage heat release. Work included the impact of spark- versus microwave-assisted spark plugs, though few details were given about the physical arrangement. This reviewer went on to say that the work could have shown a detailed analysis of the energy distribution, comparing the SACI with conventional combustion. This comparison would have been used to assess the progress towards the 45% efficiency target. Unfortunately no assessment was made here. Task 4 presented data across fuel properties based on various Primary Reference Fuels (PRFs). The data was not accompanied by basic energy balance analysis. The reviewer added that it was unclear if there was any particular direction that the authors were taking or if they had chosen a set of conditions to benchmark towards the efficiency goal. It was also unclear why the authors focused on n-heptane rather than more comprehensive surrogate formulations. As the authors indicated, the data available for n-heptane was very large and the tests the authors had run overlapped with existing data already available.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that this project from the onset had demonstrated very good university-level collaboration between UM, the Massachusetts Institute of Technology (MIT), and the University of California–Berkeley in exploring the intricate details of lean-burn gasoline engines. This reviewer added that it appeared that certain industry partners had also been involved in this project to help ensure progress was made from an OEM perspective.

Reviewer 2:

The reviewer observed a wide collaboration, almost too much to organize.

Reviewer 3:

The reviewer said that this section was vague, and suggested that more detail might be given as to the contribution of the partners.

Reviewer 4:

The reviewer mentioned that broader industry involvement might have been useful.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer asserted that the project was wrapping up.

Reviewer 2:

The reviewer affirmed that the main effort remaining was wrapping-up and reporting.

Reviewer 3:

The reviewer emphasized that, overall, the proposed future research was sound. This reviewer's suggestion was to consider adding additional work concerning the impact of ethanol blends on fuel efficiency gains in Task 4, and to consider developing reasonable thermodynamic engine or vehicle models to assess the fuel economy gains of the various combustion modes under study. This person added that starting with a purely steady state in Item 2 was reasonable. The transient controls work was important, but understanding what was possible from a fuel-economy point of view was very important as well.

Reviewer 4:

The reviewer explained that the work was expected to complete in June. This reviewer added that, as in the accomplishments section, the outline was rather vague. The authors could have been more specific as to the expectations or milestones that were sought.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that this project was relevant for future engine designs and high-efficiency targets.

Reviewer 2:

The reviewer highlighted that it was important to compare various combustion processes for efficiency potential.

Reviewer 3:

The reviewer concluded that this project was another one that explored advanced combustion modes for improving the fuel economy of today's PFI engines. Eventually, this project should provide DOE with a sense of what is possible in comparison to other projects (including LTC, RCCI, and advanced diesel combustion modes).

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that no cost extension was noted.

Reviewer 2:

The reviewer indicated that funding had been a little lower this year, but the PI stated the project was 90% complete. It was not clear if that budget cut would affect a subproject within this effort, such as a graduate student.

Flex Fuel Optimized SI and HCCI Engine: Gouming Zhu (Michigan State University) - ace021

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that transient control of SI-to-HCCI transitions was clearly a barrier, and that this project's approach addressed this challenge. This reviewer still had some concern that the results would be very engine specific and identified a need to strive for a general understanding of the approach and how it applied to other applications.

Reviewer 2:

The reviewer stated that the delays in the project, which had led to a delay of one year, suggested that the approach had some shortcomings. The PI mentioned that, in hindsight, it would have been better to use an existing engine rather than to build one from scratch.

Reviewer 3:

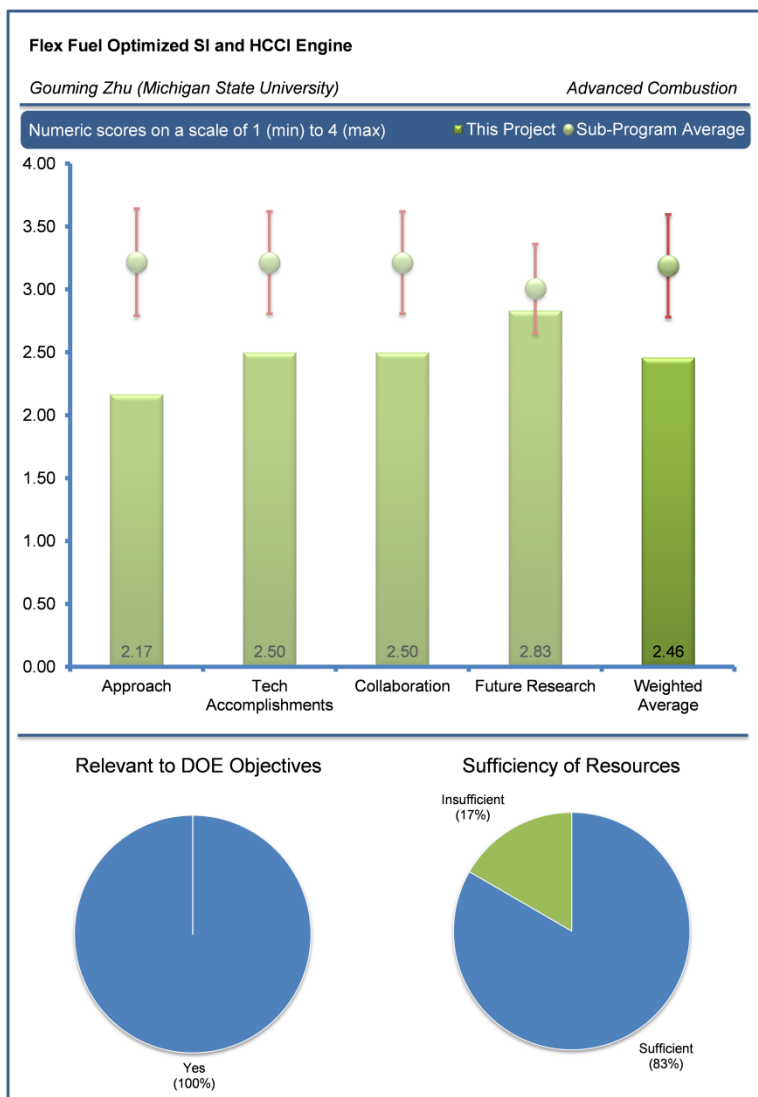
According to this reviewer, the work had been to develop a model-based control for transition between SI and HCCI; yet the effort had devoted most of its time to facilities development. In the opinion of this reviewer, there was not much reported on the actual development of the control strategy or the model that drove it. It also seemed that the project would be dependent on the specific engine configurations being used, so it was not clear to this reviewer what new knowledge for general use would be generated. This reviewer thought that this would be especially true for transient operation.

Reviewer 4:

The reviewer felt that there was clearly a need to be able to transition from HCCI mode to SI mode and vice versa, but the approach being used to handle this was a bit questionable. This person was at a loss for why optical rig testing was needed to address this transition mode, and the reviewer believed it would be better to focus the program's resources on the multi-cylinder engine and controls. Also, it was not clear what criteria would be used to determine acceptable versus unacceptable transition between the operating modes.

Reviewer 5:

The reviewer remarked that this project was focused on the HCCI engine control, which was one of the major technical barriers. The methodology was generally sound; however, to control a multi-cylinder engine on a cycle-to-cycle basis, the computation time of the model had to be very short without sacrificing the accuracy of the output (control parameter). This reviewer thought that efforts in this area were lacking.



Reviewer 6:

The reviewer commented that this project had always suffered from an unsatisfactory approach, which had been described at length in previous reviews by this reviewer. The project still continued to be bogged down by the lack of a multi-cylinder engine that was capable of running HCCI. Thus, the main objective of the project, to develop and validate a controls model of SI-to-HCCI transition, would not be satisfactorily addressed.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer pointed out that some progress had been made according to the plan despite a delay in the build-up of the four-cylinder engine.

Reviewer 2:

The reviewer observed that considerable time had been spent setting up the single- and multi-cylinder hardware. The project appeared to be poised to begin generating results just as it came to a close. The future value would be for ongoing projects for graduate students.

Reviewer 3:

The reviewer said that the accomplishments reported were primarily those of the facilities build-up. The basis for the two-zone mixing model that was important to the control algorithm was not well-described, yet it seemed that this was a critical component of the overall project. This reviewer was surprised that a two-zone mixing model would work. An explanation of why this would work would be a significant addition to the knowledge base for developing control algorithms.

Reviewer 4:

The reviewer mentioned that, overall, progress on this project seemed to be fairly slow, although progress on getting the multi-cylinder engine up and running was good. However, this reviewer added that, given all the time and effort spent on the optical engine and analyzing the images taken, it was not clear what value this would have to the overall program goals. Also, there seemed to be no data shown on the transitions between SI and HCCI modes, the issues being uncovered, and the actions being taken to overcome these issues. Thus, developing the controls was good, although more focus needed to be added to taking and reporting data during combustion mode transitions.

Reviewer 5:

The reviewer criticized that progress had been slow on this project, resulting in a one-year extension. It looked like the progress had been accelerated over the past year, but it was still not clear that the project could achieve its ultimate goal of developing an effective transition control model in the remaining four months.

Reviewer 6:

The reviewer asserted that progress had been made in the areas of the multi-cylinder build-up and testing, as well as more optical engine tests. But none of these efforts provided any new knowledge, and certainly none regarding control of SI-to-HCCI transitions, which was the aim of the project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer affirmed that there were good collaborations with Chrysler and the University of Minnesota.

Reviewer 2:

The reviewer emphasized that the collaboration appeared to be with a single OEM. This reviewer stated that it appeared as though the frequency and effectiveness of that collaboration had improved over the past year.

Reviewer 3:

The reviewer indicated that the collaboration was just with Michigan State University (MSU) and Chrysler, but added that perhaps this was enough in this case.

Reviewer 4:

The reviewer reported that it seemed that the collaboration was limited to Chrysler, the research partner. The PI claimed interaction with Ricardo relative to the wave-disk-engine project at MSU, yet it seemed that they were using the GT-POWER simulation tool.

Reviewer 5:

The reviewer highlighted that the help provided by Chrysler with all the multi-cylinder issues was recognized and greatly appreciated. However, this reviewer added that Chrysler was solicited late in the program to help. Also, what was really needed in this project was collaboration with an appropriate partner right from the beginning, a partner who could supply an HCCI-ready engine so that the project could focus on the primary objective, which was to understand and develop controls for SI-to-HCCI transitions.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer claimed that the project had a reasonable plan to complete their activities.

Reviewer 2:

The reviewer concluded that the research was close to the end.

Reviewer 3:

The reviewer summarized that focusing the future work on mapping the engine in SI and HCCI mode and validating the controls during transition mode was good, but there should have been a clear (quantitative) criteria on what defined an acceptable transition between the modes.

Reviewer 4:

The reviewer specified that there was some uncertainty as to whether the multi-cylinder engine would be able to run HCCI over the relevant load range, given the fact that the compression ratio of 11.5 might have been too low. As a correction, this reviewer added that the intake charge should have been heated to promote HCCI operation, and that work should have been focused on understanding and controlling SI-to-HCCI transitions.

Reviewer 5:

The reviewer voiced that it was not clear that the goals of completing the mapping of the metal engine (for SI and HCCI combustion) and validating the mode transition control on the metal engine could be successfully completed by the project end date of September.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the HCCI engine could reduce fuel consumption, which supported the DOE objectives of using less petroleum.

Reviewer 2:

The reviewer noted that incorporating LTC modes (such as HCCI) into vehicles could provide significant fuel-consumption reduction.

Reviewer 3:

The reviewer remarked that if the project were successful and resulted in the development of an effective controls model for the transition from SI to HCCI modes, it would advance the development and commercialization of part-time HCCI engines. This would have improved efficiencies and resulted in cleaner combustion than conventional engines, supporting DOE goals.

Reviewer 4:

The reviewer acknowledged that HCCI was an important low-temperature combustion concept that provided significant efficiency and emissions benefits but whose main barrier was the lack of good controls.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer had some concerns that the remaining tasks of completing the engine mapping for SI and HCCI combustion, and completing the validation and revision of the mode transition control model, could be completed by the project deadline of September. Despite that, this reviewer did not favor further extension of the project.

CLEERS Coordination & Joint Development of Benchmark Kinetics for LNT & SCR: Stuart Daw (Oak Ridge National Laboratory) - ace022

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that this project had an excellent approach, with a broad range of topics and a clear set of goals for improving the modeling of aftertreatment systems. The way the project was set up with access for industry and academia allowed the findings to be used widely. It can be used in universities to assist in the training of students learning how to model emissions control technologies.

Reviewer 2:

The reviewer said that the approach was very comprehensive through its use of advisors, website, technology focus groups, and workshops. There was very good leverage of other domestic and international funding resources.

Reviewer 3:

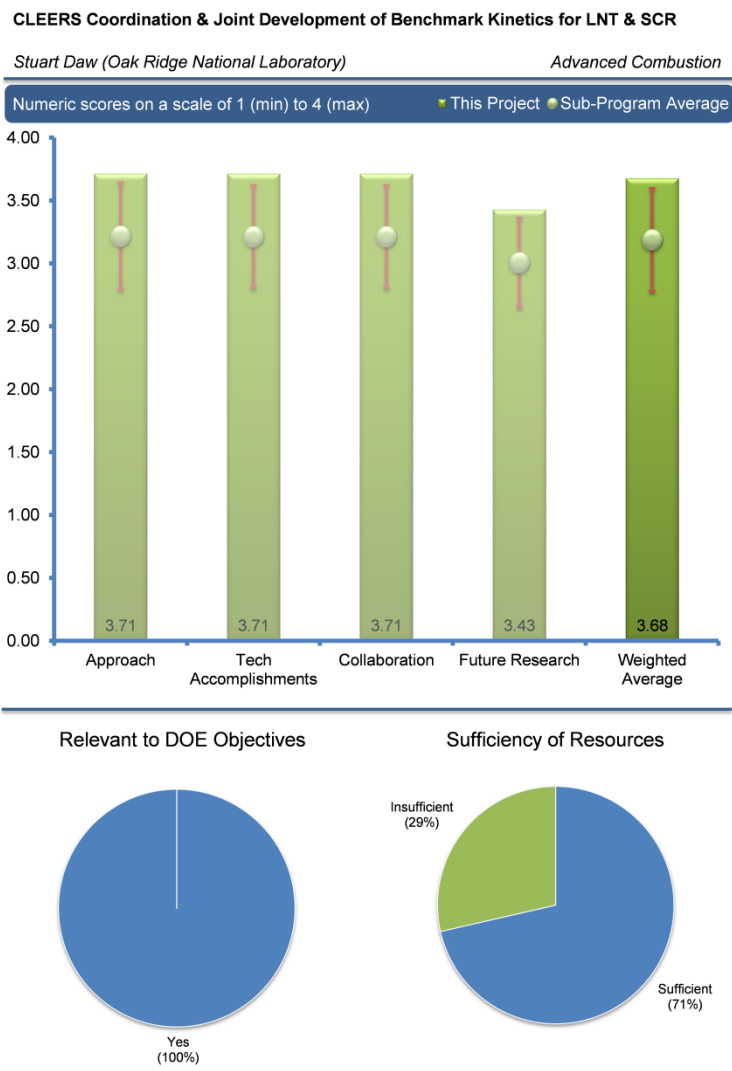
According to this reviewer, the approach of this project had provided a very positive outcome in the aftertreatment community, and that all activities under this program served to help many researchers in both the industry and academia engage and work together in the advanced aftertreatment area.

Reviewer 4:

The reviewer asserted that these simulations were critical to guiding the development of future aftertreatment applications, especially in regard to NO_x. The focus on lean aftertreatment systems was consistent and supportive of more efficient engine technologies that the industry was pursuing. In addition, the included emphasis on low-temperature catalyst reaction mechanisms would be an area of growing industry interest, as tighter emissions standards must be achieved. This reviewer added that having a central database of modeling simulations of pertinent catalyst systems was important to resource redundant efforts and to better coordinate academic and industry activities.

Reviewer 5:

The reviewer expressed that the CLEERS coordination project had been a well-constructed support of a clear and ongoing need: “the collaboration and dissemination of industry, university, and National Laboratory pre-proprietary simulation and data for emissions controls technologies.” While it was challenging to separate the pre-proprietary and proprietary activities in this industry segment, the CLEERS coordination leadership continued to seek and leverage outside resources such as universities. Limiting membership to a manageable level, hosting monthly calls, and facilitating events (e.g., industry priority survey) were examples of the excellent approach. Continued dialogue with industry was strongly recommended. It was also suggested to publish aggregated results of the



industry priority survey and to add a CLEERS use/feedback survey, as this would be a valuable addition to confirm the excellent approach. CLEERS use surveys could be done at monthly meetings, at workshops, or once a calendar year to gauge industry/researcher interest and value, and to provide feedback.

Reviewer 6:

The reviewer emphasized that the technical barriers were addressed for the NO_x control strategies, but added that the particulate kinetics should have been included in this work. These were not separate problems, and the interactions between the PM and NO_x (and components) were best studied together. CLEERS seemed heavily focused on simulation, which was great, but the simulations must be developed from experimentally determined data; again, these things did not stand alone. The proposed database would be an excellent resource and a fantastic way to disseminate data. This was truly an exemplary program that showed the benefit to DOE (and an excellent use of resources) when industry, laboratories, and academia worked together.

Reviewer 7:

The reviewer explained that CLEERS provided the aftertreatment modeling community with a forum to share ideas and approaches. However, this reviewer added that most OEMs already had models for commercial catalyst systems for the key parameters (i.e., selective-catalytic-reduction [SCR] conversion and ammonia storage).

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer strongly emphasized that the results were excellent. The project provided an excellent mechanism for sharing measured and simulated data from engines and aftertreatment.

Reviewer 2:

The reviewer explained that this project facilitated effective information exchange and dissemination, and added that the kinetics modeling accomplishments were significant as well.

Reviewer 3:

The reviewer indicated that the excellent participation during the April 2013 workshop demonstrated CLEERS' value. The venue choice was also excellent. This reviewer further noted results in key focus areas that should be of interest to industry, adding that SCR, lean NO_x trap (LNT), and oxidation catalysts were completed.

Reviewer 4:

The reviewer reported that advances in the understanding of ammonia storage for SCR and the performance of modern LNT catalysts were excellent. The improvement of models was very noteworthy. This reviewer further noted the demonstration that nitric oxide (NO) oxidation appeared not to be involved in the mechanism of standard SCR reaction.

Reviewer 5:

The reviewer said the project made good progress and demonstrated synergy (via working with external groups such as the modeling group at Pacific Northwest National Laboratory [PNNL]). Additional transient engine-out data from both LD and HD engines would add more information for the CLEERS library. The 2013 CLEERS workshop had been pretty successful; however, this reviewer added that the monthly teleconference did not seem to bring more attention. The monthly teleconference would provide a unique opportunity for both presenting and participating members to interact with ideas and suggestions. This reviewer suggested arranging a full list of speakers among the National Laboratories, universities, and OEMs for each year. External publication seemed to be light compared to the amount of work they had done, although there were many oral presentations.

Reviewer 6:

The reviewer specified that better understanding of commercial catalysts and how they functioned was helpful. However, this person added that it was a bit more of a stretch to look at pre-commercial catalysts and really support next-generation powertrain development. There was the issue of proprietary catalyst formulations that inhibited the testing of pre-commercial catalysts, and this

would always be an issue with CLEERS. This reviewer further noted that the move into low-temperature oxidation catalysts with some exploratory research was interesting.

Reviewer 7:

The reviewer voiced that BMW LNT technology might be a good reference, but it was not leading-edge technology. The problem was to obtain a supplier's newest formulations to make sure the catalyst community was working on and heading in the correct technical direction. Maintaining a database of modeling activities relevant to the automotive industry was very important to understanding catalyst behavior. However, this reviewer added that consistent and uniform modeling conditions had to be used to ensure technologies were being compared fairly. This reviewer went on to say that including low-temperature materials was an excellent expansion of the modeling activities.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer emphasized that the collaboration was excellent. There was a fantastic cut across industry, academia, and the labs, as well as international collaborations.

Reviewer 2:

The reviewer stated that CLEERS activities were among the best collaborative venues for bringing together government, university, and industry participants to more efficiently address aftertreatment needs.

Reviewer 3:

The reviewer noted significant collaboration with industry partners, National Laboratories, and universities (domestic and international).

Reviewer 4:

The reviewer felt that this project was widely collaborative in several respects, but mainly in all of the people participating in the CLEERS web calls with speakers from industry, academia, and the National Laboratories.

Reviewer 5:

The reviewer remarked that the CLEERS community consisted of a nice cross-section of National Laboratories, university, and industry participants.

Reviewer 6:

The reviewer acknowledged the project's excellent collaboration from leveraging the effort with other entities such as U.S. DRIVE, the industry survey, PNNL, Politecnico di Milano, and others listed. This effort might improve by mentioning or disclosing some of the other partners' contributions and use. (If only to reviewers, this would be okay.) This reviewer asked about the feedback and involvement of the DOE Advanced Engine Crosscut Team, the U.S. DRIVE ACEC Team, and the CLEERS Focus Group members. Lastly, this person noted that there were 10 engine/vehicle manufacturers, 11 component/software suppliers, and 10 universities.

Reviewer 7:

The reviewer pointed out that there was a very well-coordinated collaboration with world-renowned groups. This person added that one concern would be the mechanism between ORNL and international partners; collaboration often requires balanced contributions and face-to-face interaction to facilitate scientific discussions as well as to update the scope of the project. With the given travel restrictions, it would be more difficult.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the incorporation of low-temperature aftertreatment modeling activities was agreed upon by many in the community as a research area of intense interest. This person added that initiatives to improve the CLEERS database in terms of content, accessibility, and modeling specifications was essential to its adoption as a repository of shared catalyst knowledge.

Reviewer 2:

The reviewer noted appropriate topics for investigation under CLEERS kinetics and further coordination improvements.

Reviewer 3:

The reviewer mentioned that the project's inclusion of low-temperature emissions catalysts and the modeling thereof was a wise look to the future.

Reviewer 4:

The reviewer expressed that the low-temperature aftertreatment need gave CLEERS an opportunity to do more exploratory research on new pre-commercial materials.

Reviewer 5:

The reviewer indicated that the collaboration was very good, and added that it was more of the same with continuous improvement. This person went on to note that it was good form to always show a brief rationale connected to the industry partners and other users when setting priorities for future work, such as a statement like CLEERS is focusing on low-temperature ammonia storage mechanisms because x% of manufacturers and x% of researchers surveyed in 2013 indicated having a need for this.

Reviewer 6:

The reviewer highlighted that future work should (and did) include some focus on the mechanistic details lacking in the current models as well as great focus on low-temperature aftertreatment, demonstrating a timely response from the labs. This reviewer would like to see the PM work integrated into the ORNL program.

Reviewer 7:

The reviewer voiced that the fundamental catalyst characterization paired with vehicle/lab experiments was not scoped. This person added that there would be some activities under NSF/DOE projects starting in 2013; however, looking into domestic academic partners for catalyst characterization was recommended.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated yes, and expressed the belief that this program was one of the most important activities for DOE's aftertreatment portfolio.

Reviewer 2:

The reviewer emphasized the work was excellent and highly relevant to current, near-term, and long-term issues.

Reviewer 3:

The reviewer stated that this project supported DOE objectives because the improvement in lean NO_x catalysts and emissions control allowed the engine (especially in the HD environment) to run with better fuel economy but higher NO_x emissions. As such, excellent catalysts allowed these fuel savings to occur.

Reviewer 4:

The reviewer noted that CLEERS provided the data and strategies needed to model and evaluate advanced technologies for improving engine efficiency.

Reviewer 5:

The reviewer remarked that a cost-effective, productive, and durable new aftertreatment emission technology was critical to enabling many advanced fuel economy improvement techniques to become productive. Examples were advanced low-temperature combustion and lean engine operation. Basic research and pre-competitive modeling could accelerate the development of solutions to enable the near-term implementation of these fuel economy improvement technologies in a cost-effective way.

Reviewer 6:

The reviewer acknowledged that aftertreatment could be an enabler for more highly efficient powertrains.

Reviewer 7:

The reviewer commented that the work was very supportive of current and proposed catalyst technologies, adding that a well-organized database with commonized testing and modeling protocols should enhance the throughput of catalyst testing to shorten the timeline of industry products.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer expressed that the project had done admirable work with the resources given. This reviewer would like to see more money directed here. In particular, the addition of the low-temperature catalysis work would require more funding to deliver results at the same level of quality that one expected from ORNL. This person said to increase funding for this work.

Reviewer 2:

The reviewer affirmed that there had been a general consensus that there would be more low-temperature challenges in emission control for advanced combustion, and CLEERS activities captured the key areas pretty well. More resources for this project would help and facilitate all existing activities in this direction.

Reviewer 3:

The reviewer explained that the speaker said there were sufficient resources to take on the new area of low-temperature catalysis while still possibly keeping current in the SCR and LNT areas. This reviewer thought that more resources might be needed, especially at the beginning, when the project was being defined and the best systems to study and model were being chosen.

Reviewer 4:

The reviewer indicated that funding was okay for now, though exploratory research on new materials might require more funds.

Reviewer 5:

The reviewer reported that the project might have insufficient resources to accomplish all the projects and activities planned unless in-kind work was provided through industry or universities.

Reviewer 6:

The reviewer commented that the project could be more placed in this area; however, it might be more efficiently placed in Consortium-focused research to enhance the pre-competitive work.

Reviewer 7:

The reviewer indicated that there was appropriate annual funding for coordination and kinetics modeling because this had been an ongoing project since 2000.

CLEERS Aftertreatment Modeling and Analysis: George Muntean (Pacific Northwest National Laboratory) - ace023

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that the focus on catalyst aging was preferred over lots of testing and modeling of fresh catalysts. The topic areas of SCR and diesel particulate filter (DPF) were reflective of industry priorities. This reviewer added that potassium (K) LNTs were not preferred for durability reasons.

Reviewer 2:

The reviewer said that PNNL's approach on fuel-efficient engine emission control was very well-balanced, and the fundamental approach from real-world problems had demonstrated great potential to achieve the goals that DOE was targeting. This CLEERS activity was very well-paired with existing Cooperative Research and Development Agreements (CRADAs) on which PNNL was working with industry partners, which would help them bring science to solutions. However, this reviewer added that the approach on LNT subtasks was not very lined up with their portfolio with CRADAs.

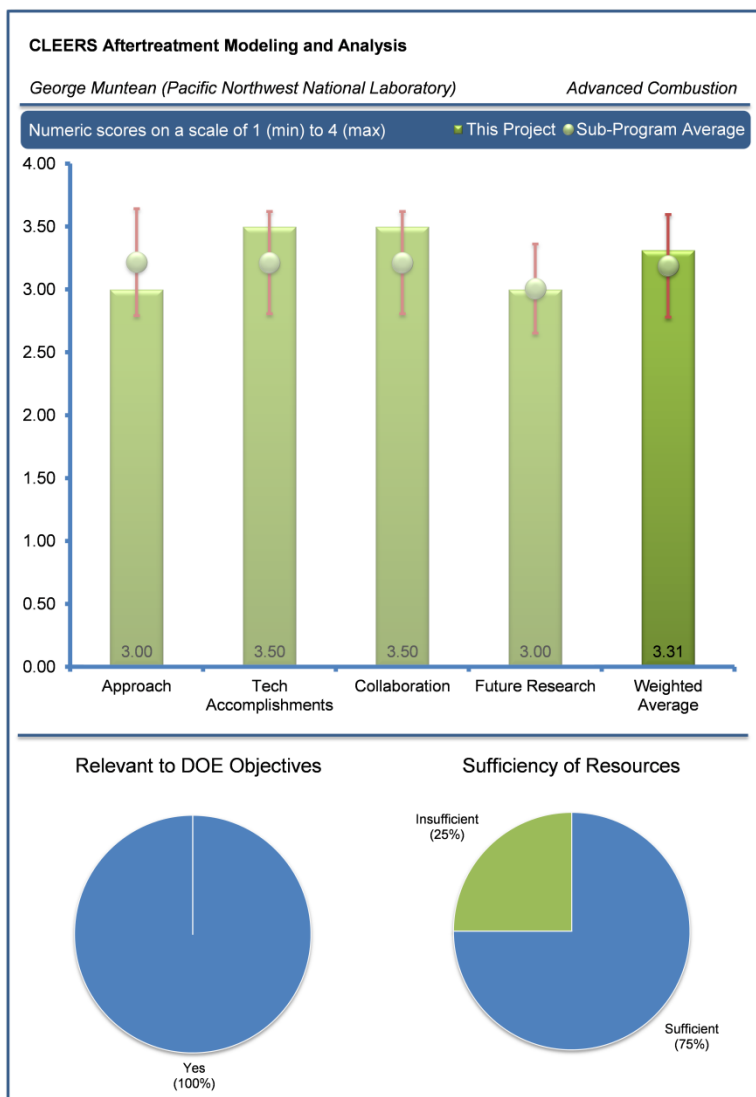
Reviewer 3:

The reviewer mentioned that the emphasis of the work presented here was on SCR technologies for lean exhaust systems, which would be increasingly important going forward as automotive OEMs tried to meet emissions and corporate average fuel economy (CAFE) standards. The presentation did not emphasize NO_x storage catalyst (NSC)-based technologies and the challenges those catalysts faced if applied to low-temperature aftertreatment. It was premature not to explore newer formulations and blending of technologies to improve performance at low temperatures. The reviewer further noted significant CRADA activities at PNNL to improve the connectivity to OEMs and universities, and to cost share/use resources effectively and address technical barriers.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer asserted that understanding how small-pore copper (Cu) zeolites aged was very important for industry, and added that longer aging times and/or higher-temperature aging would be interesting. The development of model formulations was helpful to



understanding commercial formulation behavior. This reviewer went on to say that it was good to see the NO-plus-ammonia (NH_3) mechanism explained without nitrogen dioxide (NO_2) formation.

Reviewer 2:

The reviewer affirmed good SCR characterization, as well as Cu zeolite characterization of Cu species and high-temperature K-based NSC materials. NH_3 storage and SCR reaction model were very pertinent. With respect to NSCs, the work was mostly looking at high-temperature stabilization. This reviewer added that it must also include low-temperature applications and their associated reaction challenges to help enable lean GDI systems.

Reviewer 3:

The reviewer emphasized that the PNNL team had made excellent progress and a very impressive external publication list, adding that the team had made a great contribution on elucidating the reaction mechanism of the state-of-the-art SCR technology. However, this person noted that the LNT work did not seem to have made as good of progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted many CRADAs showing good support, resources, and relevance.

Reviewer 2:

The reviewer emphasized significant CRADA activities with a number of light- and heavy-duty OEMs and suppliers.

Reviewer 3:

The reviewer explained that PNNL had been very active in collaborating with other institutions under CRADA; however, there was not very much under the CLEERS program.

Reviewer 4:

The reviewer indicated that it would have been good to see more direct industry involvement, if only as guidance. This was not explicitly shown in this project, but did happen to some extent through CLEERS and the annual priority survey.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that it was good to see low-temperature materials were playing a larger role in research and development (R&D). This reviewer was not so sure the lack of NSC research was reasonable, adding that it would be appropriate to benchmark the newer NSC technologies coming out of Europe. Characterization activities were well-founded and important to OEM industry, but the project needed more supplier interaction.

Reviewer 2:

The reviewer reported that the future activities on SCR and DPF were very well-scoped, but the planned work on NO_x storage-reduction (NSR) (LNT) was not very clear to this reviewer. The focus needed to be revised around how the market and industry moved forward. For example, LNT was having difficulties in the U.S. market due to nitrous oxide (N_2O) and durability problems. There were new efforts that suppliers were making to resolve those issues.

Reviewer 3:

The reviewer recommended moving away from LNT for diesel to passive NO_x adsorption at low temperatures (for diesel/new powertrains) or high-temperature LNT (for lean gasoline). This reviewer also suggested moving away from things like K and titania due to lack of durability.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer highlighted that CLEERS provided data and strategies that are needed to model and evaluate advanced technologies for improving engine efficiency.

Reviewer 2:

The reviewer summarized that the studies further enabled aftertreatment for fuel-efficient powertrains.

Reviewer 3:

The reviewer confirmed that the work was very supportive of many industry aftertreatment needs. The person added that, if possible, it should start to address combined catalyst technologies to achieve super ultra-low emission vehicle (SULEV)-30 and U.S. Environmental Protection Agency (EPA) Tier standards.

Reviewer 4:

The reviewer said that PNNL contributions were absolutely directly linked to DOE's goal of reduced petroleum usage via the development of aftertreatment technologies for fuel-efficient engines. One concern this reviewer had was that LNT technology had not been a viable solution for lean aftertreatment for both LD and HD vehicles in the United States, so the scope on LNT needed to be modified to be more relevant to U.S. applications.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer reported that funding was probably sufficient, but noted that there were many projects. This reviewer wondered if there were adequate resources to make the required progress.

Reviewer 2:

According to this reviewer, it was explained that funding was delayed for this program.

Development of Advanced Particulate Filters: Kyeong Lee (Argonne National Laboratory) - ace024

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer voiced that the approach was good as it included engine experiments as well as numerical modeling.

Reviewer 2:

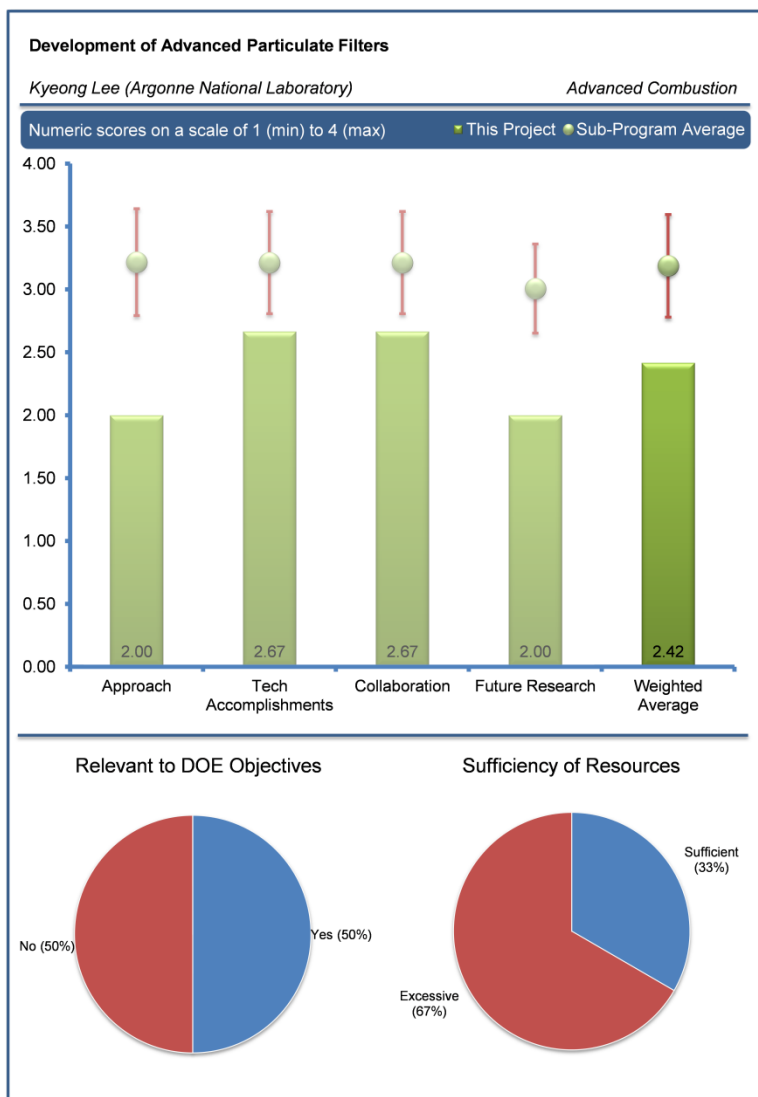
The reviewer stated that the research was proposed because of insufficient information about GDI particle emissions, filters and filter materials, and regeneration strategies. These were all excellent reasons for the research; however, there might be improvements possible in the approach for addressing each of these issues. For example, for GDI engines, there were many parameters that could be varied to generate larger or smaller amounts of soot (injection pressure, injection angle, injector spray, air- versus wall-guided spray, injection angle, EGR percentage, piston design, etc.). While the single engine sweep of injection angle did generate more and less PM, it was not clear that the results of this sweep would generate the only results that were valid for GDI particle size and chemistry. The approach should consider, at least peripherally, other reasonably varied parameters in engine control for variations in PM/soot formation to insure more broadly applicable results. The formation and regeneration of PM accumulations on a filter may also vary depending upon the underlying reason for the formation of PM material. The remainder of the approach was very good: to apply the filter in the correct location before or after the three-way catalyst, and to identify regeneration approaches such as fuel cutoff.

Reviewer 3:

The reviewer noted that the ANL group had unique capabilities in particulate-filter-related research, and the project team's expertise had been excellent. The PI mentioned that the gasoline particulate filter (GPF) needed to be designed differently; however, all of the project team's experiments were not different from what had been done for the previous DPF project. This reviewer opined that the project team has focused too much on fundamentals and morphology that were previously reported elsewhere.

Reviewer 4:

The reviewer commented that substantial instrumentation had been developed for this project. Apparently both an engine test cell and a laboratory test bench were available for this project, and integrating the results from both was a definite positive, especially since the flow from the dynamometer was routed through the test bench with filtration samples. This reviewer added that the work seemed to be a bit of a hodgepodge of techniques. Other than a focus on flow characteristics, there did not seem to be a unifying goal. It seemed as if this project was at least two years behind where the rest of the technology was headed.



Reviewer 5:

The reviewer remarked that very nice characterization and analysis equipment were available for soot filtration studies. However, this reviewer added that nothing had been shown on filtration efficiency, which was a key parameter for filter performance, especially for gasoline where there was no expected soot cake buildup. The first bullet on Slide 3 mentioned PM being a major problem for GDI. It was actually particle number that was the main problem. Particulates from GDI had been evaluated by many other groups. This reviewer concluded that the only element of the approach that was correct was the emphasis on lower backpressure, but not at the sacrifice of filtration efficiency, mechanical strength, etc.

Reviewer 6:

The reviewer pointed out that this was an extremely interesting and timely topic with a fantastic set of tools at hand. However, this reviewer believed that the approach being undertaken by this group was completely disorganized and uninformed. Therefore, a lot of effort was being expended in areas that would likely turn out to be dead ends. A more thoughtful approach to the project should have been undertaken. It currently seemed disorganized and was based on the PI's poor understanding of how GDI differed from diesel. For example, more work needed to be done on characterizing the GDI PM before the design of a GPF could be undertaken. It was clear that the PIs did not understand how the concentration (particle number density) and size differed between diesel and GDI. Also, the project team did not seem to understand the exhaust temperature differences between diesel and GDI. Most importantly in any filtration system, this reviewer strongly emphasized, filtration efficiencies must be measured. This was especially true since we know the soot cake to be the work horse for the filtration work in a DPF. And in a GDI, we know that there would not be enough PM in GDI exhaust to form a soot cake. Therefore, we would nearly always be in a clean filter regime and the filtration efficiency would be related to the substrate. Instead of parallelizing the entire project (certain parts could be done in parallel without going down blind alleys), this reviewer thought it would proceed better in a more linear fashion. The 2012 reviewer comments were not at all addressed, and the PI argued with (industrial) reviewers when they tried to explain that there was a misunderstanding regarding the GDI exhaust characterization.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the project was just getting started. Much of the equipment was installed and there was some initial analysis and data. The preliminary (DPF) data presented showed good activity; however, there was some concern about making analogies between DPFs and GPFs. This reviewer added that there was a good start on models for various filter configuration types.

Reviewer 2:

The reviewer pointed out that no actual GPF results had been presented yet, but an optimal filter design had been proposed based on experimental data findings of the virtual concept.

Reviewer 3:

The reviewer observed that particulates from gasoline engines had been known to be different from that of diesel engines, and the approach needed to be revised accordingly. The first thing that needed to be investigated would be how much gasoline particulates were different from those for diesel.

Reviewer 4:

According to this reviewer, there had been too many directions taken that were not relevant to GPF and were more applicable to DPF. Additionally, nothing had been done to lower the backpressure of GPFs, which had been a main objective.

Reviewer 5:

The reviewer criticized that most of what was shared in this presentation were discoveries by others that were already in the literature. This returned to the point that there was not a unifying discovery goal for this project.

Reviewer 6:

This reviewer expressed that, again, the rating in this category was related to the approach. No significant progress in any one area could be made when one parallelized efforts. It was clear that last year's reviewer comments had not been taken into account, and it became obvious during the questions that the PI was not even aware of them. Therefore, what progress had been made was not geared to be relevant to the DOE/industry needs. Again, the lack of understanding of the system they were designing for was problematic.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer explained that the collaborations included an OEM (Hyundai), supplier (Corning), and universities (UW, MIT, and Tokyo Institute of Technology).

Reviewer 2:

The reviewer indicated that an excellent mix of industry, university, and National Laboratory partners were identified during introduction, but that the presenter should have clearly communicated what roles each of the partners would have in the work.

Reviewer 3:

The reviewer reported that there was a solid range of partners on this project. However, it was extremely difficult from the presentation to know which partner contributed to what studies in each section of the presentation.

Reviewer 4:

The reviewer highlighted that there was industry involvement by Corning and Hyundai, but added that there was no indication that these collaborators were offering any research direction.

Reviewer 5:

The reviewer voiced that it was not clear how the substrate manufacturer would contribute to this program. The scope listed on the relevance and objectives focused more on soot and the filter regeneration; however, this work needed to lead on how to improve and develop better filters and higher filtration efficiency with lower backpressure.

Reviewer 6:

The reviewer stated that, while the project had good industry and university partners, the project apparently did not coordinate well with the partners that were participating in the work. As evidence, this reviewer noted that the project team had missed some very obvious important issues and did not seem to understand the system within which the project team was working.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that GPF systems still had technical questions to be resolved. Future evaluation of various filter models and characterization of PM emissions were very relevant and appropriate. This reviewer added that the emphasis should have been placed on GPF filtration efficiency, as the soot cake buildup for gasoline engines was much different (slower) than for that of diesel engines.

Reviewer 2:

The reviewer felt that there was a solid plan except that additional base GDI PM formation variables should have been included to insure that PM formulation had been thoroughly characterized.

Reviewer 3:

The reviewer recommended that the PI needed to look into the thermal signature of gasoline engine aftertreatment systems compared to those for diesel engines.

Reviewer 4:

The reviewer remarked that this group said that they were looking at GDI technology; however, it was clear that filtration was the crucial issue for GDI and that all this work was focused on regeneration. This was way behind the technology curve.

Reviewer 5:

The reviewer asked a series of questions about the project. The reviewer asked why the project developed filter models if the researchers did not understand or demonstrate basic concepts like filtration and what catalyst would be applied to GPF, and if a three-way-catalyst (TWC) chemistry was expected. The reviewer continued to ask why the project evaluated soot oxidation when GPF was not expected to build much soot loading and there was no close contact between the soot and catalyst and also why the project characterized the physical properties of GDI-engine PM further when many other groups were already doing so. The reviewer asked why the project evaluated soot cake formation via environmental scanning electron microscopy (ESEM) when no soot cake was expected on the GPF, and why the project modeled GPF regeneration when it was expected to be almost always passive. Lastly, the reviewer wanted to know why there was no future work planned on lowering the backpressure of GPFs, which was a main objective of the program as indicated in Slide 3.

Reviewer 6:

The reviewer remarked that it was clear that there were holes in this plan. Current and past reviewer and industrial guidance had been ignored to the detriment of the work.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer remarked that GPF enabled PM emission control from high-efficiency GDI engines.

Reviewer 2:

The reviewer commented that this was one of the very few GPF projects out of the VTO-funded projects, and it was very important to understand the challenges and to develop a better gasoline particulate technology for fuel-efficient advanced gasoline engines.

Reviewer 3:

The reviewer observed that GDI particulate formation and aftertreatment mechanisms were important, as GDI was an enabler of higher power density powertrains for downsizing engines. DI provided greater injection accuracy and improved thermal efficiency and fuel economy, but GDI had higher engine-out PM due to limited fuel mixing in the combustion chamber. This reviewer added that this could possibly lead to fuel enrichment around the spark plug, and combustion chamber wetting through reduced droplet evaporation. This, combined with the fact that gasoline particulate emission standards were being proposed in Europe and the United States (citing European emission limits [EURO 6] and U.S. emissions standards [Low Emission Vehicle (LEV) III]) along with industry pull to meet these standards demonstrated support of DOE objectives.

Reviewer 4:

The reviewer said that this work was potentially relevant but fell short due to misplaced priorities.

Reviewer 5:

The reviewer mentioned that the focus on GPF was very appropriate. The application of lean or dilute gasoline combustion would continue to dominate the LD transportation market, but the work was so far behind that it did not appear to be relevant.

Reviewer 6:

The reviewer criticized that there had been no discussion regarding how this research fit into the DOE objectives, nor were there discussions about how to make this work relevant at all were considered or addressed.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer expressed that there was good leverage of DOE VTO funding (citing a 50% cost share from an OEM and supplier).

Reviewer 2:

The reviewer emphasized that more funding and research in the area for GDI PM would be required, as there was no clear solution presenting itself near-term to meet Euro 6 and (California Air Resources Board [CARB]) LEV III PM proposed targets. All major OEMs would have interest in finding a cost-effective, reliable solution. This project was well-funded for its scope.

Reviewer 3:

The reviewer explained that the ANL team generated a lot of data and high-quality results but added that ANL was not well-focused, probably due to the large resources.

Reviewer 4:

The reviewer indicated excessive resources directed toward low-priority objectives.

Reviewer 5:

The reviewer reported poor payback. This work had been consistently reviewed low in the past and nothing seems to have changed. This reviewer did not understand why the project had been renewed in 2012, and added that just because there was industrial interest was not a justification for the project.

Reviewer 6:

According to this reviewer, the researchers had an amazing amount of tools at their disposal, which were completely misused. This reviewer recommended cancelling the project or moving it to another group with better potential for results.

Enhanced High Temperature Performance of NO_x Storage/Reduction (NSR) Materials: Chuck Peden (Pacific Northwest National Laboratory) - ace026

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the project currently targeted valid research needs (low-/high-temperature NO_x, modeling) and had followed standard methods for modeling, material selection, and deactivation (thermal, poisoning).

Reviewer 2:

The reviewer remarked that significant synthesis activity of materials occurred in this project. This reviewer added that it did highlight the conundrum of requiring a National Laboratory or academic institution to produce materials that might be a common process for one of the catalyst suppliers. This reviewer wished that closer collaboration could have been generated with the suppliers so that the National Laboratory could have focused on the instrumental and kinetics studies where the National Laboratory was the most expert.

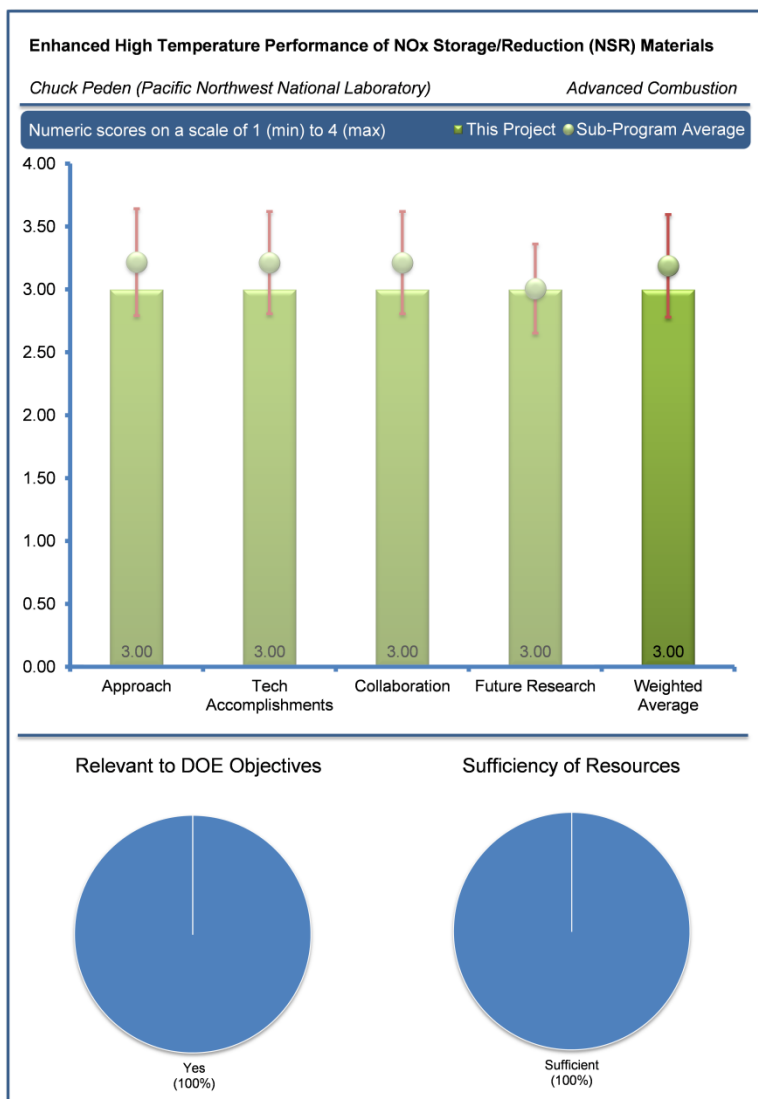
Reviewer 3:

The reviewer acknowledged a good use of CLEERS and industrial partnerships to solve relevant and timely problems. The integration with the industry and, now, two universities was helpful. This reviewer asked why the researchers used K in the NO_x trap material, as it was known to exchange with the substrate and weaken the structure. If there had been (bench-scale) studies on substrates instead of powder studies only, these effects would have likely already been noted. This reviewer further added that the Cu-CHA work for SCR was interesting, and that there was lots of room to continue working in.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer acknowledged that there was very good progress on LNT NO_x, as evidenced by multiple publications on performance. This person added that the low-temperature results were also good, considering the CLEERS-sponsored synthesis of CU zeolite catalysts, hydrothermal aging results, and the identification of solid-state ion exchange (for the addition of Cu to enable reproducible catalysts with varying Cu loading).



Reviewer 2:

The reviewer commented that the progress was very good.

Reviewer 3:

According to this reviewer, the investigation of the correct copper substitution approach was quite interesting.

Reviewer 4:

The reviewer pointed out that the group had identified solution ion exchange as not being optimal, and added that solid-state ion exchange generated more active catalysts.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer observed appropriate collaboration with an OEM and a supplier since this was a CRADA. Also, the project leveraged relevant information from CLEERS activities.

Reviewer 2:

The reviewer said that the CRADA collaboration with an OEM, supplier, and National Laboratory was a good equation, and added that the partnership results were still proprietary.

Reviewer 3:

The reviewer asserted that the new NSF-DOE project was quite exciting. This reviewer would have liked much more work on the zeolite characterization, which may come via Purdue University.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer affirmed that the proposed future research seemed appropriate as it built on recent findings.

Reviewer 2:

The reviewer indicated a well-contained scope of future work, with a targeted budget to focus on K-titanates and continued SAPO-34 work.

Reviewer 3:

The reviewer still had questions about the focus on high temperature (when the trends in exhaust temperature seemed to be going lower) as well as the use of the K component, which was likely to exhibit problems when one coated it on a cordierite substrate. This person added that there had still been no discussion of sulfur poisoning.

Reviewer 4:

The reviewer voiced that the evaluation of exchange, loading, performance, and aging of copper chabazites was appropriate for the industry. This person continued to be concerned by the thought that much of this had been examined in the supplier laboratories and was not publicly available. This reviewer thought that a more extensive analysis of the morphological character of the PNNL chabazites was warranted. The project team has had a long and storied history, and the comments in this work were reminiscent of studies done on other zeolites as many as 20 years previous. This reviewer was not sure that the focus on the potassium NO_x storage continued to be useful. With new generation exhaust temperatures dropping and LNTs going more and more into under-floor positions, it was not clear that the high-temperature functionality was such a crucial issue.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer voiced that SCR and LNT technologies were enablers for the use of lean combustion strategies, which provided significant potential to improve fuel consumption and displace petroleum.

Reviewer 2:

The reviewer stated that copper chabazites seemed to own the SCR technology right now. This work to a large degree fit into that direction.

Reviewer 3:

The reviewer noted that the low exhaust temperatures of future, more efficient engines would create major challenges for exhaust aftertreatment systems.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reported that there was no evidence that any projects were being delayed by funding issues.

Reviewer 2:

The reviewer reinforced that the resources seemed adequate as this was a 50% cost-shared CRADA with Cummins.

Reviewer 3:

According to this reviewer, the funding was reasonable for a scope of activities limited to base characterization and deactivation mechanisms.

Development of Optimal Catalyst Designs and Operating Strategies for Lean NO_x Reduction in Coupled LNT-SCR Systems: Michael Harold (University of Houston) - ace029

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the goal was non-urea passive NO_x reduction systems for lean aftertreatment systems, which was desired by the industry. Investigating combined LNT and SCR technologies to achieve high NO_x conversion was very relevant to OEMs that must also consider cost and packaging requirements for many vehicles. Investigating the role of HCs as a reductant, not only for NH₃ generation but as a source of reduction over the SCR as well, was an important topic and could help overcome the limitations of NO_x reduction and address HC slip in lean systems. This reviewer added that the use of reactor data to help model activity provided a good feedback mechanism for optimizing this approach.

Reviewer 2:

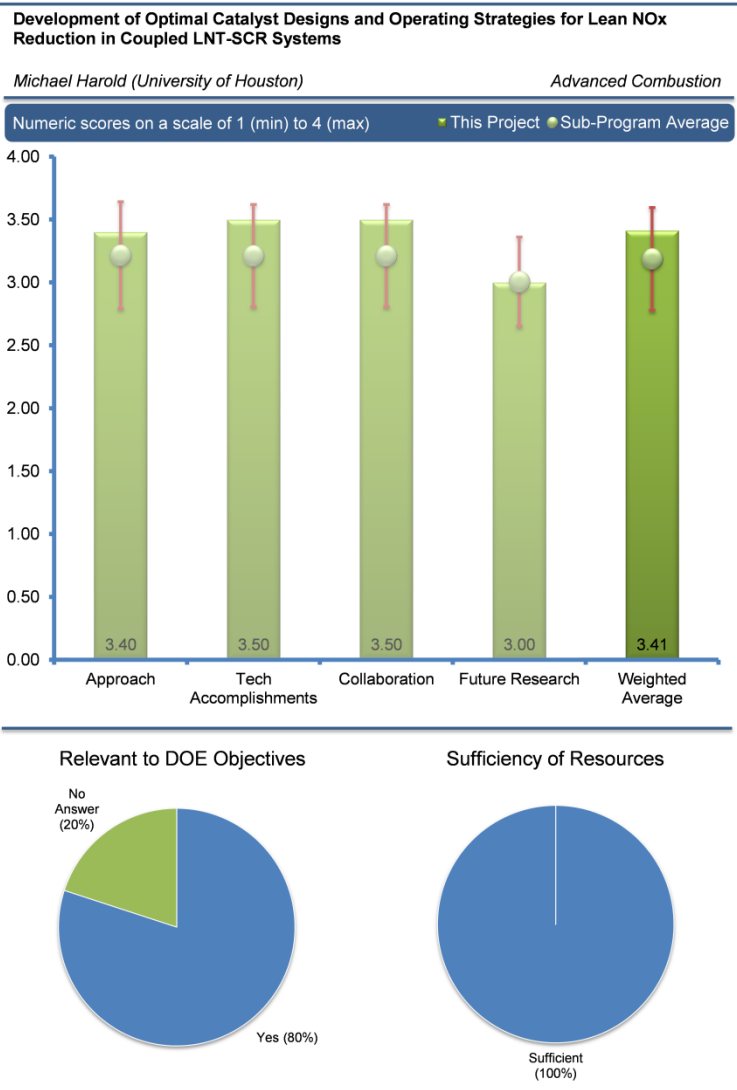
The reviewer noted a pragmatic approach to catalyst modeling that focused on computational methods that could be done in a reasonable timeframe.

Reviewer 3:

The reviewer remarked that this was the final year of the project and the approach was appropriate for completion of the remaining work.

Reviewer 4:

The reviewer pointed out that the University of Houston led this team effort. The approach that the project had taken was to combine experiments with modeling to lean and optimize the performance of LNT and SCR catalysts separately. Subsequently, the project had combined both the models to study and optimize the performance of various LNT-SCR configurations. The overall idea was to have a viable NO_x reduction aftertreatment system while reducing the precious metal content. The reviewer went on to say that the approach that these researchers had taken not only assured an optimized end product, but also provided insight into the chemical processes associated with catalysis to result in tractable modeling. The latter had long-term value. The reviewer added that it was advisable to integrate some sulfur-poisoning studies, as it could impede transformation of this technology into practice.



Reviewer 5:

The reviewer observed a great approach to the project goal of optimizing the performance in LNT/SCR systems, since LNT for this system was different than a stand-alone LNT. Diffusion issues in both catalysts were well taken care of and helped guide the approach. The project used data as the material to model and then used the models to suggest new experiments and reaction areas of interest. Although useful for studying the mechanism of the layered catalyst and the importance of diffusion, it would be difficult to put such a catalyst into production, unless there was diffusion of the metal species in the catalyst.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer pointed out that significant progress had been made in the accuracy of kinetic models.

Reviewer 2:

The reviewer observed a broad range of work covering SCR (both iron and Cu), LNTs, and LNT/SCRs, with very good modeling and characterization of each configuration.

Reviewer 3:

According to this reviewer, isocyanates shuttling back and forth from support to metal was important. Water was the most reactive species with cyanate to make ammonia. When water was not present, there was another mechanism. Showing the reaction of propylene with NO to form ammonia commented on other chemistries in lean conditions.

Reviewer 4:

This reviewer mentioned that, judging by the fact that two successful models could be developed for LNT and SCR and then integrated for the prediction of the LNT/SCR catalyst, significant progress had been achieved. While this was progress in the right direction, the reviewer added that prototyping and testing in practical systems was a few years away.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer asserted that this was a highly coordinated and collaborative project with multiple partners from the university, supplier, and industry realms. This was the right mixture of participants to help ensure the results were applicable to an end product.

Reviewer 2:

The reviewer expressed good collaboration among academia, industry, and National Laboratory researchers.

Reviewer 3:

The reviewer affirmed that the team working on this effort worked in concert while leveraging each other's capabilities and core strengths. However, this reviewer added that no reason had been given as to why the industrial partner Ford dropped out, and yet Ford's name was still being touted.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer emphasized that the scope of work identified before the completion of this project was very relevant and appropriate.

Reviewer 2:

The reviewer explained that this was the last year for the project, and added that an award had recently been received from DOE/NSF to continue some of this work.

Reviewer 3:

The reviewer indicated that this was the last year, so the work would be ending under this project. Still more characterization was needed to determine the benefits and challenges of layered LNT/SCR technology, especially for denitrogenization and desulfurization regenerations. This reviewer was not completely convinced that flow and temperature conditions over an FTP cycle were compatible with layered technologies.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that the technology pursued here could facilitate advanced combustion engine cycles that could potentially yield higher efficiencies. This would, as a result, lead to petroleum displacement.

Reviewer 2:

The reviewer noted very relevant work and support of effective lean aftertreatment applications toward achieving CARB LEV III and U.S. EPA Tier 3 emissions standards. This reviewer said that the investigators must also consider the effects of sulfur poisoning and desulfurization requirements in determining the viability of layered technologies.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer confirmed that this was a well-funded and productive project, and added that it was a very nice set of work.

Reviewer 2:

This reviewer noted that the project had received a no-cost extension for Year 4, noting that it was originally a three-year project.

Cummins/ORNL-FEERC CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines: Bill Partridge (Oak Ridge National Laboratory) - ace032

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the instrumental work in this project was very good, especially since the ammonia storage behavior is spatial in nature to a large degree. The reviewer noted that doing spatially resolved capillary inlet mass spectrometer system (SpaciMs) measurements allows kinetic development of the ammonia storage in an almost non integral behavior. Effectively fitting the kinetics as a function of position, it is as if the experiments are being done on a decreasing set of segments of catalysts. This approach was used previously on the similar kinetic effects of a diesel oxidation catalyst (DOC) catalyst, which has no significant storage. The reviewer concluded that doing the kinetic analysis spatially on a LNT catalyst allows a much better description of the kinetic interaction between storage and direct surface kinetics.

Reviewer 2:

The reviewer observed a very good and comprehensive approach, which covered a broad spectrum of real world challenges.

Reviewer 3:

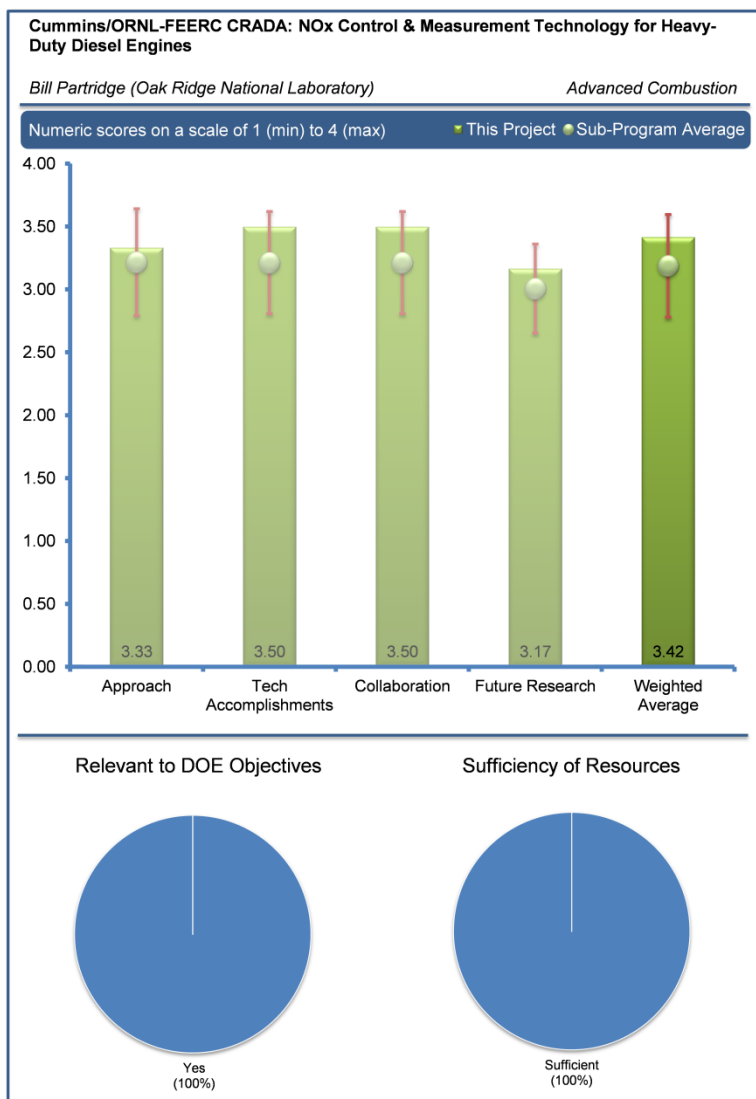
The reviewer noted that the strong collaboration with the industry partner keeps the work sharply focused on the technical barriers most impacting industry. This reviewer acknowledged excellent techniques and tools available at ORNL and pointed out that the PI was particularly talented in developing instrumentation. This reviewer felt that the combination of laboratory and field studies makes this project very strong and noted a really sharp approach.

Reviewer 4:

This reviewer stated that characterizing the nature of catalysts was well-laid out in the approach.

Reviewer 5:

The reviewer stated that characterizing catalysts with the intent of gaining insight on how to control and diagnose activity is an important on-board diagnosis (OBD) topic that is required by the EPA. This is OBD-related research, which is necessary for future emission control systems for lean applications. The reviewer said that focusing on ammonia (NH₃) storage dynamics as a function of catalyst length and temperature may be the basis of a good monitor system. The reviewer added that it was critical to know this to



diagnose catalyst health and utilization. The reviewer felt that some of the NH_3 has been performed already by others in terms of NH_3 storage as a function of temperature, but not the dynamic capacity.

Reviewer 6:

The reviewer would like to see more catalyst aging up front.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that good progress was made on associating NH_3 storage and gas phase concentration over the length of the catalyst to provide a way to measure the NO_x activity of a SCR and how well the SCR volume was being utilized. The reviewer noted that using SpaciMS/Fourier Transform Infrared Spectroscopy (FTIR) techniques for mapping concentration as a function of SCR length was a very good tool for characterization and should be employed more. The reviewer concluded that the project provides a tool to monitor catalyst activity for OBD and control.

Reviewer 2:

The reviewer stated that the project team accomplished a good correlation between SCR kinetic models and experimental data associating with a function of NH_3 storage. The project team's unique SpaciMS tool seemed to be mature and fine-tuned for better interpretations.

Reviewer 3:

The reviewer explained that there was a nice comparison of the kinetic behavior between a beta zeolite and a new generation chabazite. The reviewer added that it seemed fairly clear that the kinetic mechanism for the two different zeolites were quite similar and may differ primarily between the density of active sites.

Reviewer 4:

The reviewer expressed that good progress has been made to date towards the project goals.

Reviewer 5:

The reviewer mentioned good leverage of ORNL analytical tools to better understand a commercial SCR catalyst.

Reviewer 6:

The reviewer stated that more work on catalyst aging would be really nice.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that clearly significant work was done at the Olsson group in addition to ORNL. That was strong evidence of good collaboration. The reviewer remarked that since Cummins was a major partner in this CRADA that the voice of the industry was being heard. The reviewer applauded the number of visiting scientists on this project and pointed out that that was great collaboration.

Reviewer 2:

The reviewer indicated excellent collaborations with industry and universities and international partners. Good participation in CLEERS, DEER, etc.

Reviewer 3:

The reviewer noted a very good collaboration portfolio; however, not much results from the collaboration partner especially from universities.

Reviewer 4:

The reviewer indicated that there was narrow formal collaboration, but broad informal collaboration to better characterize SCR NH_3 activity and to develop a Cu sensor for detecting NH_3 .

Reviewer 5:

The reviewer stated that in addition to CRADA collaboration, this project also involves several universities (domestic and international) and provides data and findings for CLEERS.

Reviewer 6:

The reviewer stated that Cummins is clearly an equal partner. Additional informal collaborations enhance the overall program.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the 2013 plans are a clear continuation of the good work. There is nothing revolutionary. The reviewer felt that the work is primarily evolutionary and that 2014 plans in the presentation are pretty bland.

Reviewer 2:

The reviewer would like to see more defined future work to characterize NH_3 utilization of SCR catalysts as a tool for OBD.

Reviewer 3:

The reviewer noted that the proposed future experiments and modeling seemed appropriate.

Reviewer 4:

Although only verbally mentioned, more work on how aging affects the correlation between SCR efficiency and NH_3 storage was recommended by this reviewer.

Reviewer 5:

The reviewer noted that the incorporation of laboratory and field aged catalysts was critical to understanding the real behavior on the road.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that this was effectively industry support and the industry is very good at that. Industry support ultimately improves fuel economy.

Reviewer 2:

The reviewer stated that OBD strategies are a required essential component of lean aftertreatment systems to meet CARB LEV III emissions. Any method should be cost-effective and practical as well. The reviewer concluded that this work provides a possible way to perform this function.

Reviewer 3:

The reviewer noted that this work increases catalyst knowledge which reduces catalyst costs, enabling higher efficiency engines.

Reviewer 4:

The reviewer indicated that the ORNL team's unique SpaciMS expertise has helped in many applications related to meet DOE's objectives.

Reviewer 5:

The reviewer expressed that better understanding of lean aftertreatment systems supports higher fuel efficiency.

Reviewer 6:

The reviewer stated that improving the catalyst allows the combustion efficiency to shift in a positive direction.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources seemed sufficient.

Reviewer 2:

The reviewer stated that resources appeared to be sufficient to accomplish future work.

Reviewer 3:

The reviewer indicated that the funding level seemed appropriate for this work.

Reviewer 4:

The reviewer noted a very well-defined scope for the provided resources.

Emissions Control for Lean Gasoline Engines: Jim Parks (Oak Ridge National Laboratory) - ace033

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the area of research that is the focus of this work is very important for lean gasoline and diesel aftertreatment systems. Targeting Tier 2 Bin 2 emissions by testing various TWC/SCR/LNT configurations using only passive approach is an important and challenging area of research and development for OEMs. The reviewer noted that using both bench and engine testing is a good approach, but should try to draw a better correlation between the two. The reviewer added that including a catalyst supplier in this work is highly desirable to make sure the newest technologies are characterized.

Reviewer 2:

The reviewer indicated a comprehensive approach to enabling Tier 2 Bin 2 emissions compliance of high efficiency lean gasoline engine vehicles.

Reviewer 3:

The reviewer noted that this project has a well-balanced approach between the reactor and dyno work, and no one else can do both in-house as the ORNL team does. Also, the team scoped a wide variety of aftertreatment architectures that would enable the tight U.S. emission regulation such as Tier 2 Bin 2.

Reviewer 4:

The reviewer felt that the engine and laboratory bench studies are complementary to each other.

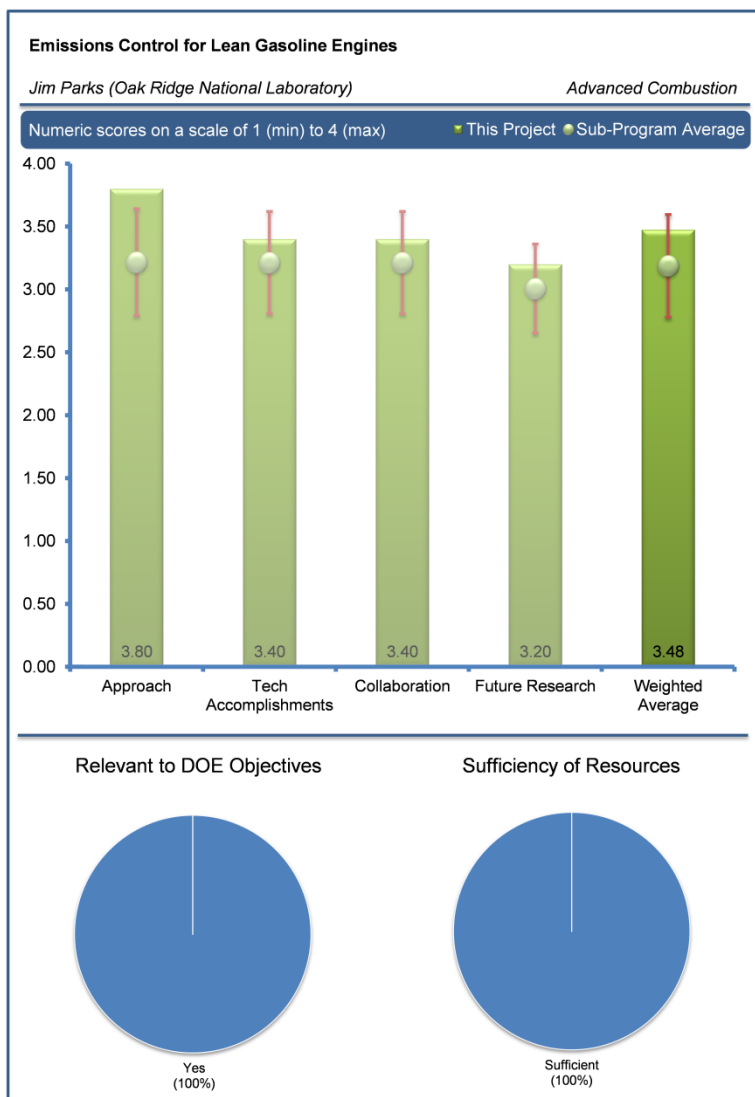
Reviewer 5:

The reviewer commented that the project was sharply focused on the technical barriers (aftertreatment) to lean gasoline combustion, which if solved, could lead to significant reductions in petroleum use, which is in line with DOE goals.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that there was a good approach. The project relies on more current technologies, but no aging effects of the system operating at different operating points. Investigations at a system architectural level should include FTP testing and aging effects to



ensure an accurate assessment of system performance and a better estimate of the fuel penalty associated with passive NSC and SCR technologies. The reviewer felt that at some point PM should also be included because of its regulatory requirement.

Reviewer 2:

The reviewer observed a tunable ammonia generator for passive SCR and noted that TWC was shown to be effective. A rich air fuel ratio is needed for ammonia generation.

Reviewer 3:

The reviewer observed that the laboratory-scale results demonstrated more than 99% NO_x conversion without using urea; TWC produced NH₃ was stored in SCR and was able to reduce engine out NO_x during the lean operation. The project team also investigated the NH₃ production efficiency under various catalyst technologies. The Drivven-based controller seems to have provided a full control capability for the BMW lean-gasoline engine in the ORNL dyno.

Reviewer 4:

The reviewer stated that there was great bench data so far and was looking forward to results from the engine.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed very good collaboration and cooperation to achieve meaningful initial results. Having input from industry OEMs and suppliers is a significant element for deriving relevant information. The reviewer noted that the use of leading catalyst formulations is also important. However, the combined catalyst technologies may also be an important element of future systems to achieve SULEV standards.

Reviewer 2:

The reviewer stated that there was very well-coordinated interaction with OEMs, a catalyst supplier, and universities.

Reviewer 3:

The reviewer indicated that the proactive approach of ORNL with OEMs was good, but it was not clear how effective this approach has been.

Reviewer 4:

The reviewer observed that the project was sharing data and findings with all three domestic light-duty OEMs, a catalyst supplier, several universities, and CLEERS.

Reviewer 5:

The reviewer said it would be nice to see collaboration with (university) partner for catalyst characterization. The reviewer also suggested adding a university partner for the PM work (in collaboration with PNNL).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked looking forward to data from the engine platform and comparison to bench studies.

Reviewer 2:

The reviewer stated that the project must look at aging and poisoning effects. Also, the reviewer added, to include challenging FTP cycle points in testing and optimal regeneration strategies for DeNO_x and DeSO_x events to minimize the fuel penalty associated with passive lean systems.

Reviewer 3:

The reviewer noted that consideration should be given to a different metric for measuring reduction in aftertreatment cost since Pt-equivalent loading does not account for potential addition of SCR.

Reviewer 4:

The reviewer expressed that dyno work will need more sophisticated control capability; it may be too early to judge how far the Driven can do. The OSC effect along with aging condition for NH₃ generation will need to be investigated. The reviewer also stated that ORNL has all the capabilities to investigate how aging would impact the passive SCR system; however, that the aging related study is not well-explained.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that there was very relevant work that can help characterize lean aftertreatment systems and which will enable more fuel efficient GDI and diesel engine strategies.

Reviewer 2:

The reviewer remarked that cost-effective and durable emission control systems are enablers for use of high efficiency engines.

Reviewer 3:

The reviewer noted that for LD applications, improving fuel efficiency in gasoline vehicles via lean combustion is so critical to meet DOE's near term objectives; however the lean aftertreatment has always been one of the biggest hurdles; therefore this project will help in developing the game changing aftertreatment technology that harmonizes the effort on advanced fuel efficient combustion.

Reviewer 4:

The reviewer indicated that enabling lean gasoline penetration into the U.S. market, with new lean, low-cost aftertreatment would allow for a significant efficiency improvement and impact petroleum usage.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that funding appeared to be sufficient.

Reviewer 2:

The reviewer indicated that there was an appropriate increase in funding for the second year of the project.

Reviewer 3:

The reviewer described project resources as well-balanced and sufficient.

Advanced Collaborative Emissions Study (ACES): Dan Greenbaum (Health Effects Institute) - ace044

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the development of appropriate test cycles with the industry and other stakeholders is well done. Careful characterization of potentially harmful emissions has been outlined in a consistent and repeatable way. The project discussed in review the possibility to consider real world variability in emissions/regeneration cycles which can potentially be significantly worse than a standard test protocol. The reviewer noted that although the study is aimed to evaluate the regulatory levels of criteria pollutants on health, the application of real world measured data corrections /estimates for real world degradation factors would add value.

Reviewer 2:

The reviewer noted a very comprehensive approach, including a vast array of stakeholders.

Reviewer 3:

The reviewer stated that the main focus on heavy duty diesel reflected the higher diesel fuel usage by that segment versus medium or light duty diesel. It is important to understand the health effects, if any, of new aftertreatment applied to heavy duty diesels.

Reviewer 4:

The reviewer said that it seemed fairly clear that improvements in aftertreatment have made appreciable improvements the detrimental effects of diesel emissions.

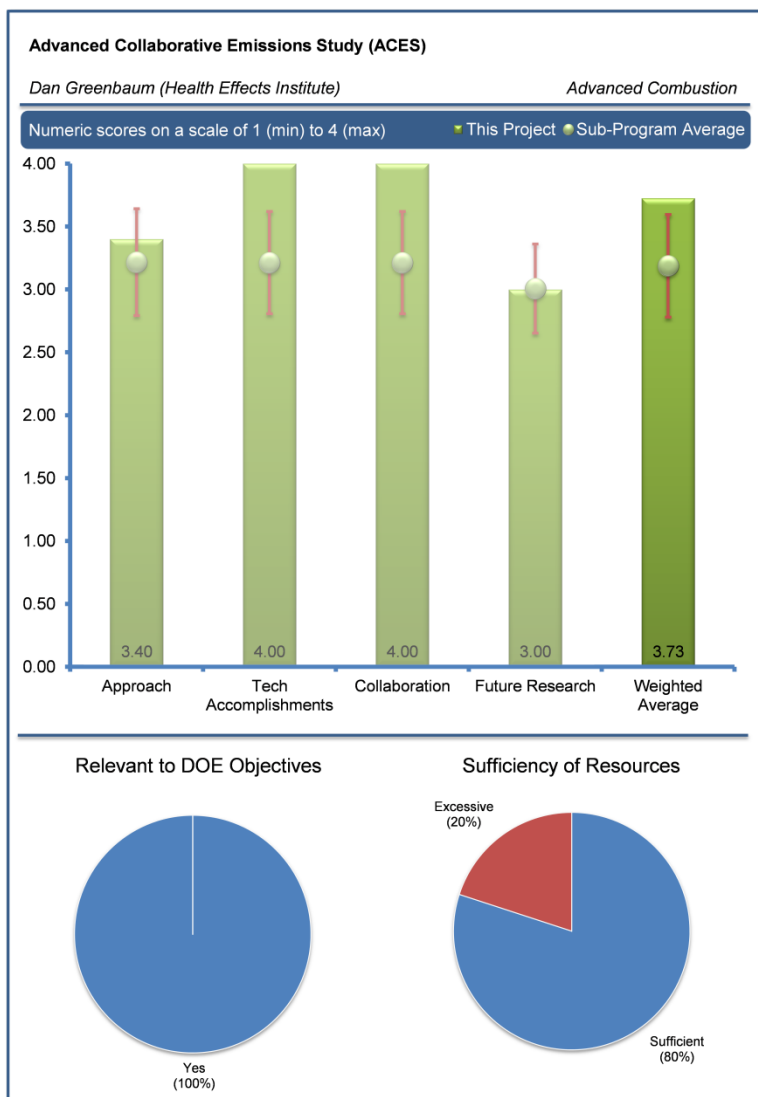
Reviewer 5:

The reviewer noted the following: heavy duty diesel based, worthwhile work with contributions from many partners (industry, DOE), heavily-funded, looking specifically at diesel emissions effects on cancer rates, and diesel has a bad image. The reviewer asked what about gasoline (lean GDI) with particulate matter and what about light duty diesel effects.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer remarked that engine studies found that emissions were well below standard. The project focused on regeneration and cold start. The reviewer noted it would have been nice to have a final Phase 2 report prior to the meeting. The reviewer added that



there was a very broad range of species and experiments to determine if PM, NO_x or other exhaust component should be considered a human toxin. The reviewer commented that engine testing was very well-thought out to keep an even comparison and noted that there was important insight and conclusions with respect to NO₂ and PM toxicity that should be considered by regulatory agencies in their policies.

Reviewer 2:

The reviewer stated that this work has made it clear that present day diesel aftertreatment should no longer be viewed as a carcinogen.

Reviewer 3:

The reviewer indicated that the project was interesting and had important findings that validated early assumptions.

Reviewer 4:

The reviewer stated that it was wonderful that the results showed little or no health effects. NO₂ effects were observed from 2007 engines. The reviewer indicated that NO₂ production is typical of a passively regenerated filter system. SCR downstream will reduce the amount of NO₂ emitted out the tailpipe for 2010+ engines.

Reviewer 5:

The reviewer commented that the project had a defined test schedule, identified emission results, conducted animal testing, and concluded no significant risk to human health (extrapolated from rodent studies) with 2007 emission levels.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated that the excellent list of university, industry and government laboratory collaborations with names shows significant credibility.

Reviewer 2:

The reviewer felt that the project was well-coordinated with very good collaborations through organizations and OEMs.

Reviewer 3:

The reviewer indicated that there was successful collaboration between Coordinating Research Council (CRC), Lovelace Respiratory Research Institute (LRRI), DOE, and EPA, as well as the advisory board.

Reviewer 4:

The reviewer indicated that there was very good collaboration with industry, university, and government agencies.

Reviewer 5:

The reviewer noted that this was an industry wide accepted standard.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the project team was sharing the results with the industry and the regulating bodies. That was the optimum need.

Reviewer 2:

The reviewer noted that the project was coming to a conclusion. Most of the work had been completed.

Reviewer 3:

The reviewer indicated that almost all of the testing has been completed. The future work of test data analysis and publication of results is very important.

Reviewer 4:

The reviewer wanted a budget to look at health effects of medium-duty diesels where the duty cycle and aftertreatment were different.

Reviewer 5:

The reviewer stated that although the results showed the regulatory approach was sound for public health, there should be the possibility to consider real world variability in emissions/regeneration cycles which can potentially be significantly worse than a standard test protocol. An understanding of real world measured in use data or at least estimates for real world degradation and subsequent consideration relative to animal studies can confirm real world health risk expectations.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer noted that evaluating the impact of increasingly sophisticated aftertreatment on health assists in determining the level of sophistication of aftertreatment that is necessary for a healthy environment. Since aftertreatment comes with a fuel economy tradeoff, this work helps to indicate where the tradeoffs occur.

Reviewer 2:

The reviewer stated that health effects are an important aspect to emission control technologies. Diesel image has been poor due to PM in the past. The reviewer indicated that this work supports the industry position that diesel engines are not the source of significant human toxins. There was very helpful information for regulatory agencies in developing their diesel policies and provides a pathway for greater acceptance of diesel engines into the automotive market to achieve increasingly difficult fleet cafe standards.

Reviewer 3:

The reviewer stated that this project indirectly supports the petroleum displacement by examining the emissions of new commercial technology engines and their health impacts.

Reviewer 4:

The reviewer stated that lower emission standards continue to be pursued in a regulatory environment and can constrain the fuel economy possibilities for combustion engines. It is important that there is justification for these standards in terms of public health and the environment. The reviewer indicated that this study provides evidence for this decision making. By understanding levels of exposure versus the risk of health issues, regulators and the industry can make effective choices balancing public health, the environment, and the methods to achieve fuel efficiency.

Reviewer 5:

The reviewer concluded that the project team studied the health effects of aftertreatment on highly efficient diesel engines.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer described the project as expensive, but very needed.

Reviewer 2:

The reviewer indicated that there was more than sufficient funding due to the relevance of this work to OEMs; well-placed funds.

Thermoelectric HVAC and Thermal Comfort Enablers for Light-Duty Vehicle Applications: Clay Maranville (Ford Motor Company) - ace047

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this project has been very well-designed. All the engineering details have been addressed, and the feasibility of employing thermoelectric (TE) heating ventilating and air conditioning (HVAC) system in vehicles have been demonstrated.

Reviewer 2:

The reviewer reported that the project proceeded by using a methodical approach that involves system-level modeling, materials development and fabrication, bench scale and vehicle testing, and an economic study. Additionally, the reviewer opined that the zonal approach for climate control was interesting, nothing that it has been in progress for several years now.

Reviewer 3:

The reviewer noted that four barriers were presented and that there appeared to be an overall effective approach to overcoming them. There was an abundance of modeling and simulation resources devoted to this effort, which is critical for most of these barriers. The reviewer felt that the presentation appeared to present a logical method for both the packaging and the scale-up barriers presented. The cost barrier is a particularly difficult barrier in that a balance remains most of the time between cost and performance. The reviewer stated that there should be some further effort in order to ensure that cost targets are met. The reviewer stated that durability is the other barrier that was not fully focused upon. There appears to be some work done in the future of the effort on durability, but at the present time, there was not a lot of focus on this barrier.

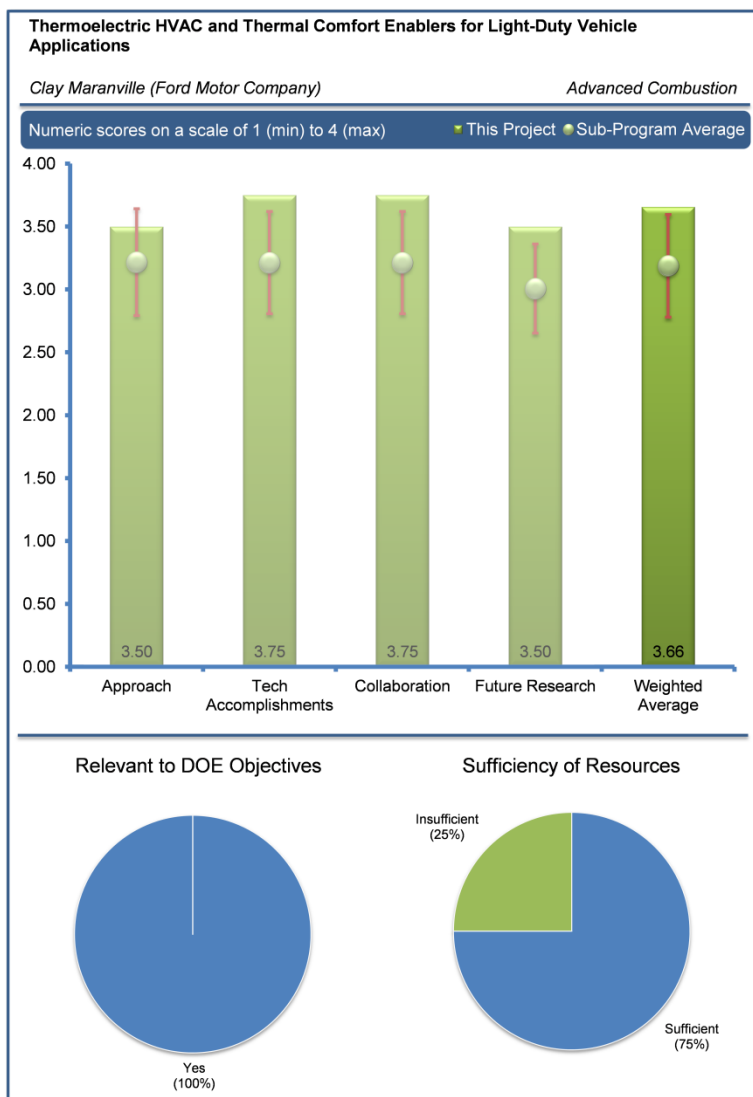
Reviewer 4:

Maranville clearly laid out the issues, and explained the approaches that Ford was taking to address those. The project team has partnered with valuable collaborators. It is a good mix of materials-devices-systems-analysis.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the approach includes a range of activities that cover a lot of bases, and is reasonable. The relevance of TE for automotive is cast in terms of fuel economy or efficiency. The reviewer indicated that the results were presented for the most part in



terms of coefficient of performance COP. In the future, it would be helpful to present the results in those terms as they will be most relevant to DOE's interests and its ability to sustain funding in this area.

Reviewer 2:

The reviewer stated that while nearing completion of the project, there still seemed to be quite a bit of work that still needs to be completed before the end of the period of performance. With the delay that was mentioned, there may need to be resources diverted from other portions of the project, increasing the risk of not overcoming all of the barriers. The reviewer reported confusion with discussing the target in terms of a 30% reduction in fuel and then only using COP for measurements during the presentation was a little discontinuous.

Reviewer 3:

The reviewer indicated that the Ohio State (porous materials) results were somewhat disappointing, but that is what university-level research is all about. The Ohio State collaborator is at the leading edge of credible research, and the reviewer had no doubts that there would be value and contributions. The reviewer added that the other collaborators have had excellent progress.

Reviewer 4:

The reviewer noted that the HVAC related tasks were carried out and completed with very good results. The Ohio State University (OSU)/ZT-plus effort on porous materials seemed to be not as well-planned. The basis for porous materials to have better ZT than dense materials was not very strong. The reviewer explained that usually the power factor loss due to high electrical resistivity can be compensated by lower thermal conductivity; but the improvement in ZT has not been shown to be significant. The reviewer indicated that it was a good indication of proper project management to terminate the effort when the potential of porous materials was not confirmed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that there was a good range of academic and industrial partners.

Reviewer 2:

The reviewer noted that there appeared to be a sufficient amount of partnership in this effort. Each partner had a specific function; even though some of the Ohio State information was not used as part of the project, it was useful information to know what was out of the scope based on test results.

Reviewer 3:

The reviewer stated that Ford's team was at the cutting edge of their respective fields and felt that this was excellent.

Reviewer 4:

The reviewer reported that this project assembled a strong team. Ford has been very successful in coordinating the research efforts among various partners.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that wind tunnel tests were mentioned but it was unclear precisely what would be obtained from them. The reviewer indicated that more details would have been appreciated. It was stated that at the end, or near the end, of the project an assessment will be made on more conventional metrics of performance (i.e., fuel economy improvement based on TE). The reviewer felt it would be preferable to engage in such projections during the period of funding (and not the end of the project) because (for better or worse) fuel economy is the benchmark that is understood by a wider audience.

Reviewer 2:

The reviewer offered that it would be helpful to show at least progress on the cost portion, as this could potentially be one of the more critical barriers to overcome, and there is only a report at the end of the study. Overall, the plan is well-laid out and has the required output mechanisms to show comparison against the barriers. The reviewer noted that there seems to be a number of steps still in need of completion before August.

Reviewer 3:

The reviewer observed that the project is on track to be complete by 2013. The completed and remaining milestones have shown that the team will achieve the original goal of assessing the feasibility of TE-based HVAC system in vehicles.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer indicated that this project was obviously very relevant. It was unclear if the ultimate outcome would be a car on the market with Thermoelectric Generators (TEGs) that could have a significant impact on fuel economy. The reviewer noted that perhaps the project team will be successful, though the presentation was not clear on that forecast.

Reviewer 2:

The reviewer stated that thermoelectric technology was a beneficial technology which in this case was taking a significant load off of the primary HVAC system and using a zonal approach to cabin cooling. The target of 30% reduction in fuel use for the system is a direct correlation to the goal of DOE objectives.

Reviewer 3:

The reviewer mentioned going a step further and acknowledged that Ford uses the profitability metric, meaning that Ford will work to field a system that can be profitable. If Ford succeeds, then everyone will win. If something is not profitable, then it will not go into cars.

Reviewer 4:

The reviewer stated that improving the efficiency of the HVAC system is part of the solution for petroleum displacement. This project has shown that the thermoelectric system is a viable alternative.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that given the large team, the resources are about what one would expect for a major automotive manufacturer developing a new technology for the market.

Reviewer 2:

The reviewer stated that there seemed to be sufficient resources. Again, there is a risk from a schedule perspective with the identified slip already in the schedule with minimal months remaining in the project.

Reviewer 3:

The reviewer stated that the project team could use a plus-up.

Reviewer 4:

The reviewer noted that the team has shown sufficient use of resources to achieve program goals.

Energy Efficient HVAC System for Distributed Cooling/Heating with Thermoelectric Devices: Jeffrey Bozeman (General Motors) - ace048

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that this project is focusing on the engineering design and testing of automotive HVAC devices to achieve a targeted COP. The team has made significant progress and is on track to complete the project by Spring of 2014.

Reviewer 2:

The reviewer found this talk to have good results, but noted that in an overall sense it was somewhat disconnected and inconsistent. The reviewer criticized that the focus is on cooling systems, yet the materials research was a summary of the power-generation work, and the supporting theory was focused on lead-telluride, which is not a material in either the cooling or the power generation.

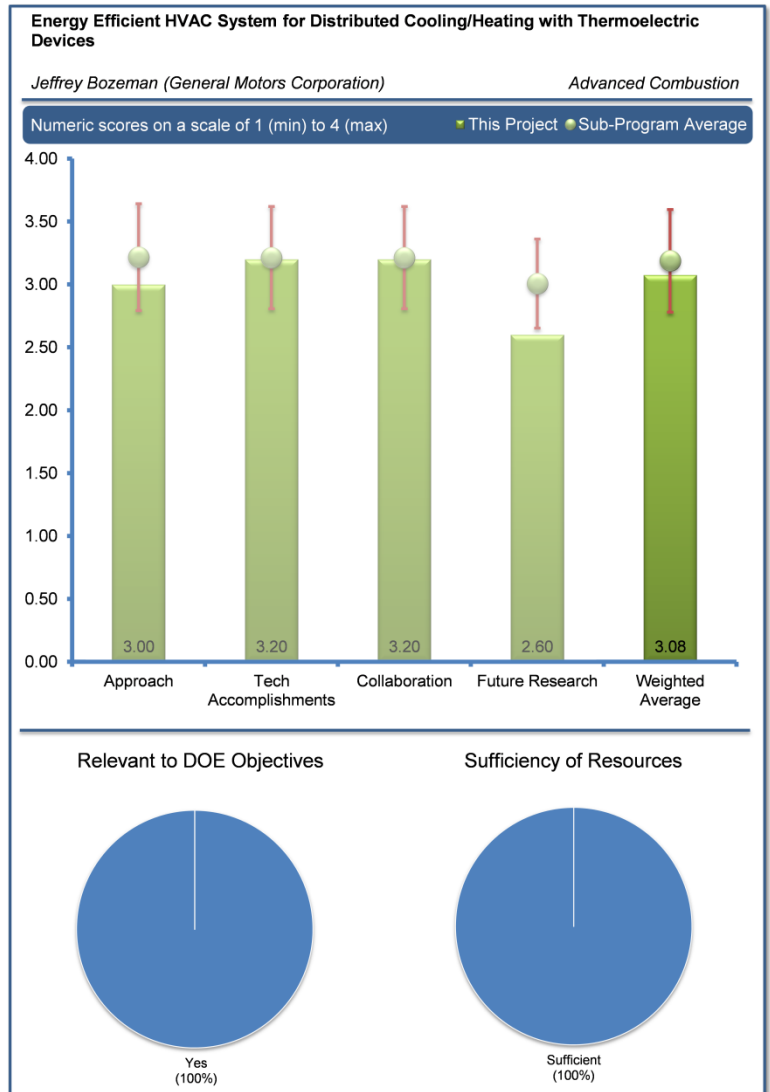
The reviewer emphasized that not all three were irrelevant and there is overlap, but recommended to re-focus the theory component to work on either better cooling materials, or to a systems thermodynamics analysis. The reviewer also suggested the researchers devote some of the materials work towards better cooling materials, better device integration or something. All of the topics were done well, but the reviewer felt there was not a glue or an overall goal that tied everything together.

Reviewer 3:

The reviewer stated that the project is organized around a range of tasks that include thermal comfort, HVAC prototype development and developing new TEG material systems. It was hard at times to understand how the individual parts of the project fit together as a directed effort to achieve an overall goal. The reviewer felt that future work should endeavor to communicate a greater degree of synergy of the components, perhaps with some sort of a flow chart that feeds into a grand target goal. Then, the presentation could speak to the individual elements. The reviewer noted that, as it stands, the presentation seemed like a communication of unrelated elements. Also, the connection with Ford's effort (and vice versa) would help.

Reviewer 4:

The reviewer stated that although the overall approach was discussed, the presentation did not address critical air conditioning (A/C) design criteria, particularly fast cool-down from hot interior cabin environments. The current thermoelectric (TE) HVAC system design cannot handle the fast cool-down transient requirements; consequently, the system design actually appears to keep the original A/C system and integrates the TE HVAC system with it to handle steady-state conditions (as explained by the presenter). The reviewer added that this creates an element of complexity that was not immediately clear in the presentation or the approach. The



focus on WHR integration also adds an element of complexity and it is not clear that the power generated from any WHR system would be enough to power the TE HVAC system. The reviewer indicated that there was no discussion of synchronizing the power generation from WHR with the power demands from the air conditioning system. This could require energy storage in some operational scenarios/conditions and this does not appear or is discussed as part of the Technical Approach. Without a well-thought out integration plan there is no reason to be doing TE materials research on WHR materials in a program designed and advertised as a TE HVAC program.

Reviewer 5:

The reviewer noted three goals/targets to performing the work (i.e., reliability, COP, and energy reduction). While initial test results showed a solid approach to meeting, if not exceeding, both COP and energy reduction targets, it still needs to be completed in a vehicle with the final design. The reviewer criticized the project for not integrating cooling in the front passenger seat. The reviewer suggested that the project should use a similar technology that indicates that a passenger needs to buckle their safety belt in order to activate cooling in the zone. It did not appear that there was enough focus on the reliability aspect of the project barrier. The reviewer stated that while it was beneficial to show performance measures, it was also important to show repeatability when identifying reliability as one of the targets. The reviewer was not sure if this barrier would be achieved with the present project plan.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the overall approach appeared to be well-thought out. Much of the work seemed to be directed toward climate control strategies.

Reviewer 2:

The reviewer indicated that significant progress has been made toward two of the target barriers. With only the virtual environment with specified test conditions, a measured savings of 29.5% versus the 30% goal was promising; also the COP of 1.4 for cooling and 2.4 for heating both exceeded the performance targets of 1.3 and 2.3 respectively. The reviewer warned, however, that based on the limited number of devices being developed, it may be difficult to conduct enough tests in order to meet the reliability concern target. There did not appear to be a clear path forward in order to meet that barrier.

Reviewer 3:

The reviewer stated that this project has been very well-designed and executed toward program objectives. The study using Volt is an excellent example of utilizing the unique advantages of both heating and cooling functions of TE devices. The reviewer indicated that the results have shown the HVAC devices meeting the DOE program target.

Reviewer 4:

The reviewer observed good results in each of the separate, disconnected focus areas. The reviewer added that to keep up the good work was in order, but the effort should be re-adjusted to succeed on the one area for which the project receives funding (i.e., cooling systems).

Reviewer 5:

The reviewer felt that this presentation left out key pieces of information (e.g., air inlet temperatures and coolant temperatures were not specified for the COP greater than 1.4 claim). There was no discussion on how TE design optimization was integrated with thermal design optimization to achieve COP and cooling capacity requirements. The reviewer stated that the unity cooling design was effective. Integration of the VC system with the TE HVAC system was effective in handling all varied requirements, but it was a complex, brute-force approach. There also was no discussion of the heat exchanger design approach, heat exchanger sizing, or design optimization to produce compact, lightweight systems that can fit within headliners and door pillars. The reviewer indicated that it was not clear what progress had been made and what challenges remained in this part of the system design. The reviewer asked if this team could really remove the necessary heat transfer at the required heat fluxes with low pressure drops, low fan powers, and low noise

levels. The reviewer noted that this presentation did not discuss any of these important system design aspects, nor the integration with the TE cooling system design. It was therefore difficult to judge and evaluate the progress in this particular design area.

The reviewer stated that the human comfort modeling was strong and effective in helping to meet requirements.

The reviewer indicated that WHR materials performance was too low to be effective in meeting DOE goals for power generation to operate the TE HVAC system. There was no discussion of integration of the WHR power generation performance with the power requirements of the TE HVAC system. The reviewer offered that this team needed to discuss and consider integration of the TE waste heat power output and synchronize the TE power output to the TE power input for the TE HVAC system. This will likely require energy storage to properly integrate these two sub-systems, but there was no discussion of this in the presentation. The reviewer then asked how the team was going to accomplish that integration. The reviewer felt that without a well-thought out integration plan there was no reason to be doing TE materials research on WHR materials in a program designed and advertised as a TE HVAC program.

The reviewer reported that this team did claim that there was progress on a control strategy for the TE components, but there was little or no specific information or discussions of this in the presentation. It was therefore difficult to evaluate the progress in this area.

The reviewer also criticized that in some cases, the presentation chart was so poorly done that one could not even read the text, labeling and language on the Figures (e.g., Slide 7). It was therefore not possible to evaluate this work and the system design message being portrayed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the team was large and covered a lot of expertise. Not much was discussed on how the partner objectives were related.

Reviewer 2:

The reviewer remarked that there was a good team, but the results and accomplishments so far were not clear or impressive.

Reviewer 3:

The reviewer stated that it appeared there was well-qualified collaboration with partners that would allow the breadth of knowledge needed in order to successfully complete the project. The interdependency shown between the collaborators was encouraging on coordination.

Reviewer 4:

The reviewer observed good collaborations.

Reviewer 5:

The reviewer noted that the project team was well managed. It was not very clear that the University of Nevada-Las Vegas (UNLV) effort was directly related to HVAC or the waste recovery. The materials the project team investigated, PbTe and Cu_{2-x}Se , did not appear to be the selected materials for HVAC and waste recovery.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the lack of a fuel efficiency target should be addressed in future work. DOE projects upwards of a 5% improvement. The reviewer noted to commercialize the design of new components (i.e., enhance imperative tradeoff and consider configuration in mainstream, hybrid, and EV applications).

The reviewer stated that some of the future targets were a bit vague (i.e., what did developing a localized strategy for Chevrolet Volt mean). More specificity in future work would be appreciated.

The reviewer noted that the performance was generally cast in terms of COP and was not preferred compared to how the DOE program has been presented, namely in terms of a fuel economy improvement (or percent improvement).

The reviewer commented that casting the performance in other terms was not always understood by high-level management, and this was the crucial selling point that needed to be accomplished to sustain the program. Also, an economic analysis was crucial to potential profitability.

Reviewer 2:

The reviewer stated that this team discussed their high-level plans, but did not discuss many important system design aspects as discussed above. Once again, there appeared to be a large focus on TE materials research (for high-temperature WHR of all things), with little focus on TE materials research directed to improve the lower temperature TE HVAC system. No mention was made of this in the presentation.

Reviewer 3:

The reviewer felt that the final deliverable appeared to fulfill a bulk of the requirements, including time for optimization of the system. The only barrier the presentation lacked was how this project was going to attack the reliability barrier. The reviewer observed that there did not seem to be much of the tasks targeting module consistency, lifetime testing or other durability studies associated with increasing confidence in this barrier.

Reviewer 4:

The reviewer suggested that the effort be re-adjusted to succeed in the one area for which the project receives funding (i.e., cooling systems).

Reviewer 5:

The reviewer noted that the remaining tasks have been well-planned. The integration of TE devices into the Chevrolet Volt seems to have overcome more challenges to become a component in future EVs.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the overall project was quite relevant to DOE's interests. The performance targets were reasonable.

Reviewer 2:

The reviewer stated yes, but it was not clear to the reviewer that this project was well-focused on the DOE objectives. The team did not provide any analyses on how much fuel savings or performance improvement their system could produce in their selected vehicle applications (i.e., Buick LaCrosse).

Reviewer 3:

The reviewer indicated that the specific barrier to reduce HVAC consumption by 30% was a clear indicator that this project supported the overall DOE objective of petroleum displacement.

Reviewer 4:

The reviewer stated that the project team would have a positive impact on waste-heat recovery even if the miles per gallon (MPG) targets were not exactly met. Whatever improvement was averaged over millions of cars, and that was a huge deal.

Reviewer 5:

The reviewer reported that the TE HVAC devices in vehicles, especially in EVs, directly supported DOE objective in petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources were adequate for the project.

Reviewer 2:

The reviewer felt that as structured, it appeared that this project would be able to complete the tasks presented. The risk of the project was to ensure that the reliability barrier was addressed to a sufficient level, as resources may need to be diverted in order to place more focus in an area that may not achieve the barrier.

Reviewer 3:

The reviewer stated to keep up the good work.

Reviewer 4:

The reviewer stated that the GM team had been very efficient in utilizing resources in this project.

Neutron Imaging of Advanced Engine Technologies: Todd Toops (Oak Ridge National Laboratory) - ace052

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the use of neutron imaging as a non-destructive, non-invasive technique seemed like an excellent approach to study a number of aspects related to combustion and emissions.

Reviewer 2:

The reviewer noted that this is a worthwhile project and has the potential to provide information that is not available by other means. It should be continued. Since it remains to be seen just what information can be obtained, the work should be continued to find out what can be done. The reviewer rated this work as outstanding if its potential is fully realized. Once the potential of this technique is understood it will be able to more tightly focus the work on specific areas of relevance to DOE's mission.

Reviewer 3:

The reviewer stated that the project still feels like a technique in search of a use for fuel injection. The reviewer felt that this was worthy work though for \$200,000 of funding.

Reviewer 4:

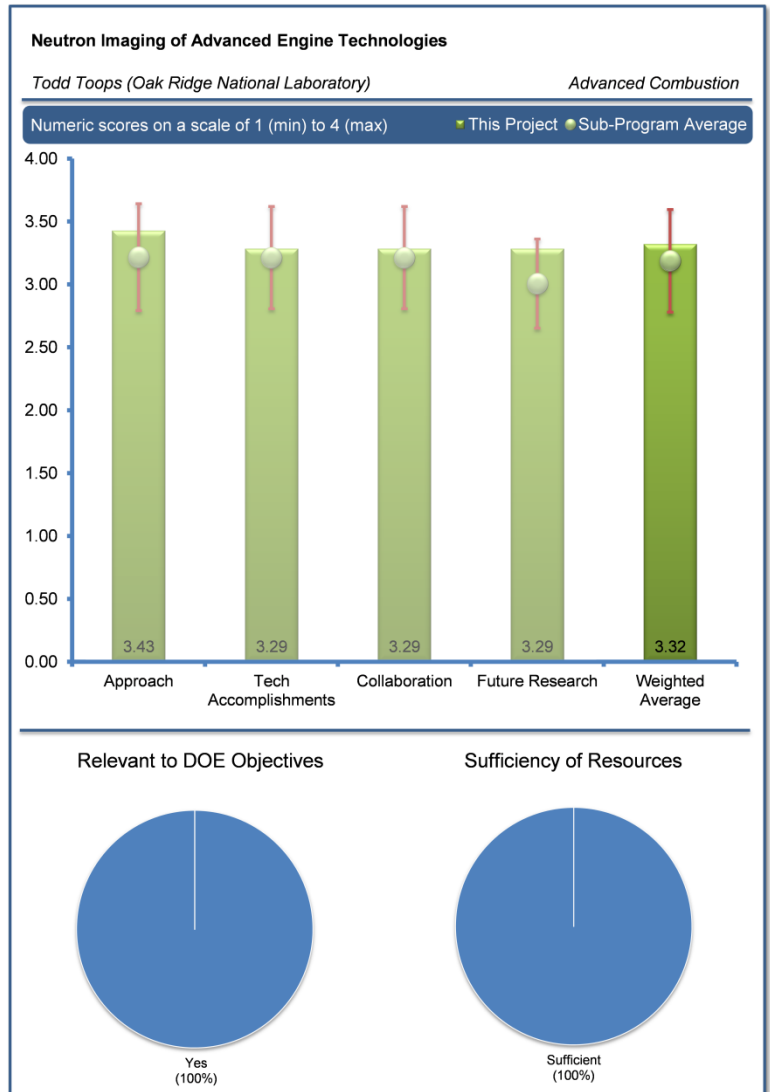
The reviewer stated that the approach is sound. It will be important to understand the unique capabilities this facility provides, as compared to other DOE facilities (e.g., ANL and APS).

Reviewer 5:

The reviewer felt that this program was looking into a very interesting area of study, allowing valuable insight into the detailed functions within both fuel injectors and diesel particulate filters.

Reviewer 6:

The reviewer stated that the neutron imaging technique has very unique capabilities and is worthwhile exploring. It is capable of non-destructive testing of certain engine components. The reviewer indicated that the technique also has some barriers, especially for fuel injector diagnostics; low neutron flux is one and resolution is the other. The reviewer suggested that more work be focused on exploring the removal of these shortcomings in order to make this technique more useful. The reviewer concluded that it seems like the technique will do well in imaging a large static component like a particulate filter.



Reviewer 7:

The reviewer noted that non-destructive techniques offered a unique opportunity for multiple study of a single device. It provides insight into intra-nozzle fluid dynamics for improved simulation and design. The reviewer pointed out that the negative slow response makes dynamic injection imaging challenging. DPF application provides the thickness of the soot layer as well as porosity of the layer, which allow the soot mass to be calculated. This reviewer also noted ash deposit. The reviewer reported that the neutron flux is low and that higher resolution is desirable, such that the opening and closing behavior of the injector can be studied.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that there was good progress. The project team designed a spray chamber to study flow injectors. The reviewer indicated that the initial proof of concept tests demonstrated could detect a denser fluid profile for fuel injected at a higher pressure. The project team obtained interesting results on soot cake density changes during DPF regeneration.

Reviewer 2:

The reviewer stated that the initial results were very encouraging and that the investigators have identified, and are working on, improvements/modifications that need to be made to enhance the value of the data and the extraction of the maximum information from the analysis.

Reviewer 3:

The reviewer asked if the resolution available will allow enough fidelity to detect the internal flow characteristics of the fuel injector that matter.

Reviewer 4:

The reviewer noted that results for GDI and DPF were interesting. The conceptual model for DPF regeneration was also good.

Reviewer 5:

The reviewer indicated that the program has made good progress and that the results presented on the DPF were of great interest. The reviewer also suggested that the one potential recommendation would be to get a better understanding of why soot layer density was changing during the regeneration process; if the packing density changing was, if the porosity changing, and to get a good fundamental explanation of how and why the packing factor (and porosity, pressure drop, etc.) changes through the regeneration event.

Reviewer 6:

The reviewer noted that a fair amount of work remained before the technique could yield results that would provide new understanding. In order to prove the usefulness of the technique, more work should tie in with ongoing particulate filtration work at ORNL or other institutions. The reviewer felt that the soot regeneration work was very interesting and was providing new knowledge. The reviewer asked if the density of the liquid within the injector discerned by the imaging could be correlated to the pressure as a function of distance along the injector passages. It seems like this data would be useful in the design of better injectors and nozzles.

Reviewer 7:

The reviewer stated that good progress had been made for both DPF and injector fronts, including that a measurement of sequential soot distribution changes in diesel particulate filters as a function during a series of partial regenerations had been completed. The determination of temporal and spatial resolution of neutron imaging with respect to fluid density and flow in fuel injectors was on target. The reviewer stated that the potential usefulness of neutron imaging had been demonstrated.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer remarked that very good collaboration existed with several key partners. The reviewer suggested that more collaboration with Navistar and others on particulate work should be pursued. The reviewer also recommended that a partnership of collaboration with a Tier I fuel injector supplier like Bosch, Delphi, Conti, etc. should be pursued, as the suppliers would be able to point to areas of interest that the technique could help with regarding designing better injectors.

Reviewer 2:

The reviewer noted that collaborations have been setup with a few industrial collaborators (NGK and Navistar) that have provided materials for proof-of-concept tests. Presumably the number of collaborations can be expanded if/when other industry members have materials they would like to have evaluated by this technique. The reviewer indicated that collaborations have been setup with other government and university laboratories.

Reviewer 3:

The reviewer observed that there was good collaboration with universities, industry, BES and the technical community at large. There appeared to be significant interest about this project from the technical community at large.

Reviewer 4:

The reviewer indicated that there was a good mix of collaborators, including academics and industry.

Reviewer 5:

The reviewer stated that the program had the right parties involved to address the program objectives.

Reviewer 6:

The reviewer noted that there was good collaboration with the industry and university partners.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer noted that there were plans to adapt the system to have the capability to investigate GDI injectors and stated that the incorporation of ash-laden and gasoline particulate samples into the particulate filter studies seemed reasonable.

Reviewer 2:

The reviewer indicated that the investigators have responded well to suggestions on applying this diagnostic to applications such as GDI. This reviewer added that the most immediate future work is being directed to technique improvement, as it should be.

Reviewer 3:

The reviewer expressed interest in the results from the GDI spray measurements, to see how the results compare to the ANL's APS. The reviewer indicated interest for the impact of multiple injections, over a range of ambient densities.

Reviewer 4:

The reviewer stated that another item that could be included is the studying of deposit formation on DI gasoline injector nozzles.

Reviewer 5:

The reviewer noted that the continuation of the current aspects was proper. The reviewer expressed the need to further improve the technique in terms of resolution to better understand of the injector. More emphasis on GDI injector would be timely according to this reviewer. The summary on page 21 lists only diesel injector, and the reviewer hopes it was an oversight. More focus could be put to study the injector behavior during the opening and closing phase of the operation.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer suggested that an improved understanding of fluid flow inside injectors should lead to better injector design and modeling and more efficient engines. Also, better understanding of particulate regeneration processes should lead to more effective regeneration procedures which are tied to emissions abatement which are related to DOE goals of clean combustion.

Reviewer 2:

The reviewer felt the project provides added insights in a non-destructive way.

Reviewer 3:

The reviewer indicated that this work would give good insight into the operation of both fuel injectors and particulate filters, both of which were directly relevant to improving engine performance.

Reviewer 4:

The reviewer stated that this project was developing a non-destructive diagnostic technique that would help develop enabling technologies for high efficiency engines like fuel injectors and particulate filters.

Reviewer 5:

The reviewer commented that any techniques which provide a better understanding of the devices which could improve the fuel economies would indirectly support the overall DOE objectives of reducing petroleum consumption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that it appeared that the resource allocation was sufficient.

Reviewer 2:

The reviewer stated that the funding was sufficient for now, but may need to expand in the future, depending on how significant (and unique) the GDI findings are.

Reviewer 3:

The reviewer noted that this program was doing very good work on a relatively small budget.

Collaborative Combustion Research with BES: Scott Goldsborough (Argonne National Laboratory) - ace054

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer summarized that this project seeks to provide fundamental research to support DOE and industry advanced projects. It attempts to build fundamental knowledge of combustion in advanced combustion regimes, and to improve the predictability capability of today's modeling tools. The reviewer indicated that the project does not give adequate description on how this work is tied up to engine efficiency or pollutant reduction. Furthermore, the reviewer felt that the connection with the industry was unclear.

Reviewer 2:

The reviewer stated that the RCM work provided a good addition to the work done via other methods.

Reviewer 3:

The reviewer noted that adding model of RCM test was a great idea to help improve the accuracy of chemistry results.

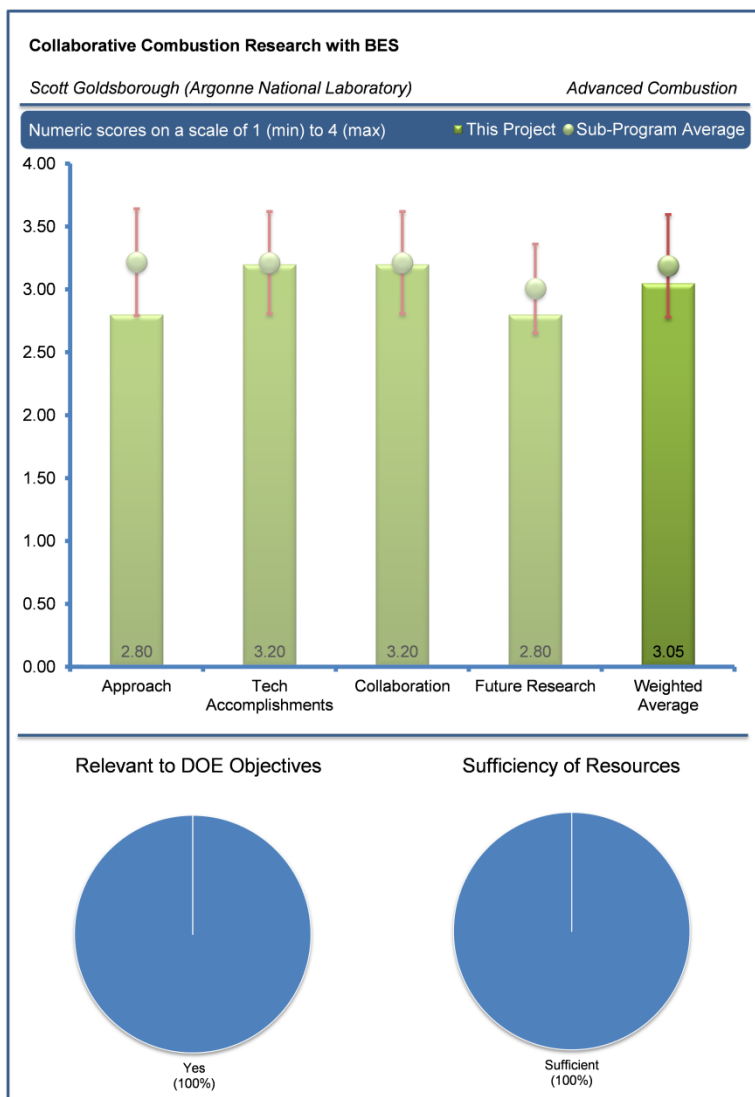
Reviewer 4:

The reviewer indicated that this project was an enabler for others as a new experimental facility for exploring the reactivity of various possible transportation fuels. The RCM is operational but still was undergoing maturation steps. The reviewer commented that more data, especially on fuels of interest to DOE and its partners were possible for next year.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the effort shown here appeared scattered. Studying the effect of crevice volumes seems outside the scope of this work. The reviewer asked what was expected by this work. There was much dedicated to the crevice geometry but it did not seem tied up with any specific goal. The authors asked if some configurations were better than others. The reviewer felt that the authors could provide the foundations for selecting these reactivity modifiers and justify the effort in the long-term development of fuel chemistry. The reviewer asked if the industry both from supplier to engine manufacturers were in line with this effort and if so, what their input was. The reviewer stated that the authors planned detailed measurements for FACE fuels with reactivity modifiers and asked how this fit in with the expectation from manufacturers and fuel suppliers. The reviewer continued to ask, how the work on phase change, the histories of pressure, temperature and EQR, got incorporated in the models. The results did not appear to be



followed through. The reviewer indicated that the experimental work across several ranges of 2-ethylhexyl nitrate (EHN) percentages was a good fundamental set of data. The reviewer wanted to know that the long term plans for this project were.

Reviewer 2:

The reviewer observed nice work to better characterize fuels and additives.

Reviewer 3:

The reviewer commented on good results with RCM, and that it was good to identify shortcomings of the chemistry model to know where to focus efforts to improve the model.

Reviewer 4:

The reviewer stated that the RCM was operational and had generated some initial data including comparison to kinetic calculations. The next year should generate significantly more data and an understanding concerning fuel reactivity of various fuels under consideration by DOE.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated there was an excellent goal with standardized tests among 14 RCM laboratories

Reviewer 2:

The reviewer suggested that more detail may be given as to the contribution of the partners.

Reviewer 3:

The reviewer stated that it was good to see the International RCM workshop.

Reviewer 4:

The reviewer stated that it was good to see collaborations with both academic partners and industrial partners.

Reviewer 5:

The reviewer indicated that there was good collaboration between ANL, Akron, and possibly UM. It would be interesting to eventually compare data generated in this RCM with data from UM for the same fuels or comparable fuels.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the outline was rather vague in the accomplishment section, the outline was rather vague. The authors could be more specific as to the expectations or milestones that the authors were seeking.

Reviewer 2:

The reviewer felt that the proposed research was logical and should yield good data. One suggestion was to consider taking measurements of ethanol-gasoline blends for comparison with other facilities as both validation and learning steps.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that basic fuel combustion data was needed for advanced modeling of combustion.

Reviewer 2:

The reviewer noted that improving the understanding of chemistry would help improve the engine combustion models that could be used to improve engine efficiency.

Reviewer 3:

The reviewer stated that this project could support others working on advanced homogenous combustion models that are focused on improving engine thermal efficiency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that funding appeared adequate for the PI to execute future thrusts given that the bulk of the RCM set-up was complete.

Deactivation Mechanisms of Base Metal/Zelite Urea Selective Catalytic Reduction Materials, and Development of Zeolite-Based Hydrocarbon Adsorber Materials: Chuck Peden (Pacific Northwest National Laboratory) - ace055

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the approach was reasonable and led to interesting results.

Reviewer 2:

The reviewer stated that the deactivation mechanisms for lean SCR systems were an important area of research. This supported efforts to enable lean engine systems to meet emissions standards as well as OBD and durability requirements. The reviewer summarized that the project also supported laboratory-based aging protocols to simulate in-field use. It was a very useful study to help meet durability requirements at OEMs.

Reviewer 3:

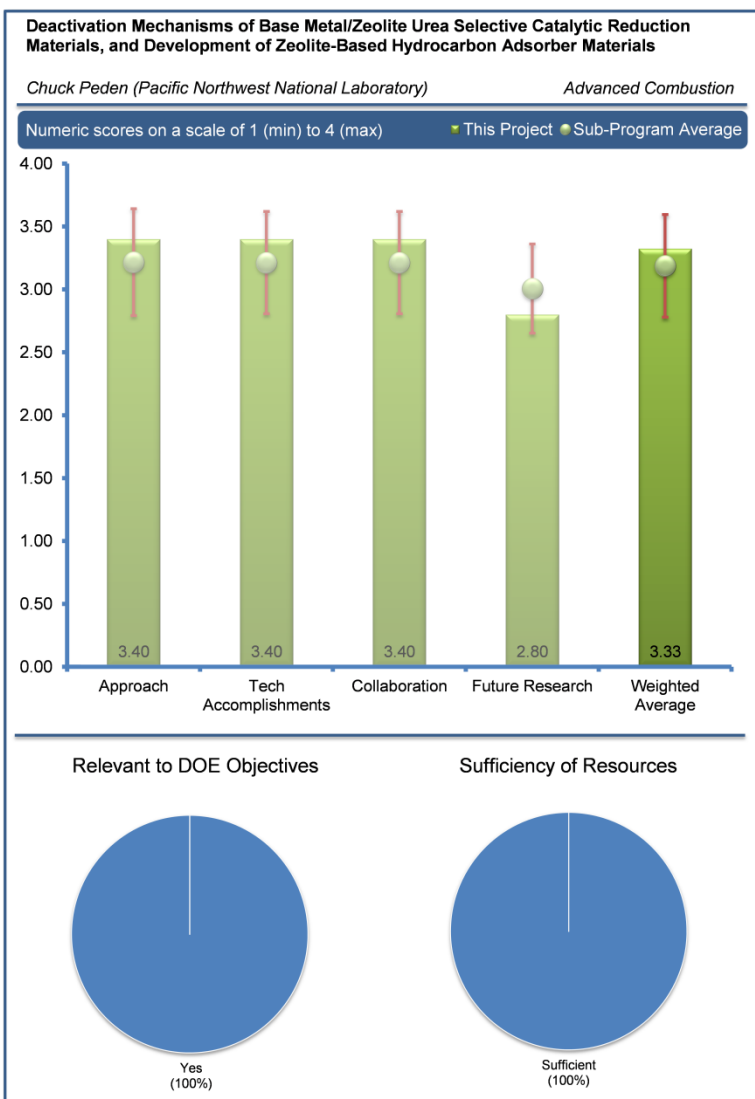
The reviewer indicated that there was a good delineation of tasks between the OEM partner and PNNL.

Reviewer 4:

The reviewer stated that the development of aging protocols helped accelerate the testing of new catalysts, saving time and money and enabling a greater number of catalysts to be evaluated. The project looked at different ethanol contents of current gasoline blends. The reviewer stated that it would have been helpful if the presenters had been mindful that some audience members were not experts in catalyst chemistry.

Reviewer 5:

The reviewer stated that the technical barrier is to develop realistic laboratory based rapid aging protocols, which effectively simulate engine based catalyst deactivation methods. Characterizing dyno aged parts and correlating laboratory aged parts to be industry standard method. Thermal and poisoning mechanisms are typical candidates and were selected for evaluation (hydrothermal), also to identify HC adsorber materials.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the project team developed an improved understanding of the catalyst aging/deactivation processes and mitigating strategies.

Reviewer 2:

The reviewer noted that the project consisted of very useful SCR work related to deactivation mechanisms and how poison type and location can affect activity. Also, this reviewer reported that a wide range of poisons and how they interacted with SCR catalysts were examined.

Reviewer 3:

The reviewer stated that experimental data and catalysis insights have enabled the OEM partner to develop realistic laboratory aging protocols for SCR catalysts. Unusual hydrothermal aging of SCR catalysts was observed. The reviewer emphasized the very relevant work on HC adsorber materials for fundamental understanding of HC Trap characteristics.

Reviewer 4:

The reviewer observed that parts were characterized as proposed and important findings were identified. This reviewer further noted that loss of zeolyte crystallinity is a proposed mechanism to loss of performance with urea having some influence on catalyst aging; SO₃ poisoning was impacting low temperature performance, but being removed at high temperatures; SO₂ was having no impact; and approximately 1-inch at the front of brick has Cu sintering/poisoning with remainder of the catalyst not impacted.

Reviewer 5:

The reviewer stated that HC progress was minimal due to the departure of previous PI.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that there was very good government/industry interaction on an important topic.

Reviewer 2:

The reviewer stated that there was good, close collaboration with the OEM partner, typical for a CRADA.

Reviewer 3:

The reviewer noted that the appropriate division of tasks between Ford (practice) and PNNL (fundamental understanding) was based on respective expertise.

Reviewer 4:

The reviewer noted a good collaboration with Ford as proposed.

Reviewer 5:

The reviewer indicated good collaboration with industry.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that this was not applicable as the projects are complete.

Reviewer 2:

The reviewer commented that there is no further funding and the project has ended. However, new projects should continue with investigating the mechanisms of urea, SO₃, and P poisoning pathways.

Reviewer 3:

The reviewer stated that this project ended in September 2012.

Reviewer 4:

The reviewer indicated that the team was ending the project as planned.

Reviewer 5:

The reviewer noted that the project was ending so there is no future work.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer indicated, yes, by working to develop and understand more effective and durable catalysts, and procedures for accelerated aging of sample catalysts to speed laboratory evaluations of them.

Reviewer 2:

The reviewer noted that the project was very relevant to enabling lean engines to enter the marketplace and meet emissions standards. In-use durability, now at 150, 000 miles for CARB LEV III systems, must be met. Deactivation mechanisms associated with common exhaust poisons were important to understand, to avoid long-term exposure to field failures.

Reviewer 3:

The reviewer noted that the rapid aging of catalysts allows optimization of materials, lower costs of aftertreatment which is critical to allow technologies which enhance fuel economy and petroleum reduction to be implemented.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that there was an excellent collaboration and use of resources.

Reviewer 2:

The reviewer noted that this was a relatively low effort, but the funding was appropriate because objectives were accomplished.

Reviewer 3:

The reviewer stated that the project is complete.

Fuel-Neutral Studies of Particulate Matter Transport Emissions: Mark Stewart (Pacific Northwest National Laboratory) - ace056

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

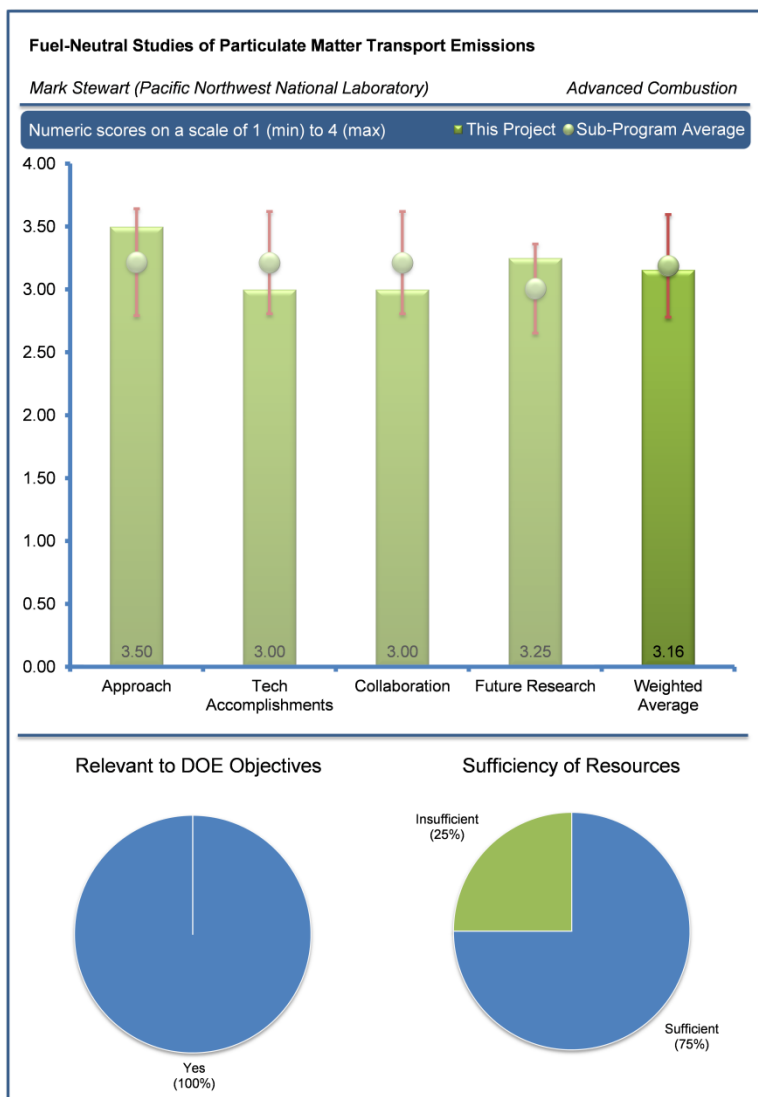
The reviewer commented that this work is great as always. It has a well-directed goal for GDI filtration. The reviewer criticized that the glaring weakness is generating or reproducing a membrane filtration technology which limits backpressure drop and has a high filtration efficiency for the small GDI particles. This presentation did not raise the reviewer's confidence in the model materials produced for this project.

Reviewer 2:

The reviewer indicated that the project was a very nice study to determine the composition and size of PM under different operating conditions and fuels.

Reviewer 3:

The reviewer stated that the approach included a good combination of filtration experiments and evaluations as well as modeling.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer expressed that after grumbling about the character of the model materials, this project has been marvelously successful in extracting the maximum information with the least resources.

Reviewer 2:

The reviewer reported that the project identified PM composition and property differences associated with load and operating conditions as well as fuel type. This was important for OEMs to know and understand for incorporating filter technology into exhaust aftertreatment systems. The reviewer noted that some of the data and information had been performed already.

Reviewer 3:

The reviewer indicated that this project had generated a lot of exhaust particulate data and the analysis resulted in a very large dataset including many characteristics of advanced gasoline particulate populations.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer reported that there was very good collaboration and effort between the university, National Laboratories, and OEM. There was very good interaction and feedback during project.

Reviewer 2:

The reviewer noted that there was good collaboration with GM and UW-Madison.

Reviewer 3:

The reviewer stated that there is no supplier involvement preventing the rating of outstanding. The UW work was great. The integration was great between the UW and PNNL. The reviewer expressed confidence that the membrane coated filters were a good representation of what might ultimately be obtained from the filter suppliers.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer noted that there were good future plans with the available resources.

Reviewer 2:

The reviewer noted that the proposed future experiments and modeling would focus on the characterization of particulates from subsequent generations of lean, high-fuel efficiency engines.

Reviewer 3:

The reviewer indicated that the proposed future activities appeared reasonable. However, efforts should be made to include new filter materials such as membrane coated filters for PM studies and the effects of fuel sulfur and HC composition of E10 and E85 fuel blends.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that the GDI particulate filtration was the high impact approach to make lean or dilute gasoline possible from an aftertreatment perspective.

Reviewer 2:

The reviewer indicated that the research in this presentation was important to perform and understand in order to characterize regulated PM, which is associated with more efficient direct injection engines and the fuels that will be used.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer felt that this work is well directed to addressing the issue of adequate filtration for GDI systems. The reviewer stated that it is believed that more could and should be done on this project. The PI has been exceptionally effective in leveraging limited funding for good technical gain.

Reviewer 2:

The reviewer noted that funds appeared to be adequate to accomplish project goals.

Reviewer 3:

The reviewer reported that good progress had been made for a relatively low level of funding.

Cummins SuperTruck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks: David Koeberlein (Cummins) - ace057

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed an exemplary approach with solid analytical and experimental work, and noted involvement of all the key suppliers and research base. The reviewer added that Cummins approach here, as well as elsewhere, does a great job of leveraging various research and supplier capabilities.

Reviewer 2:

The reviewer noted that the project approach is excellent as it focuses on priority technology advances, which will provide the largest improvements and are practical (at least technically) to implement at an engine and vehicle level. Additionally, while modeling and analysis have played key roles, the focus has been to quickly integrate the technologies on an engine and a vehicle to demonstrate real results and identify real system benefits and costs. The reviewer stated that generally, the technologies were also building block technologies that appeared to be aligned with a truck product plan so that the technologies can be implemented individually or as a whole when the value proposition for production is high enough.

Reviewer 3:

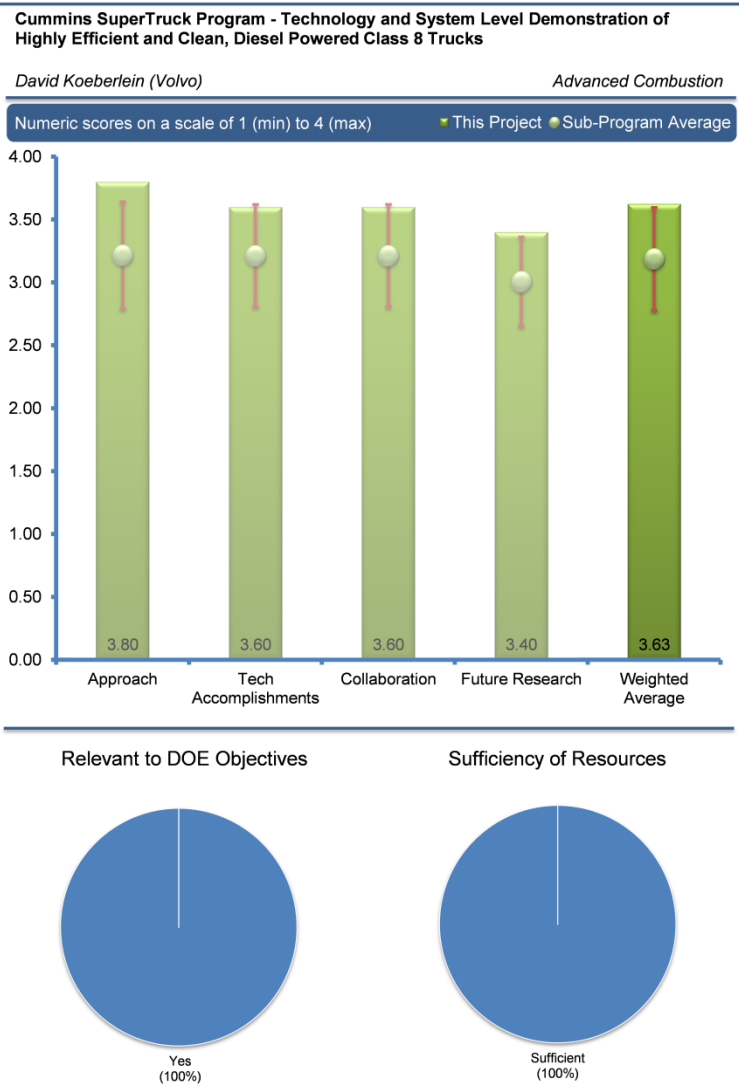
The reviewer indicated that there was an extremely excellent approach; focused on the appropriate components, from a fundamental thermodynamic approach, without having to rely on hybridization (which adds cost and weight).

Reviewer 4:

The reviewer stated that this was now the classic piece by piece approach. However, Cummins had done it well reaching 51% BTE at this point which was the best result of the SuperTruck competitors.

Reviewer 5:

The reviewer indicated that the achievement of 50% BTE goal was the most impressive technical improvement, which can be attributed to the integrated engine system approach, heavily relying on WHR with fine tuning on other technologies. The approach to 55% goal seemed to rely on homogeneous charge compression ignition (HCCI) and dual fuel, where these two technologies have not been experimentally proved to be BTE improvement friendly technologies. The reviewer warned that while dual fuel showed some promising feature, high pumping loss and stability control for transient operation was too tough to overcome. Both technologies



suffered high HC emissions. The contractor should demonstrate the technical feasibility with preliminarily convincing data at the current level.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the engine friction losses seemed to be the lowest of the SuperTruck competitors. The project team seemed to have gotten the Rankine cycle WHR running with a fluid other than ethanol and was projecting a 2.8% improvement with a low global warming potential (GWP) fluid. If commercially successful, this could be a significant breakthrough.

Reviewer 2:

The reviewer commented that it is amazing to see the targets exceeded. This is great work.

Reviewer 3:

The reviewer reported that the project has met a challenging 50% BTE with an island of high efficiency engine points, not only one single breakpoint. Emissions have been appropriately considered and addressed with data. The reviewer commented that the 50% freight efficiency target has also been met with the engine technology and that many of the vehicle technologies were now on a demonstration truck. The demonstration truck has been compared to a conventional truck with data and showed a real world fuel economy of 55%. BTE analytical work had also been completed with an excellent look at advanced combustion technologies such as HCCI, PCCI, RCCI and alternative fuels. The real world data measured approximately 9.2 to 10.1 MPG.

Reviewer 4:

The reviewer reported that the project had accomplished objectives on time to date.

Reviewer 5:

The reviewer noted that the contractor not only achieved the technical goal for 50% BTE on the engine side, but also achieved the vehicle goal, thanks to the project team's comprehensive and beyond-state-of-art technologies.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer felt that this appeared to be primarily a Cummins in-house project. The reviewer had no objection to that. The reviewer noted that the project utilized both Purdue University and ORNL but it was a bit difficult to see how involved ORNL and Purdue are in the project.

Reviewer 2:

The reviewer commented that Cummins seemed to do a wonderful job of developing solid relationships with key people and really leveraging abilities effectively. This is a consistent pattern for Cummins and is a good example to others on how to develop high technology.

Reviewer 3:

The reviewer indicated that the collaborators and key technological accomplishments or functions were identified. ORNL advanced sensing methods for combustion studies and Purdue University worked on variable valve actuation (VVA).

Reviewer 4:

The reviewer observed a large project team, incorporating laboratories, the industry, and universities.

Reviewer 5:

The reviewer commented that Slide 20 only showed two key partners for technical progress (i.e., ORNL and Purdue University), while Slide 7 showed a large number of partners. The information was kind of misleading in terms of collaboration and coordination.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that project team is on track for the evolutionary improvements that should give the project team a chance to reach the 55% goal.

Reviewer 2:

The reviewer expressed looking forward to seeing the results.

Reviewer 3:

The reviewer reported that the proposed future research follows the plan and is investigating auxiliary power unit (APU) options for improving 24-hour cycle with non-solid oxide fuel cell (SOFC) technology.

Reviewer 4:

The reviewer stated that the program was on schedule and meeting Recovery Act goals. This was clearly on track with the future work proposed to achieve objectives.

Reviewer 5:

The reviewer noted that the future plan was solid, which could further refine the impressive achievements. This reviewer cautioned that relying too much on dual fuel was risky for a 55% goal, partially due to high HC and CO emissions for cold start.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer explained that on the road (OTR) diesels probably consumed over 60% of U.S. oil imports. These improvements, if rolled out commercially, would significantly reduce dependence on foreign oil.

Reviewer 2:

The reviewer asserted that this was a direct response to efficiency needs.

Reviewer 3:

The reviewer stated that the suite of technologies could improve fuel efficiency and fuel economy by about one MPG so far. The reviewer's concern was that due to value proposition, the cost versus benefit of technologies, that many may not make it to production in five years. The Rankine cycle is one where there is still a clear constraint. Goals were to show what is possible, but with an eye toward production must improve costs to increase probability of near term production.

Reviewer 4:

The reviewer reported that the project clearly met SuperTruck goals.

Reviewer 5:

The reviewer noted that development of realistic technologies, many of which could be production-intent, leads to a reduction of petroleum consumption in the truck market. The results showing the achievement of the program goals demonstrated this purpose.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the project was moving on track and had sufficient resources.

Reviewer 2:

The reviewer said that it seemed like resources were at the right level.

Reviewer 3:

The reviewer stated that the program was on schedule. With seven million funding remaining from DOE, resources should be adequate to reach all program milestones.

SuperTruck - Improving Transportation Efficiency through Integrated Vehicle, Engine and Powertrain Research: Kevin Sisken (Detroit Diesel) - ace058

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this project had a solid approach with analysis to define needs, followed by design toward objectives and testing for confirmation and validation.

Reviewer 2:

The reviewer observed that the engine control in Slides 10-11 was kind of innovative, and really wanted to see if this technology could be implemented into vehicle demonstration.

Reviewer 3:

The reviewer said that this project was moving along steadily. Detroit Diesel had a vision of where this project should go and were solving the problems steadily. The project team exuded a sense of confidence in its direction and ultimate success. The reviewer reported that this project initiated major changes in the engine design and approach.

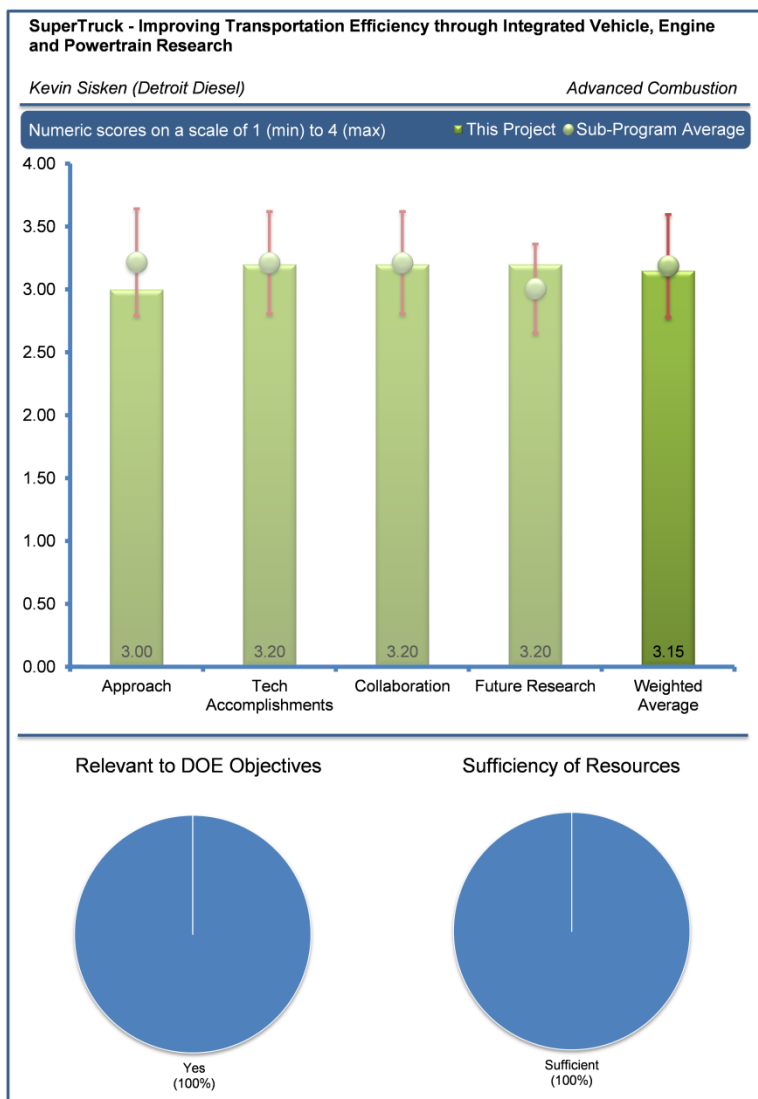
Downsizing the displacement and increasing the RPM seemed to be the correct approach for higher fuel efficiency. The reviewer indicated that the WHR was crucial and that the technology appeared to be having success. However, practical implementation of that technology was quite far in the future.

Reviewer 4:

The reviewer stated that the goals were standard for SuperTruck: 50% BTE for engine; and 50% freight efficiency improvement. Overall, the technology list was appropriate (i.e., WHR, turbo-compounding, and downsizing) and added hybrid. The reviewer voiced some concerns with the communication of the approach for downselection and the integration of technologies. The systematic selection, and possibly some de-selection of technologies had not been presented in a crystal clear way. The reviewer indicated that the data based prioritization of key fuel economy improvement technologies was only brought out in a limited way in the Q&A, and would improve the score. The expectation is also that there may be some possibility to leverage hybrid technology for the powertrain (downsizing) or to discuss the reasons it was not practical and why hybrid functions were de-selected for the powertrain.

Reviewer 5:

The reviewer stated that this was a brand new, from the ground-up approach and was not based on existing technologies. The reviewer asked if there was nothing in the Daimler arsenal to leverage for this. This reviewer was given the impression that either Daimler did



not have the confidence in anything it already had or was not comfortable about leveraging what it had. The reviewer further noted that the use of hybridization and WHR relied on immature thermoelectric technology.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that Detroit Diesel seemed to be solving problems steadily. However, it appeared as if the efficiency of the engine technology was lagging the original expectations.

Reviewer 2:

The reviewer indicated that there was good progress with a nice movement approaching the targets.

Reviewer 3:

The reviewer noted that some of the data presented on engine activity are 1.9% away from the 50% BTE goal. Some data plots could be presented in more standard ways to improve communication. For example, BSFC plot versus RPM and load, BSNO_x versus speed and load, brake-specific particulate matter (BSPM) versus speed and load are important standard plots. The reviewer indicated a further tie of the improved engine torques back to standard test and functional operating conditions would improve scores. Higher BSNO_x number by 3-5x is large. Changing non-quantitative statements like more demand on SCR to SCR size is projected to increase by X%, DPF consumption by Y% and overall cost by Z% for the aftertreatment are examples. The reviewer criticized that language like DOC and DPF met expectations should be clarified. The reviewer asked if the system met 2010 emissions or another expectation. The pressure drop data is good to clarify design requirements. The reviewer felt that the use of neural network controllers over physics based control systems is a concern. For limited operation, the data can be good and fast, however, for many vehicles and operating conditions, it is not reliable or defensible. The reviewer offered that small system changes generally require full recalibration runs. Good progress on WHR system with collaboration at ORNL and with MIT for friction reduction.

Reviewer 4:

The reviewer stated that the generational improvement on the aftertreatment represented significant improvement in aftertreatment conversion efficiency. The reviewer expressed concern about what had been accomplished with controller training and the recalibration issues mentioned; and if the project team would be able to move on to the next step.

Reviewer 5:

The reviewer indicated that the 48.1% thermal efficiency was good. The 49.1% achievement in the verbal presentation was even more impressive.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the integration of the suppliers with Detroit Diesel seemed to be very successful.

Reviewer 2:

The reviewer indicated a good set of collaborators and suppliers. It seemed that some of the suppliers were not directly involved as participants as thoroughly as might be possible.

Reviewer 3:

The reviewer noted many collaborations listed in the presentation with some good examples about actual contributions such as ORNL and MIT.

Reviewer 4:

The reviewer said that it sounded like there may be issues with some of the hardware suppliers.

Reviewer 5:

The reviewer noted that it seems that the contractor only mentioned ORNL on WHR and MIT on friction reduction for the engine related development, and no other partners were mentioned in terms of result presentation. It appears that some of other partners were also involved, such as Johnson Matthey and Corning in aftertreatment. The reviewer felt it would be helpful if individual partners could be acknowledged in those slides that utilized their works and technologies.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the project team was moving step-by-step to reach the goal. The reviewer was not quite sure if the project would be successful; if not, the project would be very close.

Reviewer 2:

The reviewer noted that a solid plan seemed set to reach the objectives in an implementable way.

Reviewer 3:

The reviewer said that the project was continuing on the specified path.

Reviewer 4:

The reviewer stated that controller training and recalibration issues mentioned were concerning as to what had been accomplished and if the project team would be able to move on to the next step according to plan.

Reviewer 5:

The reviewer stated that there was still a 0.9 efficiency to go in order to reach the 50% goal and felt that it was achievable with the current plan.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that major reductions in oil imports can occur with improvements in the fuel economy of the over the road diesels. This project will go a long ways to achieving those improvements.

Reviewer 2:

The reviewer stated that there is direct relevance to vehicle efficiency.

Reviewer 3:

The reviewer felt goals for SuperTruck were clearly identified for petroleum reduction. Class 8 Truck improvements to 50%, 55% engine BTE. A 50% improvement in freight efficiency while meeting 2010 emissions will provide pathways for reduced fuel consumption for an application that consumes 17-20% of the national fuel in MD/HD applications.

Reviewer 4:

The reviewer reported that the most valuable part of this program is to use many production-intent or refinement of the current production technologies to achieve the program goals. This road map will have an immediate impact on the current truck market in just a few years to go, thus achieving the reduction of petroleum consumption immediately.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that resources seemed to be appropriate for accomplishing the goals.

Reviewer 2:

The reviewer stated resources seemed like an appropriate level to reach the goals.

Reviewer 3:

The reviewer indicated that the resources were large, as was the task and the possible benefits.

Reviewer 4:

The reviewer pointed out that the contractor showed 60% completion in Slide 2, but it was not clear whether it was against technical achievement or budgeting.

SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer: William De Ojeda (Navistar International Corp.) - ace059

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that there were standard SuperTruck targets for the engine, a 50% BTE, a 55% technology roadmap. The approach showed a clear plan, prioritization, and the roadmap with expected contribution of technologies and the progress to goals. The reviewer indicated that the gold star was to estimate payback or to show some indication of current value proposition to customers. This indicated a clear plan to consider the implementation of the technologies considered at some date based on value proposition.

Reviewer 2:

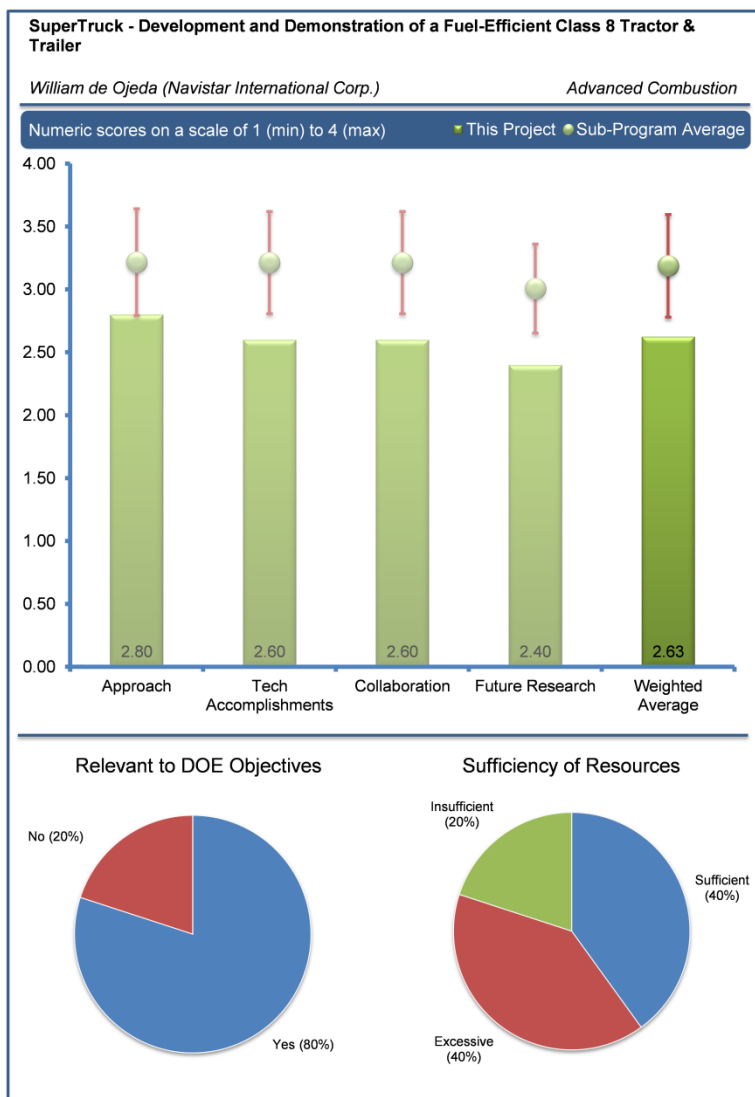
The reviewer offered that switching the SCR system from a non-workable high EGR solution was a significant step toward achieving the program goal in this year development. However, the project needed more description of how the SCR was integrated into system in such a late game, specifically, introduction of SCR into the program will require new system tuning when it works with WHR, VVA and other advanced systems. The reviewer criticized that the use of dual fuel approach for 55% thermal efficiency goal was questionable, due to its high pumping loss and high HC emissions. At this time, all potential improvements of this RCCI or dual fuel concept are demonstrated in an SCE or simulation. The reviewer pointed out that this high efficiency combustion concept had not been demonstrated in a multiple cylinder platform, not even close to the targeted 50% goal. No WHR with Rankine cycle would be a big issue of whether the program can meet the goal.

Reviewer 3:

The reviewer mentioned that this program had a pause. That did not seem like an appropriate approach.

Reviewer 4:

The reviewer felt that the original approach was very weak on aftertreatment. Now, aftertreatment seemed to be properly considered as part of the project. Navistar would do well to aim for higher aftertreatment efficiency and gain more fuel efficiency in the engine. Otherwise, the reviewer felt that there was solid work on the engine systems.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated significant progress was made so far. The temporary break from program work, while understandable in the general business climate of the company, was troublesome.

Reviewer 2:

The reviewer recognized that there was good progress from the National Laboratory collaborator, while the OEM was in pause mode due to a production launch. The reviewer felt that the project did not really seem to be on track for efficiency numbers with still almost 2% away, with limited work planned by the OEM.

Reviewer 3:

The reviewer stated that achieving the 48.2% efficiency was the key milestone achieved. However, it was not clear if the engine would meet 2010 emissions at the tailpipe out NOx emissions of 0.2 g/hp-hr, since the engine may not be completely optimized with new introduction of SCR. The reviewer commented that the pause due to corporation decision was not acceptable considering a huge DOE investment.

Reviewer 4:

The reviewer indicated that the program was on hold for a large part of the year due to current product engineering effort needed near term. The project team proactively put to use engines for dual fuel work at ANL with Wisconsin Research Consultants. The reviewer said that dual fuel BTE and especially NOx/PM reduction with dyno engines was exciting indeed. This reviewer also noted BTE improvement with emission technology reduction. The base program had progressed well and was 1.8% away from 50% BTE goal. The reviewer added that the score would be higher without a pause.

Reviewer 5:

The reviewer noted nothing much. ANL has been doing some modeling for them.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted good coordination with partners such as ANL to continue activity with the main program on pause, and to leverage hardware for next generation possibilities.

Reviewer 2:

The reviewer observed that there was solid interaction with the ANL group. Other collaborations were less clear and perhaps less integrated than with some other programs.

Reviewer 3:

The reviewer observed that much of the project was turned over to ANL.

Reviewer 4:

The reviewer stated that the only meaningful contribution from the partners is ANL for 55% thermal efficiency related to work due to the company pause decision.

Reviewer 5:

The reviewer asserted that Wisconsin Engine Research Consultants (WERC) was not a university partner, but rather a consulting firm operated by the UW faculty. The reviewer believed that the call was looking for an integrated university-lab-OEM team and this project did not meet that. Also, it seemed like ANL had to take the lead in this work.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed an excellent plan to maintain the path for diesel only technology for the 50% BTE goal while considering advanced combustion regimes using gasoline/ethanol and diesel with improved BTE than current diesels and significantly lower engine out emissions.

Reviewer 2:

The reviewer stated that with a clear history of management putting this project off, it was hard to be upbeat about the proposed future research.

Reviewer 3:

The reviewer noted that there was a good technical plan, but the program delay was troublesome.

Reviewer 4:

The reviewer stated that the OEM planned a break through 2013 into 2014 depending on partner contributions.

Reviewer 5:

The reviewer said that the future plan toward 50% goal was to rely on turbocompound, which was much less efficient compared to Rankine cycle at the DOE-designed operating point.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the full system modeling was not the same as making hardware.

Reviewer 2:

The reviewer indicated a direct contribution to vehicle efficiency.

Reviewer 3:

The reviewer stated that SuperTruck goals to develop technology with 50%, 55% BTE Engine targets and 50% improvement in freight efficiency with 2010 emissions for Class 8 trucks clearly could contribute to significant petroleum reduction.

Reviewer 4:

The reviewer reported that many key technology developments under this program could be viewed as production intent. A demonstration of 48.2 % efficiency was already a major step to reduce petroleum consumption in the truck market.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the delay of the program for one year will have an impact on the final program funding level while achieving the program goal.

Reviewer 2:

The reviewer reported that the DOE resources were sufficient but the company was not able to do its part in the short term. The program scale as appropriate even though it was delayed.

Reviewer 3:

The reviewer said that there are large resources and that there are high expectations.

Reviewer 4:

The reviewer stated that this project should be terminated and prior funds into the project should be recaptured.

Volvo SuperTruck - Powertrain Technologies for Efficiency Improvement: Pascal Amar (Volvo Trucks) - ace060

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that there was a clever approach on half the budget of the other projects.

Reviewer 2:

The reviewer indicated that there was a good approach with a comprehensive technology list.

Reviewer 3:

The reviewer noted that project team should be able to learn from the Detroit Diesel Corporation (DDC) and Cummins work. They are doing a mixed mode PCCI; however, the project team was using 20% DME and 30% propane. The reviewer was not very excited about that. The DME is a major enabler for PCCI and it is unlikely to be in any future diesel blend at those concentrations.

Reviewer 4:

The reviewer commented on the solid combination of analytical and experimental work on a reasonable set of technologies.

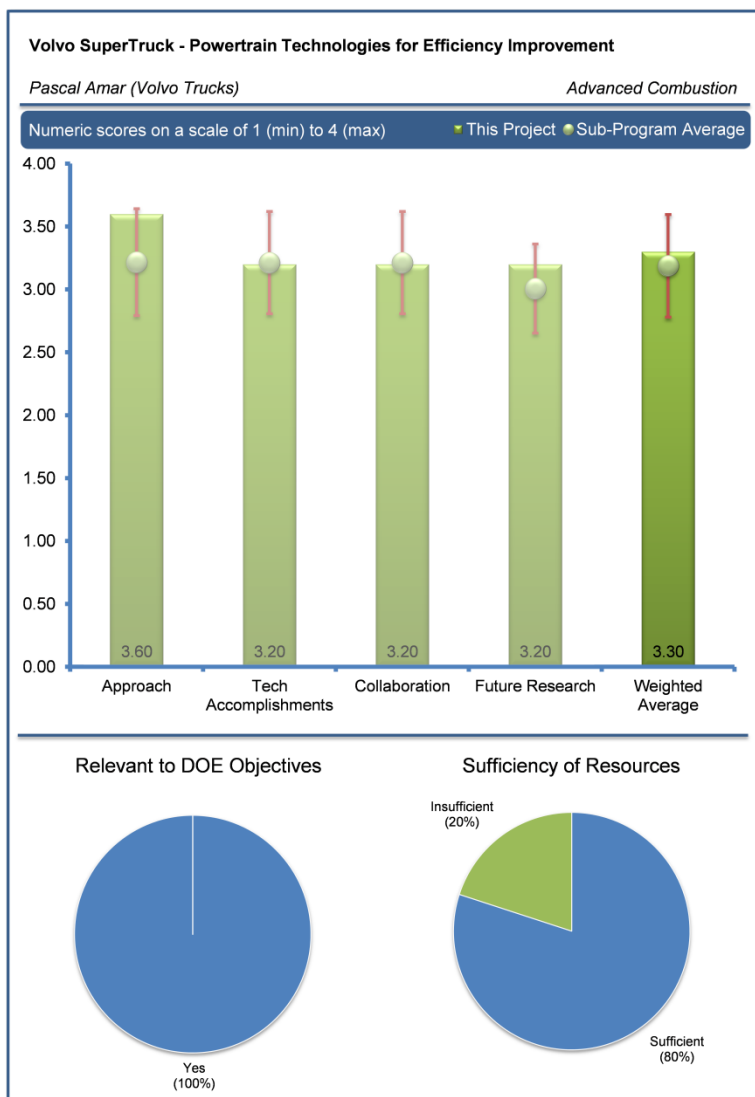
Reviewer 5:

The reviewer stated that SuperTruck project goals have clearly been embraced and the building block technologies (Rankine Cycle, Turbo Compounding, Cooled EGR) integrated into the product development plan for possible production implementation. The Rankine cycle was discussed with a clear communication of possible production use of the SuperTruck level technology. The reviewer indicated that other technologies such as robotized automatic, consideration for advanced RCCI combustion and next generation fuels such as DME were exemplary. Prioritization of key technologies and contribution were identified. There was a clear planning timeline for implementation with plans for engine and vehicle integration tests starting early.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the project team seemed to be doing well with the Rankine WHR. The project team is using ethanol as the fluid and made it clear during the question and answer session that the system could be safely commercialized. From the presentation, the reviewer assumed that the 48% BTE was using this unrealistic fuel.



Reviewer 2:

The reviewer stated that the amazing engine efficiency seemed to be approaching program goals rapidly and ahead of schedule.

Reviewer 3:

The reviewer observed that the team started much later than the other teams and had demonstrated very good results with the data even without that consideration. The project delivered a powertrain to a truck chassis with 48% BTE with many new technologies implemented. The reviewer commented that the team has designed WHR system with an eye toward production. The reviewer recognized that vehicle level data was shown for Rankine Cycle on a vehicle with a transient cycle. All efficiency improvements claimed were integrated into the full system and demonstrated as a powertrain system.

Reviewer 4:

The reviewer felt that the project was exceeding BTE goals ahead of schedule.

Reviewer 5:

The reviewer stated that the 48% achievement with a comprehensive technology list was impressive, giving such a shorter time compared to its competitors.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that the integration of partners and collaborators seemed to be quite good. Slide 16 was an excellent summary.

Reviewer 2:

The reviewer indicated a very good cross-section of partners from the industry and universities. The reviewer thought that the integration of a fuel supplier Exxon Mobile was an exemplary idea, as the expectation for the next generation systems with PCCI, RCCI will require fuel supply industry involvement for success.

Reviewer 3:

The reviewer reported a reasonable set of collaborators. Volvo seemed to do more of the work in-house than some others; not a bad thing. The collaboration Volvo is doing seems effective and appropriate.

Reviewer 4:

The reviewer stated that it was not clear how the various partners contributed to the program with the way it was presented by the contractor; even with one slide to show the list of participants.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that there was a solid approach toward the program goals with a high confidence of success.

Reviewer 2:

The reviewer indicated that there was an excellent plan for future work. The integration and production use of technologies was clearly the focus. Plans to implement PCCI DME/propane were exemplary. Significant benefits from these systems have been demonstrated from both BTE and an emissions standpoint. Some more detail on the truck/trailer integration could improve the score.

Reviewer 3:

The reviewer felt that it would be good to provide a more detailed plan of how the future work would be done in achieving the final program goals.

Reviewer 4:

The reviewer would have liked to see more discussion of the aftertreatment component.

Reviewer 5:

The reviewer went back to the fuel issue. The reviewer did not see that the path forward avoided the use of DME. If DME was required, then the reviewer was not comfortable with the path forward.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that even though the Volvo work appeared to be done with unrealistic fuels, the reviewer thought that it had long term relevance.

Reviewer 2:

The reviewer felt that the work had a direct contribution to vehicle efficiency.

Reviewer 3:

The reviewer stated that the SuperTruck objectives to develop technologies for 50% BTE, 55% BTE and 50% improvement of freight efficiency at 2010 emissions were clearly aligned with reduction of petroleum. The project had a strong focus on key technologies to achieve the goals and also showed a very strong predisposition to implement the technologies on production trucks as soon as possible.

Reviewer 4:

The reviewer summarized that the program was to develop some production intent technologies that could reduce the petroleum consumption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer offered that the project team seemed to be accomplishing solid results with the available funding.

Reviewer 2:

The reviewer stated that it seemed to be an appropriate level of effort.

Reviewer 3:

The reviewer noted that funding was sufficient to meet goals. Volvo was contributing a majority percentage of the budget as cost-share. This demonstrated the level of commitment to productive implementation of the technologies demonstrated on SuperTruck.

Reviewer 4:

The reviewer observed that this project had about half the budget of the others and had already achieved more than certain others, with a much higher probability of success.

Reviewer 5:

The reviewer indicated that the total funding was much less than their competitors, while achieving the same goals in a much shorter period.

ATP-LD; Cummins Next Generation Tier 2 Bin 2 Diesel Engine: Michael Ruth (Cummins) - ace061

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this work was an interesting project. It represented an effort to simultaneously integrate the next level of advanced technology for combustion systems, control, manufacturing, and aftertreatment into a vehicle all at the same time, while maintaining a viable and affordable product.

Reviewer 2:

The reviewer said that this was a very interesting program to make a comparison of a diesel replacing a gasoline engine in the pickup truck application. The product targets were very aggressive, and had been tackled with solid engineering approaches.

Reviewer 3:

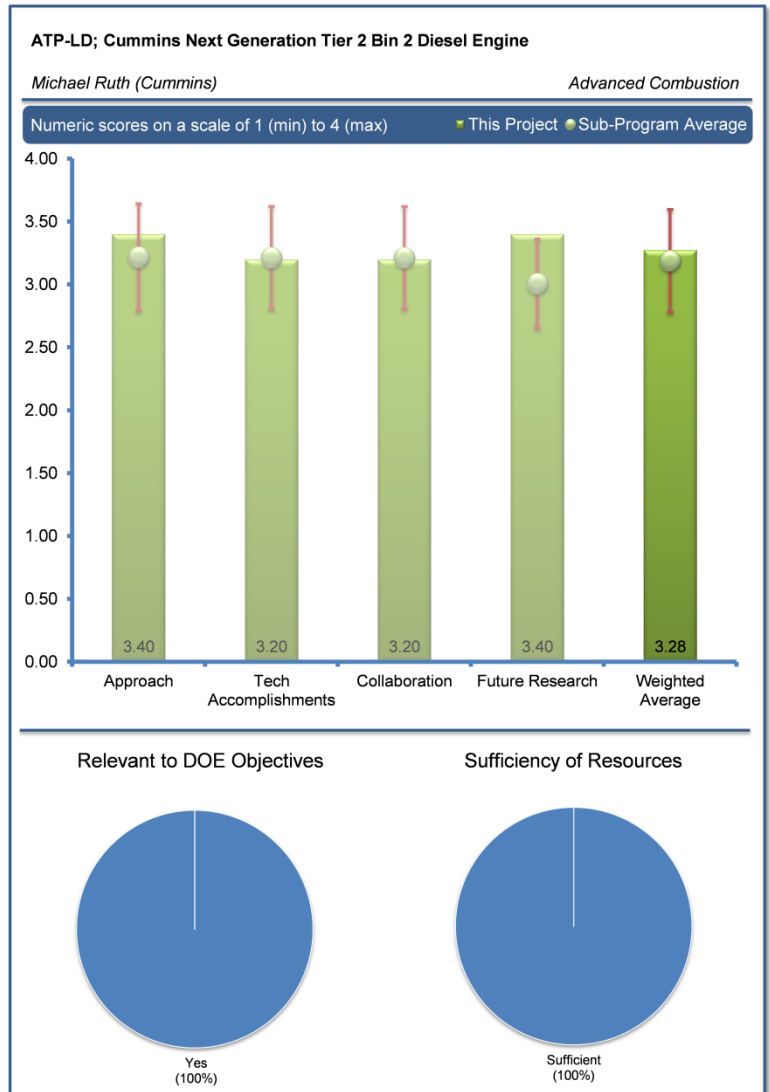
The reviewer commented on the excellent use of aluminum block supported by steel for durability. The reviewer thought that eliminating the need for any studs into AI was excellent. The downsizing approach was good. A 40% FE improvement target with Tier 2 Bin 2 emission was very good.

Reviewer 4:

The reviewer stated that this project was the only LD diesel program with a goal of 28 MPG for a half-ton truck. The project achieved Tier 2 Bin 5 in a vehicle. The new engine uses a lot of AI and represents at least a 30 pound lighter engine when compared to original, allowing for more aftertreatment. The aftertreatment included a cold start catalyst. The reviewer noted good partnership with Johnson Matthey.

Reviewer 5:

The reviewer indicated that the extensive use of aluminum material for a diesel engine was something new, where the weights saved can be used to emissions upgrade. Using Model Predictive Controller (MPC) for an air system control is challenging but great for the future of OBD development. The reviewer felt that it was not clear why gaseous NH_3 is used for the program, since there was no production future with Amminex's solid urea. Maybe this was due to the fact that the aftertreatment system had very short mixing area if the liquid urea was used. The reviewer felt that justification of using solid urea would be helpful in this program. The use of a NOx absorber was an interesting concept, but it would definitely increase the cost, thus less competitive than gasoline engine in terms of the package cost.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the progress and accomplishment were on or ahead of schedule.

Reviewer 2:

The reviewer stated that the project to date had come up with solid designs that seemed to be accomplishing the aggressive project targets. The innovative solutions to problems like low exhaust temperature during cold starts seemed to be working.

Reviewer 3:

The reviewer reported that the engine was running and showing necessary torque with significant weight reduction and was on track to meet emission standards Tier 2 Bin 2. The cold start concept was showing some promise and if it was sorted out could enable a production engine near term. The weight reduction was large enough to leave an allowance of about 152 pounds for the emission control system.

Reviewer 4:

The review indicated that 60% of goals were accomplished; the project has about 1.5 years left and is on target.

Reviewer 5:

The reviewer stated that the first shot on the mule engine seemed to show the promising features. Hopefully, the new engine to be built should be more competitive. However, whether it can meet a 40% improvement goal remained to be seen, since the progress made so far were mainly on the aftertreatment side as far as this presentation was concerned.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the attempt to integrate the Rose Hulman Institute of Technology into the project was admirable.

Reviewer 2:

The reviewer noticed that Cummins seemed to do an excellent job of integrating quality suppliers and researchers into their programs.

Reviewer 3:

The reviewer commented on the good use of partners and observed that a difficult gate decision was made on technology readiness from the Rose Hulman Institute of Technology on the NOx sensor. Nissan-confirmed interest in productive application would make collaboration outstanding.

Reviewer 4:

The reviewer highlighted partnerships with ORNL, Johnson Matthey, and universities.

Reviewer 5:

The reviewer stated that working with Johnson Matthey, Nissan, and ORNL is good.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that it appeared that the project team was on track to meet the program goals on schedule.

Reviewer 2:

The reviewer noted that the plans addressed the open issues and seemed likely to be successful.

Reviewer 3:

The reviewer felt that the project was in good shape with a status similar to some carryover engines when aggressive emissions targets were ratcheted down. The engine design appeared nearly complete with the possible exception of EGR loop optimization. The reviewer noted that the project started, but must sort out cold start NO_x CSC and SCR/filters.

Reviewer 4:

The reviewer pointed out the following regarding the project: controls work, new castings, and glow plugs.

Reviewer 5:

The reviewer stated that the future plan seemed solid. However, it would be helpful if a production road map was shown. At this time, it was still challenging to put this engine in production due to high potential cost.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that the learning obtained during this project should accelerate the introduction of more advanced fuel consumption and emission reduction technologies throughout entire powertrain into near-term products.

Reviewer 2:

The reviewer noted the large improvement in fuel efficiency of a large class of vehicles (pickup trucks) that use a lot of fuel.

Reviewer 3:

The reviewer indicated that the engine targeted 40% improvement in fuel economy when compared to a traditional gas engine and appeared commercially viable in the near term. Technical roadblocks were very difficult (durability, aftertreatment cost/durability) but were not insurmountable. The calculation is 1.5 billion barrels today if all light trucks and SUVs achieved 40%.

Reviewer 4:

The reviewer felt that the reduction of the fuel consumption was always part of overall DOE objective. A 40% reduction compared to gasoline engine is a big improvement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that the resources appeared to be sufficient.

Reviewer 2:

The reviewer noted that resources seemed to be appropriate for the levels of work taken on.

Reviewer 3:

The reviewer summarized that the technology methodology had been developed through a mule engine. The 40% remaining funding should be adequate to complete the program goal.

A MultiAir / MultiFuel Approach to Enhancing Engine System Efficiency: Ron Reese (Chrysler LLC) - ace062

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the dual path approach on combustion systems reduced risk. The reviewer noted that there was an interesting multi-plug approach, though not entirely new. Other vehicle and engine features added were reasonable. The reviewer felt that BSG was a nice addition, but similar systems in mild hybrids were already commercial; could have been in the baseline vehicle. The reviewer added that multi-loop engine and transmission cooling was not really new.

Reviewer 2:

The reviewer stated that the overall approach was very good. The use of high dilution in a stoichiometric package gave very good confidence of low emissions with high efficiency. The focus on two alternate means of ignition was unique.

Reviewer 3:

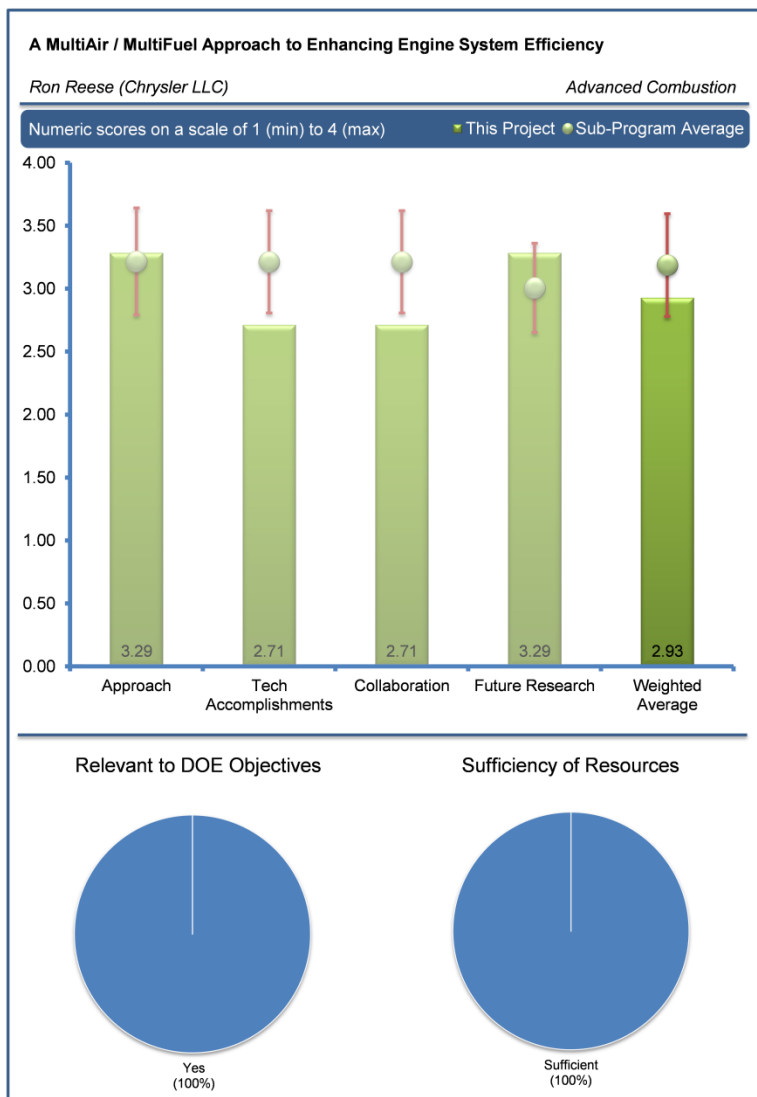
The reviewer reported that the outline of technologies list and contribution is good, however, both current technologies pathways SI Ethanol/Gas, CI Diesel/Gas are dual fuel making the production implementations much longer term and less likely to see the light of day. The reviewer noted a good list of technologies (high dilution cooled EGR, ignition) but no mention of cost/value analysis path to production reduces score when technologies are available as pathways to nearer term production. The reviewer felt that aftertreatment is not clearly addressed and WHR should be removed as not practical. Excellent work to use nine-speed transmission with low lockup. This could provide significant savings even without engine downsizing.

Reviewer 4:

The reviewer expressed that the chosen approach is somewhat conservative in that it employs stoichiometric operation with high EGR and downsizing. On the other hand, there is some novelty in the base engine design. The reviewer pointed out that the alternate approach using diesel and gas dual fuel appears to have hit an end so it was not entirely clear why so much of the presentation was spent describing the effort.

Reviewer 5:

The reviewer stated that the project looked at two combustion approaches and is downselecting to one (SI) for the vehicle demo. Both approaches (CI and SI) were of merit and aimed at higher efficiency engines. In addition to the engine efficiency gains, other engine components and vehicle drivetrain efficiency gains were also critical in the overall vehicle design choices.



Reviewer 6:

The reviewer commented that the project did really nice work, but was still concerned that the dual fuel approach would not be an adoptable path forward.

Reviewer 7:

The reviewer remarked that the project had a kitchen sink approach with downselect at appropriate times. The project had a mix of risky and not-so-risky technology. The reviewer felt that the Stoich with TWC was safe and smart but was not pushing the envelope.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that there was good progress on SI engine development and vehicle development. Not much engine data on Diesel-Assisted Spark Ignition (DASI) or Diesel-Micro-Pilot Ignition (DMP), but perhaps downselection was being made. Not much discussion of aftertreatment. The reviewer added that TWC is low risk, but there was not much proof at this point that Tier 2 Bin 2 would be achieved.

Reviewer 2:

The reviewer stated that the results presented solid progress in fuel efficiency with a good understanding of the issues and solutions available to them.

Reviewer 3:

The reviewer indicated that there were good results for BSFC versus power. The drawback is no emission numbers or targets were reported. The reviewer added that there was no identification of how emissions would be handled except to say stoichiometric. The reviewer said that many pathways were still active which indicated that more work needed to be done. The data presented from boost/EGR and air system and crankshaft balancing was good but limited data from some other critical path items were needed demonstrating value. For example, the ion sense feedback control system capability was indicated as a key technology, but limited supporting data for actual control was presented. The reviewer commented that the WHR also was a key technology identified, but was not discussed in the main presentation data or during Q&A that it was removed from consideration.

Reviewer 4:

The reviewer noted that significant benefits seem to be had from downsizing and the use of the nine speed transmission. Neither of these strategies would seem to have been enabled by DOE funding, rather these are normal product development exercises. The reviewer stated that it seems awkward to take full credit for these approaches in the 25% fuel reduction target.

Reviewer 5:

The reviewer stated that a lot of progress has been achieved, and there is still much to be done toward a vehicle demonstration. Overall, it was obvious that progress had been made on a number of fronts (that add up together to achieve greater system efficiency).

Reviewer 6:

The reviewer indicated that progress has been good, despite a break in continuity.

Reviewer 7:

The reviewer reported that there was good progress on the downselected approach, but the DMP progress was disappointing.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer expressed not being clear how or whether the research tools at ANL were being systematically applied to advance the DMP or SI approach or if it was just applied to individual experiments with interesting capabilities.

Reviewer 2:

The reviewer noted good use of ANL capabilities, and a couple vendors for components.

Reviewer 3:

The reviewer noted that there was good collaboration including leveraging ANL.

Reviewer 4:

The reviewer indicated that the collaborations with ANL and Ohio State did not seem to be very integral to the main effort at Chrysler. Rather, the collaborations appeared to be separate and parallel efforts that did not really add to the Chrysler main product selection.

Reviewer 5:

The reviewer stated that there are a number of collaborations on the project. The ANL spray diagnostics work appears to be beneficial to the project. The dual fuel CI work at ANL was decided to not go forward in the project vehicle demo, but it was not clear all of the reasons for that choice or what exactly was determined from those studies. The reviewer reported that Bosch and Delphi are contributing to the various hardware in the project; the Ohio State part of the project is providing benefits for some of the sub-system energy benefits, which seems like a good modular scope for the university partner.

Reviewer 6:

The reviewer noted nice variety of collaborators and with some roles seeming well-coordinated.

Reviewer 7:

The reviewer indicated that collaboration between institutions appears to be adequate. The reviewer suggested that perhaps the category should be asking for performance of collaborators, not how well collaborators coordinated with one another.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the project was on path to build demonstration vehicles.

Reviewer 2:

The reviewer noted that it would be very interesting to see how this work translated into the vehicle. The downselect of technologies seemed to need to be made soon.

Reviewer 3:

The reviewer stated that the plan to finish out work in dyno and on vehicle was a good typical plan.

Reviewer 4:

The reviewer noted that the path forward looks solid. The combustion approach has been narrowed which should enable good progress on the vehicle demo.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reported that there were some innovations here that could contribute to reduced fuel consumption.

Reviewer 2:

The reviewer observed a large gain in vehicle fuel efficiency.

Reviewer 3:

The reviewer stated that the 25% fuel economy technology improvement target was a good one. Some technologies could produce results in the near term such as nine speed transmission.

Reviewer 4:

The reviewer said that this project could enable petroleum displacement particularly for larger size passenger vehicles. It is important to note that the project aimed to improve large vehicle fuel efficiency as even small gains there can lead to significant petroleum savings.

Reviewer 5:

The reviewer noted a good blend of near-term technology. It was disappointing to the reviewer, that for a \$30 million program that DMP could not be implemented on a demonstration vehicle.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that resources seemed to be about right for this large effort.

Reviewer 2:

The reviewer said ARRA funds.

Reviewer 3:

The reviewer stated that the budget was the largest seen, but appeared appropriate for the scope of the study.

Lean Gasoline System Development for Fuel Efficient Small Car: Stuart Smith (General Motors) - ace063

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the technical plan was very sound and was expected to reach the project goals of 25% improvement. The lean-burn system represented a major development and appeared to prove an alternate path forward for combustion systems. The reviewer indicated that another contributor to the fuel economy goal was a start-stop system. Similar systems were already available on U.S. specification vehicles. It would be better if the goals were more aggressive or the baseline was at a higher level.

Reviewer 2:

The reviewer reported that a logical pathway was identified and subsequently followed to achieve the stated goals. The combination of lean-burn, passive/active ammonia SCR, along with the needed controls appeared a viable pathway to achieve the goal of 25% fuel efficiency improvement.

Reviewer 3:

The initial approach did not meet the FE target although it met simulations; the need for lean downsized boosted (LDB) should have been recognized sooner.

Reviewer 4:

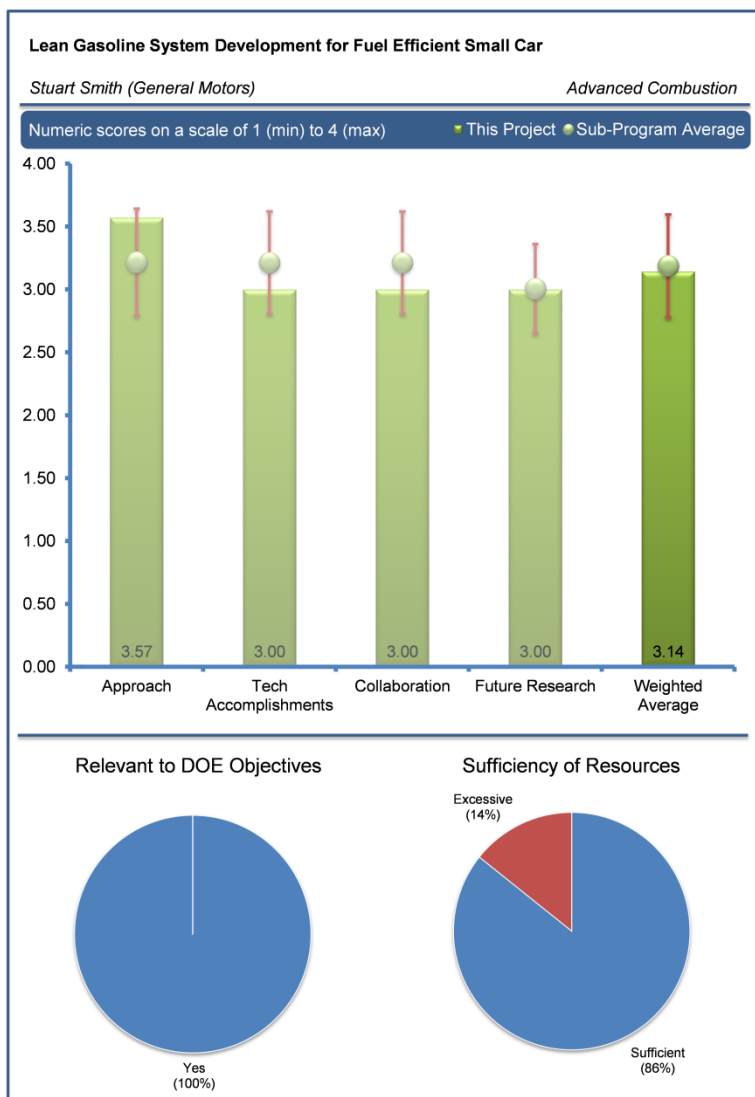
The reviewer stated that the approach to further develop lean, boosted, downsized engine and work for mature lean aftertreatment was a reasonable strategy toward a 25% FE improvement goal. Lean stratified technologies have been worked through thoroughly in the past 20 years with the limitation being aftertreatment. SCR may be acceptable to customers, and passive SCR was an excellent goal. The reviewer felt that there was a good approach to characterize the test speed and load points and to estimate real test improvement with real data. The reviewer identified that the 12 volt start/stop had concerns with customer acceptance due to NVH issues.

Reviewer 5:

The reviewer noted that the lean burn gasoline approach was relevant and appropriate for this program. It has general applicability, a good amount of risk (especially with the emission control) and good potential.

Reviewer 6:

The reviewer stated that this project uses an approach heavily focused on lean gasoline engine and emission control (+ controls) technologies. Such technologies are very appropriate for this government-industry collaboration as the technology is challenging but with research and development, and further development worth considering for commercial applications. The reviewer reported that



the progress in the move from naturally aspirated lean combustion to boosted and downsized lean combustion is significant. Greater fuel economy gains at low and moderate loads (versus stoich) were shown. The lean emission control system is novel and cost-effective (relatively speaking). The reviewer identified that urea is being utilized to make up for NH_3 needed that is not produced with the passive (over TWC) approach. It was clear that the passive NH_3 production is lowering overall urea tank/refill frequency requirements. Overall, the reviewer felt that there is a very promising approach with excellent progress shown and the reviewer is looking forward to the vehicle results.

Reviewer 7:

The reviewer said that there was a good approach and noted good application of 2.2-liter naturally-aspirated engine experience to a 1.4 liter GTDI engine.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the lean-burn aftertreatment system and combustion system developments were highly significant. The overall progress toward vehicle demonstration was excellent.

Reviewer 2:

The reviewer reported that earlier in the program, a naturally aspirated engine was converted to lean burn to determine potential benefits. As it yielded only 13% improvement, an LDB engine was developed. The LDB engine in turn achieved the 25% FE improvement while meeting the Tier 2 Bin 2 emissions target. This team is on the pathway to demonstrate the LDB engine in a vehicle after integration with vehicle controls.

Reviewer 3:

The reviewer noted that good BSFC results were achieved in a short development time on the LDB engine.

Reviewer 4:

The reviewer stated that the initial first generation engine achieved only a 10% fuel economy with lean combustion. This was not a large base engine technological feat. Leaning out traditional stoichiometric engines can yield close to 10% improvement. The reviewer described that the SCR passive ammonia generation did not produce significant ammonia to eliminate urea tank and the passive amount was not quantified. The first generation gasoline SI engine requires 1.4 times the urea as a comparable diesel. The second generation LDB engine: downsized, with cooled EGR, close coupled TWC integrated into the turbine housing was projected to have nearly a 21% fuel economy improvement which was better than traditional lean stratified but it also was projected to consume even more urea than the first generation engine and significantly more than diesel technology (approaching 2x). The reviewer noted that the PI indicated that gasoline SCR aftertreatment cost was significantly lower than diesel fuel injection system and was therefore an implementable, competitive solution. The reviewer felt that the technology could be ready in a few years.

Reviewer 5:

The reviewer stated that it was good to see that the program has now moved on to a boosted engine platform. The work on passive versus active ammonia systems for the SCR is intriguing although it was no surprise that the final design would employ some active system. What is surprising was the ability to meet current particulate standards without a filtration system. The reviewer concluded that it would be good to see verification that this was the case.

Reviewer 6:

The reviewer commented that it was excellent to see the results from the downsized lean boosted engine this year. The new engine is showing significant advancements in efficiency over both the PFI baseline and the previous naturally aspirated lean engine. Good progress on the emission control system and the calibration/controls work was also shown.

Reviewer 7:

The reviewer indicated that there was an impressive mastery of quasi-passive ammonia SCR. The engine out NO_x was 10x that of diesel but only 1.4x the urea consumption.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated that the partner selection was sound and effective; the OEM and key suppliers, including a leading aftertreatment company.

Reviewer 2:

The reviewer noted that the GM (PI) was collaborating with partners with needed expertise to ensure the success of the present project.

Reviewer 3:

The reviewer noted a use of good suppliers rather than a thorough integration of partners.

Reviewer 4:

The reviewer indicated good partners including Bosch, Umicore, and Ricardo. The third-party modeling, evaluation, and testing at a National Laboratory could improve the score.

Reviewer 5:

The reviewer felt that the team had all the right skill sets. Ideally, the aftertreatment expertise at Umicore coupled with the systems expertise at Ricardo and Bosch would be hard to beat. The reviewer criticized that it was difficult, however, to know exactly how well the team was collaborating and how much each brought to the project specifically.

Reviewer 6:

The reviewer reported that the calibrations with Ricardo, Bosch, and Umicore appeared to be beneficial to the project. However, there was no university or National Laboratory partners mentioned and asked if such partners would add benefit to the project.

Reviewer 7:

The reviewer noted that collaborators all appeared to be pulling their weight. The reviewer noted that there was a good team.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer stated that the project was in its final stages, so the future plans were moderately a relevant rating area. The reviewer asked if there was a path to commercial use. The reviewer presumed the final demonstration of goals would be based on chassis dyno and road tests, and not the steady-state mode simulation used in development.

Reviewer 2:

The reviewer stated that as a next step, the installation of the LDB engine and integration of its controls with that of the vehicle was proposed. Finally the vehicle would be tested for performance evaluation. This was a logical extension of the effort pursued so far.

Reviewer 3:

The reviewer expressed concern about real world fuel economy and thus the customer acceptance of these technologies. The reviewer suggested that the project team needed to look at higher loads and real-world driving cycles.

Reviewer 4:

The reviewer indicated that the improvements planned should result in the achievement of the 25% goal. All technology should be achievable in a few years on the vehicle and the value proposition was reasonable. The concern was consumer acceptance of urea consumption and the 12V Start Stop.

Reviewer 5:

The reviewer stated that future plans seemed reasonable.

Reviewer 6:

The reviewer reported that the future work was appropriate and focused in the right direction (vehicle integration and demo).

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer felt that yes, the proposed development could lead to fuel efficiency improvement by 25%. This can potentially wean the nation off its petroleum dependence.

Reviewer 2:

The reviewer observed a direct relevance.

Reviewer 3:

The reviewer reported that a 25% fuel economy improvement goal can be met with technology that is possible to implement in the near term.

Reviewer 4:

The reviewer noted that this project had the potential to impact the gasoline fueled passenger car market and significantly reduce petroleum from that fleet in the United States.

Reviewer 5:

The reviewer indicated that this was a very relevant demonstration. There is a high risk, high payoff approach. This is the type of demo project DOE should be funding.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer commented that it seemed okay.

Reviewer 2:

The reviewer stated that the funding was high for the activity. Significant technological stretch was not pursued. The work is valuable and well done, but the funding required for this activity could be less than \$15 million and achieve goals, especially if the technology was in the product plan for production.

Gasoline Ultra Fuel Efficient Vehicle: Keith Confer (Delphi Automotive Systems LLC) - ace064

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that there was a well-thought out, well-orchestrated effort at a very good value. Overall the gasoline direct compression ignition (GDCI) concept stood out as a very promising technology that can lead to significant fuel savings. The other two technologies (i.e., friction reduction via down speeding, and ePhasers) appeared promising with long term value.

Reviewer 2:

The reviewer stated that the overall plan included some high-risk stretch technology (good for a DOE project) as well as well-understood near-term solutions. The GDCI system was worth the exploration at the vehicle level to help determine the viability of low-temperature combustion methods and would be an important outcome. The reviewer reported that the strategy and discussion on achieving emissions goals such as Tier 2 Bin 2 were not really complete. Engine-out PM and NOx were very low in engine tests, but it was unlikely that Tie 2 Bin 2 was achievable without integrated aftertreatment system. The reviewer recalled that this was a criticism in a prior year.

Reviewer 3:

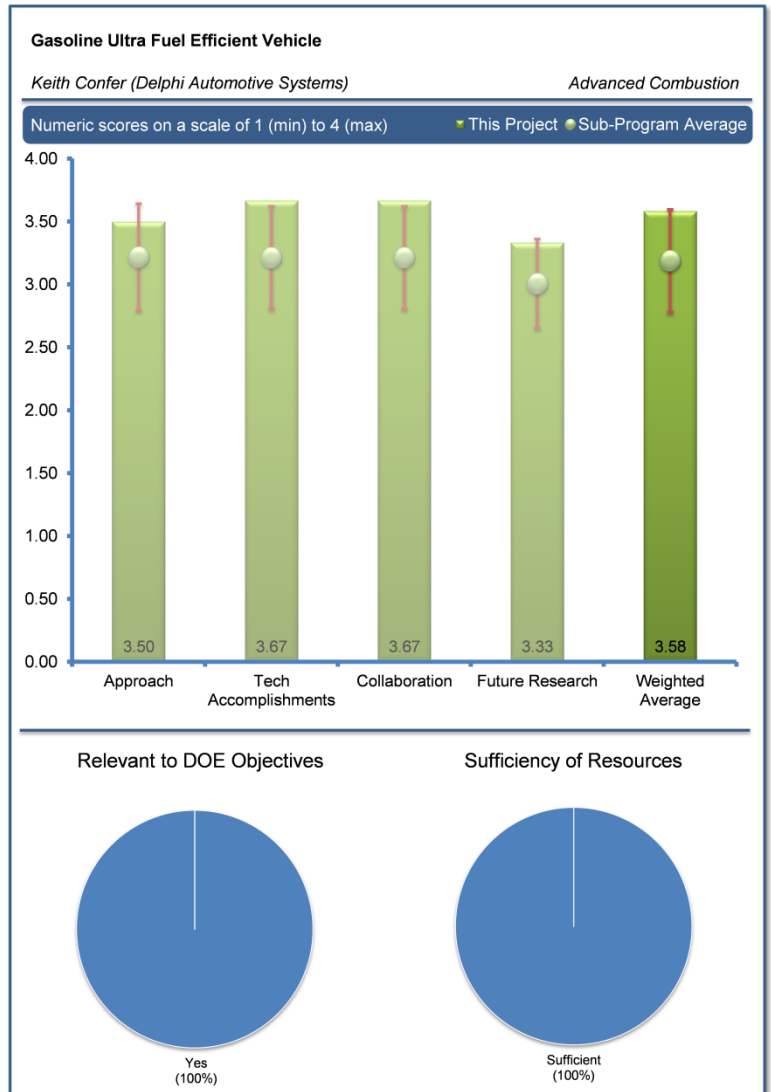
The reviewer indicated that a large number of technologies have been included in this project -- almost a shopping list rather than a concept. However, the project appropriately includes downselect and analysis of which technologies are synergistic and which are not. The reviewer stated that the method has the advantage of potentially pulling some successful ideas into production sooner, without waiting for the whole package to mature. The reviewer expressed concern that the in-use fuel variability will be a difficult problem for the CI concept, especially when the full range of cold operation is included.

Reviewer 4:

The reviewer said the project was aggressive, risky, and innovative; everything that one would look for in a DOE-funded project of this sort.

Reviewer 5:

The reviewer stated that the approach focused primarily on the GDCI technology which enables gasoline combustion with diesel-like efficiency but at gasoline scale equipment cost. The advancements made in GDCI are substantial and the team has moved away from multimode operation with HCCI. The reviewer noted that the injector technologies developed were importantly demonstrating low



PM emissions. Also, apparently NO_x emissions were controlled in-cylinder. While the project has made excellent progress with the GDCI approach, the project would benefit from more research results on the novel injector technologies shown (more sharing of the mechanisms and sprays that are enabling progress). The reviewer felt that more information on in-cylinder NO_x control mechanisms would also be beneficial. HC and CO emissions also need to be characterized and an appropriate control mechanism shown.

Reviewer 6:

The reviewer reported that the project was attempting to demonstrate a risky, advanced combustion approach.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted outstanding progress was made on base vehicle improvements and GDCI multicylinder engine builds and tests. The reviewer cannot assign an outstanding mark because the emissions question was not resolved as the vehicle phase was starting.

Reviewer 2:

The reviewer indicated that in Phase-I of this effort, two vehicles were built and tested, each with a different combination of advanced technologies. Out of these two technologies - friction loss reduction through downspeeding, and use of ePhasers - proved promising. The reviewer reported that in the Phase-II of this program, that was executed so far, the hardware configuration for GDCI was optimized to result in an engine that offered significant (greater than 25%) improvements in fuel efficiency, while meeting the emissions target. Subsequently, a multi-cylinder engine has been built and is currently being optimized before installation in a vehicle. Overall the progress achieved is very impressive.

Reviewer 3:

The reviewer noted that there was solid progress on a number of interesting technologies. Good progress in defining the ultimate package of features and integrating the concept.

Reviewer 4:

The reviewer stated that the concept of gasoline direct injection, compression ignition is very interesting indeed. This has the potential to bring many of the benefits of traditional diesel engines along with the benefits of traditional gasoline engines. Conversely, the potential exists to blend the deficiencies of both approaches. The reviewer felt that the progress made with the E' and E" test configurations is impressive. The reviewer added that it would have been nice to hear more details of the hardware but it is understandable that this is sensitive information. It will be exciting to see how this work proceeds towards addressing full transient operations.

Reviewer 5:

The reviewer stated that the project has shown excellent progress in the GDCI combustion approach utilizing the injector technology. Clearly, benefits are being attained from advanced injector design. The reviewer reported that it would be better if there were more information shared on the injector mechanisms that are the underlying source of the benefits achieved since this is a public project. The emissions are low as observed to date; it will be interesting to observe the emissions for transient drive cycles. The reviewer also indicated that the project should show more specific data related to the oxidation catalyst approach since that is identified as the emission control requirement (specifically, what temperatures were observed on the oxidation catalyst, what HC species were present, and where light-off occurred, and etc.)

Reviewer 6:

The reviewer said that although it seemed somewhat secretive, the project appeared to have mastered GDCI.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project has brought together outstanding participants from the industry and universities.

Reviewer 2:

The reviewer reported that this team effort has the right elements of partnership between a parts supplier like DELPHI and vehicle manufacturer like Hyundai. This was supplemented by modeling and testing efforts by WERC. The involvement and contribution from Wayne State was not clear from this presentation.

Reviewer 3:

The reviewer stated that close relations with Hyundai America Technical Center Inc. (HATCI) and others seemed to be well integrated in the project.

Reviewer 4:

The reviewer felt it was a good team with Wayne State University (WSU), WERC, and HATCI, but that it could be made stronger with a U.S. OEM involved. However, this was an understandable result given the awards to the three major U.S. OEMs and the conflict of interest which would arise.

Reviewer 5:

The reviewer noted that the collaborations looked good with a mix of universities and private sector entities.

Reviewer 6:

The reviewer commented that there was a good team and all members appeared to be pulling their weight.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that full emission compliance strategy was not fully addressed.

Reviewer 2:

The reviewer felt that a logical extension of the progress was achieved so far.

Reviewer 3:

The reviewer commented that the vehicle build and demonstration will be most interesting.

Reviewer 4:

The reviewer expressed excitement to see how the technical challenges are addressed in the coming year, and incorporated into the demonstration vehicle.

Reviewer 5:

The reviewer stated that much progress was needed on the vehicle demo part of the project, but the combustion footing is solid, and a good plan for moving forward was presented.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reported an emphatic yes. The concepts investigated have long term value in terms of fuel savings for the nation and reduction of GHG for the environment.

Reviewer 2:

The reviewer stated this was a big, fuel efficiency vehicle.

Reviewer 3:

The reviewer said, yes, the project has potential to substantially reduce petroleum via the GDCI combustion approach.

Reviewer 4:

The reviewer indicated the project was a high risk, high payoff approach. This was the type of demonstration project DOE should be funding.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the project team executed a well-thought out project plan and had delivered the promised deliverable at a very good value.

Reviewer 2:

The reviewer said resources seem to be appropriate.

Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development: Corey Weaver (Ford Motor Company) - ace065

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer felt that the effectiveness of the overall approach to meeting goals was solid and on target. The approach lacked any major technology leap forward, but what was proposed will likely meet the goals set by the sponsor, and the commercial viability was high.

Reviewer 2:

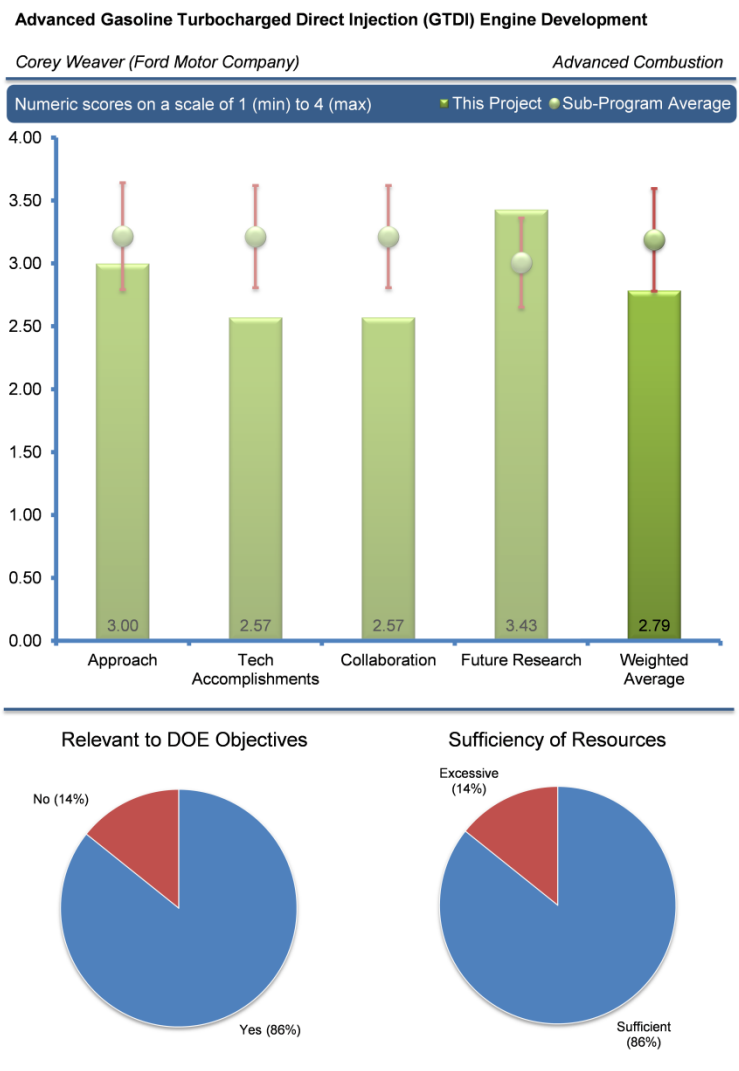
The reviewer stated that the presentation material is not very clear and that a very limited amount of information is being shared. But judging by the content, one has to guess that in addition to trying out a variety of advanced technologies, two technologies were primarily focused upon: stoichiometric burn with turbocharging and three-way catalyst; and lean burn with turbocharging and lean NO_x/SCR catalyst. The reviewer reported that all of these were pursued in addition to the main effort of downsizing. At the heart of any research program is a solid concept. The reviewer said that in this case, one gets the impression that the project is not well-designed, and facing a myriad of pathways, Ford downselected based on engine testing far down into the program.

Reviewer 3:

The reviewer felt that this is clearly a program designed to take current EcoBoost technology and move it to much higher efficiency; the project will develop a very production-ready concept likely to have a real impact on national fuel consumption. A solid approach is taken with modeling, laboratory tests, and engine tests appropriately combined.

Reviewer 4:

The reviewer indicated that the plan to meet the target of 25% fuel economy with downsized, boosted, lean combustion is a reasonable approach. This has been pursued in various forms in the past years in the industry, with limited success due primarily to lean aftertreatment. The reviewer described a well-integrated plan including single-cylinder, modeling, dyno and aftertreatment. Novel ignition system and passive ammonia generation appear as key enablers. The reviewer noted a great additional list of technologies ready for implementation in addition to downsized boost: roller bearings on front of cam journals; electric power steering; electric Twin Independent Variable Camshaft Timing (TiVCT), variable displacement oil pump; and torque converter dampener.



Reviewer 5:

The reviewer observed that there was a very conservative approach. The reviewer was not clear how this work was much afield from standard product development activities.

Reviewer 6:

The reviewer stated that this project aims to improve gasoline engine vehicle fuel efficiency via a turbocharged GDI engine and accompanying efficiency gaining technologies. However, the project lacks sufficient risk to enable large impacts in this area. The reviewer reported that there are two primary problems with the approach. The first is that a relatively large engine was chosen for the baseline point to reference progress. A 3.5-liter V6 is a very large engine for a mid-size sedan vehicle and not a true representation of a commercially available baseline sedan (a 2.0- to 2.5-liter I4 engine would have been more appropriate). The reviewer noted that this baseline engine choice causes the project's accomplishments to appear greater than they are. Secondly, the project has dropped the lean approach due to the difficulties associated with lean emission control. While the decision may be valid to drop the lean combustion approach, no other significantly advanced combustion approach was pursued in place of the lean approach. The reviewer asserted that the nature of the DOE-funded projects should be to take risks that the industry cannot justify spending their own resources on, and the project does not now have an approach with enough risk to enable the associated high reward. Therefore, it is unclear how this approach will achieve major increases in efficiency over what would normally be achieved by the industry without DOE funding.

Reviewer 7:

The reviewer stated that there was a good approach, but looked like something Ford would do anyway. The reviewer felt that this seemed not terribly risky for a \$15 million DOE investment.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted excellent progress on base engine development, boosting system, and EGR system. This reviewer also noted many engine builds. The reviewer added that the integration in the vehicle appears on schedule.

Reviewer 2:

The reviewer stated that the project pathway was identified to be modeling from SCE testing to multicylinder engine testing to vehicle testing. System evaluation along with aftertreatment was performed ultimately at the multicylinder engine level. But the selection of the aftertreatment was performed towards the end. The reviewer indicated, however, the final goal of 25% FE improvement appears viable. Per the path identified, adequate progress has been shown.

Reviewer 3:

The reviewer reported that there was solid progress in all activities. The reviewer observed that good BSFC results while meeting all the other constraints was needed for a product. The decision to avoid lean aftertreatment seemed very appropriate; being coupled with high EGR dilution to maintain efficiency with a simpler and lower cost aftertreatment system.

Reviewer 4:

The reviewer indicated that there were very good results including a no-go gate assessment of passive ammonia generation technology and refocus on high dilution EGR with three way catalyst. There were good findings on multi-strike ignition sweet spot. The reviewer felt that the larger number of engines (12) and vehicles in the build plan demonstrated confidence in designs for possible production application of the technology. The partial data shown in the presentation indicates success in meeting fuel economy goals (min-map points) and a return to stoichiometric removes a degree of risk from aftertreatment. Some data for engine out and three-way aftertreatment system reality is desired.

Reviewer 5:

The reviewer commented that the decision of Ford to abandon lean combustion was a significant disappointment. The level of risk and innovation in the chosen path forward was minimal and brought into question the legitimacy for DOE investments.

Reviewer 6:

The reviewer noted that there was good progress in building the 2.3-liter engine and collaboration studies on the ignition process and control. However, it was unclear how the new engine was substantially increasing efficiency. The reviewer reported that the downsize versus baseline was approximately a third, and without any combustion improvements, a significant gain from operating at a higher load on the map should occur. So, it was unclear how the engine improvements were specifically increasing thermal efficiency.

Reviewer 7:

The reviewer stated that the project looked successful so far.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer felt unclear where Michigan Technological University (MTU) research would be integrated into a demo vehicle and contribute to goals.

Reviewer 2:

The reviewer stated that though MTU has shown steady progress in their tasks, most of it is of academic importance. One can hardly find any significant findings transitioning towards the final product. The reviewer noted, on the other hand, no effort has been made in the review presentation to list any publications by MTU that have resulted out of this program. So, one has to assume that this project has not resulted in any knowledge building either.

Reviewer 3:

The reviewer reported that the Michigan Tech interface was solid. There was no other major collaboration. However, given the strength and breadth of in-house expertise, this did not present a problem. Indeed, the reviewer felt that it may be a strength since Ford retained the knowledge in-house.

Reviewer 4:

The reviewer stated that only MTU is given credit for collaboration. Ford may be doing all the work in house. However, it seemed to this reviewer that there may be some key suppliers not named. To improve the score, a National Laboratory or other third-party development house could be included to verify work and key supplier credits.

Reviewer 5:

The reviewer noted that the two strike ignition work done at MTU looked intriguing, but it was not clear whether Ford was actually going to employ the strategy. Now that the project team has gone away from lean burn, the reviewer asked if this ignition work would be as meaningful with a high EGR stoich engine platform.

Reviewer 6:

The reviewer reported that the MTU collaboration was solid and was providing beneficial results to the project and adding to ignition and controls development. However, there was little mention of other collaborations.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the path forward to complete the project is clear and achievable.

Reviewer 2:

The reviewer reported that during the final year, twelve mule engines, and four vehicles were being built to complete the carpet bombing of the available technologies.

Reviewer 3:

The reviewer expressed interest in seeing the results. The reviewer observed a very solid plan with ambitious testing and development schedules.

Reviewer 4:

The reviewer stated that the homework had been done on the single-cylinder, modeling, and multi-cylinder engines to achieve a 25% fuel economy improvement with a clear eye on production applications using these technologies.

Reviewer 5:

The reviewer stated that the project was on track to reach the vehicle demo stage of the project.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer reported that the project could be argued as mostly evolutionary engineering, but achieves sponsor targets and has high probable commercialization.

Reviewer 2:

The reviewer summarized that the ultimate goal of this project was to develop a vehicle that could surpass a 25% improved fuel efficiency while meeting emission targets. The improved FE supports DOE's goal of petroleum displacement.

Reviewer 3:

The reviewer noted that the high fuel efficiency was being moved toward production in a useful way.

Reviewer 4:

The reviewer stated that the 25% fuel economy target was on track to be met and technologies appeared to be possible for production in the near term, in terms of value proposition and technical readiness; performance, reliability and cost.

Reviewer 5:

The reviewer reiterated concerns about the choice of baseline engine for comparison and the lack of aggressive combustion approach that may limit this project's ability to displace petroleum versus already commercialized technologies.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer reported that this was a well-funded project.

Reviewer 2:

The reviewer stated that it seems to be appropriate.

Reviewer 3:

The reviewer indicated that a broad range of technologies have been researched, designed, and integrated, with an eye for production. The engine and vehicle build levels support funded technology to production focus.

Reviewer 4:

The reviewer noted this as one of the largest budgets. The reviewer added that it seems high given the relatively low-risk approach.

Advanced Combustion Concepts - Enabling Systems and Solutions (ACCESS) for High Efficiency Light Duty Vehicles: Hakan Yilmaz (Robert Bosch) - ace066

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this project is utilizing an advanced combustion approach (i.e., SACI) and pursuing a multimode operation to achieve performance over the engine map. The reviewer affirmed that the level of risk in this approach is appropriate by taking risks to achieve a high reward. The reviewer said that the project utilizes a team approach and has good coordination and collaboration.

Reviewer 2:

The reviewer affirmed that utilization of multi-mode combustion from HCCI to SACI to standard SI is relevant and of value.

Reviewer 3:

The reviewer said that this research team is trying to use a combination of technologies to bring a mixed mode combustion strategy comprising of SI, HCCI and SACI.

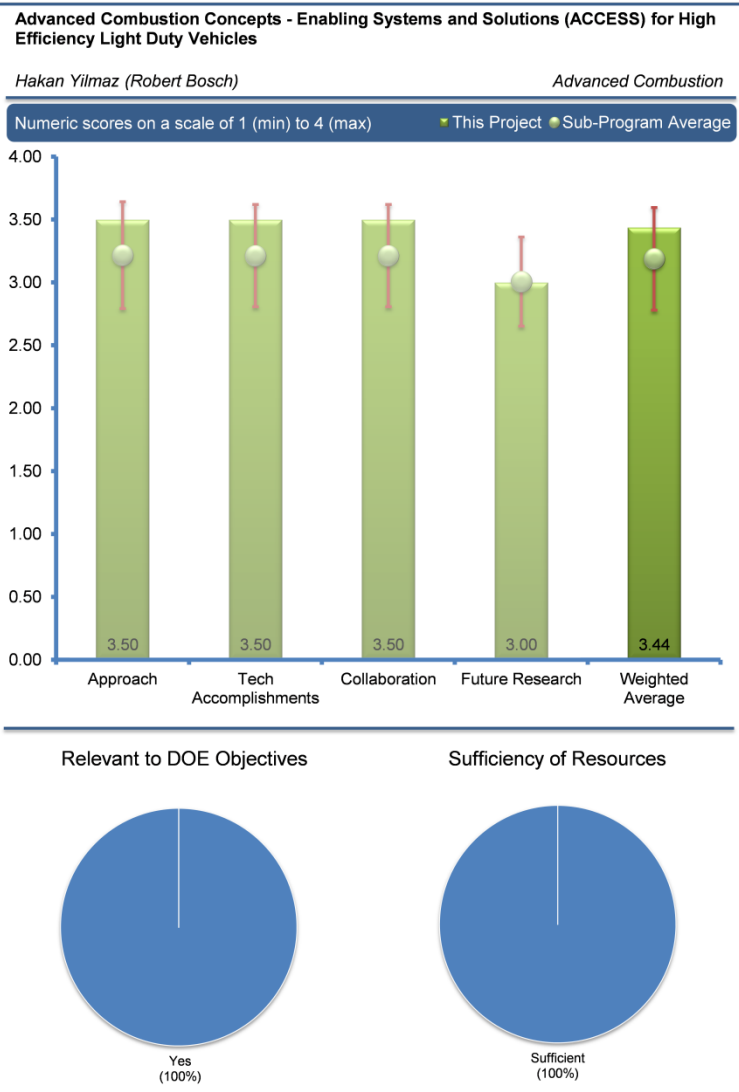
This reviewer proposed density high boosting to offset the loss in power. The review noted that with internal and external EGR the overall equivalence ratio is being maintained at 1.0, so as to able to use a standard three way catalyst. The reviewer summarized that overall the project is well-designed to evaluate the potential for the implementation of HCCI and associated combustion strategies.

Reviewer 4:

The reviewer stated that the multimode combustion approach with SI would ensure robustness and also compliment other types of combustion systems in other contracts. The reviewer added that the project had the appropriate level of stretch and risk, low-risk aftertreatment and emissions strategy, and a strong R&D team. The reviewer pointed out that significant effort would be required for controlling mode transitions in and out of HCCI. This reviewer was unsure what fuel efficiency is lost if HCCI mode (small part of operating map) is deleted and what is the value proposition of HCCI.

Reviewer 5:

According to this reviewer, the project, based on the EcoTech 2.0L, started with a downsized platform in a Cadillac. Regarding the engine, the cylinder head was changed for a central injector, electric cm phasing, 2-step cam profile, cooled EGR, and mixed-mode combustion. This reviewer went on to say that the project is developing integrated technology for drop-in OEM use.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that the collaboration and coordination of this project is excellent and that multiple entities are working closely together on the project with contributions coming from all. The reviewer said that the organization of across university and industry teams is impressive.

Reviewer 2:

The reviewer stated that this project has achieved significant progress in integrating the hardware, control strategies and software. The reviewer noted that the researchers do acknowledge the challenges associated with aftertreatment due to the low exhaust gas temperatures, but are pursuing efforts through external electrical heating. The reviewer went on to say that efforts the researchers have made to optimize control strategies are somewhat delayed, but are likely to have minimal impact on the next step of demonstrating the engine in a vehicle. The reviewer noted that no data have been presented on engine emissions verses fuel efficiency trade-off in comparison to a baseline engine during the review. The reviewer stated that the researchers will assure that this is of no concern as compared to the challenges associated with combustion control and switching between combustion modes. The reviewer remarked that as model-based-control is proposed in conjunction with in-cylinder pressure sensing, some comments on the impact on engine cost would be helpful.

Reviewer 3:

The reviewer noted that very good progress was shown on the combustion research relative to HCCI and SACI and that controls development and compression ratio selection also demonstrated progress and accomplishments.

Reviewer 4:

According to this reviewer, the majority of innovation and effort appears to be in the successful implementation of the SACI combustion approach, yet it is shown to account for only about 20% of the efficiency gain. This reviewer also wondered whether the effort is worth the benefits and asks why not implement all the other approaches, forgo SACI and yield 80% of the benefits.

Reviewer 5:

The reviewer reported switching from HCCI to SI, high compression ratio (CR), and controls works.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that this project consists of a well-coordinated team of independent labs and universities. The reviewer pointed out that the overall project would be a bit stronger with full participation by an OEM, yet the current approach may aid tech transfer to a large number of OEMs.

Reviewer 2:

The reviewer commented that the collaboration and coordination of this project is excellent. Multiple entities are working closely together on the project with contributions coming from all. The reviewer found that the organization across university and industry teams is impressive.

Reviewer 3:

According to this reviewer, the project has a very good team assembled. The team shows U.S. OEMs are involved in information exchange and technology alignment, but it would be helpful to understand in greater detail how this is actually occurring.

Reviewer 4:

The reviewer said that the project comprises of various centers of expertise that adequately leverage each other's capabilities.

Reviewer 5:

According to this reviewer, there were collaborations with Bosch, AVL, University of Michigan, Stanford, and Emitec.

Reviewer 6:

The reviewer said that the project has a really large team and budget.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the project team has a good plan forward for their technologies and technology integration. The reviewer added that there is a lot of work to perform to reach the vehicle demonstration.

Reviewer 2:

The reviewer affirmed that HCCI is essential to meet its future goals.

Reviewer 3:

The reviewer said that the project appears on path and on schedule.

Reviewer 4:

The reviewer noted that focus on emissions system and vehicle integration is appropriate.

Reviewer 5:

According to this reviewer, future activities identified for combustion control, software integration and overall hardware integration are adequate.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that this project can impact petroleum use by reducing gasoline consumption in the light-duty sector. The reviewer affirmed that the SACI approach is a key enabler for petroleum reduction.

Reviewer 2:

According to this reviewer, the project is an important indicator of how and how much advanced combustion modes and strategies can improve fuel economy at the vehicle level.

Reviewer 3:

The reviewer affirmed that the proposed concept evaluates HCCI and associated modes of engine combustion that have the potential to improve fuel efficiency of passenger cars by 25% and that this is likely to lead to support DOE's goals of petroleum displacement.

Reviewer 4:

The reviewer stated that multi-mode combustion is relevant.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer states that the project has a large team and budget, and that the program has made great progress.

Reviewer 2:

The reviewer commented that the project resources are adequate.

Thermoelectrics Partnership: Automotive Thermoelectric Modules with Scalable Thermo- and Electro-Mechanical Interfaces: Kenneth Goodson (Stanford University) - ace067

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

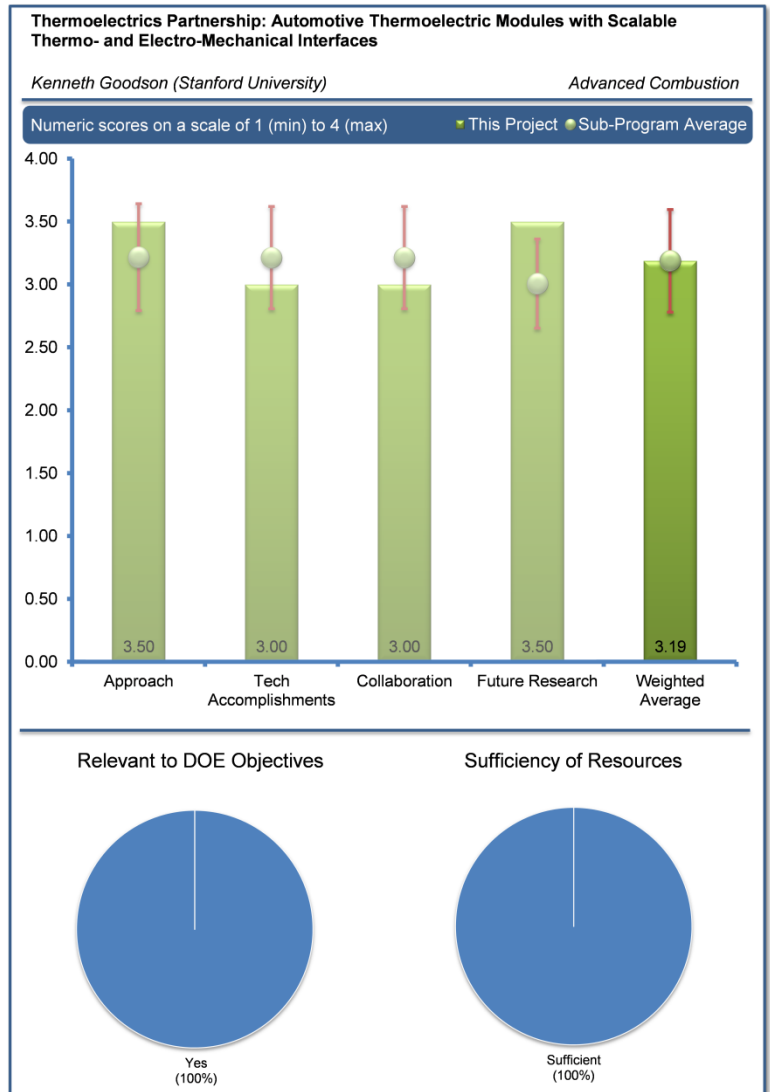
This reviewer observed that for a DOE NSF project, this team has done an excellent job to address fundamental issues in thermoelectric: improving thermoelectric figure of merit (ZT) and improving interface contact resistance.

Reviewer 2:

This reviewer stated that overall, the approach appears to have a very solid approach to overcoming the barriers presented and that the system packaging barrier did seem to be the barrier with the least amount of focus and innovation. The reviewer went on to say that from the presentation, it appears that a flat nominal wafer approach will be taken, suggesting that a bit more investigation into alternative modes to potential assemble the bridges may lead to greater advantages in the system. The reviewer noted that the remaining approaches to overcoming the barriers are focused and comprehensive in the coordinated approach.

Reviewer 3:

The reviewer said that this approach has a good focus on thermal interface materials, techniques, and solutions. The approach of using multi-physics modeling and unique experimental facilities of novel thermoelectric metrology, high sensitivity electro-thermal interface characterization, Micro-Electro-Mechanical Systems (MEMS)-based electro-thermal and mechanical characterizations, and high-temperature infrared (IR) microscopy to attack thermal interface challenges and create better interface understanding and solutions is quite good and useful in supporting DOE goals. The reviewer added that the work with reactive bonding work is quite interesting and useful. The reviewer remarked that, however, the focus on gas-liquid simulations using ANSYS & FLUENT and novel cold side heat exchanger microfluidics is redundant with other programs and does not add anything new to the DOE program. The reviewer added that the approach to work in system specifications and multi-physics codes/simulations to predict transient TEG system performance is also redundant and basically re-inventing the wheel and that DOE funds could be better spent attacking other material developments and system challenges and approaches. The reviewer said that the project's work with high-temperature TE materials (Half-Heuslers and skutterudites) is less impressive and really is not raising the bar. The reviewer stated that the project's outreach and engagement programs are useful and helpful to the future of this technology.



Reviewer 4:

The reviewer remarked that Goodson's approach has good intentions, and admirable progress. There are some issues that the reviewer thinks could be improved, such as the understanding about emissivity from the many different materials and surface finish, and how its temperature dependence can affect the measurements. The reviewer asked how the researcher can measure the temperature of a composite structure, and everything else in the field of view of the microscope, without very precise data for temperature dependent emissivity values. The reviewer pointed out that this problem is very hard, and Goodson has made truly excellent attempts to get that under control, but suggested that more work is needed. The reviewer was happy to see that the project team migrated away from carbon nanotubes and on to metal nanotubes. This reviewer was somewhat disappointed with Nolas' approach, recalling that he was systematically removing antimony from mixed pnictides and chalcogenides, in the hope of obtaining materials with low sublimation. But, the chalcogenides themselves are sublime, in many cases more than the pnictide. The reviewer stated an example that selenium has a higher vapor pressure than the respective antimony compound, and did not see value to this approach.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer stated that the project's technical achievement is very impressive. The number of publications generated is a proof of the project quality. The reviewer observed that on the NSF side, the education elements of the project also involved graduate and undergraduate students and even high school science programs.

Reviewer 2:

The reviewer said that this project has made good measurements, given the limitations, and has leveraged the measurements to extract useful information for the other performers.

Reviewer 3:

The reviewer stated that the project's work in characterizing nano-scale thermal interfaces and materials (thermal and structural properties) and their equipment is quite impressive. The team's work with metal nanowires and carbon nanotubes (CNT) to create better thermal interfaces is quite helpful. However, it concerns this reviewer greatly that these materials may be quite limited in their temperature capability and these may not work well at temperatures relevant to automotive WHR. The reviewer added that the researchers appear to be performing good work in characterizing CNT interfaces after thermal cycling and this is critical information. The project team's work with CNT mechanical simulations and experimental data are quite useful. The reviewer pointed out that this team's work on TE materials work with different skutterudites and Half-Heusler materials is unimpressive. There appears to be little work in thermal cycling of these materials and that is a serious requirement which these materials must pass to be useful in this automotive WHR application. One could easily envision any automotive TEG system cycling approximately 800-1,000 cycles each year. Any TE materials that cannot tolerate this environment should not be pursued. High Seebeck coefficients have been demonstrated in some cases, but this reviewer did not see data on the other key thermoelectric properties (electrical resistivity, thermal conductivity). The team is working with TE materials exhibiting ZT less than one. TE materials with ZTs this low will not lead to TEG WHR systems satisfying DOE's objectives. This presentation also showed no results, current work or planned work, on the mechanical/structural properties of their TE materials. In this particular automotive application, the mechanical/structural properties are just as critical as the fundamental TE properties. The reviewer noted that this is a serious deficiency in the TE materials work of this project.

Reviewer 4:

This reviewer stated that this project, having a primary focus to investigate ways to improve the interface efficiency is a significant challenge, but one worth delving into for better solutions. The project screen captures and graphical representation of the data was well-laid out and easy to follow. This reviewer also said that it appears that this effort has already accomplished some of the goals, while the remaining goals are well within reach.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that it appears that the project partners are fairly well-coordinated and that there is a solid collaboration between each entity. Even with the vast capabilities of the participants, it may be beneficial to potentially add other participants to increase the capabilities even further.

Reviewer 2:

According to this reviewer, collaborations are good, although each member is doing its own study and the overlapping of work seems not enough to generate collaborative publications that are co-authored by two or three team members.

Reviewer 3:

The reviewer said that Goodson is pursuing a very challenging approach for non-contact measurements. However, the reviewer expressed that Goodson does not have everything under control at this point, but is confident Goodson can and will gain control. Goodson has an army of excellent graduate students with very novel ideas. The reviewer also expressed a need to see more innovation from Nolas' end.

Reviewer 4:

This reviewer said that the project has exhibited and demonstrated close collaboration amongst its team members. This reviewer noted that, however, in the case of the team's TE materials research work, the team is collaborating in the wrong area. TE materials with ZT less than 1.0 will not lead to TEG WHR systems satisfying DOE's objectives.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed that the project's integration of thermal interface resistance progress and accomplishments with TE materials and potentially devices is quite good. The project demonstrated solid progress with its Time Integrity Modules (TIM) and the team's plans to extend its work with TIMs and that experimental /analytic modeling of TIMs is sound. This team will have challenges in implementing their TIMs at high temperatures (i.e., 600°C) and it is good that the team will focus on this in its future work. The reviewer affirmed that the team's work on metal nanowires is a good choice and approved of the team's approach for next year's efforts. The reviewer went on to say that the team's planned TE materials work is less impressive and it is not clear how that work will extend/expand upon current state-of-the-art. The reviewer said that the team should re-think its plans in this area.

Reviewer 2:

According to this reviewer, directions for future research are focusing on the program goals.

Reviewer 3:

The reviewer noted that the project proposed work appears to build on past progress and potentially lead to overcoming the remaining barriers that remain on the project. The bulk material area presents the most risk as the metal nanowire array technology, while showing promising data, may be difficult to integrate in a higher rate process for demand.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer observed that the project is approaching thermoelectric with multiple solutions at material and device levels and that these fundamental studies support DOE's petroleum displacement objective.

Reviewer 2:

The reviewer stated that this project is investigating how to improve upon thermoelectric technologies. According to this reviewer, thermoelectric technology can be used on vehicle platform applications to improve fuel economy, which supports the overall DOE objective of petroleum displacement.

Reviewer 3:

The reviewer noted that the project is attacking a critical problem and barrier (i.e., improving thermal interfaces) in applying thermoelectric technology in automotive WHR applications. This work will benefit all TEG systems in automotive applications and is required to allow these systems to reach their full performance potential in satisfying DOE's objectives. The reviewer questioned whether this team's TE materials work will lead to major advancements towards satisfying DOE's objectives. The reviewer pointed out that DOE funding can be better utilized in developing and transitioning higher-performing alternative TE materials to achieve its objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the project appears to have sufficient resources in order to complete this project within the stated duration of the project. The scope of the remaining work seems to justify the 34% funds remaining in the last eight months. The reviewer added that the leveraging of other work has allowed this project to get more bang for the buck.

Reviewer 2:

This reviewer affirmed that the project team is utilizing sufficient resources from its institutes for this project.

DOE/NSF Thermoelectric Partnership Project SEEBECK Saving Energy Effectively By Engaging in Collaborative Research and Sharing Knowledge: Joseph Heremans (Ohio State University) - ace068

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that the basic research approach to solve these barriers is very solid. Even though all of the team's objectives are based on the science of thermoelectric technology, the reviewer expressed a need to know if all of these objectives should be the focus of this effort. According to the reviewer, one of the deficiencies of the project appears to be that there were only efforts on the basic combinations without much focus on doping or other novel approaches to increase ZT while keeping cost low.

Reviewer 2:

The reviewer expressed that Professor Heremans' work is quite impressive. Ohio State seems to have an excellent approach to investigate lightweight, abundant magnesium/manganese based device technologies. Although the results were not as anticipated, or hoped, this is the very definition of pure academic research. The reviewer commented that if there were more Heremans, the scholastic world would be a better place.

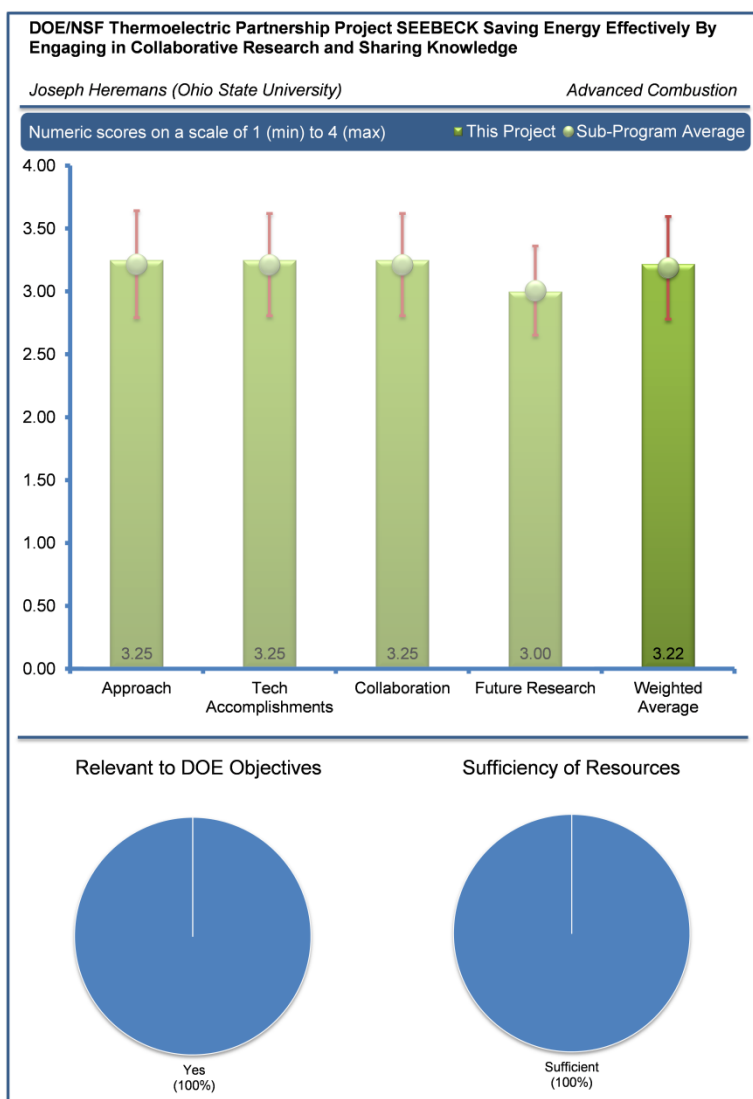
The reviewer expressed a little more disappointment in the approach from Kanatzidis, whose approach to the project seems to be to blindly mix together several materials and hope for the best. The reviewer pointed out that the explanation of the team's approach to the project comes later, even when it is a PowerPoint illustration that qualitatively proposes a mechanism, or phonon blocking, with no analysis or extra experiments to support that. The reviewer added that examining samples in the transmission electron microscope (TEM) without analysis, theory or even energy dispersive analysis of X-rays (EDAX) is somewhat empty and lacking.

Reviewer 3:

According to this reviewer, the project is focusing on high-ZT and low-cost thermo-electrics. The materials studied by the team followed this objective and they have been quite successful in gaining fundamental understanding of the issues.

Reviewer 4:

The reviewer affirmed that the project is focusing on developing thermoelectric materials with ZT greater than 1.5 while minimizing electrical and thermal contact resistances, materials metrology and durability. Of the three TE materials that this team is investigating, only one, PbS, has shown any capability to get ZT greater than one. The team achieved ZT equal to 1.3 at 923 thermal conductivity



(K). However, the reviewer pointed out that this particular material has a peak performance at around 900°K, which is too high for the automotive WHR applications on this DOE program. Many presentations have shown that automotive exhaust temperatures are less than 600°C (873°K) and that the TE materials in optimized TEG designs will only see temperatures less than about 450-500°C (723-773°K). The reviewer added that at these temperatures, it is clear that PbS has ZT of approximately 0.8 which is not high enough to create high performing TEG designs that will meet DOE's objectives. The reviewer opined that PbS may be cheap and inexpensive, but so is dirt TE devices and systems out of it. The reviewer also stated that the team has already dismissed Mg₂Sn materials because its ZT value of approximately 0.25 is not at all relevant. Zinc antimonide (ZnSb) materials presented by this team, presumably their starting point materials, has only produced ZT approximately 0.8 at 600°K, which is well below 1.0 and quite inferior to other established and characterized TE materials in this temperature range. The reviewer also said that this is not an Excellent ZT as claimed by this team in their presentation (i.e., Slide 15) and will not lead to high performing TEG systems that satisfy DOE's objectives. The ZT of the ZT plus ZnSb materials, after thermal cycling, is only 0.9 at 300°C, and appears to be less than 0.9 at 400°C. There were no TE property results presented for ZnMgSb materials, so it is unclear how well these materials might perform. The reviewer added that it is unclear why this team is investigating silver (Ag) & titanium (Ti) interfaces for bismuth telluride-based materials. At the temperatures that bismuth telluride (Bi₂Te₃) is useful, there are already effective diffusion layer materials, for example, nickel (Ni).

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that based on the information presented, there has been significant progress in achieving the barriers. The nano-silver interconnect is an interesting accomplishment. While it initially appears to solve some of the technical issues, there may be a concern of cost based on the use of silver as an element. On a small scale, data was recorded and showed to demonstrate reliability, but at a very low level. The reviewer remarked that it would be beneficial to begin a scale-up of some of the accomplishments and see how the data compares with model predictions and initial data collected.

Reviewer 2:

The reviewer stated that the project has completed planned tasks and met the milestones. The reviewer noted, however, that the project has listed no publications as accomplishments. For DOE and NSF project this should be a focus area in the following year. The reviewer, recognizing the project is just 31% complete, would not give the highest score in this category. The reviewer questioned the project Slide 1, noting that the same slide can be found online in Applied Power Electronics Conference (APEC) 2011 annual meeting's Slide 14. The only differences were some temperature parameters and Assembled TE device was added to the AMR review slide. The reviewer noted that the question was if there are the three devices shown in the picture really thermo-electrics from the project. The devices seem more like light-emitting diode (LED) devices.

Reviewer 3:

According to this reviewer, this team may have shown a ZT of 1.3 at 923°K in PbS materials, but the ZT at temperatures relevant to automotive applications, for example, less than 750 K, is less than 0.8. Repeatable ZTs appear to be 1.1, and the repeatable ZT at 750 K are less than 0.8, as well. The reviewer pointed out that this is not particularly high and will not produce high-performing TEG systems that satisfy DOE's objectives. The ZT approximately 0.8 for the team's starting ZnSb materials is not high either and will not produce high-performing TEG systems that satisfy DOE's objectives. The reviewer added that ZT of the ZT plus ZnSb materials after thermal cycling peaks are at only approximately 0.9 at 300°C and appears to be only 0.7 at 200°C and less than 0.9 at 400°C, which is simply not an impressive TE material performance. There are better TE materials available than this. The reviewer commented that there were no TE property results for their ZnMgSb materials, so at this point, no progress that can be claimed these results.

The reviewer added that thermal cycling consisting of only 50 cycles is not sufficient. High performance TEG systems for automotive WHR can easily reach approximately 800-1,000 thermal cycles per year. The reviewer pointed out that the project needs to perform many more cycles on their TE materials before they begin to satisfy DOE's objectives.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

According to this reviewer, there seems to be good collaboration between the team members and partners.

Reviewer 2:

The reviewer noted that there is good collaboration among team members.

Reviewer 3:

The reviewer observed that for this project, it appeared that some of the objectives were being conducted almost independently of others. While being fairly well-coordinated with each other, the presentation had the appearance of almost four separate efforts being combined into one as a roll-up at the end. The reviewer pointed out that based on the barriers that were being worked on, it makes sense for the project to have a bit of independence, but it would be beneficial to have a capstone that focuses on leveraging all of the advancements under the project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer observed that there was no slide for future research, although it is implied in the summary slide.

Reviewer 2:

The reviewer commented that even though there is a substantial bit of information in back-up relating to the future effort, there did not appear to be much conversation & review over the plans during the next period of time. While the effort is more than 50% completed with respect to schedule, only 31% of the funding has been utilized. The reviewer added that this raises a small concern as to how this funding will be utilized when most of the objectives have a recommendation moving forward. The assumption is that more refining and optimization will be conducted on each of the objectives.

Reviewer 3:

The reviewer stated that it is not clear from the team's presentation that future research plans are aimed at overcoming the mediocre TE materials performance that is presented in this work. The team seems to be quite impressed with their materials, even though the team has lower ZT values than other available TE materials at temperature relevant to automotive WHR applications. The reviewer also remarked that there were no concrete band structure or alignment engineering plans presented to improve the fundamental ZT performance. The team simply stated that it will be done. The reviewer expressed a need to know how the team will do this and what exactly will be done.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer observed that the project is working towards the DOE's goal on petroleum displacement by improving TE material and device performance.

Reviewer 2:

The reviewer noted that the thermoelectric technology is being developed in order to recover waste heat from the vehicle, reduce HVAC demands, and other applications to save on fuel usage. The reviewer observed that this is a fundamental research project that could act as a foundation to increase any existing system.

Reviewer 3:

This reviewer answered yes to this question, but according to the reviewer there were serious questions about the TE material performance levels exhibited in this presentation and review.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that the project has used sufficient resources for this project.

Reviewer 2:

According to this reviewer, Heremans probably deserves a plus-up and that Kanatzidis probably does not.

Reviewer 3:

The reviewer observed that based on the spend plan to date, there is a risk that there will be excess funding at the end of the project. The reviewer added that for the project there was no clear path showing use of funds. The majority of the presentation focused on the multiple barriers that the project is focusing on and giving status, leaving the use of funds portion lacking.

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Advancement in Fuel Spray and Combustion Modeling for Compression Ignition Engine Applications: Sibendu Som (Argonne National Laboratory) - ace075

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that the project is doing very good work on both spray and combustion modeling. The reviewer said that the project focus is on both computational and modeling displays inputs confound accurate modeling.

Reviewer 2:

The reviewer said that this project is well-designed to address the four technical barriers in fuel spray and combustion modeling. The feasibility of the method has been demonstrated to a certain degree. The reviewer found it encouraging noting that future work includes validation against constant volume combustion data from SNL and engine data at Argonne National Laboratory.

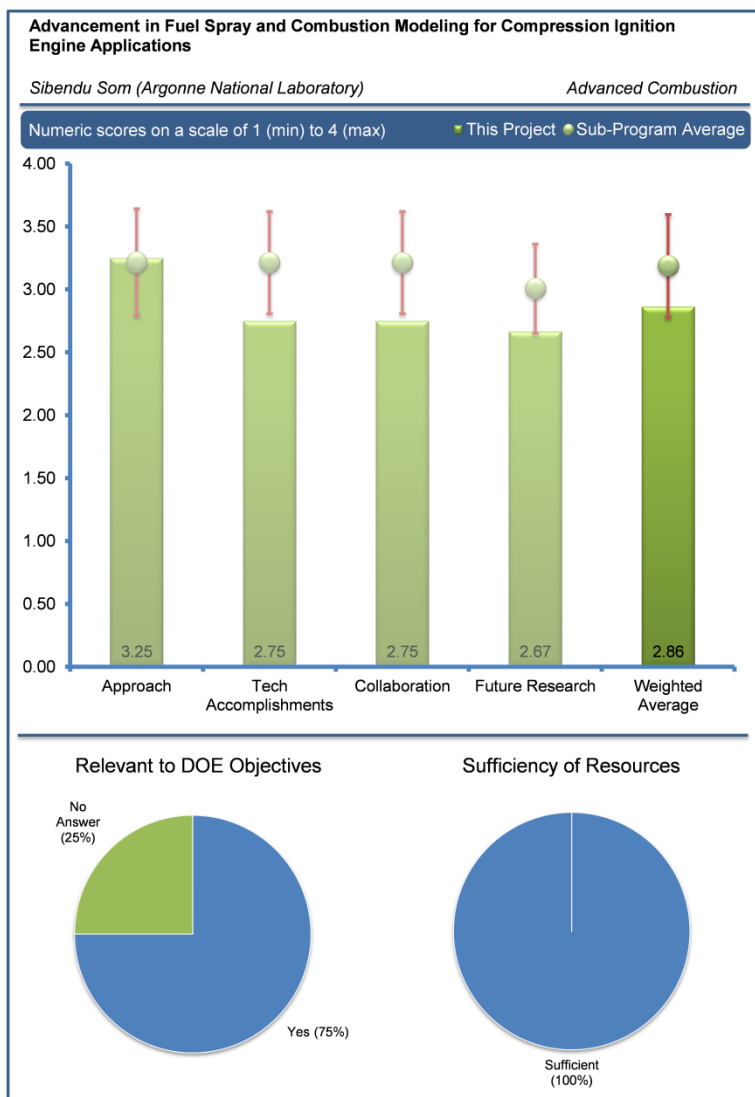
Reviewer 3:

The reviewer said that this project is particularly interesting as it represents a serious attempt to improve the simulation capabilities of combustions systems. The project attempts to make an impact on the predictive capability for future engine designs. The reviewer strongly emphasized that one thing that often lacks in these programs however is coupling the work with validation in real applications. Possibly this coupling of the work with validation in real applications is something for future efforts, but it would be important for the project to introduce this coupling early on to see indeed if the work at hand has a positive influence on engine designs. The reviewer added that the project is disappointing in that the engine benchmarks are not being shared with the public.

The reviewer noted that the project could benefit from clear milestones & benchmarks. For example, authors could establish a target to arrive at a combustion system that limits soot in low O₂ concentration environments. Effectively, it is unclear how successful the high fidelity approach is towards becoming more predictive. The authors could rank the individual contributions of their research as to the impact in the overall effort, such as spray, combustion modeling and computing capacity. The reviewer added that in the milestones for 2013, the use of high performance computing (HPC) tools to capture cylinder-to-cylinder variations seems disconnected from the other more fundamental work. The reviewer also noted that the figures on Slide 6 require labeling for proper understanding. The reviewer said that is not clear what the timeline of the project is, as no end date was presented.

Reviewer 4:

The reviewer stated the project work uses much more complex and expensive combustion and turbulence models than those used today for engine design. While the work could provide insight into combustion processes, it did not appear that this was what was



done. The conclusions were more around the benefits of the high grid resolution, LES and detailed chemistry. The reviewer also stated that it is unclear what the plan is to transfer the findings of this work to engineering models that can be used for engine design.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the project has made good progress against milestones. Grid convergences in spray modeling and engine simulations have been demonstrated. The reviewer noted that the improved load balancing algorithm has been implemented, Cycle-to-Cycle variations in fuel spray have been captured by a grid-convergent LES approach and the effect of needle off-axis motion quantified with in-nozzle simulations using X-ray data.

Reviewer 2:

The reviewer said that this project is making good progress in identifying important modeling parameters and it will be important to apply and compare with more experimental data.

Reviewer 3:

The reviewer observed that a lot of this project's model demonstration has been done showing the benefit of this high fidelity approach, but the main conclusion appears to be that this approach works reasonably well. The reviewer stated that it is not clear what the project long term vision of this activity is.

Reviewer 4:

The reviewer said that this project is particularly interesting as it represents a serious attempt to improve the simulation capabilities of combustions systems. The project attempts to make an impact on the predictive capability for future engine designs. The reviewer strongly noted that one thing that often lacks in these programs however is the coupling of the work with validation in real applications. Possibly this coupling of the work with validation in real applications is something for future efforts, but it would be important for the project to introduce this coupling early on to see indeed if the work at hand has a positive influence on engine designs. The reviewer added that the project is disappointing in that the engine benchmarks are not being shared with the public.

The reviewer noted that the project could benefit from clear milestones or benchmarks. For example, authors could establish a target to arrive at a combustion system that limits soot in low O₂ concentration environments. Effectively, it is unclear how successful the high fidelity approach is towards becoming more predictive. The authors could rank the individual contributions of their research as to the impact in the overall effort, such as spray, combustion modeling and computing capacity. The reviewer added that in the milestones for 2013, the use of HPC tools to capture cylinder-to-cylinder variations seems disconnected from the other more fundamental work. The reviewer also noted that the figures on Slide 6 require labeling for proper understanding. The reviewer said that it is not clear what the timeline of the project is, as no end date was presented.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the project has close collaboration with industry, academia, and National Laboratories in the United States and through the Engine Collaboration Network (ECN) with researchers world-wide. The reviewer pointed out that some coordination with other ongoing DOE supported LES modeling projects would be beneficial.

Reviewer 2:

The reviewer remarked that the project has an impressive lineup of teams. The reviewer added that it is however unclear about what role the OEMs (Slide 18) outlined have on the project. The reviewer would like to know whether any of these interactions can be described. The models are said to be provided to them for implementation, yet the consortium and public are not able to gauge the significance of this work. The reviewer pointed out that the project team should engage a facility that would be able to corroborate the impact of the work because by not doing this leaves the work heavily deficient.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the project focus on Eulerian-Eulerian approach for near-nozzle spray modeling is proper. The development of realistic diesel surrogate chemical kinetic model is also well-planned. The reviewer remarked that the project validation with experimental data is vital to show the value of this research.

Reviewer 2:

According to this reviewer, the presentation mentions plans to incorporate Cummins hardware. The reviewer was unsure of the scope of work planned and wonders whether these plans will be limited to X-ray or will there be plans to do engine validation.

Reviewer 3:

The reviewer noted that the project path for this work to transfer into models used by industry is not clear, as there is significant work with Converge, which provides an avenue to get into engineering models. The reviewer added that the project's vision of that transfer process should be shared.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the project's work is aimed at working towards predictive modeling, which is critical to optimizing engines.

Reviewer 2:

The reviewer observed that the project could improve simulation and predictive capabilities of fuel spray as well as combustion processes which support the development of high efficient engines with lower emissions. The reviewer added that the project study supports the DOE's objective of reducing fuel consumptions.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Improved Solvers for Advanced Engine Combustion Simulation: Matthew McNenly (Lawrence Livermore National Laboratory) - ace076

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this is another project that will enable others to explore advanced combustion system development toward meeting the DOE's objectives. Speeding up multi-dimensional chemically reactive simulations will further enable engineers to more quickly assess and design new combustion systems.

Reviewer 2:

The reviewer noted that the goals have direct application to improving engine design tools.

Reviewer 3:

The reviewer noted that the approach of developing better algorithms coupled with new computing architecture and improved physical models seems to be on target to develop simulation solvers that can be used by industry to speed up the design and commercialization of high efficiency, clean combustion engines. The reviewer was unsure if there is a lack of expertise in this area, and if the project approach and tools being used are the very best to merit an outstanding rating.

Reviewer 4:

The reviewer remarked that the project is not focused on technical barriers, but focused on cost and time barriers for conducting simulations of combustion. The reviewer added that this project will not have immediate benefits, but will in the long term help in the analysis and design of engines faster and more accurately.

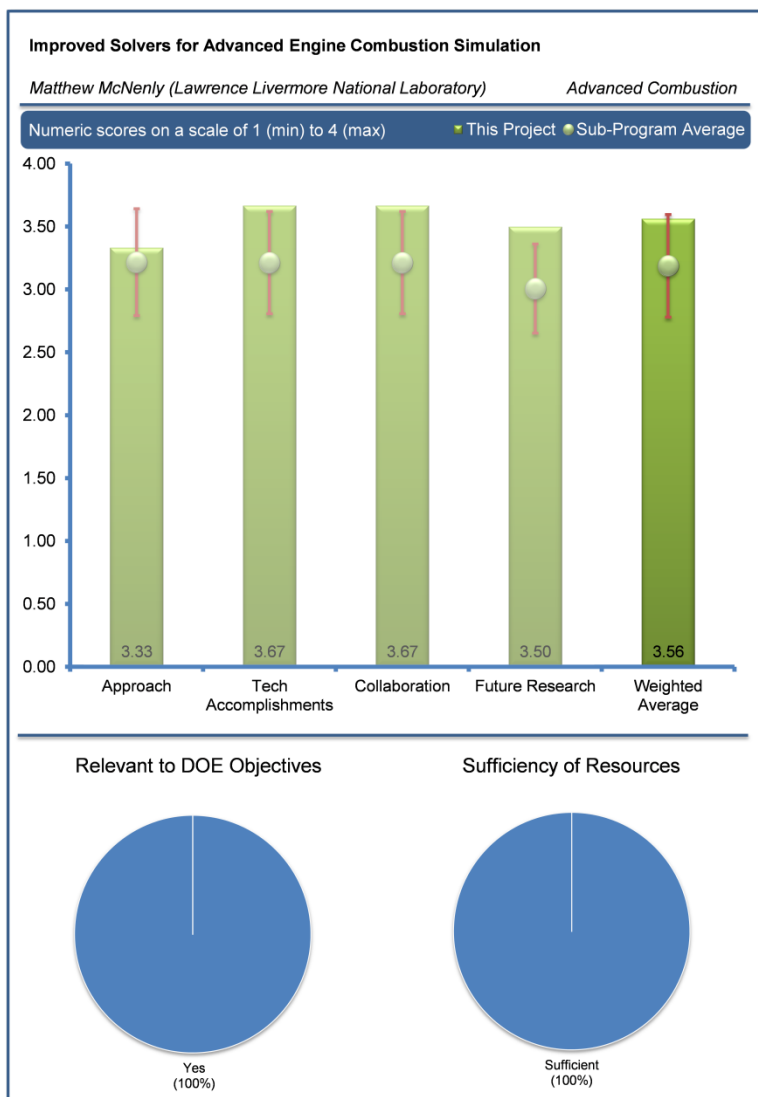
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

According to this reviewer, the project continues to show amazing improvements in clock time for chemistry solvers for engine simulation.

Reviewer 2:

The reviewer noted that the project demonstrated a number of significant accomplishments, such as the following: the development of an adaptive pre-conditioner to remove least important reactions that significantly speeds up chemistry solver time without loss of



accuracy; improvements to GPU algorithms to speed up thermo-chemical functions; and licensing of the solvers to Convergent Science.

Reviewer 3:

The reviewer observed that the project has made progress in the area of faster algorithms, better architectures, and improved physics; the adaptive pre-conditioner has sped up calculations by 10 times to arrive at the same solution; and the new solver has brought a typical gasoline-type calculation to about one day, which puts it in the realm of a design tool. The reviewer was unsure whether the project has achieved the objective of speeding up calculations, and wondered if the team knows whether it now has a design tool, and whether the team knows that the calculations are correct.

Reviewer 4:

According to this reviewer, this project has shown a noticeable decrease in computational time by about an order of magnitude through careful development and application of a clever scheme to perform chemistry reduction on the fly. The reviewer added that at some point, someone from the project has to validate these new schemes on a real world engine problem. The reviewer wondered if possibly Dan Flower's project can aid in validation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that the project's team working with Convergent Science is great as this will have a direct impact on the engine modeling tools used by industry to design and improve future engines.

Reviewer 2:

The reviewer noted that this project has been pretty well-coordinated with other engine combustion researchers and with a software development company. In particular, the later software company has been very involved and is the recipient via licensing of new solver software.

Reviewer 3:

The reviewer observed that the project has collaboration with a number of industry organizations including Ford, GM, Cummins, Bosch, and Convergent Sciences. The goal is to get these improved solvers in the hands of the team as well as having interactions with other National Laboratories including, SNL and ORNL, and also universities including University of California at Berkeley, UW, and University of Michigan.

Reviewer 4:

The reviewer noted the good collaboration exists with industry, other National Laboratories, universities, and working groups, and that the project is working closely with Ford, Bosch, and Convergent Science Inc.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the plans to further identify CFD bottlenecks, development of a turnkey chemistry solver for testing by MOU partners, and acceleration of other aspects such as multispecies diffusion are important.

Reviewer 2:

The reviewer observed that the multispecies diffusion and advection problems will be accelerated using the new solver. The reviewer added that other common applications like computing flame speed and ignition delays are also very relevant project needs.

Reviewer 3:

The reviewer noted that the proposed approach to target a few of the current time consuming algorithms is a good logical approach. The reviewer added that as stated above, at some point in time, these new solvers must be validated against engine data.

Reviewer 4:

The reviewer was unsure if, given the extraordinary results over the past few years speeding up the chemistry calculations, there is anything the project can do to speed up the fluid dynamics computations. The reviewer pointed out that rather than the chemistry, it seems like the CFD is now becoming the bottleneck in the project simulation time.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the improvements in the accuracy of detailed chemical reactions and physical models in engine combustion simulators coupled with significant reduction in computational times, will lead to design of engines with improved efficiency, lower fuel consumption, and lower emissions and that all of these are in alignment with DOE's goals.

Reviewer 2:

The reviewer noted that this project enables others to address DOE's efficiency goals by allowing engine researchers to develop future fuel efficient engine combustion systems. Acknowledging that such a tool will allow developers to more quickly develop combustion systems that could meet DOE's efficiency goals.

Reviewer 3:

The reviewer remarked that the project focuses on improving and speeding up the underlying solvers that take advantage of the latest computing platforms, and that these improvements will speed up simulation of combustion in internal combustion engines that focus on achieving high efficiency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

According to this reviewer, the project resources seem sufficient.

Reviewer 2:

The reviewer noted that the project funding seems commensurate with the effort spent by the PI's past output.

CRADA with Cummins on Characterization and Reduction of Combustion Variations: Bill Partridge (Oak Ridge National Laboratory) - ace077

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that the project has a very unique approach to investigating model validation on the EGR, and a very systematic approach to identifying the efficiency barrier.

Reviewer 2:

The reviewer notes that the project has a good approach supporting work on achieving the SuperTruck Program's 55% brake thermal efficiency target.

Reviewer 3:

The reviewer expressed this work is likable because it gets down to the nitty-gritty issue of charge distribution, and that the work is a big deal, but not very glamorous. However, the reviewer also expressed that there is truth that variations in charge distribution and subsequent cycle to cycle variation, cause more fuel economy loss and emissions than is gained from going to a more complex combustion approach.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

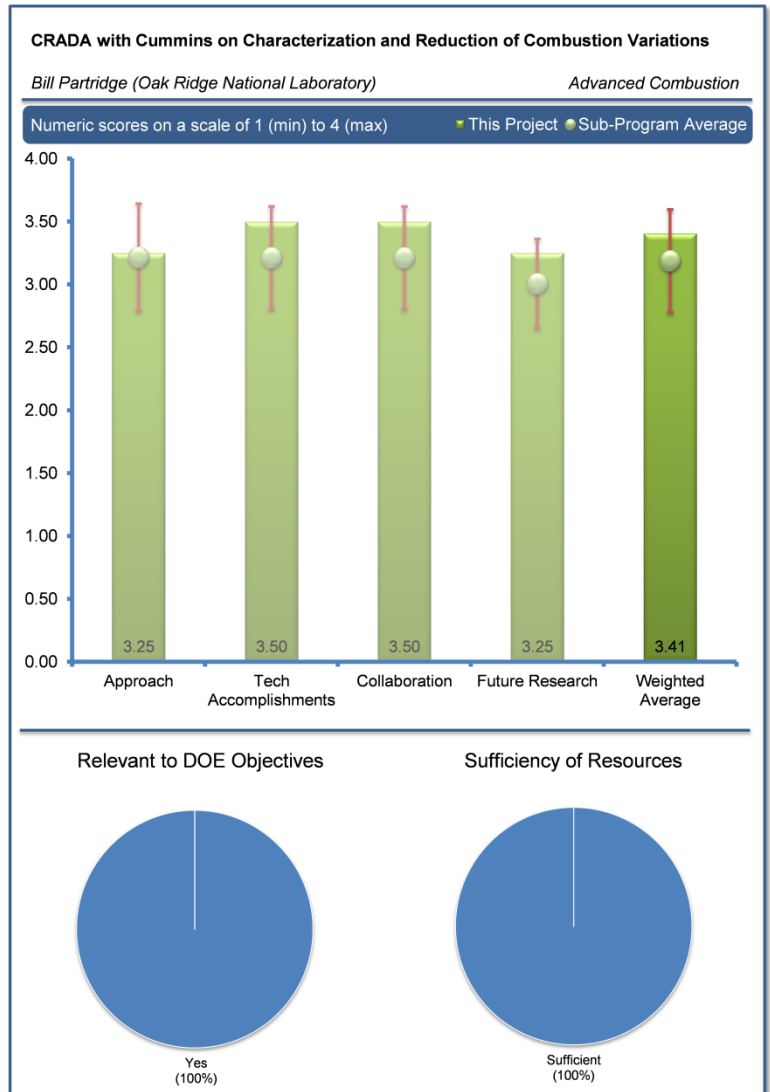
The reviewer said that the project is making very good progress on updating both hardware and map, for example, having multiple probes at various locations.

Reviewer 2:

The reviewer opined that being able to make these measurements in real engine situations is the major accomplishment.

Reviewer 3:

The reviewer observed that this project, based on the new scope, is in very early stages, but good progress has been made to date.



Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that Cummins had the project team come in and install all the sensing equipment in the project test cell, which is a very strong collaboration. The reviewer added that if there is any weakness in the program, it is that the project is apparently not making this technology available to the other participants in the SuperTruck program.

Reviewer 2:

The reviewer remarked that the project has good, close collaboration with an OEM partner; typical of a CRADA. The project also supports the Cummins SuperTruck program.

Reviewer 3:

The reviewer noted that the project team has a very strong relationship with Cummins, but once the project information is publicly available, the validation of the design tools with other hardware available at ORNL is recommended.

Reviewer 4:

The reviewer said that the project has a good link to Cummins SuperTruck program.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer observed that the future work is very relevant to supporting the SuperTruck program efforts.

Reviewer 2:

The reviewer noted that this project is very well-defined and planned.

Reviewer 3:

The reviewer observed that this project has moved very quickly. The reviewer said that instead of deciding what new thing to do, the reviewer would like to see this project technology be rolled out to other HD engine manufacturers.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer commented that the validation of numerical design tools for emission control is important for accelerating development of high efficiency engine technologies.

Reviewer 2:

The reviewer noted that the EGR uniformity is important for engine-out NOx control of highly efficient powertrains.

Reviewer 3:

The reviewer noted that the basic engine intake improvement has a major effect on the fuel economy. This project makes this improvement a refined engineering possibility.

Reviewer 4:

The reviewer affirmed that the project work will support the overall DOE objective on developing advanced fuel efficient engines.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer noted that the project is moving quite fast and that additional funds are not necessary.

Reviewer 2:

The reviewer noted that the funding seems appropriate.

Investigation of Mixed Oxide Catalysts for NO Oxidation: George Muntean (Pacific Northwest National Laboratory) - ace078

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the approach is an important area of interest to enable cost-effective lean aftertreatment systems. The reviewer said that the low-temperature focus is appropriate, but high temperature stability and survivability are equally important.

Reviewer 2:

The reviewer noted the project's approach leverages excellent catalyst characterization resources available at PNNL. The reviewer pointed out, however, that manganese (Mn) is not known for its durability in exhaust gas systems. Issues are hydrothermal and sulfur and these were not mentioned.

Reviewer 3:

According to this reviewer, the project's approach is fundamental science work on improved catalysts.

Reviewer 4:

The reviewer affirmed that this close collaboration with an OEM is evident in the approach.

Reviewer 5:

The reviewer affirmed the project's common need and approach is to evaluate and characterize methods to reduce Pt content from the DOC and LNT.

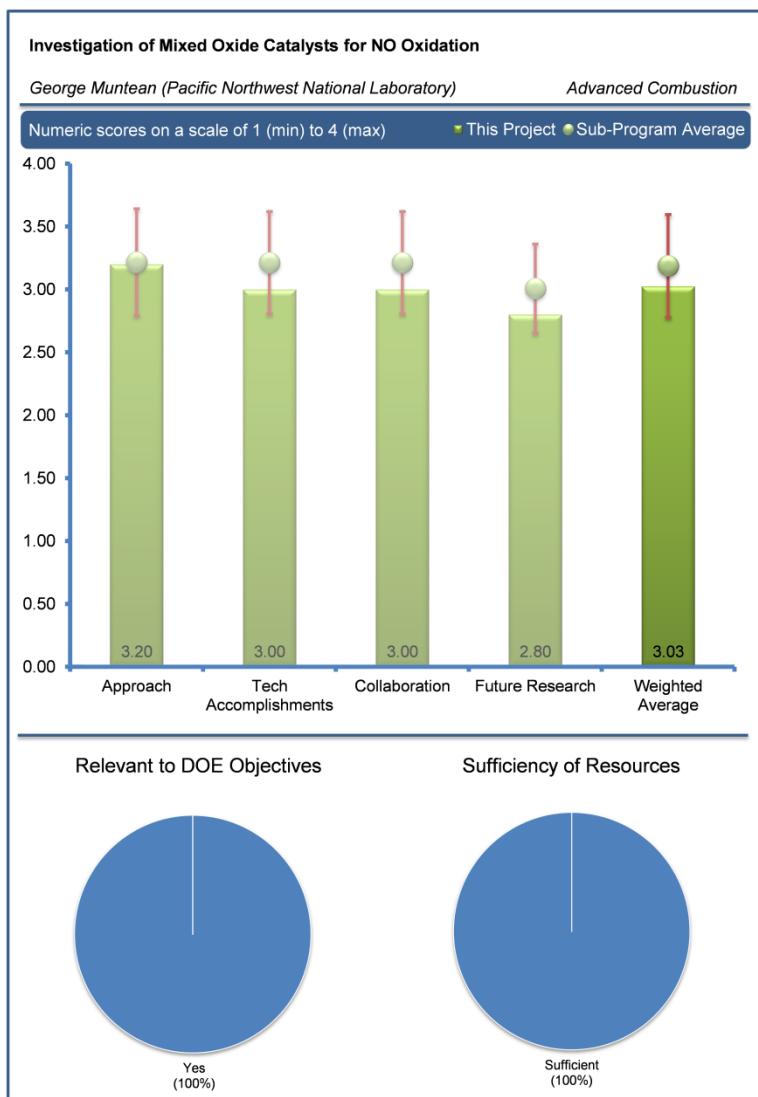
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the very good characterization progress for the different mixed metal oxide formulations has a fresh approach. The reviewer said that the lab aged samples should be checked earlier in the process to make sure the material survives potential higher temperature conditions that would be experienced in different portions of vehicle drive cycles.

Reviewer 2:

The reviewer noted this project has made good progress to date given the funding amount it received.



Reviewer 3:

The reviewer stated that the project, as planned, prepared and evaluated catalysts and reported some interesting findings (e.g., that CeO₂ can stabilize Mn, and MnO_x can lower temperature of conversion nitrites).

Reviewer 4:

The reviewer said that the project appears to have made reasonable progress since last year.

Reviewer 5:

The reviewer affirmed the project's high technical content, but the reviewer added that the projected gave no information on catalyst durability.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer commented that the project has good scope, and noted collaboration with PNNL, GM, and GM China.

Reviewer 2:

The reviewer noted that the project has an appropriate and effective partnership with GM in formulating and aging catalysts, and PNNL in performing fundamental characterization.

Reviewer 3:

The reviewer noted the project has close collaboration with an OEM and the involvement of an international university.

Reviewer 4:

The reviewer noted that the team has nice cooperation with GM, but is unsure what was done with Tianjin University.

Reviewer 5:

The reviewer is unsure of the role of GM's university partner at this time and recommended a clarification.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented same plan, more data, and concluded good idea.

Reviewer 2:

The reviewer commented continued optimization.

Reviewer 3:

The reviewer observed that the proposed future research seems appropriate for addressing the overall project objective.

Reviewer 4:

The reviewer noted that the stated areas of future work are appropriate. However, the reviewer noted that aging effects and stability are not mentioned, and that lab aging protocols and analysis should be started earlier to determine the limits of the technologies.

Reviewer 5:

The reviewer noted that it is not clear how the catalyst will lower use of platinum group metal (PGM) and how the catalyst will be scaled up from powder and made more durable.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

According to the reviewer, it is very important to reduce catalyst cost and improve effectiveness, particularly at lower temperatures.

Reviewer 2:

The reviewer said that DOC LNT precious metal content reduction can significantly reduce costs of catalysts and possibly improve performance, enabling wider use of fuel economy, improving combustion strategies, while meeting emission regulations.

Reviewer 3:

The reviewer stated that lower cost and better performing catalysts are desirable to enable high efficiency powertrains.

Reviewer 4:

The reviewer pointed out that this project needs both themes of lean NOx aftertreatment and low temperature functionality to support proposed future engine combustion strategies.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that there are no indications that project resources are inadequate.

Reviewer 2:

The reviewer stated that the project expressed no issue.

Reviewer 3:

The reviewer noted that funding for this project is relatively low, but considering it is a CRADA, the overall funding seems appropriate.

Robust Nitrogen Oxide/Ammonia Sensors for Vehicle On-board Emissions Control: Rangachary Mukundan (Los Alamos National Laboratory) - ace079

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that this project has a good approach to try a known base sensor technology but used in a different way for NOx sensing for potential lower cost.

Reviewer 2:

The reviewer said that the approach seems to be good. The reviewer added that right now, the upper temperature limit for this sensor appears to be 400°C, and finds that limiting, since an excellent application for this sensor would also be lean and highly dilute gasoline engines, as 400°C is a bit low for that application. The reviewer noted that the heater positioning on this sensor seems to cause some gradients down the sensor, which sounds like a possible calibration issue.

Reviewer 3:

The reviewer noted that the approach is focused on maximizing NOx sensor sensitivity while at the same time improving its robustness.

Reviewer 4:

The reviewer remarked that the approach is very interesting, but the mixed potential sensors will not work at temperatures above the heater temperature.

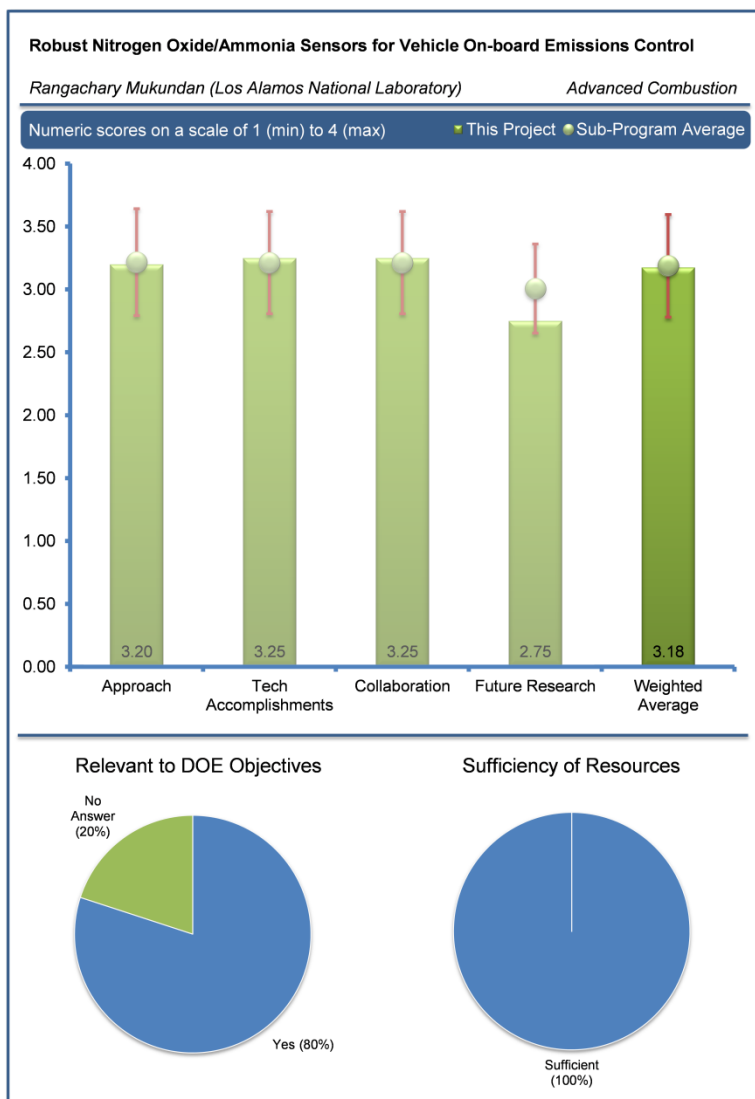
Reviewer 5:

The reviewer noted that the need for simple, cost-effective sensors that support lean aftertreatment diagnostics OBD are important to enable catalyst technologies and higher efficiency engines. Being able to uniquely monitor multiple species would be very beneficial for control and monitoring. The reviewer added that the NOx and NH₃ sensors are central to this need. Also, detection of these species at low concentrations and with interfering species present is essential to meet Tier 2, Bin 2 emissions standards.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed that the project has produced a sensor that seems to work with a reasonable response time and decent potential for manufacturability. The team has already tested the sensor on an engine system and is refining the design, an extremely comforting



approach. The reviewer affirmed that because the project sensor is responding faster than the FTIR is very encouraging because FTIRs are slow. The engine results confirm that this sensor can work under engine conditions.

Reviewer 2:

The reviewer pointed out that the developed sensor response voltage tracks the Nitric Oxide (NO) concentrations well at steady state conditions. The sensor can also track total hydro carbons when in HC sensing mode. The reviewer noted that in transient operation during cold start, improvements are needed to isolate reaction to HC and NO (interference).

Reviewer 3:

The reviewer noted that the project's researchers have addressed many of the barriers including interference, time response, and reproducibility. However, responses to poisons such as sulfur and effects of very high temperature have not been explored. These responses should be addressed sooner to make sure the materials are appropriate. The reviewer added that the Tier 2 and SULEV standards leave little room for error in detecting breakthrough species.

Reviewer 4:

The reviewer observed that the FTIR response could be more time-averaged depending on the internal volume and sample line length, and that the exhaust gas sensor is a more direct measurement. The reviewer added that not much is shown on the ammonia sensor. The reviewer was not clear if the project sensors are durable in real exhaust gas and can survive filter regenerations.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the integration of suppliers and collaborators is very good and that the project team utilizing ORNL for the engine testing is great. The reviewer said that hopefully, the project time available to piggyback the sensor testing on the engine will be sufficient.

Reviewer 2:

The reviewer noted that this project has a good supplier and academic collaborative, but only minor interaction with an OEM (Ford).

Reviewer 3:

According to the reviewer, collaborations exist with ORNL for engine testing and with ESL ElectroScience for sensor prototype development. While LANL acknowledges that upon successful prototype tests, a commercialization partner will be sought (Caterpillar showed initial interest but is currently talking to EmiSense), it would likely be beneficial to involve potential commercialization partner(s) earlier in the project.

Reviewer 4:

The reviewer remarked that this project would benefit by having an OEM formally offering direction to the project, and a commercial alliance with a sensor manufacturer would be beneficial to determine mass production potential.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed that the project is on a strong pathway for validation of the device. The reviewer added that it seems that program estimates of the costs of manufacturing are now needed.

Reviewer 2:

The reviewer noted that the project must more quickly address the continued issues related to HC, NO/ NO₂ ratio, NH₃, water (H₂O), interfering species, and sulfur as well. The reviewer added that high temperature is also still a concern.

Reviewer 3:

The reviewer said that details of next steps were not very clearly presented.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer noted that the use of sensors for OBD at a reasonable cost is a huge industry need for aftertreatment on highly efficient powertrains.

Reviewer 2:

The reviewer said that the NOx sensor is required for effective and efficient monitoring of advanced emission aftertreatment devices (SCR), which enable high-efficiency clean engine technologies of the future.

Reviewer 3:

The reviewer noted that the lean GDI and diesel aftertreatment systems need these sensors for OBD and control of catalyst activity. The project team must, however, be selective to the species of interest.

Reviewer 4:

The reviewer observed that the cost of NOx sensors has somewhat limited their application in the commercial market. NOx sensors and ammonia sensors can improve the efficiency of the aftertreatment system and subsequently lower the fuel penalty of the aftertreatment system. The reviewer affirmed that given that background, this work has strong relevance for the DOE's objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer said that this project is in its first year of a three-year follow-on project (two-year previous project) and that annual funding for the three years has been appropriately increased from that of the initial project.

Reviewer 2:

The reviewer noted that with the exception of ensuring that there is sufficient engine testing time at ORNL, this project seems to be sufficiently funded.

Reviewer 3:

The reviewer observed that this project appears to have adequate funding to carry out its work along with contributions from partners.

Thermoelectric Waste Heat Recovery Program for Passenger Vehicles: Doug Crane (Gentherm) - ace080

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the overall objective of improving the cost-effectiveness of its unique TEG design is well-thought out. Evidence of the efficacy of the design is its integration into a BMW product line, and the decision to move to a new design was made on issues that were identified that could be improved of cost, versatility, and etcetera. The reviewer added that this sort of evolutionary approach was nice to see, for example, the team was not married to a specific design. The cylindrical TEG seems to be unique. The reviewer also said that the project approach to incorporate net shape manufacturing in the TEG is novel. The evaluation of its designs involved a range of bench-scale tests and detailed numerical modeling. The reviewer commented that the modeling was a nice complement to the hardware development.

Reviewer 2:

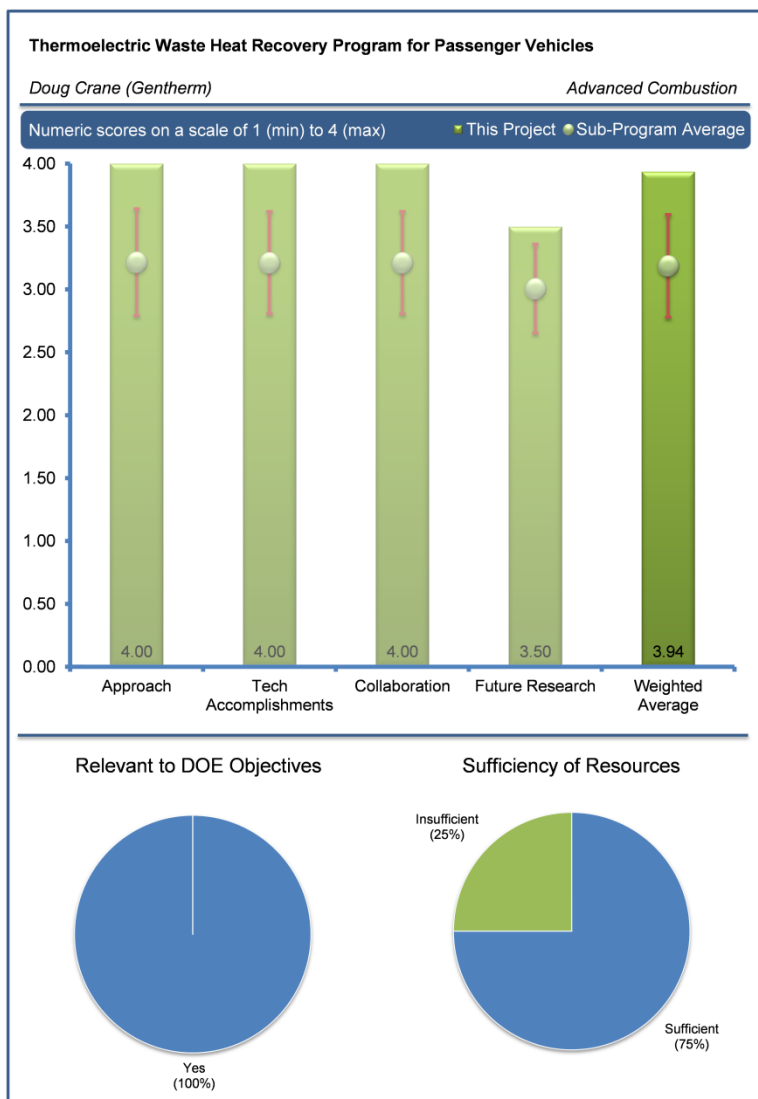
The reviewer said that Crane described a large shift in the project's approach from a holistic self-contained converter that is applicable for one platform, to a general approach based on TE cartridges. The cartridges could be integrated onto any mobile platform, or sedentary heat source. The reviewer noted that this integration is a truly big step in the field. Now, the DOE-funded work can be transitioned to anything. The reviewer felt that Gentherm is really going to make a difference, not only on success of the present program, but generally in the future.

Reviewer 3:

The reviewer observed that this project has shown a strong approach in developing its TEG design, integrating well-performing TE materials, and implementing innovative approaches in the system design. Although the team's cylindrical design approach is not that unique, for the National Aeronautical and Space Administration (NASA) Jet Propulsion Laboratory (JPL) has been using this approach for 20 years, this team has tailored it to its application quite well. The reviewer also noted that the team has demonstrated a strong use of system modeling to guide system design. This team is also solidly leveraging past accomplishments to strive for modular, scalable designs that could fit various applications.

Reviewer 4:

The reviewer observed that the project is using knowledge obtained in WH1 to investigate the scale-up potentials of thermoelectric. The approaches on using multiple smaller units and material selections are reflections on the team's focus.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the project team has been excellent in engineering the designs of the TEG. With the new material (SKU), the team is investigating a series of issue, such as sublimation prevention. The reviewer noted that Slide 9 showed ZT of n-type Ytterbium (Yb)-filled material. There is no mention of p-type material and expected performance. The reviewer also noted that it will be good to have a target ZT target in order to achieve the program goal of 3-5% fuel economy saving.

Reviewer 2:

The reviewer commented that a range of accomplishments was presented. The project developed an approach to mitigate the sublimation issues associated with the TE material the project team is employing. The reviewer also commented that the TEG architecture (Slide 12) seems quite novel. The packaging and integration of the team's TEG designs into the Ford and BMW vehicles seems to be underway. The reviewer added that the bench scale testing on a TEG building block is well developed. The model predictions from the bench scale testing are apparently being used by the team to guide further development and design.

Reviewer 3:

The reviewer noted that Gentherm & BMW team has demonstrated great TE system modeling capabilities, which have helped to guide the project system design. The reviewer added that the TE materials development work is still lagging and the team's ZT values are not that high. However, the team appears to have compensated for this with their effective system design, and is looking for coatings for Skutterudite materials. The reviewer observed that it appears that the team is not as yet successful at identifying these yet. The project team is investigating and developing pathways to develop cost-effective systems, understand cost verses performance tradeoffs, and combine cost analyses with performance analyses, and this pathway approach appears to be on track.

The reviewer commented that the project is making reasonable progress on developing the cartridge TE design. However, the project presenter did indicate that the team is working through electrical contact resistance issues, for no details were provided in the presentation. The reviewer observed that there was no discussion on how this system and design is increasing fuel economy in light-duty vehicles. The team provided no real answers from fuel economy analyses and discussion emanating from last year's review (2012). The reviewer added that even with the very good performance and power production from the Gentherm system, BMW is only projecting a 1.3% increase in fuel economy in the project's selected vehicle application. This approach is quite far below DOE's program objective and the Gentherm team was unable to provide a good pathway to achieving DOE's fuel economy goals, beyond stating that the DOE program goal is quite challenging.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that the project is very strong and showed excellent collaborations in the initial approach and design.

Reviewer 2:

The reviewer noted that the collaboration with BMW that involves the integration of the Gentherm TEG module is very strong.

Reviewer 3:

The reviewer noted the project has a strong team and good collaboration in achieving some noteworthy TEG system performance for this application.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed that the future research plan is good. The work with Tank and Automotive Research, Development and Engineering Center (TARDEC) is another example of the team's approach being recognized by potential users.

Reviewer 2:

The reviewer noted that the project Gentherm team has a good plan for future research work and has a good track record of implementing their plans on time and delivering a quality product. The reviewer stated that the Gentherm team was unable to provide a good pathway to achieving DOE's fuel economy goals, beyond stating that the DOE program goal is quite challenging.

Reviewer 3:

The reviewer noted that the future work will involve vehicle-level performance by National Renewable Energy Laboratory (NREL), continuing the modeling effort, TEG testing and evaluation, materials development, and consideration of scale-up of the TE material and TEG manufacture. The reviewer pointed out that the performance would preferably be presented in terms of efficiency going forward and MPG improvement, for example, with a TEG compared to conventional operation with an alternator. The reviewer commented that the mention of net shape manufacturing is interesting, for example, rapid prototyping. The reviewer was unsure if net-shape manufacturing will apply to the materials, housing, and etcetera. The reviewer expressed the need to look forward to seeing how the PI's team would further develop this approach.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the Gentherm team is progressing and performing the best of any of the current program teams. The project's systems will likely have the biggest impact in supporting DOE's objectives.

Reviewer 2:

The reviewer remarked that this project is very relevant and probably the top TE project in the DOE portfolio.

Reviewer 3:

The reviewer commented that this work is very relevant to DOE's petroleum displacement goal. Moving from a demo phase to scale-up phase is critical to take this technology to the market and make a real impact.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented to give Gentherm a plus-up.

Reviewer 2:

The reviewer noted that the project is using sufficient resources toward project goals.

Reviewer 3:

The reviewer noted that the resources are adequate for what is being done.

Development of Cost-Competitive Advanced Thermoelectric Generators for Direct Conversion of Vehicle Waste Heat into Useful Electrical Power: Greg Meisner (General Motors) - ace081

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that that much of this project's effort concerns materials processing and development, specifically improving p-type material development. The recognition that contact resistance is important is appropriate. The reviewer mentioned a target of 5% over US06, but not much was discussed in how this number would be achieved. The reviewer pointed out that the approach involves a range of tasks that are all relevant. The list is quite long. The reviewer noted that what seems to be lacking in the team's approach is a clear connection of the various tasks to performance targets that is at the heart of the DOE program. If 5% is a target, it was not clear beyond a broad perspective, how what the team will do would provide the information needed to assess how close the PIs will be to the performance target. Basically, a closer connection is needed between what will be done and how achieving a task would assist in allowing the PIs team to know what the actual percent improvement is, and how the work could be altered to be modified accordingly.

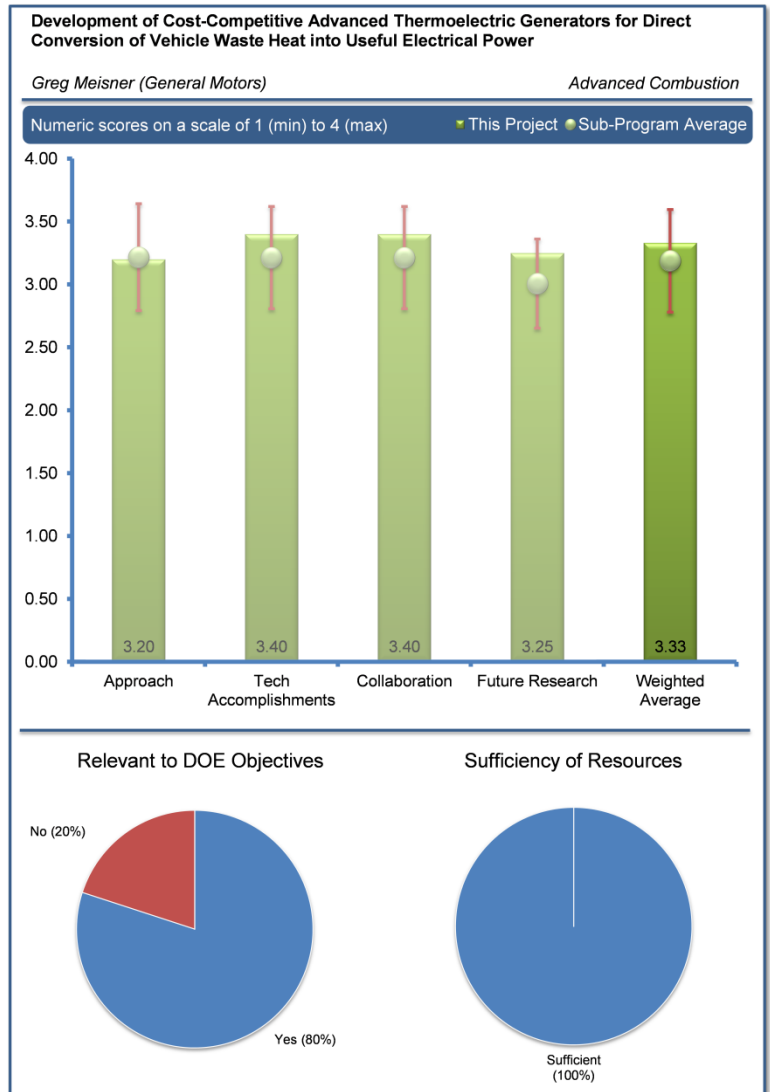
The reviewer affirmed that the approach to platform selection is quite good. As noted by the PI, certain product lines will be amenable to improved fuel economy, and others will not.

Reviewer 2:

The reviewer commented that GM has made impressive performance advances over their previous accomplishments. The project team is showing better materials and is now showing device technologies that can make a difference for DOE interests in waste-heat recovery. The project showed a high-efficiency device, but in all honesty, if the material ZT were as good as their ZT plots showed, then the efficiency should have been over 10%. The reviewer believed there is an issue with the materials and/or the measurements, but considers this a side issue. The project team has made excellent progress, but should focus on the fundamental device and materials measurements. The reviewer concluded by commenting great work.

Reviewer 3:

The reviewer commented that this project is aimed at scale-up of thermoelectric generators for mass production vehicles. The TEG involves not just materials but a multidisciplinary engineering team. The large team of expertise assembled showed the understanding of a team approach in this project.



Reviewer 4:

The reviewer noted that overall approach to overcoming the barriers is effective, since the project is fairly early on in the process it is critical to have a comprehensive approach to solving complex barriers. The reviewer said that as of now, the project foundation is in place to address the challenges; for these challenges have not been enacted, but appear feasible.

Reviewer 5:

The reviewer commented that this project has had significant problems in achieving any meaningful progress for several years. The presenter described that p-type materials have been and are still a problem for the project, where thermal and electrical interfaces and bonding and diffusion barriers are both a huge problem for the project. The project team did not properly anticipate the huge challenges they had and are having in these areas. The reviewer also expressed the need to know why this team had to go all the way to Fraunhofer Institute to do the required testing. The reviewer noted that there are plenty of other organizations in the United States that could have helped with that problem to solve these problems much quicker and more efficiently than this team started to realize.

The reviewer commented that the module fabrication and TE materials research has not been well-coordinated.

The reviewer added that this team is also not completely addressing the thermal system design. The presentation shows no results or indication of accomplishments in heat exchanger design, integration of the thermoelectric and heat exchanger sub-systems, and the necessary power electronics to control the TEG system power output to integrate it with the vehicle electrical systems. The reviewer stated that there is no mention of the thermo-structural analyses to identify thermally induced stresses in the TE modules, and within the overall TEG system. There seems to be no clear integration of these design efforts within the team, either by way of this presentation or the accomplishments from this and prior efforts.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer said that this project showing of a Skutterudite device is really a big step forward. These devices are not available in commercial off-the-shelf (COTS) form, so it is a huge deal.

Reviewer 2:

The reviewer remarked that this project team understands the importance of scale-up. The large batch melt-spin of skutterudite and follow-on characterization are important steps toward large scale production of TEGs. The team recognized the significance of interface heat loss and its impact on system performance. Although a 3-5% fuel economy saving is achievable based on the selected materials, minimizing the temperature drop and heat loss will be the key to realize the potential energy conversion efficiency.

Reviewer 3:

The reviewer pointed out that, again, this project is fairly early on and there has not been time to address all of the barriers; however, for the barriers that have been addressed, there appears to be significant progress in module development and material selection.

Reviewer 4:

The reviewer remarked that this project is comparatively new. The team has done some work, though, in ZT measurements, vehicle platform selection materials fabrication and developing an understanding of issues (e.g., the role of interfaces), which is all good.

Reviewer 5:

The reviewer commented that, after five years working on this project, the project team has some accomplishments, but it has taken many years and many ineffectively used funds to show any significant progress. The team is still heavily involved with TE materials research to try to achieve project goals. The team presented limited system design and system test data, which makes it difficult to assess whether this design can achieve performance goals and calls into question the progress of this team in meeting its project milestones/deliverables.

The reviewer added that this GM team is finally (after five years) starting to get the TE device and system design information needed to be successful. However, the team did not demonstrate in this presentation how they are interpreting and using this data to achieve their system design. The team presented no evidence of an integrated thermoelectric-thermal-structural design approach to their TE module design or their overall TEG system design. The team did not discuss critical heat exchanger designs or simultaneously optimizing thermal system and thermoelectric system design.

The reviewer said that the team did not discuss within this presentation of system testing protocols, and is only just now looking into thermal design optimization within the TE sub-system design optimization process. The reviewer observed that this project discussed the need to provide 130 pound per square inch (psi) compression to produce the 7-8% TE conversion efficiency in the tested TE modules. This large pressure and module crush is an issue and how the team will respond to repeated thermal cycling under these rather large pressures is another issue. The team provided no discussion on how it would provide such high compression pressures in its design or the weight penalties associated with this design approach.

The reviewer also observed that this project presentation gave no discussion on the production yields to produce the good test results on the three modules that were actually tested. The presenter claimed that all the modules produced were within expected tolerances on alternating current (AC) resistance testing. The reviewer remarked that this, however, is not the only diagnostic metric to examine in evaluating a TE module's health and potential performance. The presenter provided no additional elaboration on TE module diagnostic monitoring.

The reviewer noted that the GM team indicated their analyses showed their TEG system would provide a 2.5-3.0% improvement in fuel economy using their TE materials as measured on their test stand. The reviewer observed, however, that the team's power estimate was analytically derived at with no system testing data substantiating the power output required to produce that level of fuel economy improvement. There was also no comprehensive explanation of the team's analytic approach or fuel economy improvement calculations. The reviewer stated that it is troublesome that the team's fuel economy improvement levels are so far below DOE program targets and objectives and that GM should better explain these fuel economy estimates and how they are arrived at.

The reviewer pointed out that the project's thermal stability of carbon nano-tube interfaces is not necessarily good at high temperatures. This instability is going to limit the long-term system performance in this system, but the team did not discuss how it would address that design problem.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that it appears that the project Marlow collaboration is really paying off.

Reviewer 2:

The reviewer noted that the largest team on TE devices is assembled in this project. The team's work so far has shown a detailed evaluation and study on all aspects of building a TEG that is scalable.

Reviewer 3:

The reviewer observed that although it appears that not all partners are highly active at this point of the project, it appears the foundation and team that has been assembled for this effort is sufficient to accomplish the objectives. The reviewer states that the concern is about how the multiple material developers will be coordinating to ensure that there is not redundant work being conducted.

Reviewer 4:

The reviewer noted that the project is large with wide-ranging collaborations. The reviewer's rating of fair speaks to a difficulty to understand specifically how the team is integrated, so that what they do fits into a needed piece of information to achieve the overall objective of an efficiency improvement.

Reviewer 5:

The reviewer observed that the project has a potentially strong team, but noted that it has many team members, which creates severe coordination and component and system design challenges for a TEG system and vehicle integration design, with as many multidisciplinary aspects as this project has. The project loss of GE Global as a team member was a huge setback. However, the reviewer commented that it is not clear how well-coordinated this team is. There is certainly some on-going collaboration, but the team's progress has been painstakingly slow by any standard. The reviewer noted that this slow progress calls into question of how well the project system design will perform ultimately in satisfying DOE's program goals.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer affirmed that the project team keeps up the good work.

Reviewer 2:

The reviewer observed that the range of future activities seem to be directed toward TEG development and improvement, selection of TE materials and targets of TEG performance, and etcetera. The reviewer commented that it was good to hear from the team and that this emphasis is only for the upcoming year of work. The reviewer pointed out that vehicle integration, experimental protocols to measure what is needed to determine an efficiency target, and etcetera, are important to consider in parallel with the listed future work.

Reviewer 3:

The reviewer commented that this project, based on the strategy laid out in the project, the proposed work for the next quarter appears to be logical and will be effective to complete a solid prototype system that will provide a portion of the fuel economy savings objective.

Reviewer 4:

The reviewer affirmed that the proposed future research tasks are following the original plan and focused on overcoming the technical barriers.

Reviewer 5:

The reviewer noted that the project's proposed future work basically appears to be a re-do of work that should have been completed in the prior DOE OVT Waste Heat Recovery project that GM led. The project currently plans to select its TE materials in the third quarter, which indicates that the team still has significant TE material challenges to overcome. The reviewer stated that once again, the project made painstakingly slow progress for such a team. DOE appears to be considering alternate development pathways, but they are slow in implementing them.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer pointed out that the project will have a positive impact on water-heat recovery, even if the miles per gallon (MPG) targets are not exactly met. The reviewer added that whatever the MPG improvement is averaged over millions of cars, it is a huge deal.

Reviewer 2:

The reviewer stated that this project is providing a practical answer of fuel economy improvement and directly supports DOE's petroleum displacement objective.

Reviewer 3:

The reviewer said that the thermoelectric technology is an approach to take energy that is wasted in the vehicle and recovered to increase vehicle fuel economy, which supports the overall DOE objective of petroleum displacement.

Reviewer 4:

The reviewer affirmed that this project is of course relevant to DOE's objectives. The reviewer stated that it was unclear how the various elements specifically addressed the 5% target. The reviewer provided as an example what specifically would allow reaching this target that is a current problem.

Reviewer 5:

The reviewer noted that it is quite difficult to ascertain whether this project is supporting DOE's objectives, because so little system design information and so little information or backup data on fuel economy improvement projections have been provided in this presentation. In addition, all of the system design concerns discussed above call into question whether this project is supporting DOE's objectives. The reviewer commented that, unfortunately, this reviewer cannot answer yes to this question based on this presentation and review.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer observed that the resources from each partner are being utilized to make the project a success.

Reviewer 2:

The reviewer observed that the resources seem sufficient, but would prefer if GM had a higher internal investment to this area and not rely so heavily on the DOE. After all, it is GM that stands to gain profile, on the bottom line, as the ultimate outcome of this effort.

Reviewer 3:

The reviewer noted that while this project started in September, there has only been 4% of the budget expended to date. Based on the discussion, there appears to be sufficient resources for this effort. But cost and schedule are both risks this early on in a project and should be monitored closely to ensure that they stay at appropriate levels based on projected status.

Nanostructured High-Temperature Bulk Thermoelectric Energy Conversion for Efficient Automotive Waste Heat Recovery: Chris Caylor (GMZ Energy, Inc.) - ace082

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer affirmed that the approach is well-thought out and that its performance is admirable, commending it as an excellent project.

Reviewer 2:

The reviewer observed that the approach is good to achieve the DOE's program goals. The element of scale-up and mass production is not as strong. The reviewer noted that without a committed automotive partner, the approach must be very general.

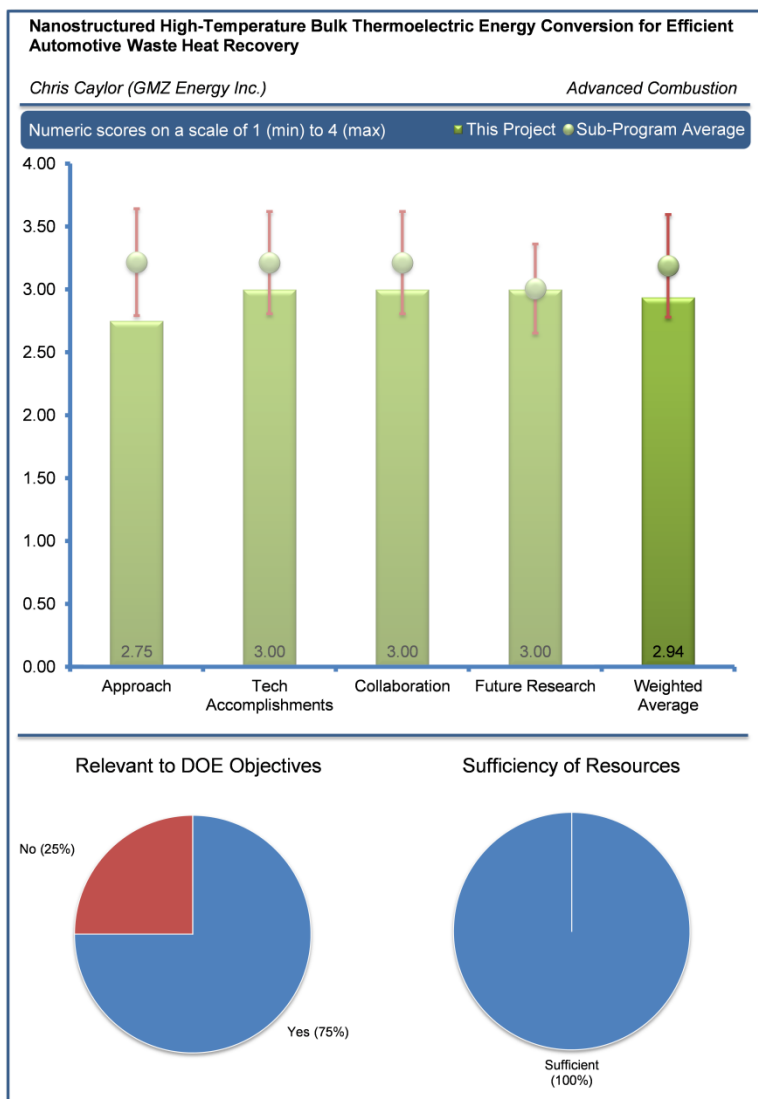
Reviewer 3:

The reviewer stated that the TEG system to be developed will employ Half-Heusler materials in the first, high thermal (T) stage, and Bi₂Te₃ materials in the low T stage. The materials are nanostructured (Half-Heusler) with apparently low cost compared to competing materials.

The reviewer said that the effort includes materials production, device fabrication and testing, system level modeling, and a cost assessment. The TEG designs have also been developed based on a hermetically sealed configuration that integrates a multichannel heat sink with the TEG modules. Furthermore, the reviewer noted that vehicle testing is included to provide a baseline for fuel economy. The reviewer also noted that this vehicle testing is an activity that is crucial.

Reviewer 4:

The reviewer commented that this project is not particularly well-designed. This project is focusing on Half-Heusler (HH) materials in designing its TEG system. These TE materials were shown to have ZT values of approximately 1.0 and less at relevant temperatures by the GMZ Energy group, and this does not represent high material performance as claimed by the GMZ Energy team. The reviewer stated that there was little evidence presented that these materials perform at a high enough level to achieve DOE's targets. This team has shown that the material ZT temperature dependency exhibits a pronounced reduction at 300°C at ZT approximately 0.6. In fact, the reviewer noted that past experiences and knowledge of this reviewer and other performers on this DOE program would clearly indicate that ZT values of approximately 1.0 will not achieve a system design satisfying DOE's program requirements. No design information was presented by this project on how to deal with the rapid ZT degradation at temperatures that are still well within the required operating range associated with this automotive WHR application.



The reviewer went on to say that there was little evidence presented that this team is performing the needed thermoelectric design optimization and thermal system optimizations necessary to produce an effective design. The reviewer added that according to the presenter, the team has just now obtained some capability in its TE modeling and analysis software and algorithms.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed that this is truly impressive, having gone from essentially a University-level demonstration of a nanostructured Half-Heusler device, to a working device having excellent performance.

Reviewer 2:

The reviewer affirmed that the project has used good approach to draw-on lessons learned from the WH1 teams. It is important that the team recognized both the material challenges and engineering challenges of building TEGs for mass production, and that the Half-Heusler (HH) material has shown great potential. The reviewer noted that the team's use of p-type materials still lags and could impact the overall system performance. If HH reduction could not achieve targeted ZT, the reviewer commented that an alternative approach will be helpful.

Reviewer 3:

The reviewer noted that GMZ Energy is now fabricating Half-Heusler hermetically sealed TEG modules, which is an interesting concept. The heat exchangers are a layered flat configuration, with plate fins in between, and the heat exchangers are hermetically sealed. The reviewer noted that the cost assessment was well done and found to be in the range of \$4 per watt down to its \$3 per watt target.

The reviewer added that the project group has also done actual measurements showing the influence of removing the alternator on a Chevy van. This activity will provide a baseline preformation target that TEG integration would work toward. The reviewer said that these sorts of measurements are crucial to assessing the performance of a TEG and benchmarking the results to know what the actual limits are.

Reviewer 4:

The reviewer pointed out that this project has demonstrated TE module efficiencies of only 4% at temperatures of relevance to this application. This is not high enough to produce enough energy to meet DOE's program goals, further verifying that that focusing on Half-Heusler materials alone will not achieve DOE's goals. There does not seem to be a strong plan on how their TE device and system design will produce enough power, 480 watt (W), to achieve even the modest light-duty fuel economy improvement targets the project team proclaims of 2.9%, which are well below the DOE's program goal of 5%. The reviewer stated that as a result, the project final fuel economy improvements will likely be much less than 2.9%.

The reviewer described that that this program is supposed to be a system design deployment program, but once again, this supposedly TE application program has morphed into focusing on TE material development. The team showed little or no thermal/TE design integration information or data. The reviewer added that the team did not discuss thermal interface challenges, and how the team is addressing and solving thermal interface challenges in either the TE device design or the TE system design.

The reviewer added that the team's presentation of the thermal cycling information was incomplete and did not give a strong sense on how the team's TE materials and modules will perform in the actual automotive waste energy recovery environments anticipated. In this automotive application, the devices could easily see nearly 1,000 cycles per year, and the 50 thermal cycles shown so far by this team is unimpressive. This reviewer recommended that more attention be paid to this derived design requirement.

The reviewer noted that the project is working on a sectioned TEG design whereby lower temperature Bismuth Telluride materials and modules would be employed in a downstream, in the lower temperature region of the exhaust stream, in order to recover more energy and increase power production. However, there was no design data presented on how the team was optimizing this sectioned design. The presenter indicated that the team was concluding that this downstream, lower temperature section was not cost-effective and was

considering eliminating it. This reviewer simply believed that the team has not or cannot properly design or optimize such a design. Other teams on this program have shown this approach effective.

The reviewer noted that this project is working on mass production of TE modules. However, very little progress was demonstrated on that mass production. The reviewer opined that 15 modules per month was not impressive. That fact does not represent much progress toward the high volume production levels needed to support DOE's objectives.

The reviewer observed that the TE device encapsulation system design is not optimized, and the team has not quantified heat losses, heat transfer rates, or thermal fluxes for given encapsulation design, nor has the team addressed any design issues surrounding thermal interfaces associated with this design. The presenter indicated that this encapsulation design could potentially be dropped into existing TEG designs, and according to the reviewer that is simply not true. Finally, the reviewer stated the this project design information on the plate fin heat exchanger and pin fin heat exchanger design is quite simplistic. The team does not appear to have any type of sophisticated thermal design capability based on this GMZ team AMR presentation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that Robert Bosch is a major industrial partner for vehicle integration. ORNL is pursuing the dynamometer testing, Houston is working on materials development, and Boise State is pursuing heat exchanger design. The reviewer also noted that Honda is apparently also involved, but its contribution was not especially clear (e.g., Honda is providing an automotive OEM, commercial perspective on system cost and production volume, which seems a bit vague).

Reviewer 2:

The reviewer observed that the project team seems to have experienced multiple leadership changes. The reviewer noted that it is important to maintain the leadership role to make sure the project can be carried out with no major interruptions.

Reviewer 3:

The reviewer noted that there is some instability in personnel. The reviewer opined that it is fine that the work seems to be following the people, but there are inherent time delays and inconsistent focus on the work. In some cases, the people have left the field (Caylor) and no doubt that is a drag on progress. The reviewer affirmed that the project results are obtained on-time and are impressive. The reviewer was sure that it was not easy to attain these results.

Reviewer 4:

The reviewer noted that although the project does seem to have some on-going collaboration between partners, this team is the weakest of the three teams performing on this VTO WHR. There is no real strong TE design or thermal design partner on this team.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the project will have a positive impact on waste-heat recovery even if the MPG targets are not exactly met. Whatever improvement is averaged over millions of cars will be a huge deal.

Reviewer 2:

The reviewer stated that the future research plan is good and that the project has met all the planned milestones.

Reviewer 3:

The reviewer noted that this future work will include pursuing a range of topics, including finalizing the heat exchanger for incorporation into a vehicle, vehicle testing with TEGs providing electricity to determine baseline performance metrics, a cost study for the materials and TEGs being developed, and partnering with TARDEC to integrate a TEG into a Bradley fighting vehicle. The

reviewer pointed out that the inclusion of a study of bismuth telluride devices may not be advisable even though it is apparently proposed in the two-stage TEG devices. In the long term, tellurium will probably not be preferred in an automobile (e.g., rare earth, limited supply, etc.).

Reviewer 4:

The reviewer observed that there was no real discussion about how this team will overcome the performance weakness of the Half-Heusler TE materials. This team's continued focus on Half-Heusler materials, with no real plan to overcome its performance weaknesses, will not produce acceptable power production performance, eliminate performance barriers, or advance the program. The reviewer added that the proposed future work plan is sufficiently vague and that it is unclear how this program will reduce the risks that this reviewer sees.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer notes that this project will have a positive impact on waste-heat recovery even if the MPG targets are not exactly met. Whatever improvement is averaged over millions of cars is a huge deal.

Reviewer 2:

According to this reviewer, the project is relevant to DOE's petroleum displacement goals.

Reviewer 3:

The reviewer affirmed that this project is highly relevant to DOE's objectives. The tasks are all directed toward developing the ingredients to allow evaluation and determination of the efficiency metrics of the TE integration. The reviewer added that the vehicle testing with and without TEGs to establish benchmarks is important.

Reviewer 4:

The reviewer elaborated that many of the reasons for arriving at this conclusion are stated above: focus on mediocre performing Half-Heusler materials; no plan to overcome Half-Heusler performance deficiencies in achieving the required power levels; little demonstrated progress on the system TE design, system thermal design, and multi-disciplinary integration; and serious TEG/thermal system design deficiencies.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked that the project funding level seems sufficient for the tasks proposed.

Reviewer 2:

The reviewer observed that the project team is using sufficient resources from each member.

High Efficiency GDI Engine Research, with Emphasis on Ignition Systems: Thomas Wallner (Argonne National Laboratory) - ace084

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the single-cylinder work and simulation is good. The reviewer was unsure whether there would be an optical dimension to this as well, potentially using Lyle Pickett's lab. The reviewer added that an optical dimension would make this project more valuable and provide more in-depth insights.

Reviewer 2:

The reviewer commented that the project focus is on two of three technical barriers, for example, the lack of systematic assessment of ignition systems and their potential in combination with lean/dilute combustion; and the absence of robust modeling tools. The approach to task is technically sound in general.

Reviewer 3:

The reviewer commented that the approach of an integrated assessment of combined effects of ignition system and combustion on engine efficiency and NO_x seems reasonable. The reviewer noted that it is important to focus on aspects not already well investigated already by the OEMs.

Reviewer 4:

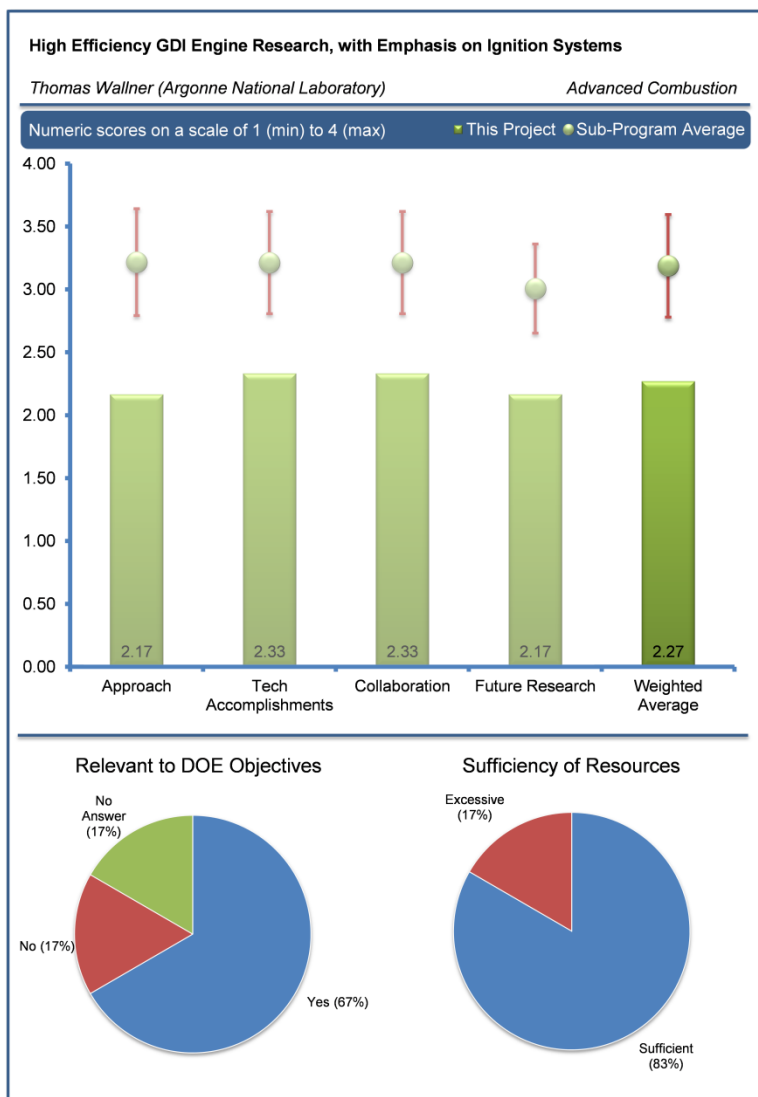
The reviewer commented that the project work is just starting. However, it seems that this work is focused on current technology and known approaches to extending the lean limit and EGR tolerance. The reviewer was not clear what new fundamental learning will result from this work.

Reviewer 5:

The reviewer observed that the approach involves using tools, methodology, hardware and concepts that industry is already familiar with and has been for about 15 to 20 years. This approach is very hardware and apparatus dependent and is best done on a competitive level by individual industrial entities and will offer little precompetitive knowledge.

Reviewer 6:

The reviewer observed that this project did not seem to present anything really new and unique, perhaps because of the team's presentation style. The team's approach for tackling lean burn GDI is fine, but it does not seem to be entering into a new area of understanding, for example, charge air motion, stratification, and etcetera are not really new areas.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that this project is only six months old so most of its accomplishments are related to engine setup, baseline testing and CFD tools validation for lean premixed combustion.

Reviewer 2:

The reviewer noted that this project is progressing with milestones: single-cylinder work established homogeneous lean combustion limit; 4% gain in indicated thermal efficiency (ITE); detailed chemistry CFD simulation yield good information on cyclic variability on intake flow; combustion simulation; quantify the ignition energy to be (current and voltage) 25 to 30 millijoule (mJ); and ignition system suppliers identified. The reviewer added that at this stage of the project, the team has made no significant progress towards any barriers.

Reviewer 3:

The reviewer noted that the engine is set up and running, but that no significant results have been shown thus far beyond what has been shown by other researchers doing like work.

Reviewer 4:

The reviewer remarked that again, the project work is just starting; however, to date, things that have been accomplished are fairly routine characterizations and analysis. It also seems that the results will be dependent on the engine configuration being used. The reviewer added that it seems that the team is not going to investigate anything particularly novel in terms of ignition systems, and perhaps laser ignition systems applied to smaller engines could be considered new.

Reviewer 5:

The reviewer observed that some relevant engine data has been obtained, but that this data is of little or no value. The reviewer noted that the team has not yet studied any effects of ignition energy or ignition concept. The effect of swirl plate position is very hardware dependent and does not offer value out of its local context. The reviewer noted that the same is true of the team's CFD calculations.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

According to this reviewer, the project demonstrates good collaborations with industry and with universities and DOE labs.

Reviewer 2:

The reviewer noted that the collaboration on this program is good, and meets the program needs.

Reviewer 3:

The reviewer remarked that the project had very limited collaborations. The reviewer pointed out that the team could partner with Lyle Pickett as one option to improve this communication, adding that it would be good for the team to acknowledge other research in this field, and potentially gain additional partners. It would also help the project to focus this work on areas that are fruitful and have not already been explored.

Reviewer 4:

The reviewer commented that some collaboration exists. However, the reviewer added that collaborations should be established with organizations that have prototype laser ignition or other novel ignition systems. The reviewer also pointed out that the effect and value of conventional inductive or capacitive ignition systems is well-known and need not be revisited.

Reviewer 5:

The reviewer noted that this collaboration seems to be mainly with the participants. The reviewer opined that it would be nice if a metric of the level of interest from the community at large could be shown.

Reviewer 6:

The reviewer remarked that the number of collaborations seems limited, primarily restricted to obtaining some equipment from Ford and Altronic and some input, with no real details given, from ACEC members.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer affirmed that the planned assessment of directed energy ignition system (DEIS) system and laser ignition seems to be the logical path.

Reviewer 2:

The reviewer said that the future research plans seem reasonable.

Reviewer 3:

The reviewer commented that only laser or other novel ignition systems should be pursued. The reviewer noted that a spray guided combustion system is also very hardware dependent and should not be entertained within the scope of this project as it will defocus from the main ignition system part of the project.

Reviewer 4:

The reviewer noted that the project should be clear about what innovative approaches will be used in this program. The laser ignition source is interesting, but even that is not really ground breaking. The reviewer would like to see something added to really try and advance the state-of-the-art, either in the approach or improving the understanding of how/why the combustion behaves as it does.

Reviewer 5:

According to this reviewer, the project appears to lack of originality in its work. If this project is to be successful, Thomas needs to explore something new and unique in his work.

Reviewer 6:

The reviewer commented that the project does not seem to have planned any novel future research.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that GDI lean-burn combustion is a growing trend in reducing fuel consumption, which is DOE's objective. The reviewer added that a robust ignition system for such a combustion concept is essential.

Reviewer 2:

The reviewer noted that lean burn GDI SI engines have the potential to improve fuel economy which leads to lower petroleum-based gasoline consumption which is in line with DOE's goals.

Reviewer 3:

The reviewer was unsure.

Reviewer 4:

The reviewer commented that the research is relevant, but the relevance of the current plan is questionable.

Reviewer 5:

The reviewer pointed out that the bulk of what the project has planned and what has been accomplished is ground that has already been ploughed.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer affirmed that this project funding is sufficient for the moment. The reviewer expressed that there is a need to give Thomas another year to prove that he can find something new and unique. If he cannot do this in the coming year, the reviewer recommended a reduction in the project funding.

Reviewer 2:

The reviewer stated that unless this project is redirected in a major way, this project should not be continued to be funded.

Low Temperature Emission Control: Todd Toops (Oak Ridge National Laboratory) - ace085

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer expressed that it was very good to see that low temperature technologies are being actively pursued to deal with more efficient engines and Tier 2 Bin 2 emissions standards. The reviewer stated that this is a necessary and critical area for future aftertreatment development. This reviewer expressed an interest in knowing why the researchers chose CO instead of HC or NO_x as the team's first area to explore in the low temperature area. Most of the industry need is in the area of HC and NO_x remediation, however, this interesting novel approach is worth exploring further in combination with other PGM metals.

Reviewer 2:

This reviewer stated that collaboration with DOE BES to translate fundamental science to useful, applied systems is a great example of an integrated approach. The approach is definitely contributing to the knowledge base on catalysis, and hopefully, in turn, the project will contribute to overcoming the low temperature activity barrier.

Reviewer 3:

This reviewer observed that the approach is ideal; the idea is to bring the results from BES-funded project to the vehicle level catalyst technologies with required elements such as sulfur and hydrothermal aging requirement. However, using gold (Au) as a commercial catalyst may not be practical as the cost impact will be big.

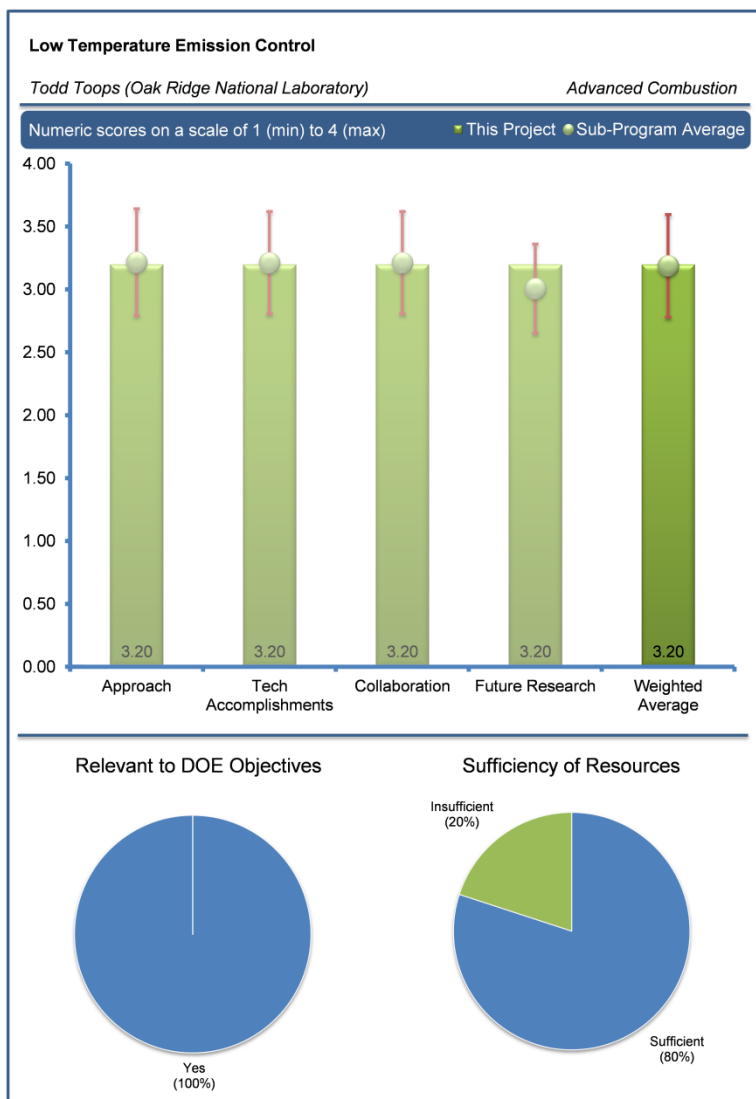
Reviewer 4:

This reviewer thanked the project team for listening to the ACEC and the goal of 90% conversion at 150°C. The reviewer added that the project had good alignment with BES for new materials. At first, the reviewer wondered why there should be concern about low temp CO oxidation, but upon further contemplation, expressed that it would be good to remove CO as interference to other light off reactions. In addition, the reviewer pointed out that there should be more emphasis placed on realistic aging.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer stated that, especially considering a lot of the initial work was unfunded, there has been exceptional progress.



Reviewer 2:

This reviewer expressed a need to forward to future results from this project.

Reviewer 3:

This reviewer said that there was very good technical progress, for just starting the project. It is important to recognize early on, through appropriate testing, to determine the viability and limitations of the technology. The reviewer remarked that if a technology is poisoned by HCs in an exhaust stream, then it severely limits its applications. The reviewer added that HCs and NOx activity at low temperature is more critical than CO.

Reviewer 4:

This reviewer pointed out that it may be too early to make judgment, as the project just started a few months ago. However, the evaluation condition and durability measurements need to be scoped appropriately.

Reviewer 5:

This reviewer commented that the catalysts studied show promise in increased durability and effective conversion at low temperatures, but challenges remain.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer indicated that this is one of very first attempts to work with the BES Community, and the project will be a great synergy if coordinated right.

Reviewer 2:

This reviewer observed that the project had active collaboration with basic energy sciences researchers, CLEERS, USCAR and U.S. DRIVE.

Reviewer 3:

This reviewer stated that all the ORNL projects have a sharp focus on the industry goals and nice collaboration with other researchers.

Reviewer 4:

This reviewer observed that the project collaborations with U.S. DRIVE, including OEMs and Tier 1 suppliers, will be the key in moving forward with this work.

Reviewer 5:

This reviewer stated the project consisted of mostly internal ORNL activity, and asked if the project had any partnerships.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said for the project team to keep up the good work.

Reviewer 2:

This reviewer remarked that the future work is sharply focused on the low-temperature catalysis that will be the key to enabling future research.

Reviewer 3:

This reviewer observed that the project had a very well outlined, vehicle level, and validation plan.

Reviewer 4:

This reviewer stated that this was the first year of this project and future work seems appropriate.

Reviewer 5:

This reviewer commented that the project team must know the operating conditions and limitations of the Au and copper (Cu) system better, and in combination with Pt and Al_2O_3 . The reviewer added that if HC poisoning will be an issue, it will limit its usefulness.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer pointed out that low temperature emissions control technologies are greatly needed to meet future emissions standards and to enable more efficient lean GDI engines.

Reviewer 2:

This reviewer stated that low temperature catalysts will be the key to enabling novel efficient combustion strategies.

Reviewer 3:

This reviewer indicated that this project is very important for low temperature aftertreatment that harmonizes the advanced combustion.

Reviewer 4:

This reviewer said that improved engine efficiency leads to lower exhaust gas temperatures, which causes issues for effective emission control. The reviewer added that this project investigates aftertreatment technologies for low exhaust gas temperature operation.

Reviewer 5:

This reviewer remarked that aftertreatment that is active at lower temperatures is going to be needed for highly efficient powertrains.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer commented that low temperature materials are a broad research area that will require additional funding to support a larger effort to pursue these materials and technologies.

Reviewer 2:

This reviewer observed that the project has had impressive work to date considering this started as unfunded work. The reviewer added that the project team did an excellent job in leveraging DOE/BES resources.

High Energy Ignition and Boosting/Mixing Technology: Edward Keating (General Motors) - ace086

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that this project plans to evaluate a plan to achieve high efficiencies by using boosting, high levels and EGR and improved ignition system. A clear path to implementation and success is somewhat muddled per the presentation. However, it merits pursuing due to the novelty and difference from other efforts.

Reviewer 2:

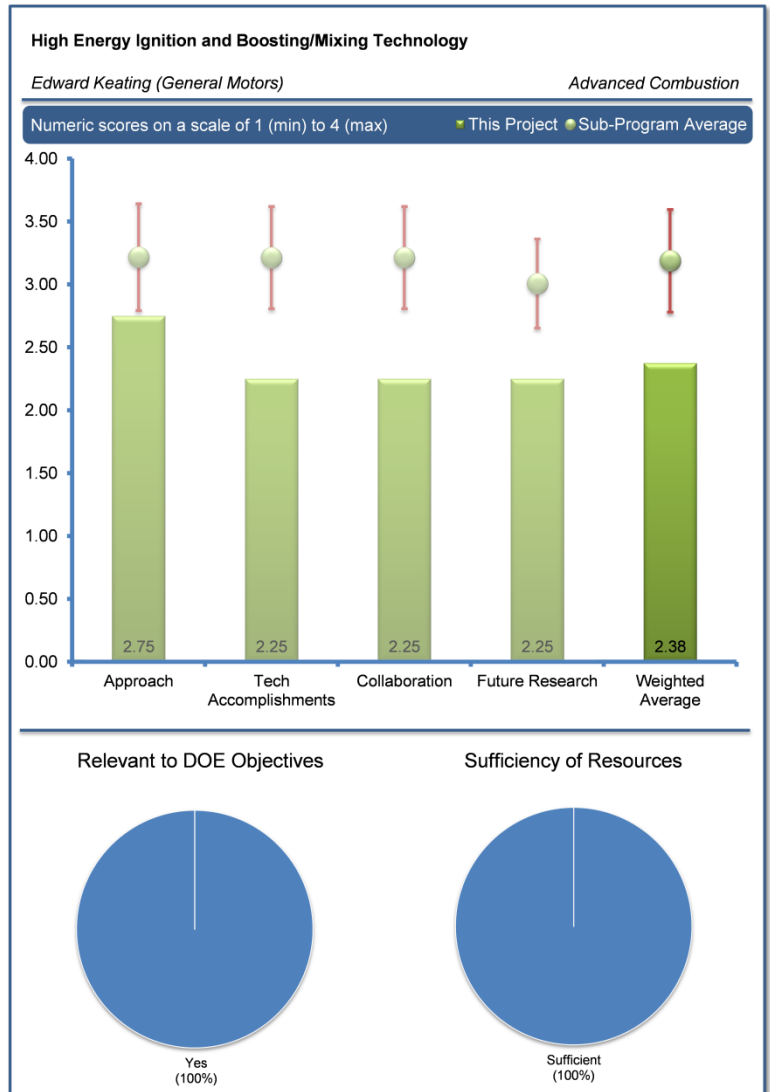
This reviewer stated that it is good to have a vehicle manufacturer assess the viability of this novel concept being pursued at Southwest Research Institute (SWRI).

Reviewer 3:

The reviewer stated that this is an enabling technology project and not a full vehicle system development. The reviewer added that the ignition system and dedicated-Exhaust Gas Recirculation (D-EGR) technologies are interesting and have high potential. The reviewer indicated that this is known from a number of presentations and public papers from the SWRI High-Efficiency Dilute Gasoline Engine (HEDGE) program. The reviewer indicated that it is unclear why the DOE needs to carry this next step to commercialization. The reviewer noted that there is limited new discovery and technology development in this project.

Reviewer 4:

The reviewer stated that this project aims to improve fuel efficiency by the application of advanced ignition systems and boosted combustion. While technically, the project's plans may address barriers, the approach taken appears to be inconsistent with the purpose of a publically-funded project. Specifically, the reviewer said it appears that GM is subcontracting the majority of the work to SWRI and pursuing only technology evolving from SWRI's consortium. Thus, it is not clear why DOE funding is need to perform such tech transfer. Furthermore, the reviewer indicated that some questions were not addressed based on proprietary limitations from GM's involvement in the consortium. Thus, the reviewer added that there are concerns about intellectual property limiting the benefits from this project to the public research community.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer pointed out that the project was a recently awarded (i.e., July 2012). So far the baseline engine tests with cooled EGR and an improved form of ignition have been conducted. The reviewer commented that in the future, the presenter should share a table that gives a timeline of different phases of the program.

Reviewer 2:

This reviewer stated that it is still early in the project and the accomplishments were planning and evaluation.

Reviewer 3:

The reviewer said that the project has taken steps to make the D-EGR more robust and controllable.

Reviewer 4:

This reviewer noted that the project is in the beginning stages and that there is not much to evaluate the project on in this category yet.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that this work is between SWRI and GM. However, the other members of the consortia at SWRI are also considered as part of the collaboration, so the learning gained in this project should be disseminated within that group.

Reviewer 2:

This reviewer observed that SWRI has developed most of the concepts proposed under this effort under the HEDGE program. The reviewer added that SWRI is an ideal partner with GM to evaluate these concepts.

Reviewer 3:

This reviewer stated that SWRI seems to be doing the project and that there is too much overlap with HEDGE.

Reviewer 4:

This reviewer stated, as mentioned in the approach section, GM is utilizing only one primary subcontract, and that is SWRI, which has already pursued these technologies via industry consortia. Given that, the reviewer asked what additional benefits this project will provide in technology advancement. The reviewer added that it would be much better if a university or National Laboratory partner was involved. Then, further research could be applied to the SWRI technologies with potential to either better understand the technologies or advance the technologies with the aid of experts external to the original development team.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer noted that the program appears to be on track in terms of planned modifications and the effort to incorporate this concept into a vehicle.

Reviewer 2:

This reviewer said the pursued effort follows a logical train of thought.

Reviewer 3:

This reviewer opined that future work should be more focused on a vehicle demo and full transient dynamometer (dyno) evaluation, yet appears to be repeating part of HEDGE in a different engine, which is not a criticism of GM.

Reviewer 4:

This reviewer indicated that the future research plan does not include any new technology tasks or collaborators that can further develop the technologies beyond the progress already made by SWRI.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer stated that if successful, the approach can lead to improved fuel efficiency via the advanced combustion proposed.

Reviewer 2:

This reviewer said the technologies have potential for fuel savings.

Reviewer 3:

This reviewer observed that the proposed concepts may offer fuel savings through improved engine efficiency. However, high levels of EGR will reduce engine specific power and improved boosting may not be sufficient for typical vehicle use. The reviewer added that future efforts need to address this issue along with efficiency improvement and emissions reduction.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Next-generation Ultra-Lean Burn Powertrain: Hugh Blaxill (MAHLE Powertrain LLC) - ace087

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer observed that this project had interesting enabling technology. Not the first time a pre-chamber has been attempted, but preliminary results published last year were promising. This reviewer indicated that some work and reports on this technology pre-date the contract start. The reviewer also said that this project is a good contribution in optical engine studies and that it appears boosted engine work will be new data compared to prior work.

Reviewer 2:

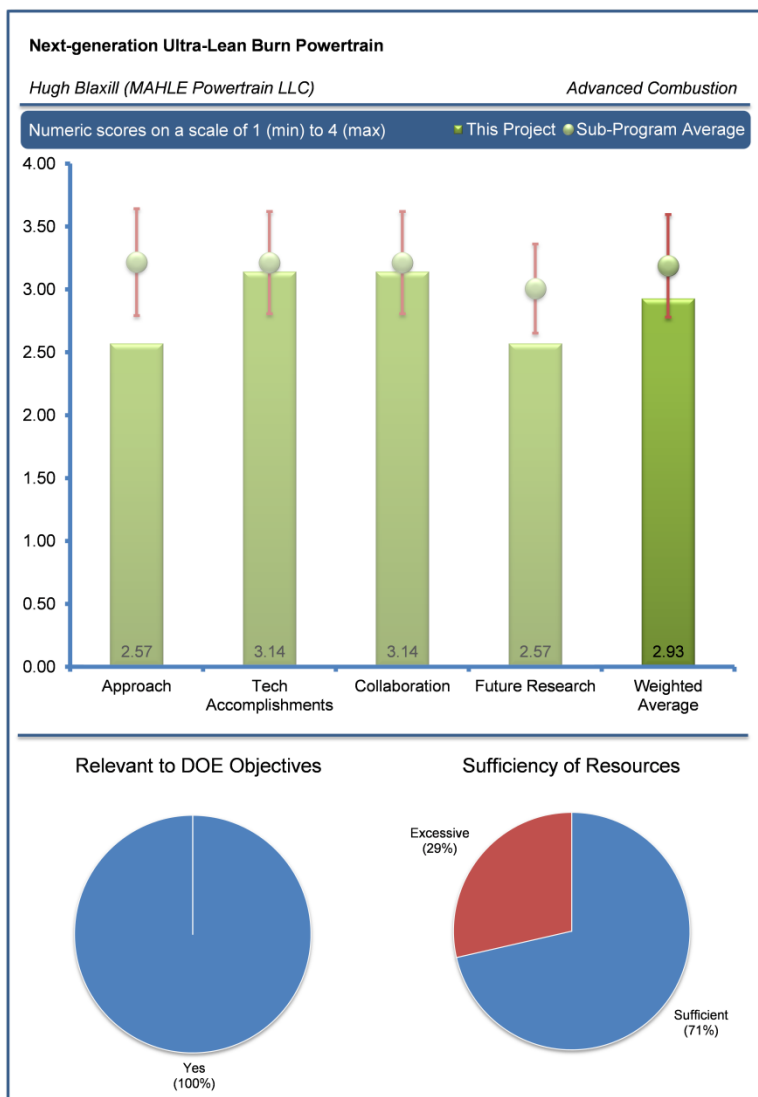
This reviewer remarked that the approach is good. However, the reviewer expected some issues and the program should address issues such as: low temperature cold start, which has been problematic for previously proposed pre-chamber systems; heat losses where pumping hot gas, whether flaming or just hot, through orifices with enough velocity to make ignition jets is bound to cause high heat transfer. A careful heat balance needs to be done, as the reviewer asked if the system fuel efficiency gains enough to offset increased heat loss to coolant; similarly, forming jets requires pumping work to be done on the gasses. The reviewer commented that a careful thermodynamic analysis is needed. If the engine runs ultra-lean, then the residual gas trapped in the pre-chamber may be mostly air, and adding fuel may achieve stable ignition. The reviewer added that under conditions like higher or lower load and cold start when main chamber mixture cannot be that lean, the high residual content in the pre-chamber may cause problems.

Reviewer 3:

This reviewer stated that this team is investigating the use of fueled pre-chamber with an objective to achieve 45% engine efficiency. With the use of pre-chamber, high velocity combustion jets issue into the main chamber and ignite an overall lean fuel-air mixture. The reviewer added that such an arrangement for ignition offsets the reduction in flame velocity, thereby enabling the use of ultra-lean mixtures, and hence higher engine efficiency.

Reviewer 4:

The reviewer thought that this turbulent jet ignition approach has potential to impact fuel consumption by enabling lean combustion. There are several challenges that will need to be overcome to achieve impact. The reviewer noted that one current weakness is the lean limit anticipated by the technique (λ equals 2.2), which is not much leaner than what conventional ignition approaches can achieve for (DI systems). A leaner combustion goal may be more appropriate or, perhaps if the NO_x emissions are lower with this approach, versus lean stratified GDI, and then more data demonstrating that would be good.



The reviewer said additional experimental approaches are recommended as well. While the optical engine and CFD tools are valuable for this project, the project needs further application of research tools to characterize the internal jet pre-chamber and in-cylinder exhaust chemistry and net air to fuel ratio (AFR). Likewise, the reviewer said that the engine out emissions characterization would be beneficial to characterize any benefits compared to more conventional ignition approaches. The reviewer noted that it is recommended to add these tools to further characterize the complex processes occurring and to validate CFD results.

Reviewer 5:

This reviewer thought that the jet injector pre-chamber design is novel and claims to have significant advantages such as being able to run lambda 1.0 (stoichiometric) at wide open throttle (WOT) or full load with less spark retard and power enrichment (PE). The reviewer stated this could be interesting in that downsized engines running at full spark and at lambda 1.0 at WOT may provide fuel economy benefits from significant downsizing. Typically, power enrichment (rich Air Fuel Ratios 11:1-13:1) is needed to protect engine hardware. This reviewer added that the data presented to justify this approach is not compelling. This reviewer stated that more detail on the hypothesis would be helpful for higher marks. Additionally, the reviewer expressed some concerns with cold start and warm-up operation as well as emissions with pre-chamber from many years of industry experience. If initial experiments are promising warm, cold start performance must be added to the approach.

Reviewer 6:

The reviewer opined that this is a been-there-done-that approach. The reviewer stated that all the OEMs and just about everybody else has tried some variation on jet ignition for ultra-lean mixtures. There was no real identification of anything new in this approach.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer thought that the progress on optical engine and modeling work are excellent.

Reviewer 2:

This reviewer said that it is early on in the project and that there was good progress to date.

Reviewer 3:

This reviewer indicated that there is good progress in the initial phases of this work particularly related to the optical engine and CFD work. This reviewer added that advancements in progress related to understanding the AFR and chemistry in jet are needed in the next phases of the studies.

Reviewer 4:

This reviewer said that the initial results show expected pre-chamber results.

Reviewer 5:

This reviewer commented that the project is just getting underway and that no quantitative performance data was presented.

Reviewer 6:

This reviewer observed that the team appears to be making steady progress per the proposed schedule. However, with the data presented so far, undue importance was given to optical engine testing. The reviewer indicated that the pre-chamber geometry optimization could have been performed with just tests on a thermodynamic engine and by using CFD simulations. Other combinations of ignition technologies that ignite lean mixtures and piston designs that improve turbulence at the end of the compression stroke could have been tested instead.

Reviewer 7:

This reviewer opined that the accomplishments were nothing special, except there was a lot of hardware building. The reviewer stated that perhaps the six jet pre-chamber injection system is new, but the reviewer is not sure that it is a particular technological accomplishment.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer said the project had excellent collaborations and interested parties.

Reviewer 2:

This reviewer said the project team was a comprehensive team and that there was not much to improve on in a project on enabling technology.

Reviewer 3:

This reviewer expressed that the team members complement each other's capabilities to result in a high quality program with a tangible hardware deliverable, and that there is also benchmarking of the potential gains associated with that technology through tests and CFD simulations.

Reviewer 4:

This reviewer pointed out that this project seems to be primarily an in-house effort, with engine help on components from Ford and Delphi, which seems like a reasonable approach.

Reviewer 5:

This reviewer indicated that there were lots of subcontractors for this project.

Reviewer 6:

This reviewer indicated that collaborations with Ford and Delphi appear valuable. However, it is unclear what contributions are being made by WERC.

Reviewer 7:

This reviewer expressed a need to see more university collaboration, where WERC is a consulting firm.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer observed that there was a reasonable transition from single-cylinder to multi-cylinder. However, there was very limited data provided to justify future work.

Reviewer 2:

This reviewer said that the experiments and studies in boosted engines will be important contribution and expansion of knowledge. The reviewer added that the project team needs to consider or discuss costs.

Reviewer 3:

This reviewer said that previous work performed in (stationary) natural gas engines has resulted in the use of a non-fueled pre-chamber that offered similar results but with far simpler hardware complexity. The reviewer stated that it is worth the effort here to conduct tests comparing the performance of a non-fueled pre-chamber with a fueled pre-chamber.

Reviewer 4:

This reviewer indicated that the plan seems to be appropriate to define normal operating modes like FTP. However, the reviewer thinks there are more severe conditions like very cold starting that may make the concept unworkable; the work plan needs to address such issues.

Reviewer 5:

The reviewer commented that at this stage, the project appears too narrow in the approach for the next phases of the project. The reviewer pointed out that it appears that more research will be needed in the next phases to better characterize and understand the jet chemistry issues to maximize the feasibility of this approach. The reviewer recommended adjusting the proposed next steps to include more research versus the proposed development and testing.

Reviewer 6:

This reviewer expressed that the project is just moving along in a predetermined direction with no clear indication that there is anything new in the approach.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer indicated that the technology being developed in this project can potentially increase the efficiency of light-duty gasoline engines to 45% from the current level of 36%. In other words, the improved engine efficiency facilitated by this technology supports the DOE objective of decreasing gasoline consumption.

Reviewer 2:

The reviewer noted that this project has good potential enabling technology for dilute combustion engines.

Reviewer 3:

This reviewer commented that significant downsizing and related fuel economy benefit may be possible if WOT lambda 1.0 can be achieved at full spark advance and no cold start issues. The reviewer added that this project could be an enabler for dual fuel applications as well with a very controlled pilot.

Reviewer 4:

This reviewer stated that if the project works, the project would be a contributor to a very lean and therefore high efficiency engine.

Reviewer 5:

This reviewer said the project aims to enable lean combustion which can reduce petroleum use.

Reviewer 6:

The reviewer expressed that a project is only relevant if there is something new. The reviewer commented that there is not anything new in the presentation.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer commented that the resources are sufficient for the initial evaluation and that more funding may be needed if initial results are promising.

Reviewer 2:

The reviewer noted that this seems like appropriate funding, although more might be needed to cover the expanded boundary conditions that the reviewer thinks are important.

Reviewer 3:

This reviewer pointed out that the resources at this stage are sufficient. However, the optical engine appears to have adsorbed most of the resources; other diagnostics related to plume and engine out emission characterization would be valuable to add.

Reviewer 4:

This reviewer expressed that the project received a lot of money to build engines without any clear, unique application.

Reviewer 5:

This reviewer observed that the allocated funds are somewhat excessive. The reviewer added that the insight obtained with the optical engine development and tests yielded very little information. The pre-chamber geometry optimization could have been performed without this task being performed.

Heavy Duty Roots Expander for Waste Heat Energy Recovery: Swami Nathan Subramanian (Eaton Corporation) - ace088

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer said that this appears to be a very well developed commercial development project. The reviewer lauds Eaton for putting this together. This reviewer added that the project has a solid chance of success and that the project is weak on safety technologies for a catastrophic event.

Reviewer 2:

This reviewer observed that the project had a very good technical approach with simulation and planned experiments. A comparison of cost and performance with other types of expanders would have been beneficial.

Reviewer 3:

This reviewer stated that given the initial assumption that the roots device is the right one, this seems to be a good approach to configuration and design.

Reviewer 4:

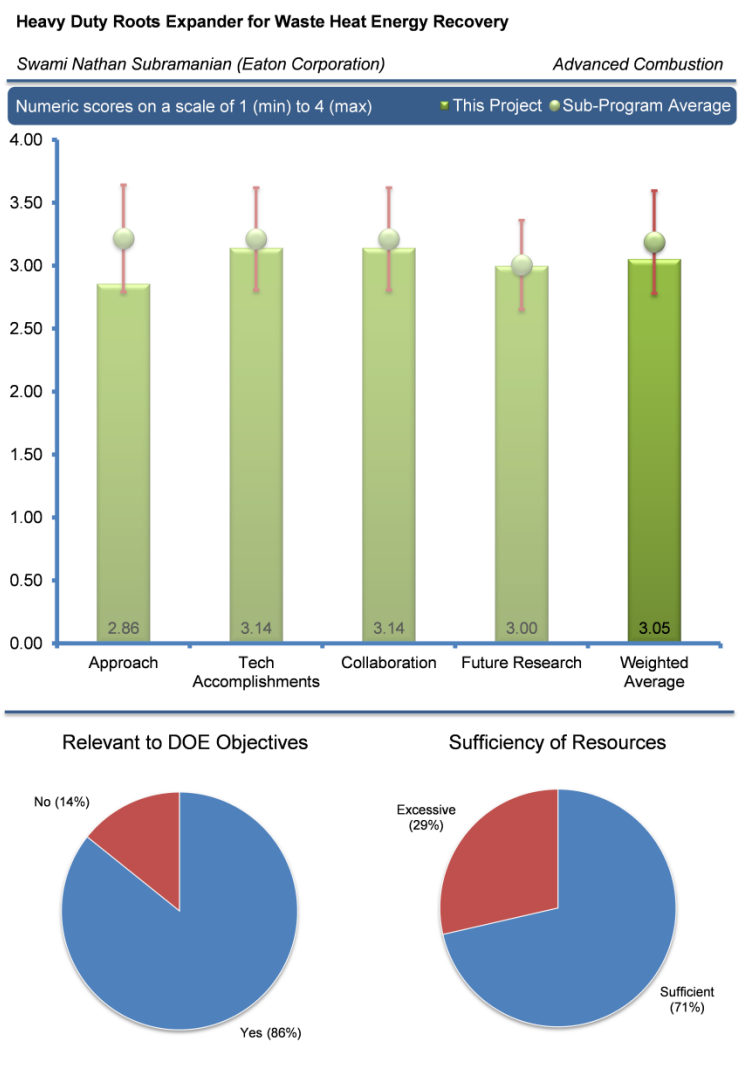
This reviewer pointed out that the project is in the beginning stages, but there are plans for the approach to achieve potential benefits relative to more conventional approaches. Specifically, the Roots Expander can potentially offer greater efficiency and the ability to manage multiphase flow.

Reviewer 5:

This reviewer observed that the basic idea of using Rankine Cycle, to harvest waste heat and transform it to useable shaft power, is being pursued by various companies. However, the present effort aims to develop a novel Roots expander which has the primary advantages over the other competing technologies of operating at 10-times lower speeds, and having the capability to withstand two phase flow during the expansion process.

Reviewer 6:

This reviewer indicated that it was a good approach to make use of expander, but it seems that the decisions regarding materials selection and working fluid selection are not quite as fully developed as they could be yet. In particular, the reviewer expressed concern about the ethanol (EtOH)/oil separator for which no details were given.



Reviewer 7:

This reviewer thought that the re-use of roots blower in reverse is a creative idea. However, significant concerns arise relating to applying an air based system to exhaust gas. The reviewer indicated that the main re-use is engineering for flow across the device. The materials, bearings, seals all need to be re-evaluated and re-designed. The reviewer said that the project must at a minimum compare the proposed device to other current solutions in terms of cost, weight, complexity, functionality, and packaging. The reviewer stated that one of the key attributes must be that there is an advantage to pursue a roots expander. These attributes were not conveyed clearly. Also, the reviewer thought that the project should have considered leveraging the other SuperTruck evaluations of WHR for modeling effort and may still consider plugging in roots type expander to other models. The approach should discuss design changes needed if working fluid were changed in the future. Additionally, the reviewer said the design does not have to accommodate other fluids, but could package protect for other possibilities.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer expressed that the approach that is being followed is very logical, and the progress is on schedule. Through engine tests, the base engine performance was established and potential available energy in the EGR stream and in the exhaust streams was estimated to result in appropriate estimates for the size of the roots expander. The reviewer indicated that these estimates were further substantiated through 1-D computer simulations. A prototype expander was designed and built. The reviewer added that problems associated with sealing, high roots impeller mass, etc., were adequately addressed through design innovations. This reviewer indicated that the prototype single-stage expander will be integrated with an engine and tests will be conducted as a part of future effort.

Reviewer 2:

This reviewer commented that this project appears to be well on its way to producing a quality product.

Reviewer 3:

This reviewer remarked that the project was a very comprehensive analytical exercise. The reviewer said the project had a good start on hardware design and development. The reviewer added that multiple expander stage design is good.

Reviewer 4:

The reviewer was not completely sure how much is simulation and how much is test result. The reviewer added that it seems that there are good preliminary results in the first program year.

Reviewer 5:

This reviewer observed that the initial progress of the project has focused on analytical and design studies. The reviewer added that the progress is fair at this stage, with more progress expected in the next year with prototype building commencing.

Reviewer 6:

This reviewer said that there was good progress to perform modeling and initial prototyping of single stage device. The reviewer also stated that there are concerns with using engine oil and ethanol oil separator. The reviewer recommended using separate lubrication loop, and to consider alternate designs as risk to engine oil is a significant concern. It is understood that the additional complexity and losses of a separate pump will reduce the value of the system.

The reviewer is unsure about the increase of EGR from base engine calibration for WHR efficiency. The reviewer inquired whether it was possible to increase EGR on the base engine without WHR, or is the presence of the WHR improving EGR tolerance in some way. Also, the reviewer expressed surprise to find NO_x and HC improvement with exhaust restriction. Understanding the mechanism causing this improvement is important.

Reviewer 7:

The reviewer stated that there are insufficient details to fully assess progress.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer indicated that each of the team partners' expertise is being adequately leveraged to result in a high quality product.

Reviewer 2:

This reviewer said the project has solid collaboration with partners, especially John Deere.

Reviewer 3:

This researcher remarked that collaboration with an engine manufacturer, John Deere, is good. Also, collaborations with Modine and seal suppliers are notably valuable.

Reviewer 4:

This reviewer commented that excellent for credibility is the identification of a good cross section of partners and their roles, with the inclusion of key suppliers, which are not necessarily official project partners.

Reviewer 5:

This reviewer said the project had a very complete and comprehensive team. The reviewer said that a possible improvement would be adding an on-highway engine OEM.

Reviewer 6:

This reviewer said there seems to be an appropriate choice of suppliers and that it is not clear how integrated they are in the design process.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer said that the proposed future research was an overall solid plan and has some go/no-go points.

Reviewer 2:

This reviewer indicated that the project is on track to a decision point in 2015 for a possible commercial product. The reviewer believed that this is an acceptable timeline.

Reviewer 3:

This reviewer said the future plans are well established at this early stage in the project.

Reviewer 4:

This reviewer indicated that the project had a solid approach to the design and evaluation of this device.

Reviewer 5:

The reviewer observed that the base engine used is one typical of off-road equipment and as a result steady-state tests are being conducted here. This reviewer added that it may prove effective to evaluate the performance of the roots expander for vehicular application by performing some transient tests.

Reviewer 6:

This reviewer stated that the future research plan is reasonable. The reviewer indicated that the plans to lightweight and harden first prototype design and to develop multistage system is good. Also, the project should include alternate lubrication schemes and be sure to show concept selection approach. The complexity and content of multistage system is very high. The reviewer pointed out that there is a need to provide some kind of value proposition and advantages for roots design over other designs. The reviewer asked if the

balance of the system is made simpler/less-costly at all with roots expander. The reviewer commented that the project should provide some idea about benefits of a roots type expander and system as well as cost or at least cost target range.

Reviewer 7:

This reviewer had concerns about the oil/EtOH separator. The reviewer would like to know which direction (or both) is the separation. This does not seem trivial and could be a big deal for the lubricating oil if there is residual ethanol.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said WHR for Class 8 trucks and associated 6% estimated fuel economy improvement, if realized and implemented, can provide significant petroleum reduction potential for Class 8 trucks which consume 17-20% of the fuel for Medium duty/Heavy duty trucks in the United States.

Reviewer 2:

This reviewer commented that this project could contribute to several of the SuperTruck programs since several are using EtOH fluid WHR systems.

Reviewer 3:

This reviewer indicated that the project addresses WHR technologies, which are a worthwhile approach to reducing petroleum displacement by recovering heat energy in the exhaust that would otherwise be wasted to the surrounding atmosphere.

Reviewer 4:

This reviewer stated that this project would be stronger with an OEM that is a premier on-highway manufacturer. The reviewer added that it was good to see projects pertaining to HD trucks.

Reviewer 5:

This reviewer expressed that there are a number of commercial entities attempting to commercialize Rankine WHR. The reviewer asked why not let the market take care of this development.

Reviewer 6:

This reviewer indicated that the proposed invention could potentially improve the efficiency of diesel engines by 5-6% thereby reducing our petroleum consumption significantly.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer observed that at this stage, the resources are appropriate.

Reviewer 2:

This reviewer said that the allocated funds are sufficient.

Reviewer 3:

This reviewer said that there are generous resources for project objectives.

Reviewer 4:

This reviewer stated that the total resources seem appropriate. The reviewer noted that it was surprising that DOE accepted much less than 50/50 matching.

Reviewer 5:

This reviewer said that considering that Eaton is developing a proprietary device that they hope to commercialize, the reviewer feels that the level of DOE funding is truly excessive (2:1).

Reviewer 6:

This reviewer is unsure if the DOE should fund this project.

Radio Frequency Diesel Particulate Filter Sensor and Controls for Advanced Low-Pressure Drop Systems to Reduce Engine Fuel Consumption: Alexander Sappok (Filter Sensing Technologies, Inc.) - ace089

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

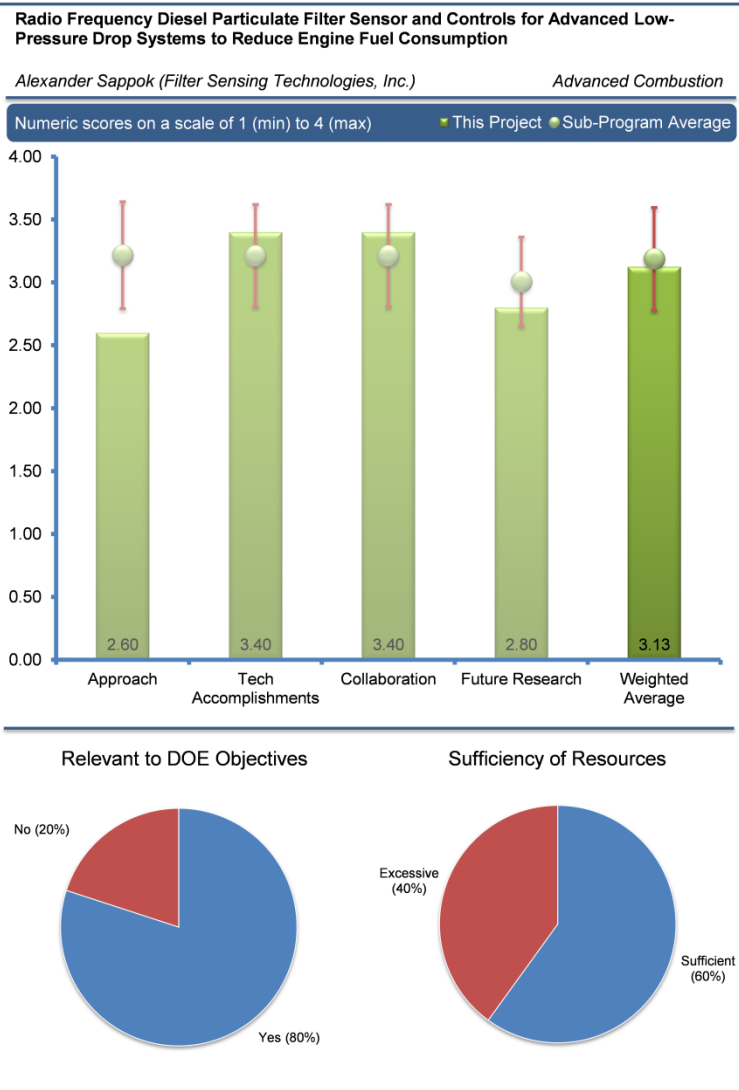
This reviewer stated that this project had an excellent, well-integrated approach that leverages previous DOE-funded work at MIT to develop a real world OBD device. The project makes good use of industrial and National Laboratory partners; however, there should probably be some parametric testing of fuel/lube oil effects, especially as they relate to soot and ash composition. The reviewer asked how will engine wear (metal components that become part of the ash) impact the sensor calibration over time.

Reviewer 2:

The reviewer said that this technology was developed as a diagnostic during the PhD. program of the PI. It appears that the intent of the proposed effort is to reduce this diagnostic to practice, so as to be able to measure particulate loading in Diesel Particulate Filters (DPFs) of trucks. The advantage of this technique is that it yields a direct measurement of the soot loading in DPF as compared to the standard technique of measuring the pressure drop and thereby estimating the soot loading. From a controls point of view, one just needs a feedback signal so as to initiate a regeneration cycle for the DPF and the necessity of having to know the exact DPF particulate loading is overkill. Also, the reviewer stated that the pressure drop across the filter is a better feedback signal as it has a direct impact on backpressure and the overall engine efficiency.

Reviewer 3:

This reviewer observed that the use of low-cost Radio Frequency (RF) sensor technology with the possibility of use for sensing DPF loading is an interesting approach. Many barriers have been identified for the use of such sensors. The reviewer indicated that the top priority barrier, which is being pursued in parallel to sensor development, is to characterize soot and ash accumulations. A key element in this activity is to identify a reasonable metric and verifiable laboratory grade test/ sensing equipment to identify the percent filled, percent plugged or other appropriate proxy for DPF loading across many products and engines. The reviewer noted that the current plan includes a DPF loading device, but it is the correlation and characterization of dyno, and actual in use vehicle loading that will be critical to end use. Once the proxy for loading is identified, which is somewhat universal across devices and engines, then the RF sensor value proposition can truly be established. The reviewer added that without a standard method to clearly identify the loading, or plugging, of the devices, each device, DPF material, truck, and possibly duty cycle may require a characterization or calibration implying at least a cursory set of tests and possibly an extensive study being required. The reviewer said that if a



characterization or calibration is required for each DPF device (and possibly truck application) and the characterization is not very straightforward or very standardized then it will be difficult to take advantage of the low cost sensor universally. The reviewer said that it appears that the goal of the project is to sense DPF loading inexpensively and universally to avoid detailed characterizations of specific applications each time. A clear test process with metrics for what constitutes DPF loading is the first step and can become an extensive activity by itself. Critical Assumptions and Issues (part to part, durability, OBD) are key barriers and should be formally reflected as such.

Reviewer 4:

This reviewer indicated that the approach is clearly and well-thought out. The reviewer's recollection is that changes in the RF cavity (i.e., DPF) caused changes in the calibration. This was very cavalierly swept under the rug. The reviewer expressed that this was a serious omission. The reviewer indicated that this approach has been considered before. The reviewer does not see any reference to the other attempts, these references would be relevant.

Reviewer 5:

This reviewer noted that the project was an interesting approach to DPF monitoring. It should help in monitoring loading, but the reviewer asked is it able to perform OBD sufficiently. The reviewer answered probably not, since it may not detect all modes that might cause soot leakage.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said that in spite of the short time period from the date of award to the first review, considerable progress has been achieved. The reviewer said that through relevant tests the effects of frequency and temperature on the signal response were determined. Subsequently, adequate modeling and validation were conducted for various levels of particulate loading. Also, the reviewer indicated that the necessary engine test setups have been readied in order to conduct the performance tests.

Reviewer 2:

This reviewer commented that the project has made impressive progress and accomplishments to date. The reviewer added that the project had impressive facilities commissioned and were running tests.

Reviewer 3:

This reviewer pointed out that the project made very good progress in the first year, apparently including commissioning an engine test cell. The reviewer added that the means of translating resonant frequency into an output signal is not explained.

Reviewer 4:

This reviewer stated that initial tests showing proof of concept to measure loading on a single DPF with a single loading device have been shown. Also, the reviewer noted that the design is progressing well from previous work; however, results must focus on common metric which can be easily characterized in a simple test or which requires no characterization at all. For the goal of the project, the reviewer said that production use of this type of sensing is paramount and is not a trivial task. Priority focus on this technical barrier should be stated and worked on aggressively with top priority.

Reviewer 5:

The reviewer stated that there was nothing new here except the instrumentation. There was no evidence of self-correcting approaches to fix the calibration. The reviewer added that swap out as fixes are not good, way too much warranty costs.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer stated that the integration of very disparate working groups seems to be successfully handled, and that the project team did a good job.

Reviewer 2:

This reviewer said that the collaboration is a good buy-in from DOE, industry, and the labs.

Reviewer 3:

This reviewer noted that the contractor seems to have built a strongly leveraged team of competent people and organizations.

Reviewer 4:

This reviewer commented that there was a very extensive list of collaborators. This reviewer suggested considering a “loaded return part” program from multiple fleets to confirm capability of the sensors across a range of products.

Reviewer 5:

This reviewer expressed that the team appears to have more players than necessary. Also, the reviewer pointed out that the roles DDC and the City of New York Department of Sanitation (DSNY) were not clear and appeared superfluous.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer indicated that there were solid future plans for a technology that could be implemented. The reviewer added that the project needs a better definition of durability and repair.

Reviewer 2:

This reviewer stated that the proposed future activities comprise the necessary tests to validate the performance of the technology under development.

Reviewer 3:

This reviewer said the project has a solid approach, assuming the intermediate points are successful. The reviewer also expressed that it would be nice to have a clearer picture of what success would look like and how the sensor would be used in a vehicle system, leading to an estimate of its value in the system.

Reviewer 4:

This reviewer remarked that the project needs to focus on characterization of a common metric to overcome barrier of part to part and ash formation capabilities before looking at alternative fuels.

Reviewer 5:

The reviewer said to see previous comments.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer observed that this project could possibly reduce maintenance cost of DPF devices.

Reviewer 2:

This reviewer indicated that this project is part of the potential means for meeting emissions.

Reviewer 3:

This reviewer said if the damage/wear problem is well addressed.

Reviewer 4:

This reviewer stated that it is not clear to the reviewer how this technology would lead to fuel savings, if any.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said the resources seemed to be appropriate. The reviewer is surprised the DOE required much less than 50/50 matching. This may be appropriate for a small company such as this.

Reviewer 2:

This reviewer stated a recommendation that a Go/No-go decision be made after Phase-II (FY 2013-2014). If the relevance of the program to DOE goals cannot be justified, the subsequent phases should be curtailed.

Reviewer 3:

This reviewer expressed that the project could use a value proposition for pay back.

Reviewer 4:

This reviewer expressed that there is too much money in this project for the possibility of success.

Acronyms and Abbreviations

Acronym	Definition
3D	Three Dimensional
AC	Alternating Current
A/C	Air Conditioning
ACEC	Advanced Combustion and Emissions Control
AEC	Advanced Engine Combustion
AFR	Air to Fuel Ratio
ANL	Argonne National Laboratory
APS	Advanced photon source
AMR	Annual Merit Review
Au	Gold
Bi₂Te₃	Bismuth Telluride
BES	DOE Basic Energy Sciences
BMEP	Brake Mean Effective Pressure
BNL	Brookhaven National Laboratory
BSFC	Brake-specific fuel consumption
BSNOx	Brake-specific NOx
BSPM	Brake-specific Particulate Matter
BTE	Brake Thermal Efficiency
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board
CE	Coulombic Efficiency
CFD	Computational Fluid Dynamics
CI	Compression Ignition
CLEERS	Cross-Cut Lean Exhaust Emissions Reduction Simulations
CNT	Carbon Nanotubes
CO	Carbon Monoxide
CO₂	Carbon Dioxide
COP	Coefficient of performance
COTS	Commercial-Off-the-Shelf
CR	Compression Ratio
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council
Cu	Copper
dB	Decibel
D-EGR	Dedicated-Exhaust Gas Recirculation
DASI	Diesel-Assisted Spark Ignition
DDC	Detroit Diesel Corporation

Acronym	Definition
DEIS	Directed Energy Ignition System
DERC	Diesel Engine Research Consortium
DI	Direct Injection
DISI	Direct Injection Spark Ignited
DMP	Diesel-Micro-Pilot Ignition
DOC	Diesel oxidation catalyst
DOE	U.S. Department of Energy
DoE	Design of Experiment
DPF	Diesel particulate filter
DSNY	City of New York Department of Sanitation
E10	10% Ethanol blend with gasoline
ECN	Engine Collaboration Network
ED/AX	Energy Dispersive Analysis of X-Rays
EGR	Exhaust Gas Recirculation
EHN	2-Ethylhexyl Nitrate
EPA	U.S. Environmental Protection Agency
EQR	Equivalence Ratio
ERC	Engine Research Center
ESEM	Environmental Scanning Electron Microscopy
EtOH	Ethanol
FACE	Fuels for Advanced Combustion Engines
FE	Finite Element
FE	Fuel Economy
FMEP	Friction mean effective pressure
FPE	Free-piston engine
FTP	Federal Test Procedure
FTIR	Fourier Transform Infrared Spectroscopy
FY	Fiscal year
GDI	Gasoline Direct-injected
GDCI	Gasoline Direct Compression Engine
GM	General Motors Corporation
GMZ	GMZ Energy Inc.
GPF	Gasoline Particulate Filter
GPU	Graphics Processing Unit
GTI	Gas Technology Institute
GWP	Global Warming Potential
H₂	Hydrogen
H₂O	Water
HATCI	Hyundai America Technical Center Inc.
HC	Hydrocarbon
HCCI	Homogeneous Charge Compression Ignition

Acronym	Definition
HD	Heavy-Duty
HEDGE	High-Efficiency Dilute Gasoline Engine
HH	Half-Heusler
HPC	High Performance Computing
HPLB	High-pressure, lean burn
HVAC	Heating, ventilation and air-conditioning
ICE	Internal Combustion Engine
IMEP	Indicated Mean Effective Pressure
ISFC	Indicated Specific Fuel Consumption
ITE	Indicated Thermal Efficiency
JPL	Jet Propulsion Laboratory
°K	Temperature in degrees Kelvin
K	Potassium
Kn	Knudsen Number
KIVA	Computational Fluid Dynamics Modeling Software
LANL	Los Alamos National Laboratory
LD	Light-Duty
LDB	Lean Downsized Boosted
LED	Light-Emitting Diode
LES	Large Eddy Simulation
LEV	Low Emission Vehicle
LII	Laser Induced Incandescence
LLNL	Lawrence Livermore National Laboratory
LNT	Lean NO _x Trap
LRRI	Lovelace Respiratory Research Institute
LTC	Low Temperature Combustion
MATLAB	Numerical Analysis Software
Mg	Magnesium
Mn	Manganese
MCH	Methylcyclohexane
MD	Medium-Duty
MEMS	Micro-Electro-Mechanical Systems
MIT	Massachusetts Institute of Technology
mJ	Millijoule
MOU	Memorandum of Understanding
MPC	Model Predictive Controller
MPG	Miles Per Gallon
MSU	Michigan State University
MTU	Michigan Technological University
N₂O	Nitrous Oxide
NH₃	Ammonia

Acronym	Definition
NASA	National Aeronautical and Space Administration
NO	Nitric Oxide
NO_x	Oxides of Nitrogen
NO₂	Nitrogen Dioxide
NREL	National Renewable Energy Laboratory
NSC	NO _x Storage Catalyst
NSF	National Science Foundation
NSR	NO _x Storage Reduction
NVO	Negative Valve Overlap
O₂	Oxygen
OBD	On-Board Diagnostics
OEM	Original Equipment Manufacturer
OH	Hydroxide
ORNL	Oak Ridge National Laboratory
OSC	Oxygen storage capacity
OSU	Ohio State University
OTR	On the Road
PCCI	Premixed Charge Compression Ignition
PE	Power Enrichment
PFI	Port Fuel Injection
PGM	Platinum group metal
PI	Principal Investigator
PM	Particulate Matter
PNNL	Pacific Northwest National Laboratory
PPC	Partially Premixed Combustion
PRF	Primary Reference Fuels
Pt	Platinum
PZEV	Partial Zero Emissions Vehicle
R&D	Research and development
RANS	Reynolds-Averaged Navier Strokes
RCCI	Reactivity Controlled Compression Ignition
RCM	Rapid compression machines
RF	Radio Frequency
RI	Ringling Intensity
RON	Research Octane Number
RPM	Revolutions Per Minute
SACI	Spark assisted compression ignition
SCE	Single-Cylinder Engine
SCR	Selective Catalytic Reduction
SCTE	Single Cylinder Test Engine
SI	Spark-ignition

Acronym	Definition
SIF	Spray-Interactive Flamelet
SIDI	Spark-ignition direct-injection
SKU	Skutterudite
SNL	Sandia National Laboratories
SpaciMs	Spatially Resolved Capillary Inlet Mass Spectrometer System
SULEV	Super Low-Emission Vehicle
SWRI	Southwest Research Institute
TARDEC	U.S. Army Tank and Automotive Research, Development and Engineering Center
TE	Thermoelectric
TEG	Thermoelectric Generator
TEM	Transmission electron microscopy
TIM	Time Integrity Modules
TiVCT	Twin Independent Variable Camshaft Timing
TWC	Three-Way Catalyst
UDDS	Urban Dynamometer Driving Schedule
UHC	Unburned hydrocarbons
UM	University of Michigan
UNLV	University of Nevada-Las Vegas
USCAR	U.S. Council for Automotive Research
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability
UW	University of Wisconsin
UWM	University of Wisconsin-Milwaukee
VCT	Variable camshaft timing
VTO	Vehicle Technologies Office
VVA	Variable Valve Actuation
WERC	Wisconsin Engine Research Consultants
W	Watt
WH	Waste Heat
WHR	Waste Heat Recovery
WOT	Wide Open Throttle
WSU	Wayne State University
ZT	Thermoelectric Figure of Merit

5. Fuels & Lubricants Technologies

The Fuel and Lubricant Technologies subprogram supports research and development (R&D) to provide vehicle users with cost-competitive options that enable high fuel economy (FE) with low emissions, and contribute to petroleum displacement. This is accomplished through exploitation of fuel-properties to enable advanced combustion, development of efficiency-improving lubricants compatible with new and existing engines and vehicles, and fit-for-service evaluations of low-carbon alternatives to petroleum-based fuels. Future transportation fuels will be produced from refinery feedstocks derived increasingly from non-conventional sources including heavy crude, oil sands, shale oil, coal, and renewable resources such as biomass, vegetable oils, and waste animal fats. The impact of changes in refinery feedstocks and processes on finished fuels is an area of interest in terms of impacts on engines, emissions regulations, and end uses. Additionally, new lubricants will require increasingly-sophisticated additive packages and higher-quality base fluids that can deliver higher efficiency with better engine protection.

Subprogram activities are intended to: (1) enable future advanced combustion regime engines and emission control systems to be more efficient while meeting future emission standards; (2) develop efficiency-improving lubricants including products compatible with legacy vehicles (i.e., enabling lubricant retrofits); and, (3) reduce reliance on petroleum-based fuels through direct fuel substitution by non-petroleum-based fuels. These activities are coordinated with and supportive of the U.S. Environmental Protection Agency's fuels and emissions-related activities, as mentioned in their strategic plan.

The major subprogram goals for Fuel and Lubricant Technologies are:

- By 2020, expand operational range of low-temperature combustion to 75% of light-duty Federal Test Procedure (FTP).
- By 2015, demonstrate cost effective lubricant with 2% FE improvement.

Benefits

The Energy Independence and Security Act of 2007 (EISA, P.L. 110-140) mandates the use of enormous amounts of renewable fuels (36 billion gallons annually by 2022). Current ethanol markets are not able to absorb the volumes mandated; use of intermediate blends may be required. In addition, future feedstocks for fuel production are expected to come from alternative fossil sources. Understanding of the impact of these fuels and fuel blends on current and advanced combustion engines is critical to increasing their use. Technical issues that need to be addressed include: lack of data and tools for predicting fuel and lubricant property effects on engine operation; fuel and lubricant effects on emissions and emission control systems. This subprogram is developing data and tools, in collaboration with many partners in industry, academia and government impacting new and old vehicles, as well as small non-road engines.



Different fuels meeting the same specifications can have widely-varying impact on engine performance and emissions.

Subprogram Feedback

The U.S. Department of Energy (DOE) welcomed optional feedback on the overall technical subprogram areas presented during the 2013 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area presentations.

The reviewers for a given subprogram area who volunteered to provide subprogram overview comments responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE Vehicle Technologies Office (VTO) subprogram's

activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1: Was the subprogram area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Question 3: Does the subprogram area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Office's needs?

Question 4: Other Comments.

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc., as reviewer responses were optional.

Subprogram Overview Comments: Kevin Stork (U.S. Department of Energy) – ft000

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer stated yes, and that there was a good explanation of mission and strategy. This reviewer acknowledged to not having attended the plenary.

Reviewer 2:

The reviewer noted it was a very brief overview, but with good coverage. This reviewer further acknowledged a useful discussion of fuel versus lubricant philosophy.

Reviewer 3:

The reviewer remarked that the sub-program area was adequately covered, and that important issues and challenges were identified. This reviewer added that the previous year's project status (for the purposes of comparison) was not provided.

Reviewer 4:

The reviewer acknowledged that the sub-program area was quite adequately covered. However, it was noted that enabling advanced combustion to improve the efficiency would be a challenge. At this time, next generation biofuels and developing efficiency-improving lubricants would pose some difficulties, especially in the timeframe envisioned. This reviewer added that the progress toward the goals seemed a little unclear as well.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Reviewer 1:

The reviewer commented that important research on the impact of fuel on spark-assisted homogeneous charge compression ignition (HCCI) and on reactivity controlled compression ignition (RCCI) had been addressed. The lubricant strategies and tasks were identified, and these covered a large area of current interests in lubrication. The lubricant area appeared to be well covered and the goals were admirable.

Reviewer 2:

The reviewer acknowledged good coverage within the budget. This person added that the fuel/combustion interactions were strong with other offices.

Reviewer 3:

The reviewer pointed out that it was a good idea to have expanded the emphasis on lubricant technologies, because these could result in immediate FE savings.

Reviewer 4:

The reviewer observed that low-temperature combustion was listed as an efficiency improvement option. This reviewer added that RCCI was touted and the major efficiency enabler. However, the reviewer noted that these posed very difficult real-world integration paths.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:

The reviewer said yes, further mentioning the good focus and clear directions.

Reviewer 2:

The reviewer asserted that the sub-program appeared to align with the DOE VTO needs.

Reviewer 3:

The reviewer affirmed that the sub-program area appeared to be well planned and that many of the challenges were identified. This reviewer further noted that it was impossible to assess the management of the overall sub-program with the current information, although individual programs presented appeared to be well managed and were addressing important fuel and lubricant research needs.

Reviewer 4:

The reviewer stated yes, but cautioned that some of the projects being supported by this program were experiencing disruptions in funding, which was highly counterproductive. Oscillations in funding levels impeded the ability to get the maximum benefit from the previous years' investments in facilities, personnel, and research.

Question 4: Other Comments**Reviewer 1:**

The reviewer emphasized that dimethyl ether (DME) was poised to become a practical pathway for the utilization of natural gas, biogas, and solar energy in the transportation sector. This reviewer went on to say that there was an accumulated need for research on key areas of the use of DME in diesel engines. The sub-program should work with stakeholders involved in DME production and utilization in transportation systems to address these needs through new projects in 2014.

Reviewer 2:

The reviewer explained that there was more information on the slides than could be followed in such a short time.

Reviewer 3:

The reviewer expressed that the timeline was tight. More progress was needed that would mean more resources.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, as well as numeric scoring responses (*on a scale of 1 to 4*). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Fuels for Advanced Combustion Engines	Brad Zigler (National Renewable Energy Laboratory)	5-5	3.60	3.50	3.50	3.50	3.53
Performance of Biofuels and Biofuel Blends	Bob McCormick (National Renewable Energy Laboratory)	5-8	3.29	3.33	3.33	3.33	3.32
Fuels and Combustion Strategies for High-Efficiency Clean-Combustion Engines	Chuck Mueller (Sandia National Laboratories)	5-12	3.33	3.67	3.67	3.33	3.54
Advanced Lean-Burn DI Spark Ignition Fuels Research	Magnus Sjöberg (Sandia National Laboratories)	5-17	3.33	3.50	3.50	3.33	3.44
Fuel Effects on Emissions Control Technologies	Scott Sluder (Oak Ridge National Laboratory)	5-22	3.50	3.83	3.83	3.00	3.65
Gasoline-Like Fuel Effects on Advanced Combustion Regimes	James Szybist (Oak Ridge National Laboratory)	5-26	3.50	3.25	3.25	2.75	3.25
Lubricants Activities	Jun Qu (Oak Ridge National Laboratory)	5-29	3.67	3.00	3.00	3.67	3.25
Overall Average			3.46	3.44	3.44	3.27	3.43

Fuels for Advanced Combustion Engines: Brad Zigler (National Renewable Energy Laboratory) - ft002

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the combination of engine, bench scale, and numerical simulation studies is an excellent approach to identifying and selecting fuels to support advanced combustion. The reviewer noted that the project has broad collaboration and is producing valuable insights, which is a reflection of a well-constructed project and technical approach. The reviewer stated that the project's collaboration with a broad group of partners helps to advance predictive capabilities and understand how evolving fuels behave in the combustion processes.

Reviewer 2:

The reviewer observed a strong systematic approach for improving the accuracy of the ignition delay model for biofuels. The reviewer stated that using the same combustion chamber as another National Lab, and sharing the knowledge for different aspects of combustion and emission studies, seems very effective.

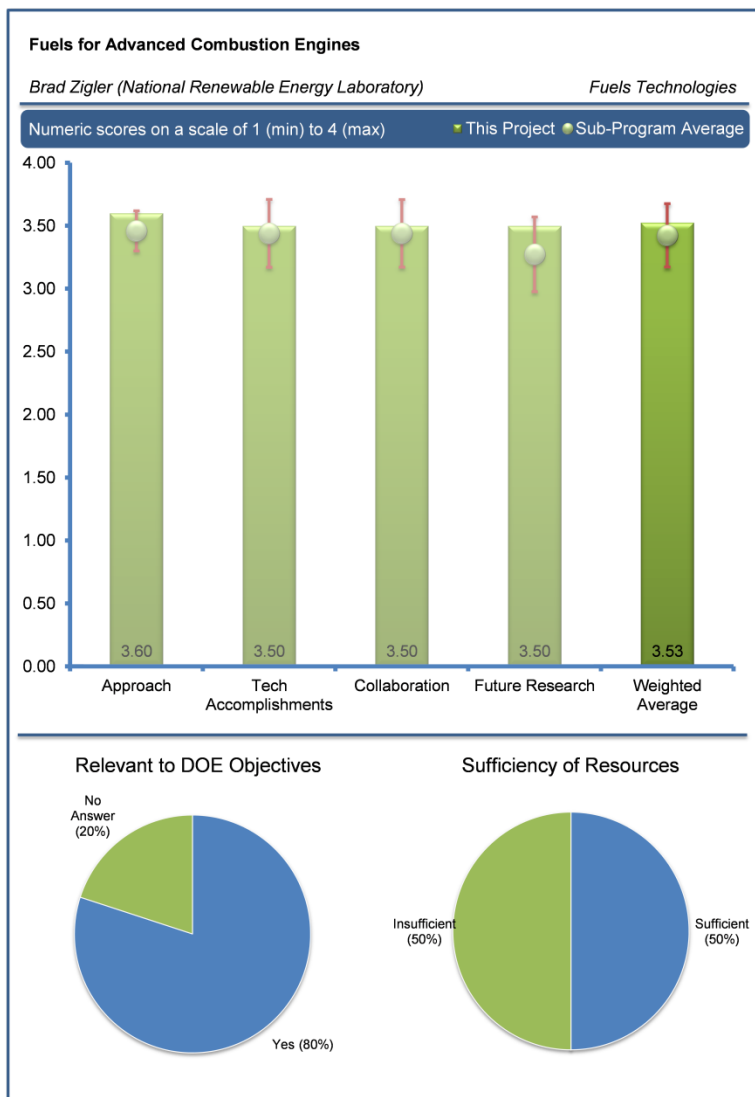
Reviewer 3:

The reviewer noted that the project was well organized and had been reprioritized according to budgetary constraints.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that a number of papers have been produced or are in progress. The reviewer noted specific progress on direct injection spark ignition (DISI) engine studies of ethanol and particulate matter (PM) emissions and on autoignition and simulation of autoignition in an ignition quality tester (IQT) (cetane rating instrument). This reviewer indicated that data on PM/nanoparticulate emissions are quite valuable in understanding the impacts of operating conditions and fuel formulation on PM number emissions. The reviewer added that this can help automakers define how to control PM number emissions, either via in-cylinder or exhaust aftertreatment strategies. This reviewer also noted that strategies to reduce PM number emissions were identified and shared with original equipment manufacturers (OEMs).



The reviewer concluded that the simulation and comparison to the IQT results for ignition delay are both impressive and a very valuable outcome, because they can provide rapid feedback on kinetic mechanism reduction and tuning of kinetic parameters.

Reviewer 2:

The reviewer observed valuable information correlating ethanol content and injection strategy with particle number (PN). This reviewer noted a study based on wall guided direct injection (DI). Further, wall guided is available now and additional work to compare both may be valuable. This reviewer stated that IQT is now a useful research tool.

Reviewer 3:

The reviewer noted very interesting results, but that the project has not directly shown the results for tackling the following barriers: inadequate predictive tools for fuel property effects on engine efficiency optimization (providing the link for this direction would be valuable); and inadequate predictive tools for fuel effects on emissions and emission control.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that there was very strong collaboration among the team of 24 industry, university and National Laboratory partners.

Reviewer 2:

The reviewer stated that this was a broad team that included industry and universities as well as National Labs, considering the interaction, the principle investigator (PI) and project have with the Advanced Engine Combustion (AEC) Memorandum of Understanding (MOU).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer believed that the work on the single-cylinder gasoline direct injection (GDI) engine will close the loop for this study. This reviewer also said that it is important to coordinate the work in such a way that a predictive tool for fuel effects on engine efficiency is obtained.

Reviewer 2:

The reviewer noted that the project will continue GDI engine emissions work with high octane oxygenated fuels to look into optimization, and added that it was unclear how the emphasis on efficiency is differentiated from the ongoing work at Oak Ridge National Laboratory (ORNL). The reviewer did not feel that this redundancy would be a problem, but believed that there should be more clarity on the uniqueness that the National Renewable Energy Laboratory (NREL) work will provide.

Reviewer 3:

This reviewer commented that the General Motors Corporation (GM) 2.0L LNF Ecotec is a side injected gasoline turbocharged direct injection (GTDI) engine, and the reviewer believed more information might be gained by comparing with a wall guided and spray guided lean burn technology.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer stated that the project's relevance to PM reduction and mid-blend ethanol is important.

Reviewer 2:

The reviewer believed that advanced combustion can lead to improvements in thermal efficiency, thereby reducing petroleum demand. The reviewer added that advanced/renewable fuels can displace petroleum, depending on their renewable content. The reviewer commented that the data support simulation and predictive capabilities for engine design by providing validation of chemical kinetics mechanisms.

Reviewer 3:

The reviewer believed that this project provides an understanding of and a tool for optimizing engine performance based on fuel characteristics, leading to fuel saving in internal combustion (IC) engines and includes a study of biofuels that reduces the dependency on petroleum fuels.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that this valuable program appears to have suffered a significant disruption in its funding. This reviewer added that this is quite unfortunate, and the disruption in funding erodes the value of investments made in previous years to develop personnel and facilities being used in this project.

Reviewer 2:

The reviewer noted that portions of the project were delayed due to insufficient funds.

Performance of Biofuels and Biofuel Blends: Bob McCormick (National Renewable Energy Laboratory) - ft003

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought this was a very widely-focused program with excellent execution.

Reviewer 2:

The reviewer noted that the project is considering a spectrum of biofuels and has recently had a focus on levels and types of oxygenates that can be used as drop-in fuels in practice. This reviewer also thought the scope of fuels and considerations is excellent, and is providing valuable input to stakeholders. The reviewer indicated, in particular, that the interaction with the American Society for Testing and Materials (ASTM) has high impact and has provided significant guidance to the biofuel and fuel industries.

Reviewer 3:

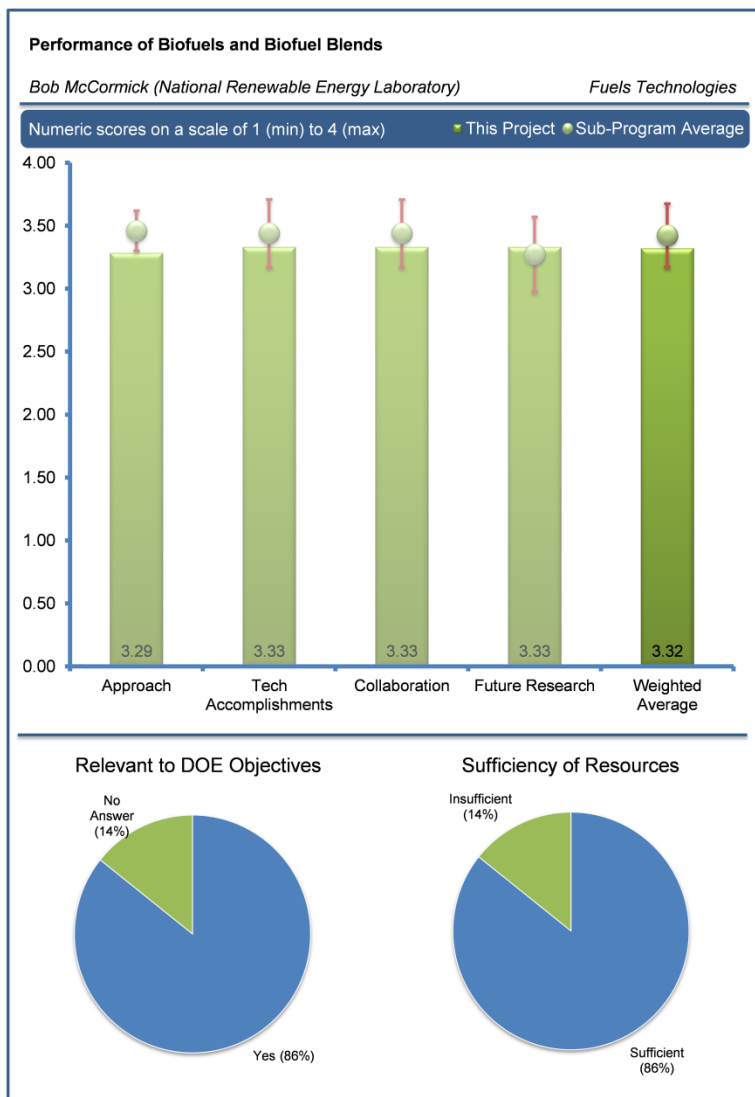
The reviewer commented that the presentation focused on a number of issues important to the feasibility of commercial deployment of various bio-derived fuels. Some of the issues included the long-term stability of biodiesel, and properties of specific components, some of which contain higher oxygen content and different components than traditional fatty acid methyl ester (FAME) biodiesel. The reviewer also mentioned the interesting concept of only removing some of the oxygen from bio-derived fuel components, but concluded that it will need to be thoroughly tested to evaluate the impacts on emissions and engine systems, and on the performance, durability, and materials compatibility of aftertreatment systems. This reviewer also said that blends of various alcohols that are not co-produced (i.e., ethanol and butanol) could conceivably complicate or add expenses to commercial fuel blending. The reviewer went on to say that from a logistical and economic perspective, it is likely better off to just select one alcohol to use for any fuel formulation (unless it is manufactured as a blend).

Reviewer 4:

The reviewer acknowledged several different projects, each one a year in duration. The reviewer recounted that the approach focuses on solving technical problems which are preventing expanded markets, and pointed out that both current and emerging biofuels are considered with some novel approaches. Lastly, the reviewer confirmed that drop in fuels are hydrocarbons (HCs).

Reviewer 5:

This reviewer noted that it would have been nice to see more cars, but recognized the limitations on the budget. The reviewer also thought a wider range of fuels would have been of interest. The reviewer indicated that the use of OEM strategy is appropriate, but if the budget permitted, a recalibration would be interesting for determining the best candidate fuels.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commended solid results despite a limited sample of vehicles. The reviewer also said that it was nice to see real test data on biodiesel aging in a carefully controlled manner.

Reviewer 2:

This reviewer expressed that the project had very interesting results. The reviewer also cautioned that the emission results on a vehicle, located on Slide 10 of the presentation, have been performed at a superficial level, which makes it hard to accept any strong conclusion from this work. The reviewer applauded the very impressive range of activities, and suggested that an integration of these activities would be very valuable in illustrating the impact of this project on addressing the technical barriers. The reviewer went on to say that this will help to better evaluate the impact of this project.

Reviewer 3:

This reviewer explained that the project examined the chemical composition of pyrolysis oil to understand how much it must be upgraded in order to be a functional feedstock or fuel. The reviewer thought it addressed an important consideration for the cost-effective production of pyrolysis oil for fuels and biocrude production. The project made progress on acid content and composition, which the reviewer considered valuable, because acid content is an impediment to stability, performance, and refining. The reviewer also described that the project examined oxygenates from pyrolysis oil in diesel mixtures in order to assess impacts on fuel performance, deposits, elastomers, and other factors. The reviewer believed this to be a valuable approach for gauging drop-in capability.

The reviewer highlighted that the project made new observations of the impact of alcohol blends, including butanol, on emissions, and performed hydrogenation of potential biofuel precursors to produce better fuels for diesel applications. The reviewer remarked that this was very interesting, because some of the fuels and precursors show potential from the production side, such as bisabolene. The reviewer also highlighted very interesting results on the impact of diesel composition in the production process on the storage stability in biodiesel blends.

Reviewer 4:

The reviewer indicated an improved approach to acid characterization that differentiated between weak and strong acids, and observed that phenol shows a poor detection limit while acknowledging that the work is ongoing. This reviewer also noted a detailed characterization of oxygenated compounds, and remarked that the properties of fuels are not altered at 2% by-volume concentrations. The reviewer mentioned the milestone project involving gasoline, ethanol, and butanol blends. The reviewer pointed out that only one car was tested due to budget constraints, and carbonyl emissions increased. The reviewer stated that terpenes were characterized. The reviewer explained that hydrogenation to open the rings resulted in 2,6-dimethyl octane and farnesane. The reviewer was concerned that long term storage of biodiesel is an issue. The reviewer summarized that the project measured the oxidation stability, and that accelerated storage of 13 weeks is equivalent to 1 year. The reviewer recounted that the project is currently being finished and the last project is concerned with low temperature operability. Lastly, the reviewer remarked that FAME content influences the cloud point.

Reviewer 5:

This reviewer observed that progress was made in a number of areas. The reviewer pointed out the following to support the concept of using partially hydrotreated bio-products: an improved approach to acid characterization; and the evaluation of the effects of adding low levels of pure model compounds of residual oxygenates present in hydrotreated biomass. The reviewer also found interest in findings that older flex-fuel vehicles (FFVs) cannot or may not readily adapt to mid-level ethanol blends. Lastly, the reviewer highlighted the importance of finding that a significant fraction of the blend of 85% ethanol with gasoline (E85) that was sampled from stations around the United States did not meet ASTM Reid vapor pressure (RVP) specifications, and wondered what was being done about it.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer applauded the excellent collaboration among a team of university, National Labs, and industry, including startups.

Reviewer 2:

The reviewer commended this project for providing real leadership over a broad range of concerned parties, and thought this was a major strength.

Reviewer 3:

The reviewer thought the project showed good collaboration with bio-industry such as the National Biodiesel Board (NBB), Renewable Fuels Association (RFA), and biofuels startup companies. The reviewer also noted collaboration with OEMs through the Engine Manufacturers Association (EMA) and the Coordinating Research Council (CRC).

Reviewer 4:

This reviewer appreciated that the project is working with a long list of partners and that the team is comprehensive.

Reviewer 5:

The reviewer pointed out the fairly long list of collaborators.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer remarked that the broad range of activities ranging from fundamental to practical was excellent. The reviewer observed that Impact of High Octane Biofuels on DI Engine Efficiency does not seem to be a new topic. The reviewer offered that an extensive literature survey before doing the work and comparison with other works will be very valuable.

Reviewer 2:

The reviewer commented on continuing efforts to emphasize drop-in fuel requirements and impacts. The reviewer also mentioned work on ASTM specifications, which the reviewer expressed is essential to ensure that fuels perform effectively in the marketplace. The reviewer also pointed out that the program has been responsive to AMR input.

Reviewer 3:

The reviewer suggested that the project should keep this work going.

Reviewer 4:

The reviewer highlighted future research which focuses on pyrolysis oil. The reviewer reported that ASTM specifications, high-octane biofuels, and lubricants will be evaluated.

Reviewer 5:

This reviewer thought that the plans seem reasonable.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer explained that biofuels can directly displace petroleum, provided they have sufficient renewable content. However, biofuels can create a spectrum of compatibility issues. The reviewer went on to say that the work of this team is essential to find and fix the problems that biofuels can create, or to capitalize on benefits of biofuels.

Reviewer 2:

This reviewer expressed that this is a key part of the alternate fuel process.

Reviewer 3:

The reviewer asserted that the focus of this program is biofuels and biofuels blends which are non-petroleum based fuels. The reviewer indicated that if cost-effective commercial deployment of these fuels is successful, they would directly displace petroleum, which is a primary DOE goal.

Reviewer 4:

The reviewer reinforced that this project provides understanding that can be used to optimize engine and vehicle performance based on fuel characteristics, leading to fuel savings in vehicles. The reviewer added that this project centers on biofuels, which reduces the dependency on petroleum fuels.

Reviewer 5:

The reviewer stated that the project is quite relevant.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that the project funding was sufficient in the previous year. The reviewer emphasized that because of its significant impact on the fuels industry, this project should be insulated from funding disruptions in the present and next project years. The reviewer went on to recommend that the VTO should continue to support this project to ensure progress on this important activity.

Reviewer 2:

The reviewer said that sufficient budget was available.

Reviewer 3:

The reviewer expressed that resources seem sufficient.

Reviewer 4:

The reviewer said the project had a generally appropriate level of funding, although a larger test fleet would be nice.

Reviewer 5:

The reviewer suggested that more cars should be tested in gasoline, butanol, and ethanol blends. The reviewer cautioned that the data are too preliminary to draw conclusions.

Fuels and Combustion Strategies for High-Efficiency Clean-Combustion Engines: Chuck Mueller (Sandia National Laboratories) - ft004

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer affirmed a good approach of selecting fuels from the Fuels for Advanced Combustion Engines (FACE) Diesel matrix to study the effects of fuel properties on mixing controlled combustion in an optical engine with a variety of diagnostic tools. The reviewer observed that development of a fuel-flexible high pressure common rail system sounded like it filled an existing gap.

Reviewer 2:

The reviewer reinforced that the approach of using existing diagnostic capabilities, in collaboration with key stakeholders and the technical expertise from the laboratory, has proven to be an excellent technique to evaluate fuel effects on combustion for high efficiency clean combustion (HECC) engines.

Reviewer 3:

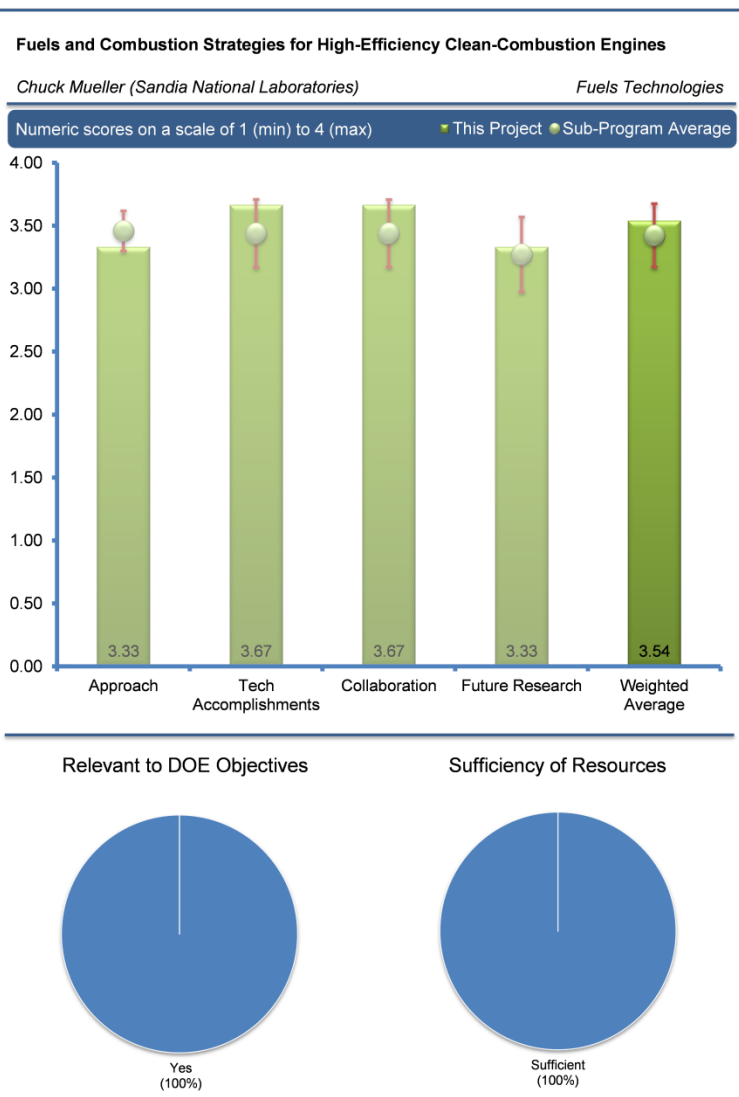
The reviewer recounted that the project had used the heavy-duty optical engine to probe fuel and combustion process impacts on efficiency. The reviewer mentioned that through partnerships with engine and fuels companies, as well as labs and universities, the project is considering fuel impacts on mixing controlled combustion, and pyrolysis oils as fuels in addition to looking at lean lifted flame combustion (LLFC). The reviewer emphasized the project's use of optical diagnostics and conventional combustion studies to achieve project objectives and add a unique ultra-high-pressure common rail. The reviewer noted that the project developed a comprehensive approach for studying the effects of fuels on mixing controlled combustion, which involves a combination of diagnostics and a two-hole injector to eliminate jet-jet interactions. The reviewer described that for LLFC and conventional combustion, the project is using P-trace, thermodynamics, emissions (including laser-induced incandescence [LII] of exhaust soot), and in-cylinder diagnostics to characterize effects of fuel and injection strategy on the spray and the combustion processes.

Reviewer 4:

The reviewer stated that the project is well organized, and based on 2011 comments, the project is on track.

Reviewer 5:

The reviewer commented that the approach is good in looking at the interplay between fuels and engine combustion parameters, and in developing methodology that can be used for evaluating fuels and mixing controlled engine strategies. However, the reviewer noted that presentations are sometimes confusing in distinguishing whether leaner lift-off is a key parameter to be targeted in all mixing control strategies, or simply the initial strategy being evaluated – and the reviewer wondered whether it will apply to all fuels. The



reviewer cautioned that despite the response to last year's comment, it is still not clear the extent to which fuel parameters of alternative and renewable fuels will be amenable to engineering versus pre-determined by the feedstocks and economics of processing them. The reviewer suggested that what may be amenable to such designing could be more conventional fuels and possibly blends of conventional fuels with renewable fuels, or possibly mixtures of different renewable fuels, etc. The reviewer recounted that in response to an oral question, the PI confirmed that such blends are planned to be looked at after heavy esters but it was not identified in the presentation slides. The reviewer offered that presentations might benefit from using less generic or abstract language and describing more specifically how the tools being developed would be used – other than in theoretical exercises indicating that a fuel with ideal properties used in an engine designed and optimized specifically for that fuel would not produce soot. The reviewer explained that many alternative and renewable fuels have been promoted as beneficial when used in such purpose-built engines but such engine-fuel combinations are simply not feasible. Lastly, the reviewer indicated that the presentation talked about a parametric study of five fuels, but did not identify what they were and did not mention the results.

Reviewer 6:

The reviewer said that the project approach is reasonable, though integration with modeling efforts will help to better address the technical barriers of creating predictive tools for fuel property effects on engine efficiency and emissions.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer applauded the technical accomplishment of quantifying fuel effects on mixing controlled combustion, saying it was excellent. The reviewer emphasized that showing how fuel property changes can significantly affect emissions and showing that differences cannot be offset by changing combustion phasing were both important results. The reviewer also asserted that the development and building of a high pressure common rail fuel supply system is a major accomplishment and will be used in future analysis of fuels.

Reviewer 2:

The reviewer thought that the LLFC information was very valuable. The reviewer explained that spray geometry, coupled with designer diesel fuels, could potentially obviate the need for particulate filters. The reviewer explained that this approach is comparable to particulate benefits seen in the Mercedes Benz (MB)/Bosch spray-guided fuel injection and stratified lean burn combustion.

Reviewer 3:

The reviewer mentioned that progress has been good. The reviewer acknowledged that diesel fuel property effects on engine performance and emissions were studied under mixing controlled conditions. The reviewer pointed out the assessment based on available literature data, concluded that the use of raw liquids from fast pyrolysis of woody biomass was not very feasible in current compression ignition (CI) engines because of issues such as instability, corrosion, and poor injection quality. The reviewer also highlighted the modified engine that enabled injection pressures up to 3,000 bar.

Reviewer 4:

The reviewer remarked that high-pressure common-rail fuel-supply system (HCFS) is valuable equipment set for the fuel research community. The reviewer noted that the results on the Slide 3 (i.e., Quantifying Fuel Effects on Mixing- Controlled Combustion) were very interesting, and pointed out that further work to better understand the results is essential.

Reviewer 5:

The reviewer noted that the detailed impacts of fuel on emissions using FACE and reference fuels were demonstrated, and new understanding and careful measurements of sensitivity of diesel combustion to fuel variations were generated.

The reviewer reported that pyrolysis oil was assessed for direct use as a diesel fuel. The reviewer indicated that the fuel has a great deal of water, high corrosivity, and other problems; and it needs to be refined or upgraded before use.

The reviewer also acknowledged development of a fuel-flexible high-pressure common rail system that is hydraulically driven.

Reviewer 6:

The reviewer acknowledged that data and analysis is still in progress on the fuel parametric study. This reviewer commented that the literature search on pyrolysis oils seems to be somewhat of a diversion from the project itself. The reviewer indicated that it was apparently responding to the instigation of one of the industry partners, whom the reviewer thinks should probably have conducted such a literature search on its own, outside of this project. The reviewer commended the development of a robust fuel delivery system and characterized it as an important achievement pre-requisite to future experiments but cautioned that that achievement alone appears to fall short of the expectations of what was to be accomplished over this year.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer expressed that collaboration and coordination with other institutions is excellent in this project. The reviewer stated that combustion research with the AEC working group helps provide for improvements to the project. The reviewer acknowledged that discussing the projects with OEMs and energy companies is a very good practice. The reviewer applauded the project for working with the CRC on surrogate diesel fuel research, which brings a high quality of technical expertise to the project.

Reviewer 2:

The reviewer noted very strong collaboration among a team of 27 industries, universities, and National Laboratory partners.

Reviewer 3:

The reviewer said that through the Advanced Combustion MOU and other partnerships, this work links to industry, other labs, and university partners. The reviewer noted that this project holds a leadership position in CRC work on diesel fuel research, and that there are many fruitful collaborations in place.

Reviewer 4:

The reviewer thought it seems like a good, direct, collaboration with Ford and Caterpillar. The reviewer also mentioned collaboration with the members of the CRC's Project 18 under Advanced Vehicle/Fuel/Lubricants (AVFL-18) on development of improved surrogate diesel fuels. The reviewer noted that the members of the AEC MOU were mentioned, but no specifics were given on how extensive those collaborations are beyond the time period for the two presentations made at those meetings per year.

Reviewer 5:

The reviewer remarked that the broad group of project partners appears to include members from all key industries, but described the reference to energy companies as a broad and vague term. Further, because the individual companies were not named, it could not be determined by the reviewer if they reflected an adequate base within the industry or merely a group of companies interested in promoting their own alternative fuels and identifying opportunities in alternative fuels, rather than a realistic perspective on the following: extent to which identified fuel parameters are economically achievable; required critical mass/economies of scale; and chicken-and-egg issues between fuel and engine availability, etc. The reviewer commented that these issues do not negate the desirability of developing the analytical tools being developed in the project, but that they are important in setting priorities for future research directions, applications, etc.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer remarked that evaluation of the effects of oxygenated fuels and engine testing of diesel surrogate fuels in the future will provide valuable data, and continuation of the work with CRC Project AVFL-18a is important.

Reviewer 2:

This reviewer claimed to be looking forward to the study being performed on FAME to assess the oxides of nitrogen (NO_x) and soot effects. The reviewer suggest that additional studies may benefit from the combination of the new high pressure fuel pump system developed, since there may be interactions between FAME stability or polymer formation and fuel pressure and temperature during adiabatic expansion during injection.

Reviewer 3:

The reviewer mentioned that the project will survey fuel and combustion processes using the evaluation strategy, including biofuels and surrogates, and will continue the development of surrogate diesel fuels in collaboration with CRC. The reviewer wondered whether this effort can help guide the formulation and production of next generation fuels (i.e., an ultimate biodiesel) and noted that this point was not addressed in this year's presentation. The reviewer highlighted that the work from this engine could guide fuel production, not just formulation and that the work from this facility has had great impact in the past and should also have impact on the future work that is planned.

Reviewer 4:

The reviewer commented that the focus on fuel surrogates is plausible because it can provide a more general approach for creating predictive tool to characterize fuel effects on engine emissions and performance.

Reviewer 5:

The reviewer described that plans to complete the analysis of the engine test results of the FACE Diesel fuels, engine testing of the CRC AVFL-18a diesel surrogate fuels, and development of a better understanding of in-cylinder soot formation, distribution, and oxidation, are good and worthwhile. The reviewer commented that the value of testing biodiesel esters and heavy ethers will depend on the specific compounds and the concentrations investigated. For example, the reviewer explained that it is well known that FAME has properties that limit concentration that can be used. Another issue the reviewer brought to light is whether the ethers will be tarred by the same brush as methyl tertiary butyl ether (MTBE), despite having different properties and water solubilities.

Reviewer 6:

The reviewer cautioned that continuing work on biodiesel ethers and heavy esters is valuable but it should be remembered that biodiesel continues to cost substantially more than petroleum diesel to produce so that its use as a neat fuel is probably limited; and there has been considerable work on heavy ethers as CI fuels for many years but essentially no use of the ethers in the marketplace. The reviewer pointed out that the PI confirmed that work on more conventional HC type CI fuels (and their blends with oxygenates), which can also be made from renewable feedstocks, is anticipated, but it was not part of the presentation, only in response to a question. The reviewer added that HC fuels may be more amenable to an adjustment of properties than oxygenates and the blends may be further amenable and such knowledge may have much more immediate application on wider scale.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer noted that HECC can lead to improved efficiency and broaden the types of fuels used in transportation, both leading to reduced petroleum consumption. The reviewer acknowledged this effort is producing high impact results and has both great depth and long-term value.

Reviewer 2:

The reviewer thought that improved fundamental understanding of high efficiency, clean combustion engines and the understanding of fuel properties that can help enable them should ultimately result in improved engine efficiency and possible use of alternative fuels, both of which would reduce petroleum requirements.

Reviewer 3:

The reviewer stated that the objective of this project to develop a science base to enable high efficiency, clean combustion engines using fuels that improve energy security is definitely relevant.

Reviewer 4:

The reviewer remarked that, yes, this project could lead to soot mitigation without need for aftertreatment, which would substantially displace petroleum through greater efficiency. The reviewer also said that it could point to better strategies for utilization of renewable fuel alternatives.

Reviewer 5:

The reviewer noted that this project provides understanding which can be used to optimize engine performance based on fuel effects on mixing controlled combustion, leading to fuel saving in IC engines.

Reviewer 6:

The reviewer remarked that the project incorporates advanced fuels with constituents other than petroleum and incorporates the potential fuel savings from LLFC and reduced soot formation, requiring reduced soot burn off.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that funding seems sufficient and stable.

Reviewer 2:

The reviewer noted milestones are being met on timely basis, which suggests resources are sufficient.

Reviewer 3:

The reviewer indicated that for the work proposed, the resources seem adequate.

Reviewer 4:

The reviewer remarked that resources appear to be appropriate to the objectives and work plan.

Advanced Lean-Burn DI Spark Ignition Fuels Research: Magnus Sjoberg (Sandia National Laboratories) - ft006

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer described that the project is using a DISI spray guided engine system, which provides significant insights into combustion process optimization. The reviewer observed that the project is exploring limits of combustion stability under lean stratified conditions by blending ethanol and gasoline and doing experiments in optical and metal engines, and using the optical engine to probe specific conditions to further their understanding. The reviewer indicated that the project is developing the understanding to overcome barriers to higher efficiency engines. The reviewer commended the project, saying that overall, this is a strong technical approach and the tools being employed can provide transformative increases in understanding.

Reviewer 2:

The reviewer applauded the good approach of combining metal engine tests with optical engine tests and computational fluid dynamics (CFD) and kinetic modeling.

The reviewer noted that the project had a strong mix of modeling and experiments (optical engine and metal engine) to understand the fuel effects on combustion for DISI engines.

Reviewer 3:

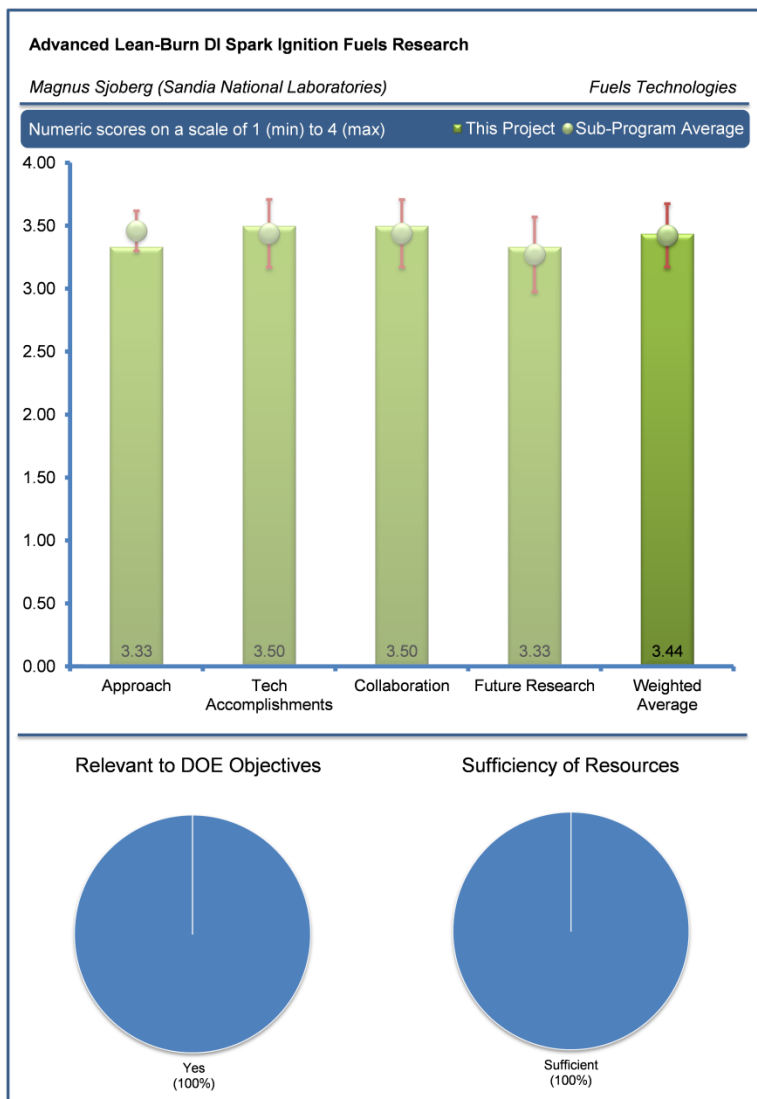
The reviewer described that the project's approach of using engines, then applying to CFD, extends the value of the data obtained into the modeling domain.

Reviewer 4:

The reviewer asserted that the approach of combining metal and optical engine experiments and modeling to develop a broad understanding of the impact of fuel properties on engines has proven to be a very good technique. The reviewer reinforced that this project addresses barriers to high efficiency and low emissions by increasing the knowledge base.

Reviewer 5:

This reviewer remarked that the PI has defined the project as providing a scientific basis for determining fuel characteristics to enable advanced combustion engines that would be as efficient as possible, and possibly reducing emissions to the point where aftertreatment may no longer be needed. The reviewer asserted that this scientific basis should be important for a range of future research. The reviewer remarked that the specific research performed to date could also be useful in future engine design to the extent that it shows



that gasoline combustion and E85/70% ethanol blend with gasoline (E70) combustion share characteristics to some degree that point to possible future design improvements.

The reviewer referred to the research that shows significant differences in combustion behavior between E85 and gasoline, with E85 being less sensitive to mixing irregularities, and the need for near top dead center (TDC) injection for E85 head ignition, etc. The reviewer then described the value of this part of the research as questionable and thought perhaps the value of it was never explained so that non-expert reviewers could see it readily. The reviewer explained that for many reasons, there is little chance of engines being purpose-built or even optimized to take advantage of the characteristics of E85/E70, particularly to the extent that they run contrary to the optimization for gasoline operation, which appears to be what this research shows (e.g., retarding spark timing to avoid head ignition, effects of temperature, etc.) unless future engines were to reincorporate fuel sensors that would adjust the spark timing, etc., according to the ethanol content or oxygen content of the fuel, which seems doubtful.

The reviewer elaborated that by defining the work's purpose as providing scientific understanding, the approach and accomplishments appear to be more favorable than if it was defined as overcoming actual barriers to specific technology developments. The reviewer expressed that the presentation does not make clear that it is actually providing such a broad scientific basis but focuses on differences and similarities between gasoline and E85/E70 rather than on development of analytical tools per se.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the project examined E85 operation with near-TDC fuel injection and showed ultra-low nitric oxide (NO) and soot emissions. The reviewer remarked that the project performed particle image velocimetry (PIV) measurements of in-cylinder flows during compression and the role of air flow on well mixed and stratified operation, showing that mixing is needed to avoid soot formation for a gasoline type fuel, but that there is less sensitivity to mixing for ethanol. The reviewer acknowledged the further examination of the NO_x-PM trade-off using a spectrograph to show what species are present for operating conditions, and noted that one could see evidence of excessively rich conditions based on the spectra observed. The reviewer stated that the fact that late high pressure injection leads to rapid mixing and cooling of products, which reduces/circumvents NO formation, was a very interesting result. The reviewer complimented that the experimental approach and design are really outstanding, and the ability to interpret the observations to yield important insights is a great strength of this project.

Reviewer 2:

The reviewer acknowledged the good progress that was made on identifying the potential benefits and issues associated advanced lean burn DISI with high ethanol content fuels. The reviewer cautioned that work was still needed to determine whether this concept has enough benefits to pursue development.

Reviewer 3:

The reviewer offered that accomplishments and progress has been very good, especially the examination of E85 operation with near TDC fuel injection for ultra-low NO and soot and the comparison of E85 and gasoline showing NO emissions much lower with E85.

Reviewer 4:

The reviewer remarked that by defining the project in terms of gaining understanding, accomplishments seem to be significant even if the results are not encouraging in terms of overcoming actual barriers. The reviewer characterized that it is not clear how broad the applications of the analytical tools actually being developed are, since the focus of the presentation is on a specific application - gasoline versus E85 on DISI and focusing on a few combustion properties, which may be key to DISI more broadly, but that was not clear from the presentation.

The reviewer elaborated that the presentation did not clearly describe whether the results of this year's research point to ways in which both gasoline and E85/E70 combustion could be jointly made more efficient with lower emissions versus the extent to which the two require conflicting engine changes. That seems to be the key to coming to any practical conclusion from the research. As an example,

the reviewer explained that if the two are largely incompatible, that is an important lesson, which may suggest that future FFVs should work on optimizing at lower ethanol levels, although automakers seem to be coming to that conclusion independently of this research.

Reviewer 5:

The reviewer indicated insightful results for the impact of in-cylinder flow field on stratified-charge combustion. The project provides a very good understanding for the impacts of fuel on engine performance. However, the reviewer went on to say that given the large combustion control space parameter, the results still does not provide predictive tools or models for fuel property effects on engine efficiency optimization. Developing a proper model as a predictive tool will be very valuable for optimizing engine performance.

Reviewer 6:

The reviewer explained that understanding the effects of fuel ethanol blend on stratified injection and combustion is a key success since ultimately, un-throttled operation will remove one of the largest inhibitors to increased efficiency in the spark ignition (SI) engine.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer recounted that the project has active collaborations with different partners, including university partners, through direct collaborations and through involvement in the Advanced Combustion MOU.

Reviewer 2:

This reviewer described that the project's primary industry collaboration appears to be with GM on hardware issues/supply. The members of the AEC MOU are mentioned, but it is unclear how much collaboration actually exists outside of the information that is disseminated and questions that are asked at the semi-annual meetings. The reviewer wondered if perhaps the collaborations with AEC MOU members are outstanding, but had no information to make a determination. The reviewer also noted collaboration with USC on flame measurement and corona ignition.

Reviewer 3:

The reviewer mentioned that the collaborations with GM, University of Michigan and the 15 industry partners in the AEC MOU makes for a strong team to support this project.

Reviewer 4:

The reviewer remarked that the presentation identifies an adequate list of collaborators with appropriate technical roles identified for each, but does not appear to include any role for ongoing discussion of practical applications as related to future research directions.

Reviewer 5:

This reviewer characterized very strong collaboration among a team of 17 industry, university, and National Lab partners.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted the continuation of ongoing work and the addition of an advanced ignition system. The reviewer indicated that the work to date is very informative, and expects that the continuing work will be equally significant.

Reviewer 2:

The reviewer expressed that plans to further pursue a fundamental understanding and evaluation of this concept are reasonable.

Reviewer 3:

The reviewer asserted that future work planned both of the continuation of projects, and the initiation of examining the use of advanced ignition for lean combustion, will continue to provide valuable results.

Reviewer 4:

The reviewer recounted that presentation indicated that effects of ethanol fuel blends will continue to be studied across the range of 0% ethanol blended with gasoline (E0)-100% ethanol (E100), which could include some blend levels that would be particularly relevant [e.g., 10% ethanol blended with gasoline (E10)-30% ethanol blended with gasoline (E30)], but is not more specific than that. The reviewer was concerned with the relevance the project believes the E100 range could have. While this research could continue to provide some scientific and theoretical understanding, this reviewer saw no reason why it should not focus on fuels that are likely to have practical results. E85 has already been shown to be too high a blend level for most applications and there is no question of E100 being a practical fuel for the United States. Moreover, gasoline-ethanol blends involve complex interactions between the ethanol and HC molecules so that merely studying straight gasoline and E100 does not necessarily express much about how the blends will behave. The reviewer suggested that it would make more sense to vary not only the ethanol concentration within a meaningful range, but also to vary the specific HC composition, particularly with those HC groups most prone to forming azeotropes with ethanol as well as those not so prone to do so.

Lastly, the reviewer stated that the future research is proposed entirely of highly technical phenomena, whose relevance is not explained at all and is incomprehensible.

Reviewer 5:

The reviewer noted that the future approach is well planned with sufficient details.

Reviewer 6:

The reviewer offered that concentrating on mid-blends [20% ethanol blended with gasoline (E20)-50% ethanol blended with gasoline (E50)] in conjunction with stratified combustion, will provide a forward look at SI engines of the future. Combining prior research on this project with turbocharged induction (as MB has with their HOS homogeneous stratified lean burn combustion) will reveal even greater benefits.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer explained that lean un-throttled SI spray guided engines can provide substantial improvements in FE and thereby displace petroleum. Efficiency gains can be 30-60% depending on the operating condition relative to conventional combustion.

Reviewer 2:

The reviewer observed that the objectives of determining fuel characteristics that enable current and emerging advanced combustion engines to be efficient is relevant to DOE goals of petroleum displacement.

Reviewer 3:

This reviewer stated that if this engine approach/concept is successful with fuels that contain high amounts of ethanol, then presumably fuel efficiency will be improved and lower amounts of petroleum derived gasoline components will be needed.

Reviewer 4:

The reviewer emphasized that this project provides understanding of, and a tool for, the optimization of engine performance based on fuel characteristics, which can lead to fuel savings in IC engines. The reviewer also recounted that it includes the study of bio-fuel blends, which reduces the dependency on petroleum fuels.

Reviewer 5:

The reviewer remarked that the project helps relate the effects of ethanol (EtOH) fuels on lean burn combustion, which has the potential to further reduce the gap to CI thermal efficiency.

Reviewer 6:

The reviewer expressed that improving the scientific understanding of DISI combustion to make it more efficient could indirectly lead to petroleum displacement. But in order for that to be true, the reviewer explained, the project either needs to focus much more on more relevant applications and/or needs to be explained much better, leaving out if necessary the hyper-technical minute details and explaining what has really been accomplished and what is planned for future work.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer noted that funding seems sufficient and is stable.

Reviewer 2:

Reviewer stated that resources seem sufficient.

Reviewer 3:

The reviewer commented that the resources are sufficient for the projects identified.

Reviewer 4:

The reviewer felt that given the nature of this research, this level of resources is required. However, as described above, the relevance needs to be better defined or better explained in order to justify this commitment of resources.

Fuel Effects on Emissions Control Technologies: Scott Sluder (Oak Ridge National Laboratory) - ft007

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer recounted that the project is examining fuel impacts on exhaust gas recirculation (EGR) cooler fouling, which is an activity that is wrapping up. The reviewer also mentioned that the project is examining ways to make the most of alcohols in fuels to achieve lean-NO_x reduction, and examining biodiesel impacts on emissions control devices. These efforts rely on the high quality facilities and methodologies developed at ORNL, which permits significant new knowledge generation.

Reviewer 2:

The reviewer noted the project's approach of using engine tests coupled with micro- and bench reactors seems like a good approach.

Reviewer 3:

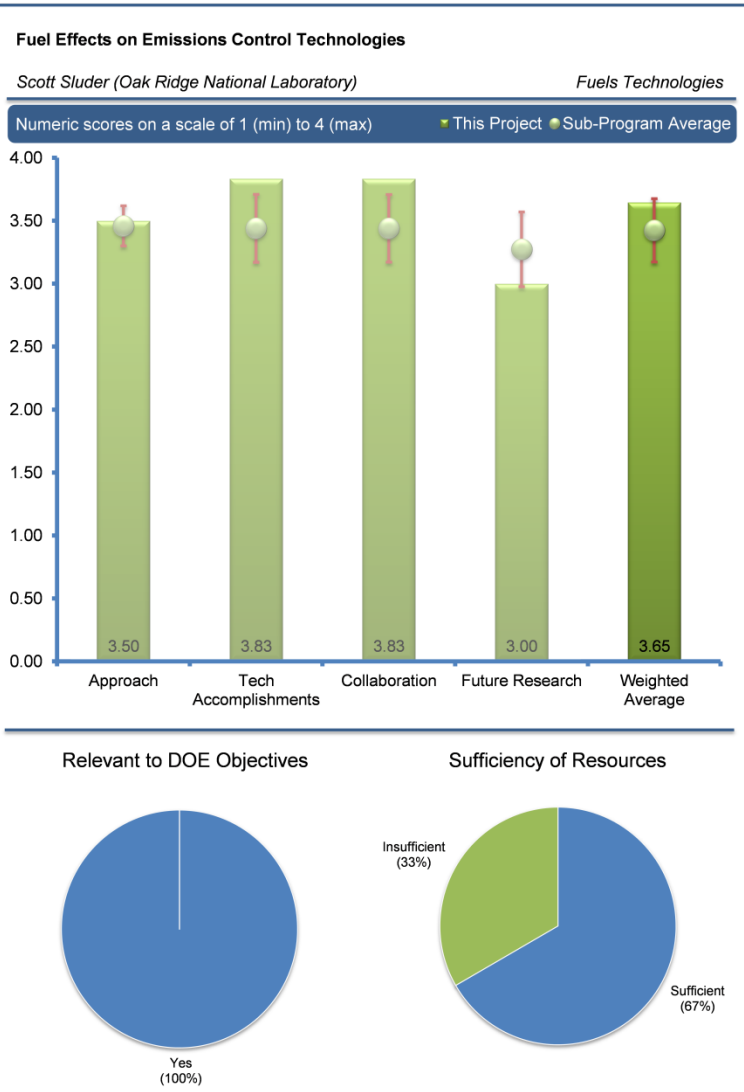
This reviewer remarked that the approaches used in the various tasks seem well thought out and executed. It was identified that high boiling point HC emissions have a strong influence on EGR plugging, but there seemed to be little information on how biodiesel effected these HC emissions. The reviewer pointed out that in this particular program, the question of whether biodiesel blends and other non-traditional fuel formulations worsen cooler fouling does not seem to have been answered; although it could be simply a lack of understanding of this reviewer or perhaps the data was not presented because of time constraints.

Reviewer 4:

The reviewer remarked that the approach involving engine data and modeling-based output provides greater leveraging of data.

Reviewer 5:

The reviewer thought that the project's approach directly addresses the challenge of inadequate data on the long-term impact of fuel on emissions control systems, but it is unclear how the results from this work will address the following barrier of inadequate predictive tools for fuel effects on emissions and emission control system.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer acknowledged that the project showed that HC deposition in the fouled layer in the EGR cooler deposits lead to stabilization of the heat transfer effectiveness loss, even though deposition continues. The deposit does not need to be removed to achieve stabilization, and no fuel effect on stabilization was observed. The reviewer indicated that this is a significant result in that there have been concerns that biodiesel could worsen fouling effects. The project provided important observations on means of avoiding plugging.

The reviewer reported that silver-alumina catalysts can enable generation of ammonia (NH_3) using ethanol as a reductant. The project demonstrated on a flow reactor that NH_3 production can be very effective from ethanol. So, combination of lean burn with ethanol, combined with an ethanol selective catalytic reaction (SCR) (via the NH_3) could provide a much improved scenario for high ethanol fuel blends, overcoming the tank mileage penalty of E85 (for instance) and enabling high efficiency with higher ethanol blends.

The reviewer described how the project showed that among typical biodiesel contaminants [calcium (Ca), sodium (Na), potassium (K)], poisoning from Ca was much less severe than for Na and K. The reviewer mentioned that the project showed that out-of-specification biodiesel could lead to emissions system failure, although biodiesel within specifications did not impede meeting emissions at 150,000 miles. This gives the biodiesel industry guidance for ensuring compatibility with future vehicles systems that will need to meet more stringent emissions legislation.

Reviewer 2:

The reviewer commended the fact that accomplishments have been made in several areas, including better understanding of causes of EGR cooler fouling from biodiesel. The determination of effects of metals (Na, K) in biodiesel on the diesel oxidation catalyst (DOC) and SCR catalysts, and the discovery that ethanol can improve lean NO_x control over $\text{Ag}/\text{Al}_2\text{O}_3$ catalyst were also acknowledged by the reviewer.

Reviewer 3:

The reviewer observed that the researchers have made significant progress toward understanding fuel effects on various emissions control systems. The understanding of the role of Na and K in the substitution of copper (Cu) in the zeolite could lead to more effective, longer lasting diesel emission systems. The reviewer indicated that this will definitely be a benefit to OEMs, as well as their customers. The shift from fundamental investigations to bench-reactor based performance studies has demonstrated the ability to produce NH_3 without the normally required rich cycle or onboard urea. Lastly, the reviewer remarked that the role of high boiling point HC on the formation of EGR deposits should lead to a more sophisticated fuel or combustion based approach to reducing EGR deposits.

Reviewer 4:

The reviewer asserted that the project provides interesting and conclusive results on two topics: the effect of biodiesel blends on EGR cooler fouling; and biodiesel compatibility with catalytic converters.

Reviewer 5:

This reviewer stated that there were two key points. Fuel composition on EGR fouling and plugging is important because the reviewer's field data illustrates intake and EGR fouling is associated with polymeric deposits and with oxidized biodiesel. The reviewer also pointed out that the impact of EtOH blends on lean- NO_x reductant generation and particulate formation in conjunction with other studies (un-throttled lean burn) has the potential to further reduce the gap between diesel and gasoline efficiencies.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted the wide-ranging collaboration with industry, academia, and other labs.

Reviewer 2:

The reviewer thought the project appears to have very good collaboration that has been setup with the OEMs, for example, Cummins, Ford, GM, and Cross-Cut Lean Exhaust Emission Reduction Simulation (CLEERS) members. Other collaborations included NREL and NBB for biofuels issues, as well as several universities including University of Tennessee, University of Michigan, and Chalmers University.

Reviewer 3:

The reviewer reported that collaboration with universities and industry are strong and should lead to marketable solutions.

Reviewer 4:

The reviewer summarized the project's strong collaboration among a team from industry partners, universities, and National Labs.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the identified future research seems appropriate and builds on past work. The reviewer believed that lubricant effects such as phosphorus have been studied by both OEMs and the lubricant industry, and hoped that this proposed research has taken into account these earlier studies.

Reviewer 2:

The reviewer explained that the plans are to continue the work on ethanol lean NO_x and biodiesel impacts.

So far, the biodiesel used is conventional soy oil derived biodiesel. The reviewer suggested that given the amount of interest in algal biodiesel, it would be interesting to consider the peculiar FAME profile and trace contaminants composition for algal fuels and how that might impact EGR coolers, and aftertreatment devices.

Reviewer 3:

The reviewer affirmed plans to continue and complete the work in progress as well as ramping up work on phosphorus degradation of aftertreatment devices and the impacts of fuel and lubricant on PM formation.

Reviewer 4:

The reviewer stated that planned future activities are logical, and indicated more emphasis can be directed to the challenge of providing predictive tools for fuel effects on emission and emission control system (Barrier 2.4D).

Reviewer 5:

The reviewer suggested incorporating aged biodiesel starting at or near zero-hour induction period (IP) and increasing in acid number to potentially arrive at a similar failure mechanism to EGR and intake sludging when compared to warranty field returns.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer pointed out that as mentioned at the outset of the project overview, ethanol and biodiesel are common alternatives to petroleum. Given these alternatives are generally more mature, and have penetrated the market, it seems logical to conduct research to optimize their use.

Reviewer 2:

This reviewer remarked that identification and successful resolution of issues associated with use of biofuels in engines would decrease dependence on petroleum.

Reviewer 3:

The reviewer mentioned that this project addresses the fuel technology barriers with regard to higher efficiency combustion and lower emissions as well as addressing the risks of fuel formulation impacts on engine aftertreatment systems.

Reviewer 4:

The reviewer remarked that this project centers on emission controls challenges for using biofuels. Understanding these challenges helps to overcome the barriers to viable biofueled powertrains, helping to reduce the dependency on petroleum fuels.

Reviewer 5:

The reviewer stated that EtOH and lean-burn is a powerful combination both for the fuel efficiency and renewability aspects and the specific power output.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the funding level has been dramatically cut and may not be permitting the project to overcome the barriers to improving emissions performance of high efficiency engines.

Reviewer 2:

The reviewer stated that given the importance of emission reduction, FE, and finding acceptable alternatives to petroleum, the resources appear to be insufficient. In addition, as fuel and lubricant research matures, there will likely be more need for engine testing, which requires significant resources.

Reviewer 3:

The reviewer said that resources seem sufficient.

Gasoline-Like Fuel Effects on Advanced Combustion Regimes: James Szybist (Oak Ridge National Laboratory) - ft008

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer applauded the outstanding approach using fundamental understanding of the problem through CHEMKIN simulation to single cylinder engine testing, multi-cylinder engine testing and vehicle simulations. Excellent to see these integrated results in one project.

Reviewer 2:

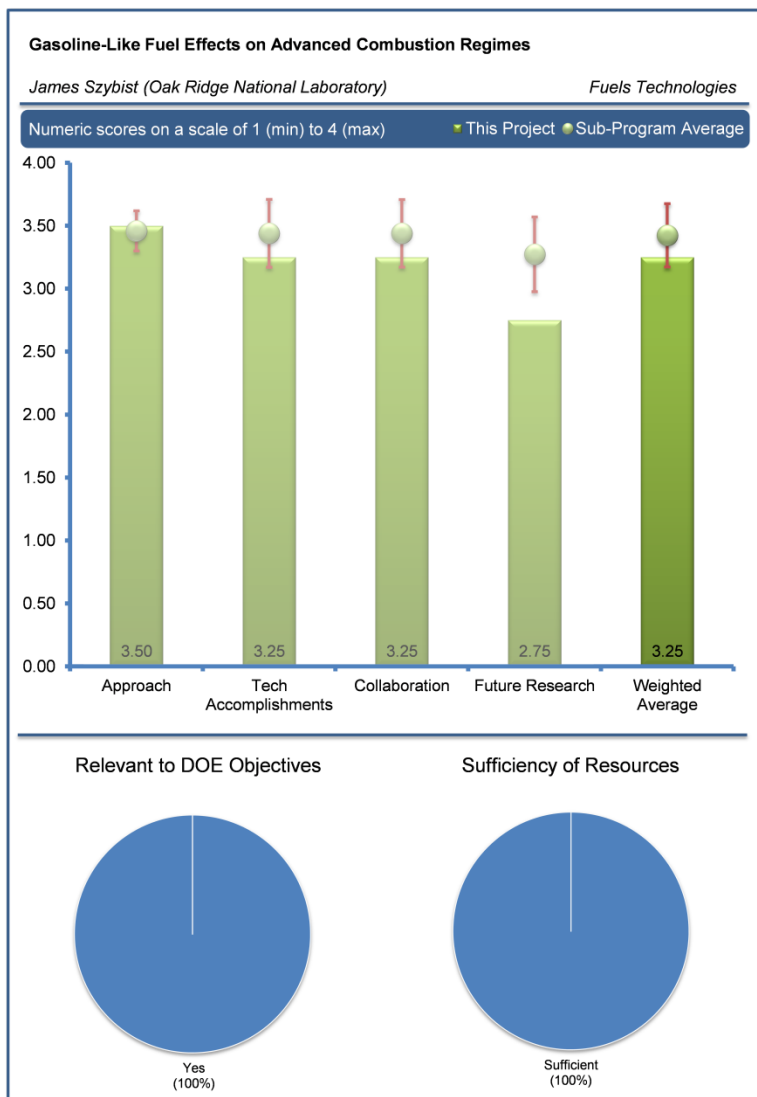
The reviewer commended the nice experimental approach to a couple of good questions.

Reviewer 3:

The reviewer remarked that the project is a good combination of engine tests with Autonomie simulation. Engine platform has been designed to be flexible and permits a range of operating conditions and advanced combustion modes to be studied. The reviewer applauded that the RCCI concept was being tested in a multi-cylinder engine. Some tests were done with six-stroke engine operation and others with methanol (severe health issues). The reviewer was not certain if either are commercially viable, but felt they are okay for R&D. The reviewer also mentioned that some tests were done with renewable super premium, containing 30% ethanol. While this would increase use of ethanol and possibly have engine performance and emissions benefits, the reviewer wondered if those are paper benefits (i.e., for economic reasons, many owners of vehicles today that require or recommend the use of premium fuel use lower grades and those that have FFVs and access to E85 do not always use it). The reviewer wondered how many drivers would be willing to pay more for super-premium and actually fuel vehicles with it.

Reviewer 4:

The reviewer recounted that the project is characterizing the fuel chemistry in a single cylinder engine. The reviewer described the project's use of multimode RCCI combustion, multimode HCCI engine mapping. The reviewer pointed out that the multi-cylinder approach to RCCI is used by ORNL. The reviewer acknowledged that a different engine platform and multiple combustion strategies are used, along with three different fuels. Single zone CHEMKIN modeling is used to assist in analyzing negative valve overlap (NVO) chemistry.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer acknowledged that two out of three of the high-level DOE milestones have been met with the third one on track for being met. The project demonstrated that use of a blend of 20% neat biodiesel (B20) in place of conventional diesel expands RCCI operating range by about 14%. The reviewer remarked that the drive cycle simulation work led to the claim that over 70% of the drive cycle can be covered by RCCI. The reviewer found the results on the NVO studies at lean conditions and use of oxygenates interesting.

Reviewer 2:

The reviewer reported interesting results on RCCI, and an interesting experiment on NVO, but thought it would be nice to see more of the intermediate and reforming products and their effect on combustion.

Reviewer 3:

The reviewer affirmed that biodiesel allows RCCI load expansion, and increased RCCI coverage improves FE. The project spanned a wide range of fuels in six-stroke engines. The reviewer mentioned that HCCI kinetics are impacted by fuels undergoing reforming, and that the project is on track for three fuels and a single cylinder engine.

Reviewer 4:

The reviewer commended the project's excellent progress, and wondered if the simulation results from Autonomie will be reliable for transients in a FTP cycle, given the project has only used steady-state maps.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the collaboration list includes OEMs such as GM, Chrysler, Ford, MAHLE, the American Council of Engineering Companies (ACEC), CLEERS and several universities including University of Wisconsin and University of Michigan. As with most of the presentations, it is difficult to tell just from the list how frequent and extensive the level of collaboration is.

Reviewer 2:

The reviewer noted solid interaction with the combustion community.

Reviewer 3:

The reviewer mentioned collaboration with Sandia National Laboratories, ACEC, GM, and universities. The high-octane fuel symposium was a result of several investigations. The reviewer explained that the E20 optimum for efficiency advantages can overcome the energy density penalty when using E20 in an optimized engine.

Reviewer 4:

The reviewer commended strong collaboration among a team from industry, university, National Lab, and working groups.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that plans seem reasonable.

Reviewer 2:

This reviewer commented to investigate alternative fuels.

Reviewer 3:

The reviewer thought that the future work does not clearly show how the barrier of creating predictive tools for fuel property effects on combustion and engine efficiency optimization will be tackled.

Reviewer 4:

The reviewer indicated that the RCCI work needs to address the real issues with RCCI. First, the cold start FTP. The reviewer noted that 90% of emissions are made in the first 60 seconds of running on the FTP. The reviewer pointed out that no one ever seems to try running cold, so the major emission issues are not addressed. Second, the reviewer thought the project should address real world FE. There are already complaints that downsized and boosted engines are not getting the expected FE improvement in the real world. RCCI does not fully cover the limited FTP and Highway Fuel Economy Test (HWFET) range; one needs to look at US06 Supplemental Federal Test Procedure (SFTP/US06) and real world conditions.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer said the project is quite relevant.

Reviewer 2:

The reviewer stated that the focus of this program is the evaluation of bio-based fuel blending components to improve the efficiency and lower the emissions in engines operated in advanced combustion modes. If successful, this would directly displace some petroleum use in the vehicles fuels market.

Reviewer 3:

The reviewer mentioned the contribution to high fuel efficiency.

Reviewer 4:

The reviewer indicated that this project provides understanding for optimizing engine performance based on fuel characteristics and combustion mode, leading to fuel savings in IC engines. It also includes a study of biofuels which reduce the dependency on petroleum fuels.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer pointed out that milestones are being met, so resources seem sufficient.

Reviewer 2:

The reviewer stated resources are sufficient.

Reviewer 3:

The reviewer noted that there seems to be a close relation with some other projects, and was not completely clear what work was funded in which, but overall the effort seems appropriate.

Lubricants Activities: Jun Qu (Oak Ridge National Laboratory) - ft014

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer acknowledged that the technology barriers identified, for example, parasitic friction losses, emission catalyst poisoning, and wear protection in low viscosity oils, are well known and important challenges for which major innovations are long overdue. The use of ionic liquids (IL) to overcome these barriers is a novel and promising technology. The reviewer cautioned that one of the most basic challenges, the solubility of ILs, has been solved by the judicious employment of chemists and chemistry. The reviewer believed this is an extremely important step that this project has embraced and it has yielded excellent results. In addition, the overall project approach seems logically sequenced and feasible.

Reviewer 2:

The reviewer thought the approach would be more beneficial if it included global powertrain impacts, such as effects on combustion.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

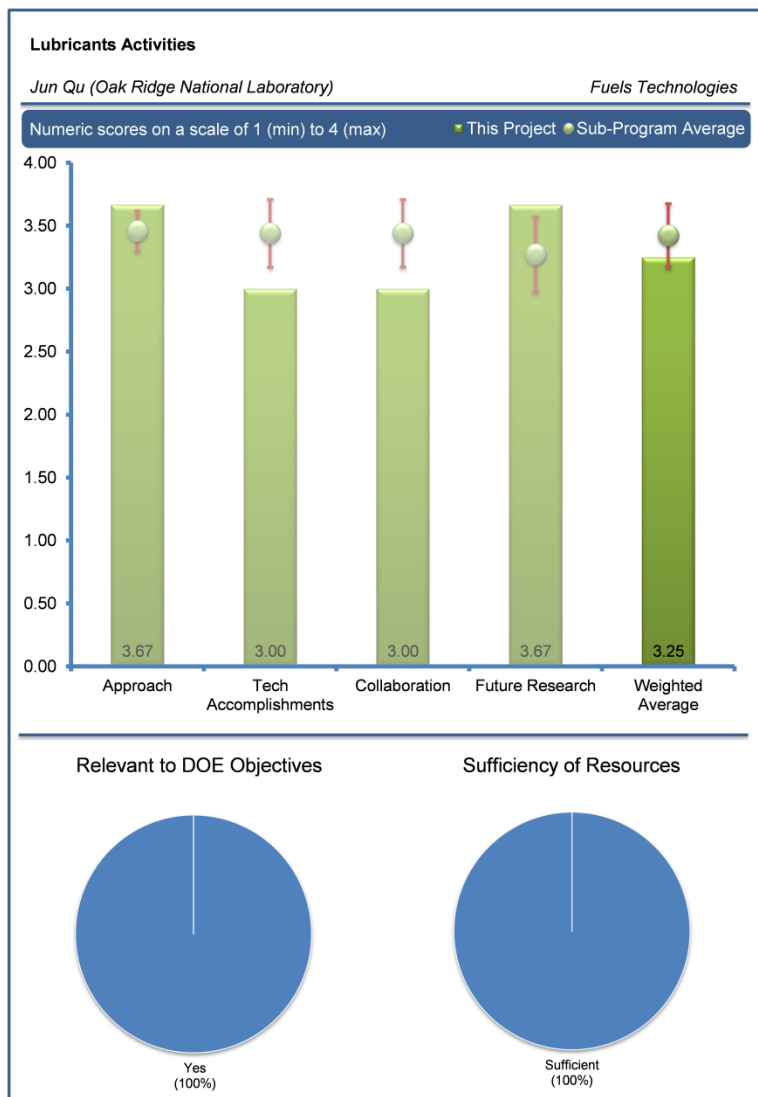
The reviewer reported very promising results, and mentioned looking forward to seeing the results of testing on an engine dynamometer test cell for a broad engine speed-load operation.

Reviewer 2:

The reviewer noted that significant technical progress has been made, including the design and synthesis of oil soluble ILs, the demonstration of corrosion resistance, and storage stability. Additionally, anti-oxidation and significant friction and wear reductions in mixed and boundary lubrication regimes compared to oils formulated with zinc dialkyl-dithio-Phosphate (ZDDP) was highlighted.

Reviewer 3:

The reviewer stated that the accomplishments are in accordance with desired objectives.



Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer remarked that there is a strong potential for this project to expand collaboration, so that different aspects of ILs application for automotive will be elaborated.

Reviewer 2:

The reviewer commented that although collaboration has been restricted to ORNL and Shell Global Solutions, this seems appropriate at this stage of the project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer expressed that the proposed future research, including optimization of the ILs, further bench testing, modeling, and fired engine tests, are appropriate and a logical continuation of the current work. More detailed compatibility studies with other common additives such as dispersants, detergents, viscosity modifiers, etc., may be appropriate in future work.

The reviewer commented that future work should include the potential impact of IL on renegade or mega knock, as low viscosity lubricant migrates into combustion chamber. Future work should also include studies to assess sulfur corrosion on bearings and other materials.

Reviewer 2:

The reviewer suggested that understanding the link between molecular structures of ILs and lubricating performance and friction coefficients (i.e., the link between Slides 11 and 16) would be very valuable.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer brought to light that the use of ILs is relatively novel and innovative and could lead to a class of oil additives that provide important efficiency benefits for a variety of applications, both automotive and industrial. Lubricant development over the years has been a very slow and deliberate process with few real game changing innovations. The reviewer concluded that the development of IL additives, although maybe not game-changing, has the potential to be a very significant improvement over conventional lubricants.

Reviewer 2:

The reviewer stated that this project helps to increase the mechanical efficiency of IC engines by reducing friction loss.

Reviewer 3:

The reviewer noted that friction is a major contributor to fuel consumption, and there is clearly room for improvement in the mechanical losses in an IC engine.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that although funding up to this point has been sufficient, future work which includes fired engine testing will likely require a greater funding stream, especially during the phase when multi-cylinder-fired engine testing is planned.

Acronyms and Abbreviations

Acronym	Definition
ACEC	American Council of Engineering Companies
AEC	Advanced Engine Combustion
AMR	Annual Merit Review
ASTM	American Society for Testing and Materials
AVFL	Advanced Vehicle/Fuel/Lubricant Committee
AVFL-18	Project 18 under Advanced Vehicle/Fuel/Lubricants of the Coordinating Research Council
B100	Biodiesel blend of 100% neat biodiesel
B20	Biodiesel blend of 20% neat biodiesel
Ca	Calcium
CFD	Computational Fluid Dynamics
CI	Compression Ignition
CLEERS	Cross-Cut Lean Exhaust Emission Reduction Simulation
CRC	Coordinating Research Council
Cu	Copper
DI	Direct Injection
DISI	Direct Injection Spark Ignited
DME	Dimethyl Ether
DOC	Diesel Oxidation Catalyst
DOE	U.S. Department of Energy
E10	0% Ethanol blend with gasoline
E10	10% Ethanol blend with gasoline
E20	20% Ethanol blend with gasoline
E30	30% Ethanol blend with gasoline
E70	70% Ethanol blend with gasoline
E85	85% Ethanol blend with gasoline
E100	100% Ethanol
EGR	Exhaust Gas Recirculation
EISA	Energy Independence and Security Act of 2007
EMA	Engine Manufacturers Association
EtOH	Ethanol
FACE	Fuels for Advanced Combustion Engines
FAME	Fatty Acid Methyl Ester
FE	Fuel Economy
FFV	Flex-Fuel Vehicles
FTP	Federal Test Procedure
GDI	Gasoline Direct Injection
GM	General Motors Corporation

Acronym	Definition
GTDI	Gasoline Turbocharged Direct Injection
HC	Hydrocarbon
HCCI	Homogeneous Charge Compression Ignition
HCFS	High-Pressure Common-Rail Fuel-Supply System
HECC	High Efficiency Clean Combustion
HWFET	Highway Fuel Economy Test
IC	Internal Combustion
IL	Ionic Liquids
IP	Induction Period
IQT	Ignition Quality Tester
K	Potassium
LII	Laser-Induced Incandescence
LLFC	Lean Lifted Flame Combustion
MB	Mercedes Benz
MOU	Memorandum of Understanding
MTBE	Methyl Tertiary Butyl Ether
NBB	National Biodiesel Board
NH₃	Ammonia
NO	Nitric Oxide
NO_x	Oxides of Nitrogen
NREL	National Renewable Energy Laboratory
NVO	Negative Valve Overlap
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PI	Principal Investigator
PIV	Particle Image Velocimetry
PM	Particulate Matter
PN	Particulate Number
R&D	Research and Development
RCCI	Reactivity Controlled Compression Ignition
RFA	Renewable Fuels Association
RVP	Reid Vapor Pressure
SCR	Selective Catalytic Reduction
SFTP	Supplemental Federal Test Procedure
SI	Spark Ignition
TDC	Top Dead Center
VTO	Vehicle Technologies Office
ZDDP	Zinc Dialkyl-Dithio-Phosphate

6. Materials Technologies

Advanced materials are essential for boosting the fuel economy (FE) of modern automobiles while maintaining safety and performance.

Because it takes less energy to accelerate a lighter object than a heavier one, lightweight materials offer great potential for increasing vehicle efficiency. Replacing cast iron and traditional steel components with lightweight materials such as high-strength steel, magnesium (Mg) alloys, aluminum (Al) alloys, carbon fiber (CF), and polymer composites can directly reduce the weight of a vehicle's body and chassis by up to 50% and therefore reduce a vehicle's fuel consumption. A 10% reduction in vehicle weight can result in a 6%-8% FE improvement.

By using lightweight structural materials, cars can carry additional advanced emission control systems, safety devices, and integrated electronic systems without increasing the overall weight of the vehicle. While any vehicle can use lightweight materials, they are especially important for hybrid electric, plug-in hybrid electric, and electric vehicles (EVs). Using lightweight materials in these vehicles can offset the weight of power systems such as batteries and electric motors, improving the efficiency and increasing their all-electric range. Alternatively, the use of lightweight materials could result in needing a smaller and lower cost battery while keeping the all-electric range of plug-in vehicles constant.

Using lightweight components and high-efficiency engines enabled by advanced materials in one quarter of the U.S. fleet could save more than 5 billion gallons of fuel annually by 2030.

The Vehicle Technologies Office (VTO) collaborates with industry to improve materials that will increase vehicle efficiency while meeting consumer and industry expectations. It does this through multiple approaches, including working to lower the cost and improve the properties of lightweight materials while maintaining safety, comfort, reliability, performance, recyclability, and cost.

The major research and development (R&D) goal for Lightweight Materials is:

- By 2015, validate the ability to reduce the weight of a passenger vehicle body and chassis system by 50% compared to a 2002 vehicle. This reduction needs to be cost-effective and the materials need to be recyclable as well.

Subprogram Feedback

The U.S. Department of Energy (DOE) welcomed optional feedback on the overall technical subprogram areas presented during the 2013 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area who volunteered to provide subprogram overview comments responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1: Was the subprogram area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Question 3: Does the subprogram area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Office's needs?

Question 4: Other Comments.

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc., as reviewer responses were optional.

Subprogram Overview Comments: William Joost (U.S. Department of Energy) – Im000

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer recounted that last year had also been good. The topic, objectives, and roadmap were exceptionally well understood, and this was communicated very effectively.

Reviewer 2:

The reviewer voiced that the sub-program was adequately covered. The depth and breadth of the program was explained.

Reviewer 3:

The reviewer stated that the sub-program was well focused on many materials. The projects provided inputs to policymakers and regulators as well regarding various aspects of lightweighting, such as lifecycle assessment, accidents, and cost models. The portfolio of projects was quite diverse. This reviewer noted that, as many of the past projects were coming to an end, the share of Mg was slowly reducing. With the opening of the CF manufacturing center, more projects on this area might be expected. However, this reviewer added that the portfolio should not drop the long-term focus and support some fundamental studies on material development.

Reviewer 4:

The reviewer remarked that the sub-program covered the big four structural materials being considered for lightweight applications (steel, MG, Al, and CF composites). However, this reviewer added that CF composites were only a subset of the category of composites. The focus on low-cost CF composites should continue to be an area of research; however, additional combinations of composite materials should be and were being considered for research and application development. These composite solutions included mineral, glass, carbon, etc., and spanned the spectrum of aspect ratios (short, long, and continuous). Composites also included plastic-metal-hybrid structures (steel, Al), hence the focus on the joining of dissimilar materials. Multi-material solutions became even more key to lightweighting, not just in the multi-material vehicle (with individual components constructed of different materials), but as multiple materials being processed into individual applications.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Reviewer 1:

The reviewer pointed out that issues and challenges of the four categories of structural materials have been identified, adding that multi-material solutions were becoming more critical to developing lightweight vehicles. This reviewer further noted that categorizing research by material type precluded the idea of the multi-material solution, and suggested that perhaps a new category should be considered.

Reviewer 2:

The reviewer observed that the plan was in place to achieve the objectives. The reviewer added that a gap existed that was not discussed, which was the issue of specifically what would happen if low-cost CF was not successfully developed. A significant level of accomplishment had been realized in the area of Mg cast and wrought product.

Reviewer 3:

The reviewer said that the plans were clear as far as the past solicitations could allow. This person added that the future plans were a bit weak in details.

Reviewer 4:

The reviewer mentioned that, as the department moved toward more solicitations, it might be difficult to focus on fundamental issues. This reviewer added that there should be some allocation of funds for the basic sciences on materials for automotive structures. Also, it should be determined whether the materials currently in use were suitable for additive manufacturing processes.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:

The reviewer said that yes, it was a very focused effort that was well planned and executed.

Reviewer 2:

The reviewer affirmed that it was very well managed.

Reviewer 3:

The reviewer said it was focused.

Question 4: Other Comments**Reviewer 1:**

The reviewer stated that overall, as a tax-paying technology person, the monies spent were well directed and managed toward a focused goal. This reviewer applauded the good job.

Reviewer 2:

The reviewer indicated a very good lead into the sub-program roadmaps.

Reviewer 3:

The reviewer specified it was a presentation on the evolution of technologies as funded by this program from the past to the present (i.e., what technologies/materials had been funded in the past, and how the success/failure of those projects drove the current developments).

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, as well as numeric scoring responses (*on a scale of 1 to 4*). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Carbon Fiber Technology Facility	Lee McGetrick (Oak Ridge National Laboratory)	6-6	4.00	3.50	3.50	3.25	3.59
Advanced Oxidation & Stabilization of PAN-Based Carbon Precursor Fibers	Dave Warren (Oak Ridge National Laboratory)	6-9	3.75	3.00	3.00	3.50	3.25
Scale-Up of Magnesium Production by Fully Stabilized Zirconia Electrolysis	Steve Derezinski (MOxST)	6-11	3.40	3.20	3.20	3.20	3.25
Low Cost Carbon Fiber Composites for Lightweight Vehicle Parts	Jim Slike (Materials Innovation Tech)	6-14	3.75	3.75	3.75	3.00	3.66
Development and Commercialization of a Novel Low-Cost Carbon Fiber	George Husman (Zoltek)	6-17	3.00	2.75	2.75	2.00	2.72
On-Line Weld NDE with IR Thermography	Dave Warren (Oak Ridge National Laboratory)	6-19	3.50	3.00	3.00	2.75	3.09
Non-Rare Earth High-Performance Wrought Magnesium Alloys	Curt Lavender (Pacific Northwest National Laboratory)	6-22	3.00	3.00	3.00	3.00	3.00
PNNL: Mechanistic-Based Ductility Prediction for Complex Mg Castings	Xin Sun (Pacific Northwest National Laboratory)	6-25	3.00	3.00	3.00	3.00	3.00
Low-Cost Magnesium Sheet Production using the Twin Roll Casting Process and Asymmetric Rolling	Murali Muralidharan (Oak Ridge National Laboratory)	6-27	3.00	2.75	2.75	2.75	2.81
Aerodynamic Lightweight Cab Structure Components	Mark Smith (Pacific Northwest National Laboratory)	6-29	3.80	3.60	3.60	3.40	3.63
Improving Fatigue Performance of AHSS Welds	Dave Warren (Oak Ridge National Laboratory)	6-32	2.67	3.67	3.67	3.00	3.33
Microwave Assisted Plasma Processing of Carbon Fiber	Felix Paulauskas (Oak Ridge National Laboratory)	6-35	3.00	3.00	3.00	3.50	3.06
Vehicle Mass Impact on Vehicle Losses and Fuel Economy	Barney Carlson (Idaho National Laboratory)	6-37	3.50	3.25	3.25	2.75	3.25
Analysis of Casualty Risks by Vehicle Type and Make	Tom Wenzel (Lawrence Berkeley National Laboratory)	6-39	3.00	3.00	3.00	2.75	2.97
Multi-Material Lightweight Prototype Vehicle	Tim Skszek (VEHMA)	6-42	3.25	3.50	3.50	3.75	3.47
IR Heat Treatment of Hybrid Steel-Al Joints	Thomas Watkins (Oak Ridge National Laboratory)	6-45	2.50	3.25	3.25	2.00	2.91
SPR Process Simulation, Analyses, & Development for Mg Joints	Elizabeth Stephens (Pacific Northwest National Laboratory)	6-48	2.20	1.60	1.60	1.60	1.75
High Speed Joining of Dissimilar Al Alloy TWBs	Yuri Hovanski (Pacific Northwest National Laboratory)	6-52	4.00	3.80	3.80	3.80	3.85
Understanding Protective Film Formation by Magnesium Alloys	Kinga Unocic (Oak Ridge National)	6-55	3.20	2.80	2.80	2.80	2.90

in Automotive Applications	Laboratory)						
Mg Intensive Vehicle Front End Sub-structure	Alan Luo (USAMP)	6-58	3.25	3.50	3.50	3.25	3.41
Aluminum Formability Extension through Superior Blank Processing	Xin Sun (Pacific Northwest National Laboratory)	6-61	3.40	3.00	3.00	3.20	3.13
Enhanced Room-Temperature Formability in High-Strength Aluminum Alloys through Pulse-Pressure Forming	Rich Davies (Pacific Northwest National Laboratory)	6-64	3.00	3.00	3.00	3.00	3.00
ICME Development of 3rd Gen Advanced High Strength Steels	Lou Hector (USAMP)	6-67	3.00	2.75	2.75	3.00	2.84
GATE Lightweight Materials Center	Uday Vaidya (The University of Alabama at Birmingham)	6-70	3.67	3.33	3.33	3.33	3.42
Microstructure and Deformation Fundamentals in Advanced High Strength Steels	Xin Sun (Pacific Northwest National Laboratory)	6-72	2.75	2.75	2.75	3.00	2.78
Overall Average			3.22	3.11	3.11	2.98	3.12

Carbon Fiber Technology Facility: Lee McGetrick (Oak Ridge National Laboratory) - Im003

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this project is an excellent example of an idea brought to reality with industry and government involvement. Also, the reviewer noted that the Carbon Fiber Technology Facility (CFTF) is a great national asset to the U.S. technology base and should be showcased.

Reviewer 2:

The reviewer stated that the approach was a good capital investment for future research.

Reviewer 3:

The reviewer stated the CFTF was the best investment in which DOE and the Oak Ridge National Laboratory (ORNL) could have invested. In addition, the reviewer observed that scaling the lab process to a make-like-production facility to produce low-cost carbon fibers (LCCF) is just starting the process. The reviewer expressed interest in seeing three of these systems, like the one at ORNL, replicated in industry to supply the LCCF.

Reviewer 4:

This reviewer remarked that the key milestone of the project was achieved on March 26, 2013. This reviewer observed that the Environmental Health and Safety (EH&S) requirements of the facilities appeared to have been well thought through. The reviewer also noted that training requirements for the employees were addressed and a good training curriculum was put in place.

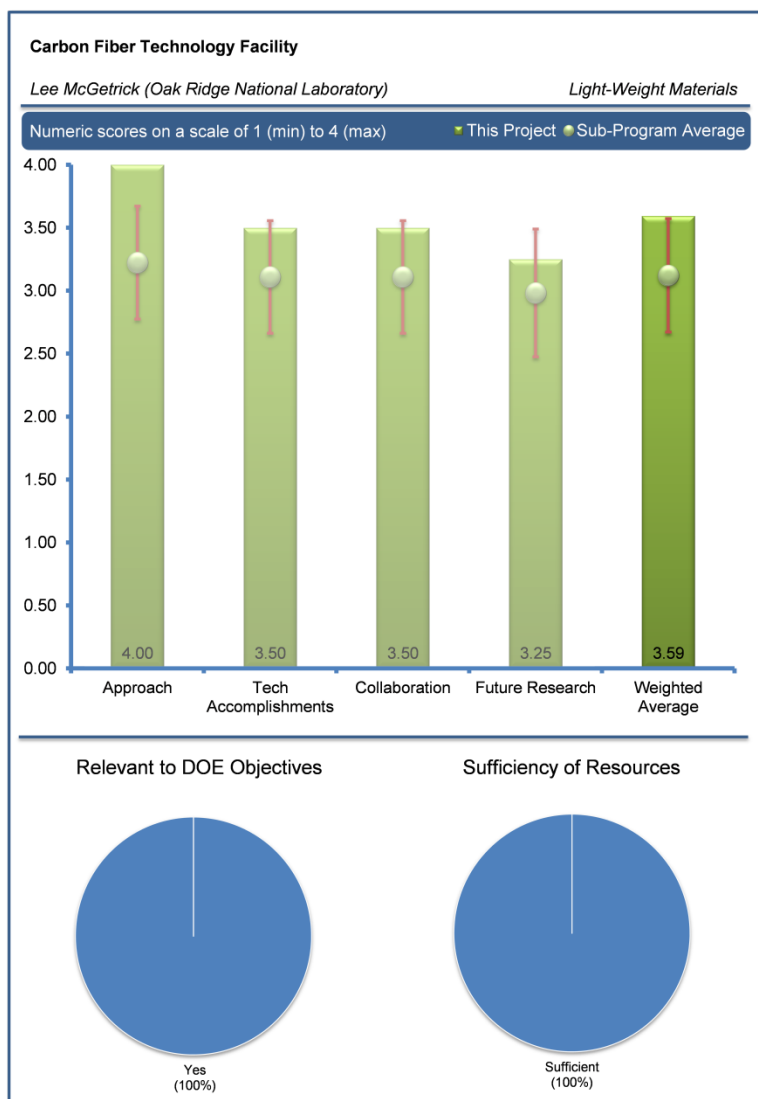
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted excellent work that was ahead of schedule and under budget.

Reviewer 2:

The reviewer observed good progress in getting the equipment ready ahead of schedule.



Reviewer 3:

This reviewer stated that establishing a running facility was a major success.

Reviewer 4:

This reviewer said that although there were start-up issues, significant progress was made getting an industry first system up and running.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer stated that the researcher had a good list of partners for executing the construction of the facility. The reviewer observed that the researcher also had an excellent list of potential partners for future clients of the center.

Reviewer 2:

The reviewer said that the researcher had a very solid comprehensive list of collaborators, and partnerships with key outside organizations were established.

Reviewer 3:

The reviewer stated the ORNL facility has done an excellent job reaching out and offering CF product for testing.

Reviewer 4:

The reviewer observed that the doors are open for collaboration.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that this project is a national asset and one of the best investments. The reviewer also stated that the investigator should continue to focus on the next R&D body of work required to replicate this project, and develop the knowledge to scale this project to a full production operation.

Reviewer 2:

This reviewer noted that for composites to grow and compete against other technologies, it becomes key to educate current and future engineers on the capabilities of CF composite. The reviewer also noted this national asset could play a part in this type of education. This goes beyond the workforce training outlined in the presentation.

Reviewer 3:

The reviewer stated there were lots of ideas to be tested.

Reviewer 4:

This reviewer noticed that technology scaling was addressed, and there seemed to be sufficient levels of industry partnerships. However, the reviewer observed there could be more emphasis on reviewing the impact of the scaled-up facility on the overall cost picture of CF composite.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that having a center of excellence like this can help the technical community focus on the science of LCCF, and research projects, like microwave-assisted or plasma-assisted oxidation.

Reviewer 2:

This reviewer stated that lab scale R&D to large scale-up is very important aspect of the overall DOE objective. This reviewer also noted the capabilities within the facilities are certainly a key enabler.

Reviewer 3:

This reviewer stated that CF delivers the future weight savings needed in the automotive industry. Further, the reviewer said to press on with the progress, as it is 110% relevant.

Reviewer 4:

The reviewer stated the project enables the final validation of the project products from other activities.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated this project was a well-spent \$35 million of taxpayer dollars.

Advanced Oxidation & Stabilization of PAN-Based Carbon Precursor Fibers: Dave Warren (Oak Ridge National Laboratory) - Im006

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the outline of the approach is very well documented and explained. The reviewer also noted that, as outlined in the presentation, this work addresses one element of the major cost elements of CF costs.

Reviewer 2:

This reviewer said it is understood that this project is export controlled and not too much data could be presented, but that regardless, there was excellent progress. This reviewer also observed plasma oxidation is a major potential enabler to a universal sizing of the tow, hopefully eliminating the need for specific sizing and using tailored resins.

Reviewer 3:

This reviewer stated the project reduces the oxidation time extensively.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

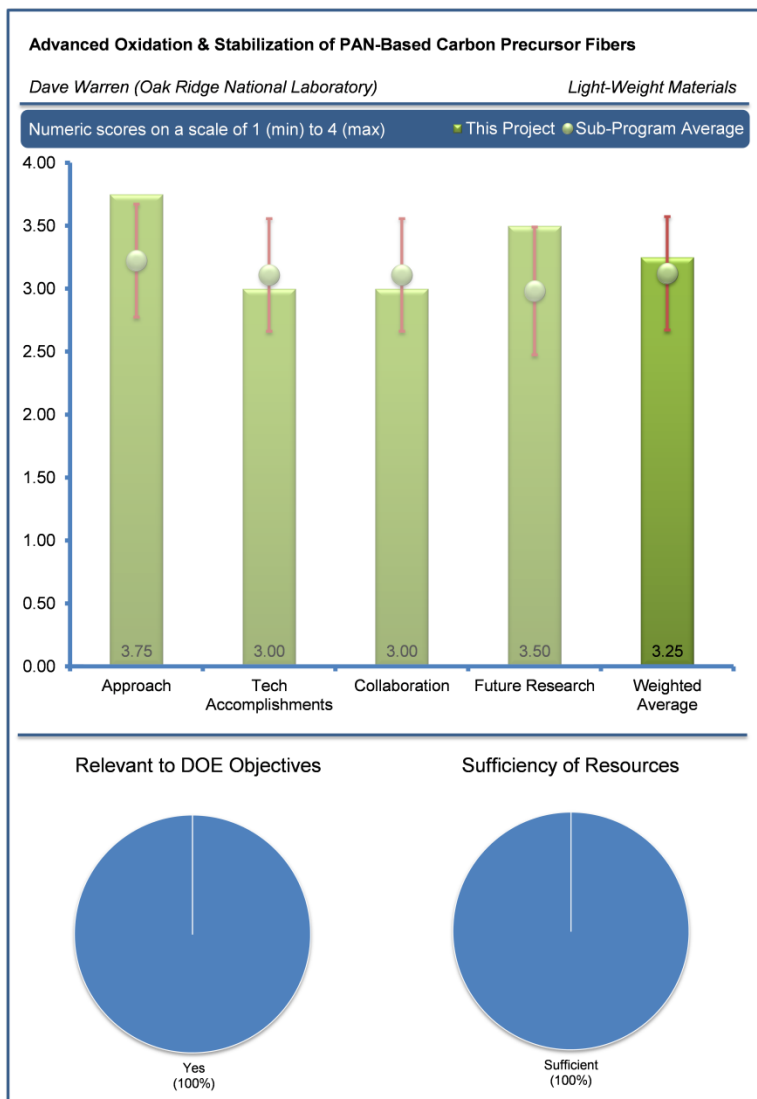
This reviewer stated technical accomplishments appear on track with improvements in strength and modulus, and good surface of the fibers. The reviewer noted the modulus is a bit low, but improving. In addition, the reviewer said some concern was expressed during the review with respect to the spread of the data (specifically modulus after carbonization), but would be expected during scale-up. The reviewer also observed process consistency will be critical when final production scale materials are ready.

Reviewer 2:

This reviewer stated residence time needs to be shortened for large tows.

Reviewer 3:

This reviewer said progress is slow, but measurable and in the right direction. The reviewer observed there was not enough discussion on the cost for plasma oxidation, which should be focused on during the next review in 2014.



Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer stated despite export control, the project still managed to have acceptable collaboration.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said this technology shows promise. The reviewer looks forward to seeing the end result.

Reviewer 2:

The reviewer observed this project is an excellent R&D process and that the project looks like a promising new technique for processing CF.

Reviewer 3:

This reviewer reported 3 tows or more of 20,000 in less than 30 minutes.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer feels this technology is right on track with developing a LCCF material that can be used for lightweight, structural, and automotive applications.

Reviewer 2:

This reviewer said this project nicely supplements the CF programs at ORNL.

Reviewer 3:

This reviewer commented that the project has the potential to effectively address the oxidative stabilization long processing time.

Reviewer 4:

The reviewer affirmed that the cost of CF is being reduced.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer would not add additional funding, but continue on with current track or R&D.

Scale-Up of Magnesium Production by Fully Stabilized Zirconia Electrolysis: Steve Derezinski (MOxST) - Im035

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer said excellent work, on track and on schedule.

Reviewer 2:

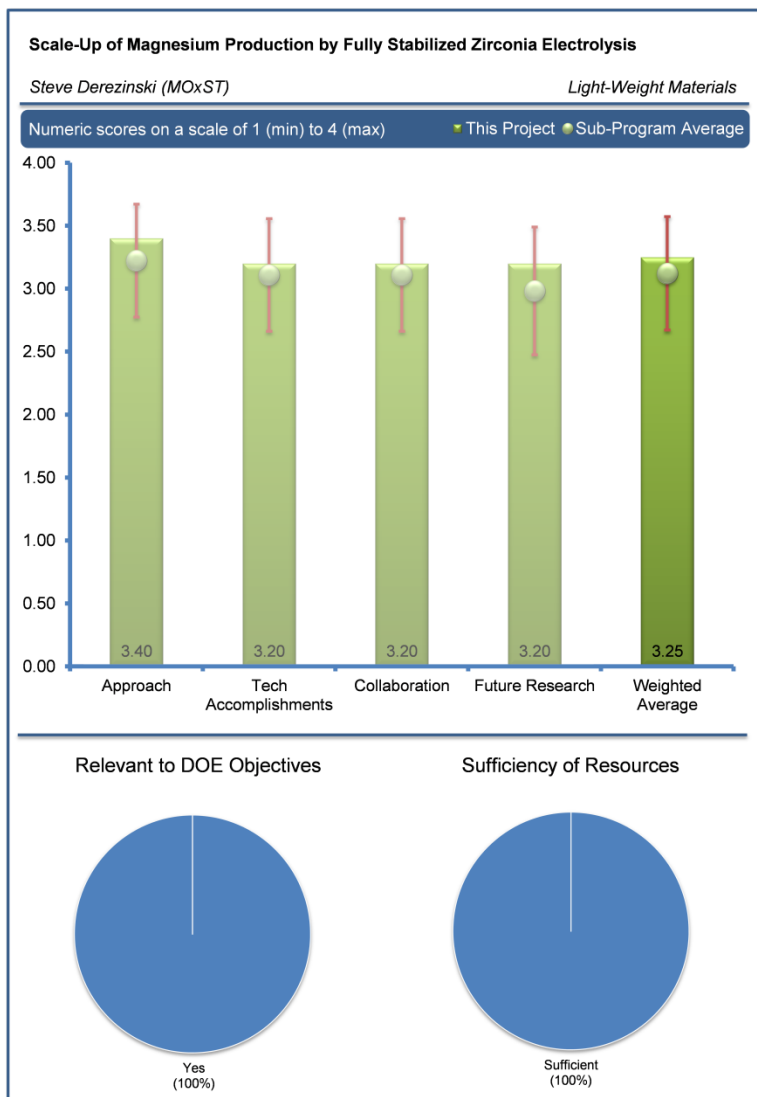
This reviewer asserted the approach towards commercialization seems effective. The reviewer also noted the technical barriers are identified and being addressed.

Reviewer 3:

This reviewer said it would be a good idea to set up the alpha-unit and run continuously, as doing this should help with predicting and production bottlenecks. This reviewer would like to see how the modeling predicts what is going on in the alpha-unit and how it shaped the production of the beta-unit.

Reviewer 4:

This reviewer affirmed the scaling up is planned well; however, it is to be seen how the larger-scale production will turn out. The reviewer also noted the reliability of the zirconium oxide tubes over larger scale and size is to be proven; however, by using many small electrodes the risk of complete cell failure may be reduced.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer stated there were very good technical accomplishments and progress. The reviewer remarked this activity includes many barriers, some of which will not be observed until production scale.

Reviewer 2:

This reviewer mentioned the development of the electrodes is progressing well. The reviewer also stated the completion of alpha design for the cells is commendable as it is proven for 500-hour operation. The reviewer also mentioned design of the beta cell is in progress. This reviewer remarked the development of a production site should be a business activity and should not be counted as a technical achievement. The reviewer is not sure how this can be taken as a deliverable for the DOE proposal as this is a business decision, not technical.

Reviewer 3:

This reviewer stated it looks like biggest barrier is the anode. The reviewer also voiced a need to address or show how the modeling is helping overcome this barrier.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer noted there was outstanding collaboration with third-party consultant reviewers and employees to overcome barriers.

Reviewer 2:

This reviewer noticed many suppliers are involved in the project, as it is necessary when scaling up is planned in future. Also, the reviewer noted it is good that a primary metal company is being involved as marketing and inventory buildup will require resources.

Reviewer 3:

This reviewer would like to see more early collaboration with equipment manufacturers, especially when dealing with scale-up. In addition, this reviewer would like to see some early collaboration with the User Community where this will be used, how are alloying elements going to be added, etc. The reviewer observed that this was not entirely clear in the presentation.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer stated scaling up is the proposed plan and that it appears that the team is progressing well.

Reviewer 2:

This reviewer noted that there were outstanding plans to commercialize. This reviewer also observed application of oxide reduction processing is being applied to rare earth series. A slight concern of this reviewer is that government funds are being redirected to include multiple material systems. This reviewer also stated the results are promising.

Reviewer 3:

This reviewer would like to know more about the Beta-furnace and how it will be used to overcome technical barriers seen in the alpha-unit. The reviewer also inquired about the type of problems foreseen in the beta-unit based on the modeling and simulation and the alpha-unit.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer emphasized absolutely.

Reviewer 2:

This reviewer stated Mg is a potential replacement for other metal alloys in transportation industries. The reviewer also observed if Mg could replace other materials mass savings would be significant. In addition, the reviewer noted a significant challenge for the present project is the generation of Mg alloys that can be stamped at room temperature without immediate fracture (i.e., activation of non-basal slip systems).

Reviewer 3:

This reviewer stated that a need exists for more domestic supply of low-cost Mg.

Reviewer 4:

This reviewer remarked Mg is the lightest material that can be used to reduce the weight of the vehicle. The reviewer observed that a very limited supply exists in North America, which is also energy-intensive. The reviewer stated the project is researching ways to reduce the energy consumption of the primary Mg production, which can pave the way for more use of this material in vehicles.

Reviewer 5:

This reviewer observed lower-cost Mg production will help with the transition from steel-centric automotive structure to light alloys, reducing the weight of vehicles. The reviewer remarked this project will indirectly help this goal.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that resources seem appropriate to move beyond demonstration of principle.

Low Cost Carbon Fiber Composites for Lightweight Vehicle Parts: Jim Stike (Materials Innovation Tech) - Im047

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer said a great method for recycling of CF.

Reviewer 2:

This reviewer remarked good demonstration of different types of parts, simple to complex geometries, and that the approach seems to be completely focused on process development. The reviewer also stated reasonable progress has been made in 2013.

Reviewer 3:

This reviewer stated the approach for this work is a good example of the straightforward application of an idea into commercialization. The reviewer noted innovating on the idea of slurry systems, combined with recycled materials, combined with production applications and market need helped drive this project. The reviewer said the approach is solid.

Reviewer 4:

This reviewer said recycling is still important, and must be addressed as a system to deliver CF for transportation applications. The reviewer also remarked that this project is a very important aspect of secondary and tertiary use of CF, a very expensive commodity.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

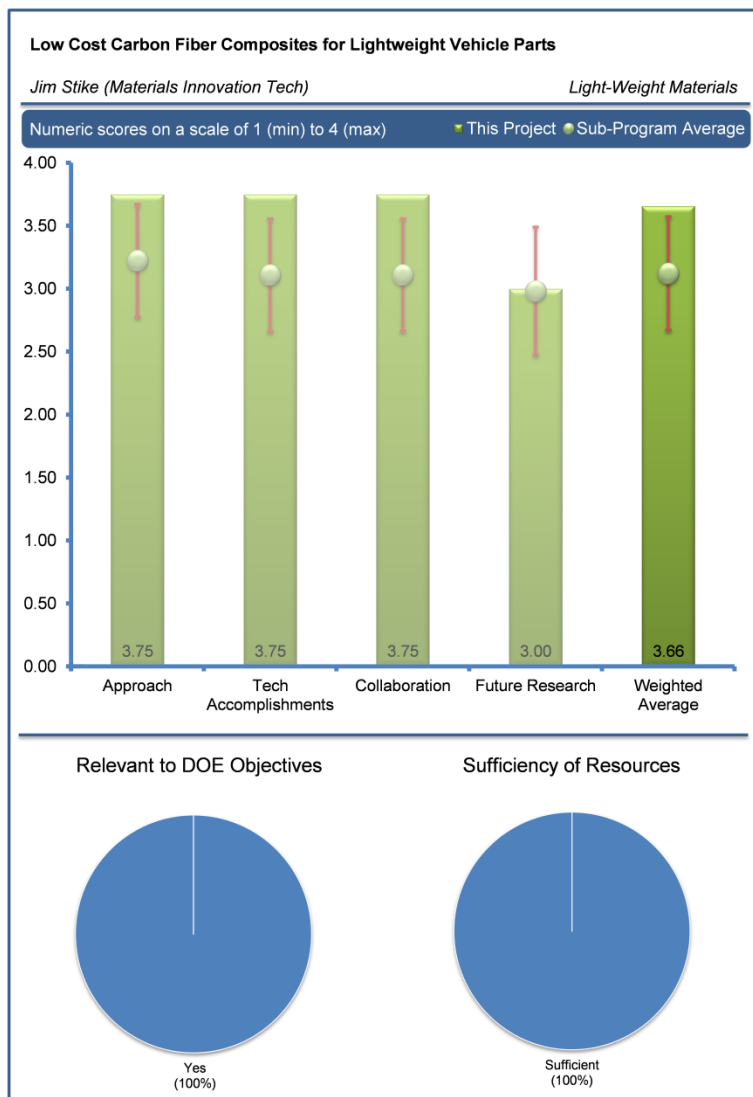
This reviewer observed good progress in scaling the process for both the roll and three-dimensional engineered preform (3-DEP) tank processing. The reviewer is very interested in the hybrid systems combining high cost CF with lower cost nanofiber (NF) products.

Reviewer 2:

The reviewer stated components were made with recycled fiber.

Reviewer 3:

The reviewer pointed out that the end results (i.e., prototype automotive and bus parts) were exhibited. The reviewer stated the objective was commercially launched programs; however, the developments to-date show good progress, both with the rolled goods and the 3-DEP process. The reviewer remarked technical data on material properties is lacking. The reviewer stated that the



presentation lists 40% mass savings, which is the high-level objective, but asked what properties were/can be obtained. The reviewer believes strength and stiffness versus thickness data should be shown and compared to traditional (glass, wood, etc.) low basis weight materials.

The reviewer noted that the schematic of the 3-DEP process and the images of the tank and tool do not clearly explain what the actual process is. The reviewer stated that viewing the video made the process self-explanatory, and described it as very impactful. The reviewer suggests better imagery in a stand-alone document.

Reviewer 4:

The reviewer stated that much of technical accomplishments have been presented on fabricating parts for commercial viability. The reviewer remarked that the presented progress lacks review of mechanical, thermal, and dimensional properties. The only reference in the presentation was a discussion on 1% density variance.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that there was an excellent list of reputable tiers and original equipment manufacturers (OEMs).

Reviewer 2:

The reviewer indicated that there were good collaborations with OEMs and composite molders.

Reviewer 3:

This reviewer noticed that there appears to be a cross-collaboration of activities on multiple fronts: customer engagement, procurement of materials, and putting in place capabilities to scale up the operations.

Reviewer 4:

The reviewer stated that the project appeared to have the same collaborators [i.e., Protera, General Motors (GM), Ford, International Automotive Components (IAC), etc.].

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer noted that there was a good list of potential work. Predicting fluid (and fiber) flow in 3-DEP tank using computational fluid dynamics (CFD) will be very challenging.

Reviewer 2:

The reviewer observed that much of the proposed future work is focused around customer buy-in and process scale-up prove out. It would be good if some focus could be given to possible design/material selection guidelines associated with the process. The reviewer added that relative cost comparison would also provide a better understanding of the project merits as well. The reviewer indicated that a review of energy consumption in producing parts with roll goods and 3-DEP process would also be beneficial.

Reviewer 3:

This reviewer noted that future research is focused more on scale, which is acceptable, but not necessarily research. Rather, this is process development.

Reviewer 4:

This reviewer indicated the project needs to look into higher-value parts.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that this project was an excellent connection to upcycling CF.

Reviewer 2:

This reviewer stated that the project definitely focused on achieving lightweight solutions for applications that may not require the full benefits of continuous CF reinforcements. The reviewer added that the project also addressed the unique abilities of the process in using reclaimed CF.

Reviewer 3:

This reviewer said that avoiding landfills encourages the use of CF composites.

Reviewer 4:

The reviewer indicated this technology will help take mass out of applications that are already produced in lightweight materials. The overall impact will be small with respect to other (more structural) technologies; however, it is still in line with the DOE objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that this program looks to be well-funded and on track.

Development and Commercialization of a Novel Low-Cost Carbon Fiber: George Husman (Zoltek) - Im048

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the objective and approach on this project are well defined, quantifiable, and measurable.

Reviewer 2:

The reviewer remarked that the approach of mixing lignin with polyacrylonitrile (PAN) is a reasonable route.

Reviewer 3:

The reviewer pointed out that the decision to delay the project for addressing technical issue was the correct decision.

Reviewer 4:

This reviewer indicated that not much progress was made on creating a robust lignin/PAN polymer blend precursor (L/P) that represents a reasonable chance of reducing the cost of CF down to the \$5 per pound price range. The reviewer added that the issues with the molecular weight (MW) distribution are a concern and it looks like there is still an unknown as to what ratio should be used (i.e., 35%, 25%, 15%, etc.). The reviewer stated that the project team should continue to work toward a robust process; this project still looks highly experimental as opposed to a precursor for make-like-production.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

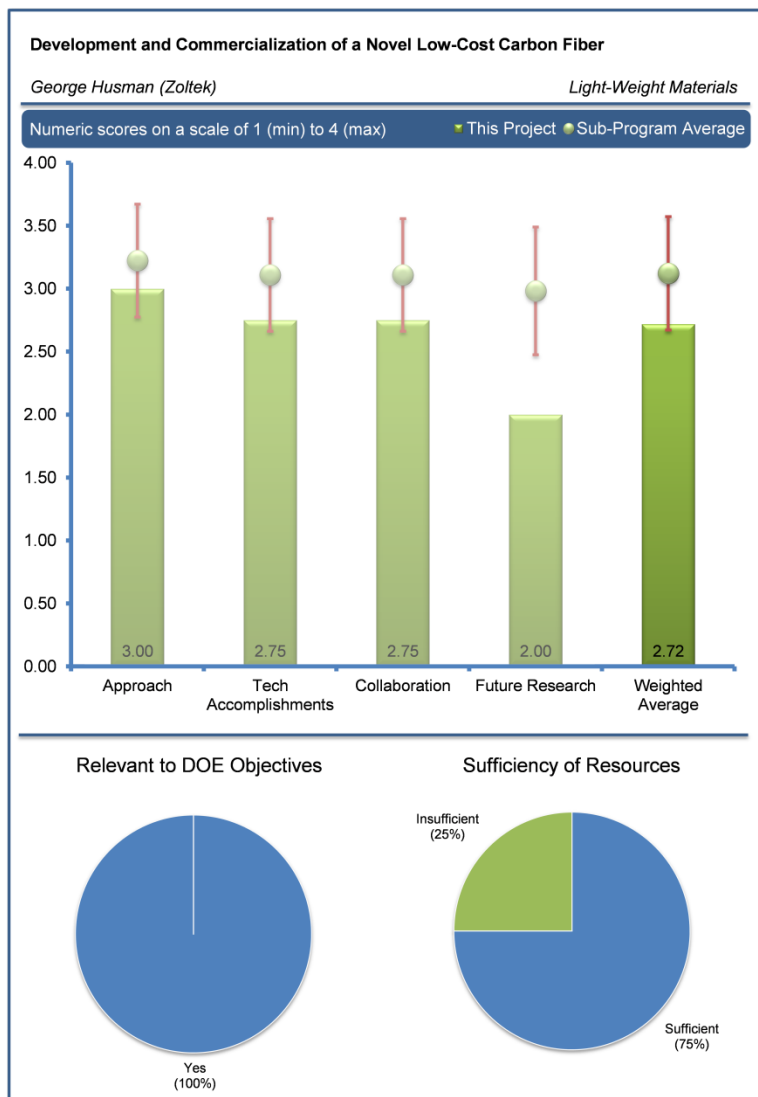
The reviewer stated that the technical accomplishments show progress towards the goal.

Reviewer 2:

The reviewer indicated that the mechanical properties of the fibers are not as good as they should be.

Reviewer 3:

This reviewer opined the issues seem to be more of a lack of knowledge of the chemistry than equipment issues. There still seems to be a big unknown in the processing of the final product into CF in Europe.



Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer suggested that the project team should continue to reach out to end users, automotive, etc., to test and validate performance. But based on the variety of L/P systems sent to Europe, it does not look like a lot of material will be available. The reviewer stated that the U.S. production of the L/P should increase significantly to allow for more available CF from Europe.

Reviewer 2:

This reviewer said that collaboration on addressing technical barriers could have been articulated better.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer opined that the plan forward needs to be addressed now that the unexpected challenge of mixing the morphologies of PAN and lignin has arisen. It was not clearly outlined in the presentation what the steps were to improved MW distribution. The reviewer added that although the specifics may be proprietary, a high-level outline could be provided.

Reviewer 2:

This reviewer stated that oxidation on lignin fundamentals was not referenced. The reviewer indicated that the researcher was not very clear on the level of complexities involved in bringing closure to Phase I deliverables. The reviewer questioned, based on learning to date, if Phase II project details shown on page five are adequate.

Reviewer 3:

This reviewer stated that there does not seem to be a clear path forward to improve mechanical properties.

Reviewer 4:

This reviewer observed that there was really no talk about future research, with the team mostly trying to get the existing L/P chemistry to work.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer pointed out that the development of LCCF supports automotive applications that are lightweight, in turn helping to reduce our dependence on foreign oil.

Reviewer 2:

This reviewer said that the low-cost aspect is supported.

Reviewer 3:

This reviewer stated that the project group should continue to focus on \$5 per pound; the reviewer heard more like \$7 per pound at this stage. For L/P, this is getting too expensive.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer indicated that the funding is appropriate.

On-Line Weld NDE with IR Thermography: Dave Warren (Oak Ridge National Laboratory) - Im054

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer pointed out that the three-pronged approach to this problem is efficiently directed to yield the best results. Additionally, the infrared (IR) post-mortem database of welds with associated quality metrics will serve as a great addition to the industry's knowledge.

Reviewer 2:

This reviewer stated that the approach seems detailed and sound.

Reviewer 3:

This reviewer stated that the project had a good approach but it needs a weld systems supplier (Fronius, Valiant) to integrate technology with the project's weld control.

Reviewer 4:

The reviewer summarized the project by saying the project tested many steel variations including thicknesses and surface conditions. After welding the quality of the weld as well as defects created are detected. Many of the measurements have been compared with IR measurements. The reviewer indicated that the approach is balanced but some correlation with actual mechanical testing of the assessed welds would have been more useful.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

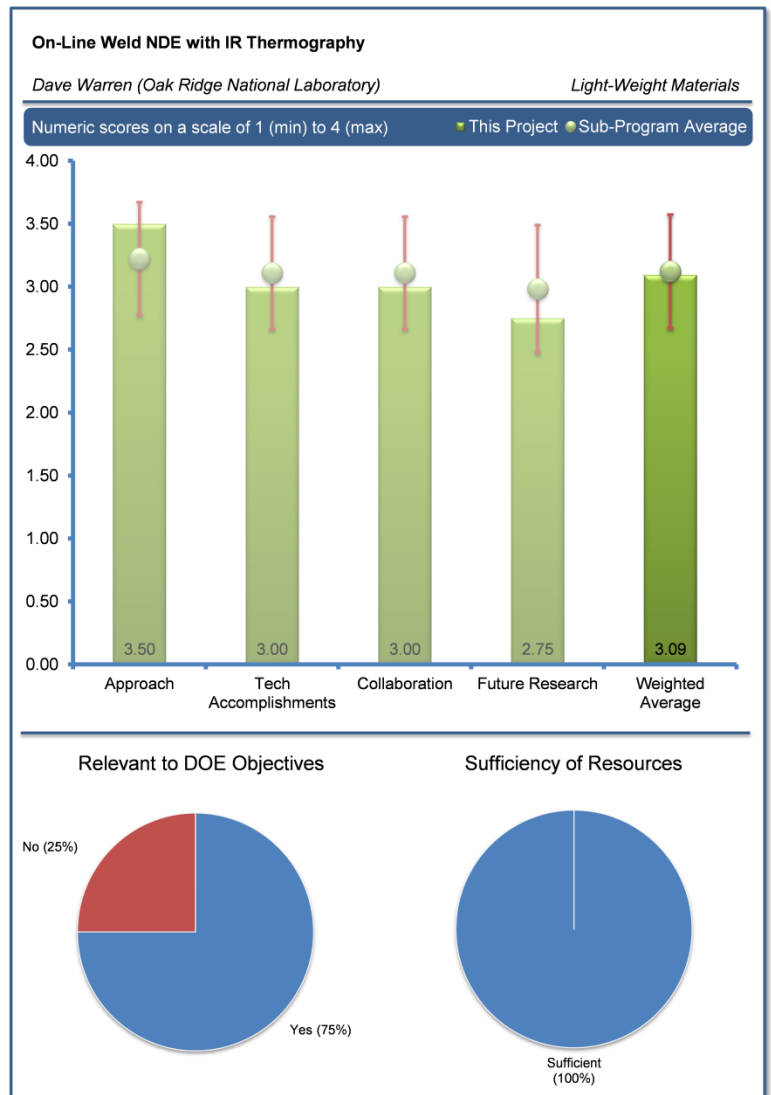
This reviewer stated that excellent progress has been made towards both the original goals and the expanded goals for more welds of different materials and coatings. Hopefully, further efforts can be initiated on reducing the cost of the inspection system to below the \$30,000 point.

Reviewer 2:

The reviewer observed that the database and the user manual for the steel combinations with various thicknesses and surface conditions are an excellent outcome of the project. Technical demonstrations will help make this procedure a more widely used one.

Reviewer 3:

The reviewer stated that good progress was demonstrated in the hardware, software and user interface in the lab setting. The reviewer added that the project team will still have to ensure that the system and methodology will apply in actual plant environment.



Reviewer 4:

This reviewer noticed that there were good accomplishments, and progress is slow due to the lack of a partner.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer observed that the team contains all the right members in automotive, steel, IR equipment and software industries. The reviewer added that there were good efforts, good planning, and good teamwork.

Reviewer 2:

This reviewer said that there appears to be good involvement of auto and steel company representatives.

Reviewer 3:

This reviewer indicated that three North American OEMs and at least one steel supplier are partnering in the project. The database can be used by many producers. The reviewer added that publication and demonstration of the technology will help make this test method more widely used.

Reviewer 4:

This reviewer stated that this is the issue, and the statement says it perfectly.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer stated that the proposed future work to beta test this system in a plant environment is critical. Additionally, the commercialization with a non-destructive evaluation (NDE) partner for widespread use of this technology is also critical.

Reviewer 2:

This reviewer commented that the project is completed in the current Fiscal Year (FY) and no future funding is being requested; however, the presented plans were for conducting work on non-ferrous metals. The reviewer added that the effort should be expanded to multi-material joints as well, if possible.

Reviewer 3:

This reviewer remarked that continuation should be dependent on identifying a commercialization partner.

Reviewer 4:

This reviewer stated that the plans for the current project seem appropriate. Also, plans for additional future work appear to be rather general. The reviewer added that the plans seem to be based on the assumption that joints in the other materials and joining processes will automatically have the same characteristics as did the steel resistance spot welds.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer stated that if successful, this technique could encourage the increased use of higher strength and or lighter materials, and it could also reduce the cost to manufacture vehicles thereby further motivating increased use of those lighter materials.

Reviewer 2:

The reviewer remarked that this project addresses a key potential stumbling block to the further use of advanced high-strength steels (AHSS) in future lightweight vehicle designs. The reviewer commented that the quality of the welding is critical for the performance of lightweight steel structures. Additionally, the cost of current destructive testing can be reduced.

Reviewer 3:

This reviewer observed that spot welding is still the largest joining process used for metals for vehicle production. Also, the quality of these welds needs to be checked periodically, and this project is developing an on-line/offline test method which will improve the reliability. The reviewer added that this project is an enabler, if the database is extended for multi-material joints.

Reviewer 4:

This reviewer stated that this is a quality and reliability issue with little impact on lightweighting technologies

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer pointed out that with the demonstrated accomplishments on the weld database and NDE analysis, the team appears to have sufficient resources for this project.

Non-Rare Earth High-Performance Wrought Magnesium Alloys: Curt Lavender (Pacific Northwest National Laboratory) - Im056

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the development of wrought Mg alloys for high impact strength is the objective. The reviewer observed the modeling efforts to predict the best material necessary is good approach. The reviewer added that consideration has been given to the corrosion resistance as well as the cost of material; however, the alloy can be expensive if it is not easily processed. Non-conventional alloying additions such as silicon and a new extrusion process can increase the cost significantly; however, if the fundamental mechanisms are understood it is possible to reduce the cost in future.

Reviewer 2:

This reviewer remarked that the project team has had good initial success replacing high cost alloying elements with high cost processing to get Mg alloy up to the objective. In addition, the process to reduce cost can only create limited shapes, but is still appropriate for some commercial parts for weight reduction. The reviewer added that the project team is trying to optimize this selected process through combined modeling, intermetallic elements, and testing, which seems to have a good chance for success, but the final cost is still a question.

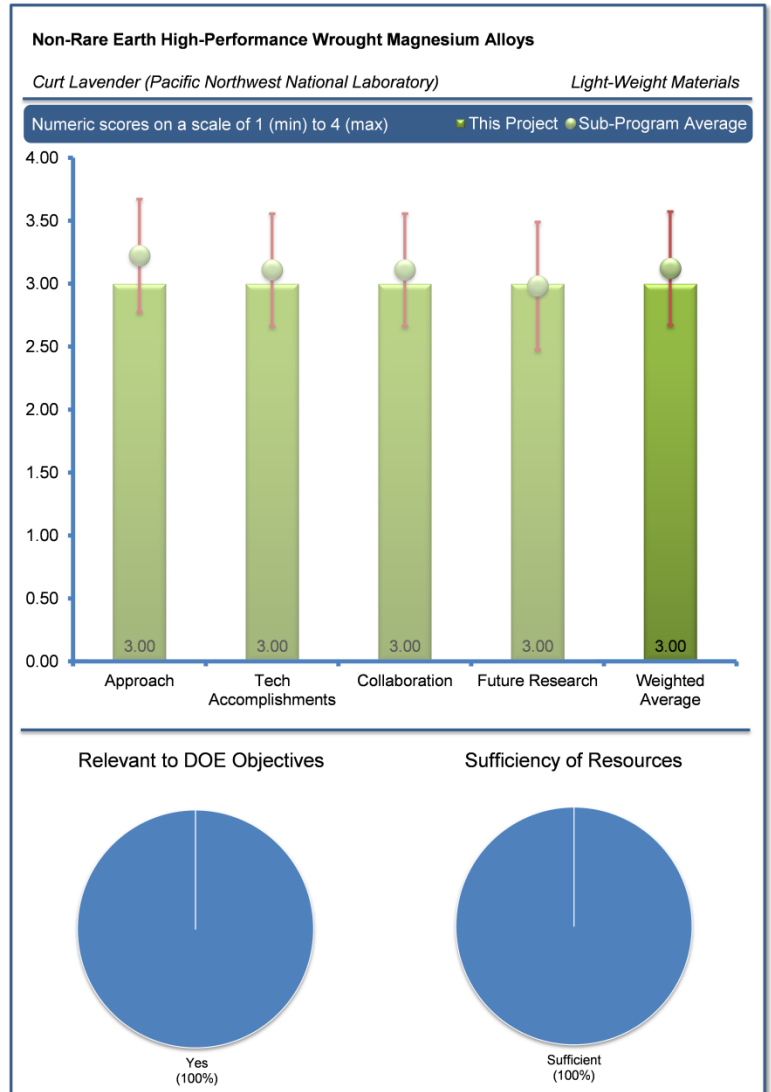
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer stated that the development of a new manufacturing process, shear extrusion, is a significant development. The reviewer added that the development of microstructure during this process and the loading simulation is good work; however, economic feasibility of the new alloy and the process needs to be proven.

Reviewer 2:

This reviewer indicated that the high shear extrusion process to produce the fine grain tubes at a semi-reasonable rate may reduce the production cost. The performance goals are still being met, but still some work needs to be done. The reviewer added that the project team is trying to optimize this selected process through combined modeling, intermetallic elements, and testing which seems to have a good chance for success, but the final cost is still a question. Also, the reviewer stated that the modeling using viscoplastic self-



consistent (VPSC) adds a seemingly semi-physical parameter that can capture the overall grain effect (but this was not the presenter's technical strength). The inverse modeling seems more physical and might aid the chances of success.

Reviewer 3:

This reviewer commented that there was good progress to make tubes; the reviewer would like to see the results of expanding to a bigger cross section. The reviewer stated that it would be more useful for automotive and defense applications.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer pointed out that the team seems capable in their areas of specialty, but deeper understandings might not be transferred between the team members.

Reviewer 2:

This reviewer stated that the basic work of this project has a good partnership with academic researchers. Involving some of the material suppliers and users is good sense.

Reviewer 3:

This reviewer observed that it is clear that the Georgia Institute of Technology is collaborating in the modeling and simulation, but it is unclear what Magna/Cosma is bringing to the table. The reviewer would like to see collaboration grow, especially in providing guidance with what type of structural components are being targeted.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer looks forward to seeing the scale-up of alloy extrusion.

Reviewer 2:

This reviewer commented that the work plan is more on modeling development and less on experimental work. The reviewer suggested that the team think about a commercial alloy AS21, which has 1% silicon. This will reduce the cost of production. Also, alloying with calcium was suggested to refine the silicon structure. Calcium will reduce the castability but this can be explored.

Reviewer 3:

This reviewer observed a need to increase section sizes, and determine what types of automotive structural components are being targeted. The reviewer added that this project should guide what further type of component-level testing will be needed.

Reviewer 4:

The reviewer remarked that forward direction seems clear building on current success; this includes the scaling up to actual part size product, which will aid to actual cost estimates. Also, the reviewer stated that no decision points were given for any course correction.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said lightweighting.

Reviewer 2:

This reviewer indicated that the process to reduce cost can only create limited shapes, but still appropriate for some commercial parts for weight reduction. In addition, the reviewer said the project will be scaled up to full size parts this year.

Reviewer 3:

This reviewer commented that rare earth metals can strengthen Mg alloys but the cost and availability of these materials is questionable. The reviewer added that efforts to improve the strength of Mg without the use of rare earth metals will significantly improve the feasibility of using these materials in vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that the team seems to have the appropriate technical resources, and the increased funding level combined with industrial in-kind should be sufficient for the next years' work.

PNNL: Mechanistic-Based Ductility Prediction for Complex Mg Castings: Xin Sun (Pacific Northwest National Laboratory) - Im057

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer said that the project team had a very good and sound approach as far as the modeling of the Mg alloys is concerned. The reviewer added Mg alloys are good candidates for lightweighting materials. The reviewer's hesitation for an outstanding score is related to the fact that there are no target specifications for these alloys and, therefore, the castings appear to serve only the modeling. This is important but producing castings with respect to target specifications is more relevant.

Reviewer 2:

This reviewer pointed out that a mechanistic model would be a dramatic improvement; the reviewer was unclear how the necessary input parameters will be determined. The reviewer stated that overall the project draws heavily from experimentation, but the reviewer did not see how the modeling work will be fed back to affect the experimental work.

Reviewer 3:

This reviewer opined that the work at Pacific Northwest National Laboratory (PNNL) always seems to be brute-force modeling of a particular system from which no generalizable insights can be drawn.

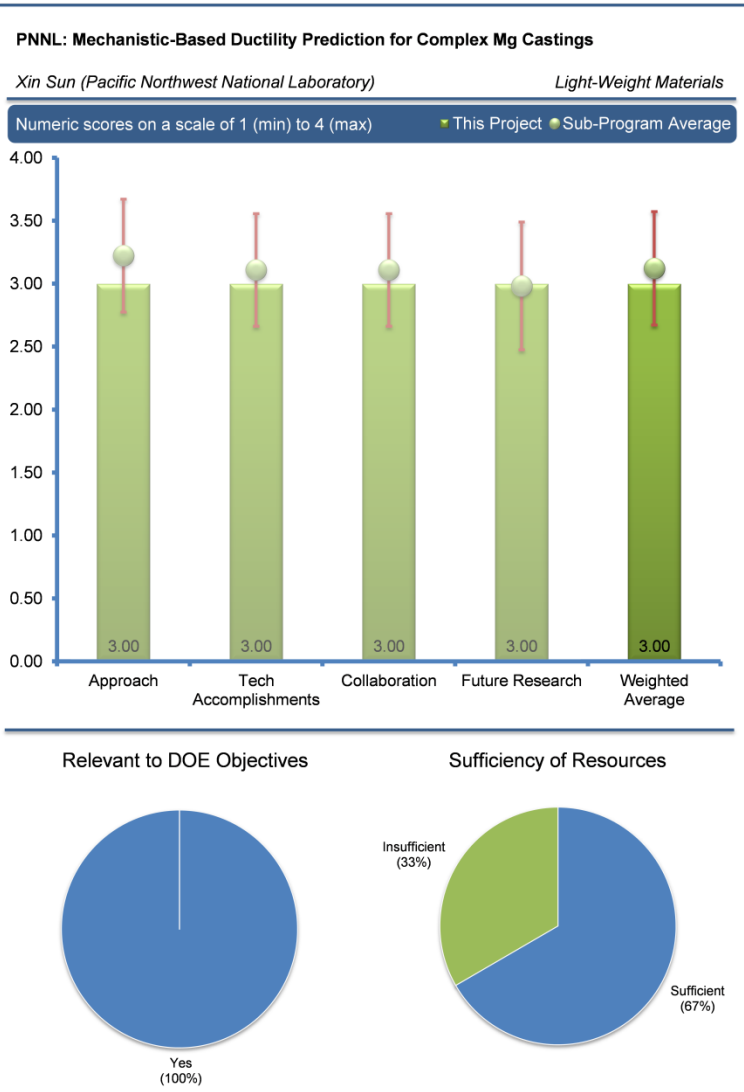
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer stated that the progress is indeed excellent.

Reviewer 2:

This reviewer is concerned that the combination of creating a mechanistic-based model and creating a model that includes the ductility variation may be too ambitious for the time remaining.



Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer doubts that Ford is the only car maker interested in Mg alloys and their castings. This reviewer stated that to be fully relevant, all car makers should be involved in such research. The reviewer commented that publications are good for PNNL but what really matters here is generally not published.

Reviewer 2:

This reviewer observed that other participants do not seem as deeply involved as personnel at PNNL.

Reviewer 3:

This reviewer stated that not many details were provided other than Ford cast the parts, and Michigan modeled this.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer commented that the modeling of Mg castings is getting refined and/or improved.

Reviewer 2:

This reviewer pointed out that the remaining goals seem very broad and appear to be a large challenge to complete.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said of course, it does.

Reviewer 2:

This reviewer stated that if the goal of a mechanistic-based predictive model can be realized, this will allow lighter Mg alloys to be evaluated more easily.

Reviewer 3:

This reviewer observed that this topic needs to be addressed, but the reviewer was not sure if the brute-force models that are being produced are extensible beyond the experimental space within which they were taught.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer commented that linking the properties into the model seems to be the key for this project's effectiveness. The reviewer added that in light of the long list of work to be completed, it is not clear that this element of the project will get the attention necessary to complete it.

Reviewer 2:

This reviewer said probably.

Low-Cost Magnesium Sheet Production using the Twin Roll Casting Process and Asymmetric Rolling: Murali Muralidharan (Oak Ridge National Laboratory) - Im058

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer indicated that the approach seemed to be based in the idea that twin roll casting would reduce the cost of Mg sheet material, but how this occurs was not clear. Similarly, the reviewer did not see a strong predictive modeling component to the work.

Reviewer 2:

While this may be a good approach, this reviewer observed wanting to do too much and give too much detail, and further expressed difficulty in extracting the essence of the project. The reviewer inquired about the minimum sheet dimensions required by car makers. The reviewer also asked about the target price per sheet of interest to car makers.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer stated that the accomplishments were difficult to deconvolve from the presentation, and that many were presented with little experimental data to back them up.

Reviewer 2:

The reviewer sees this project more like a lab exercise rather than industrial research. To the reviewer, the absence of any car maker as a partner is not good.

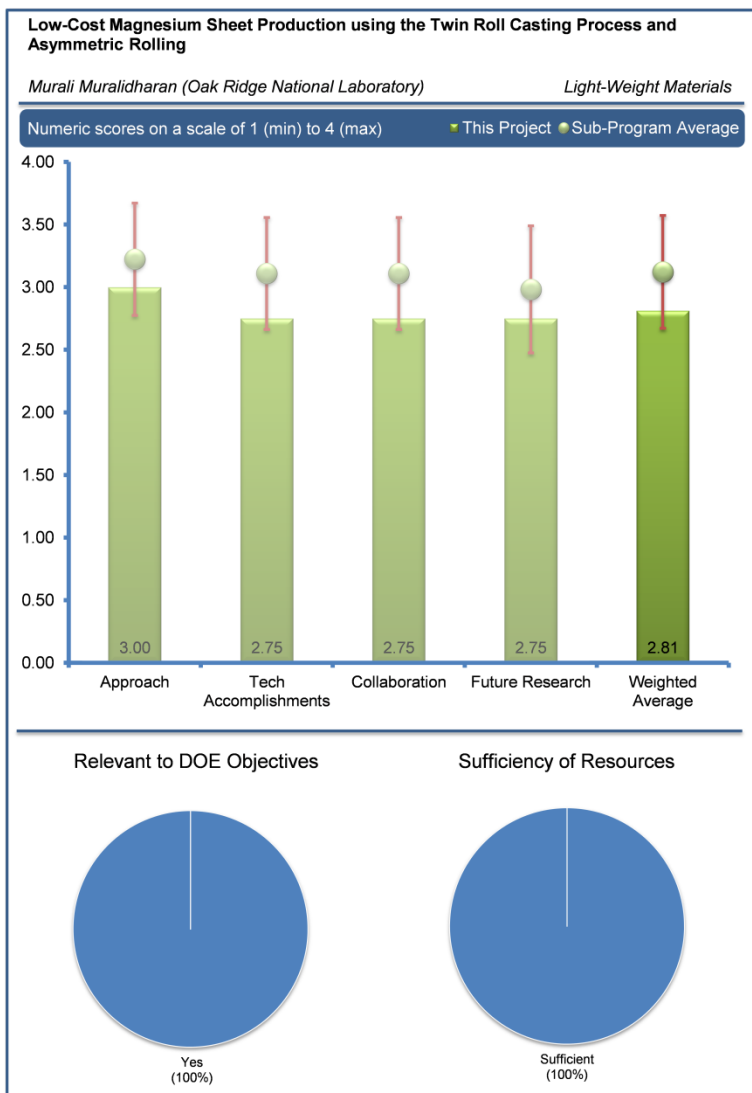
Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer stated that car makers should be involved in such a project; otherwise, this indicates a lack of interest from them.

Reviewer 2:

The reviewer indicated it was not clear how strong the collaborations were beyond supply of material.



Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer remarked that it would be helpful if the future work included a formability evaluation of small sheet components beyond the current dome test.

Reviewer 2:

This reviewer said that there seems to be more future research planned than there is time to work on.

Reviewer 3:

This reviewer indicated that it was more of the same, and that the project should be either abandoned for now or restructured from its inception with input from end users. The reviewer then asked with respect to what is the product low cost.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer said definitely.

Reviewer 2:

This reviewer indicated that from the presentation the petroleum displacement from this technique would seem to be rather modest.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer observed that it was not clear what milestones remained.

Reviewer 2:

The reviewer stated sufficient but just like low cost, the reviewer did not really know what it means.

Aerodynamic Lightweight Cab Structure Components: Mark Smith (Pacific Northwest National Laboratory) - Im060

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that it is definitely a good project: reducing truck cabin weight by up to 40% is outstanding.

Reviewer 2:

The reviewer commented the approach was good. The reviewer added that this speaker focuses on practical issues and plans for eventual implementation by industry which is precisely the right approach in the reviewer's view.

Reviewer 3:

The reviewer stated that the combination of some hot and cold forming has been demonstrated as a reasonable solution to the forming of complex/aerodynamic parts with weight savings as compared to the current sheet model compound (SMC). Also, the reviewer observed that scaling up has been scheduled for this year and that the low production numbers are sufficient for the market being considered here. Additionally the reviewer indicated that the cost for the energy to hot-form the parts could limit wider application.

Reviewer 4:

This reviewer stated the overall approach seems reasonable, and seems likely to be a pathway for use. The reviewer added that there will likely be other issues for full production that will be encountered as the die design failure shows.

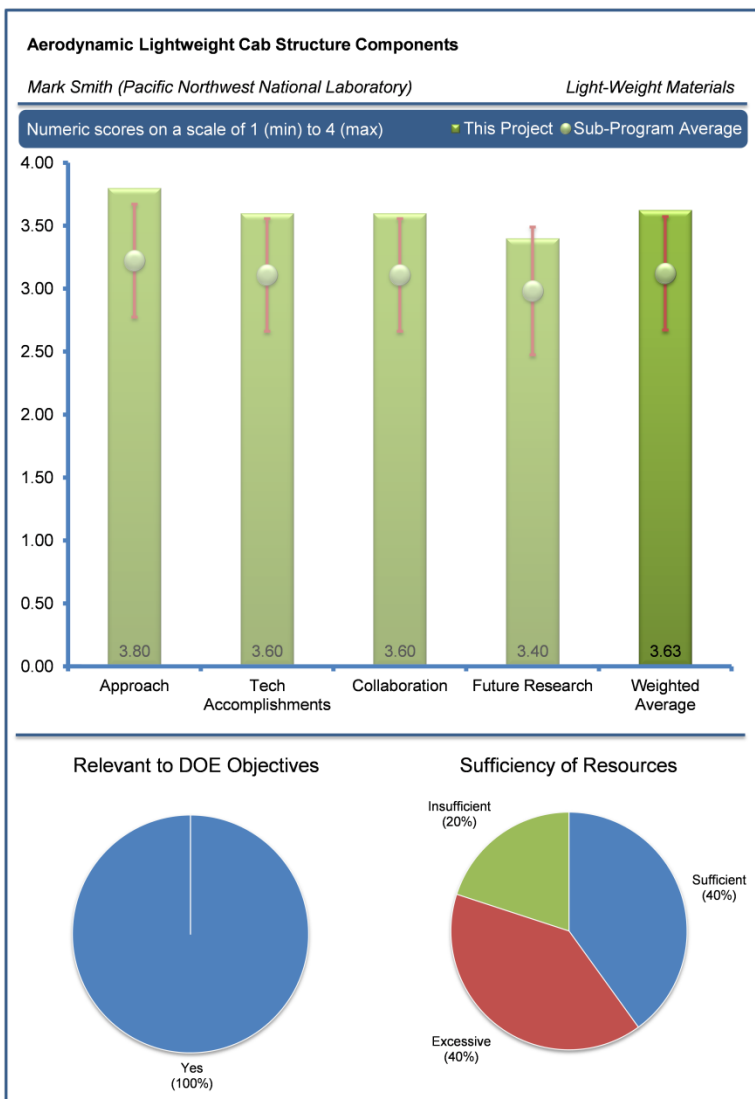
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer observed excellent work and that the project seems very solid.

Reviewer 2:

This reviewer stated the progress toward a successful final part has been very good, and fast with quick down-sampling of options. The reviewer added that this might be in part that the required 40% savings was not a difficult target. The reviewer said it seems like the project will likely be fully successful, but could do significantly more technical accomplishments in optimizing the result if a wider view of options is considered (other alloys larger matrix of hot-forming/cold-forming combinations). The reviewer stated that PACCAR has set some limits that are more risk-averse than might be really needed.



Reviewer 3:

This reviewer said the project seems on track.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer indicated that the project looks to be very effective and that the project team has a strong plan to pass the technology over to industry. The reviewer pointed out that it would be good to see if this technology could be migrated over to higher volume applications such as light truck and passenger car (presently the project is aimed at Class VIII truck cabs).

Reviewer 2:

The reviewer remarked that the addition of Magna seems to have rounded out the team skills needed to make the project successful, especially at the current stage of making a demonstration part for testing.

Reviewer 3:

This reviewer stated that the number of collaborators was small, but well-focused.

Reviewer 4:

The reviewer opined that the fact that PACCAR is part of the project is really what matters here. As a side note, the reviewer would have liked to see more than one AI producer/furnisher.

Reviewer 5:

The reviewer recommended work with Magna to identify other potential vehicle structures with this process that can be used.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the project looks to be very good. The reviewer advised that the team keeps their eyes on the wider applications to larger volume industry segments.

Reviewer 2:

This reviewer said that the plan for future work is well specified and seems in line with current work.

Reviewer 3:

This reviewer indicated that the plan forward with Magna suggests the possibility of other alloys that could be considered. The reviewer said that the work on an actual part to be tested should decide if the method can be successful to achieve the overall project objectives. The reviewer also noted that no specific decision points were given.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer stated that the mass savings are good as well as the additive effects of improved aerodynamics.

Reviewer 2:

This reviewer indicated that the project was definitely a good fit in the petroleum displacement agenda.

Reviewer 3:

The reviewer stated that although the project makes one particular part lightweight, its real strength is opening the market for other replacement parts in long-haul trucks.

Reviewer 4:

The reviewer listed the following: weight saving; aerodynamic profile; and finish.

Reviewer 5:

This reviewer remarked that the project team should show how this project is being used to eliminate technical barriers in the SuperTruck project.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer pointed out that the promise of the implementation of such technologies should be fully exploited, not limited. The reviewer added that when one considers the importance of trucks in this country, it appears that the savings can be enormous.

Reviewer 2:

This reviewer said that for the scope of the work, the project resources seem appropriate, but the reviewer thinks there is room for more resources to improve this project as it is well-defined and managed.

Reviewer 3:

The reviewer remarked that no issues were perceived.

Reviewer 4:

The reviewer indicated that it seems like the project could do more if the partners would be willing to go a little more out of their comfort zone.

Improving Fatigue Performance of AHSS Welds: Dave Warren (Oak Ridge National Laboratory) - Im062

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer stated that the project team had a good project design to understand barriers as well as ORNL, material supplier, university and weld equipment supplier.

Reviewer 2:

The reviewer indicated that the project team was taking a sound scientific approach to develop technologies that can eliminate the root cause of premature fatigue of AHSS; however, the project appears to lack quantifiable goals. Thus, any improvement could be considered a success. Also, the reviewer recommended that specific targets for improvement should have been developed based on the literature search.

Reviewer 3:

The reviewer pointed out that the project does a fair job of addressing the barriers identified. The reviewer does not see any effort addressing the project's third barrier, D, Predictive Modeling Tools, in this project. Additionally, the reviewer stated that the barriers are real and the work proposed starts to address the first two barriers. The reviewer remarked that since there was little discussion on how the different filler materials were chosen, it is difficult to evaluate the approach. Aside from the 10Cr (chromium)-10Ni (nickel) developed in the 2003 publication, there is no indication on the approach to develop the filler wire. Also, there is no mention of the thermo-mechanical weld process control concepts for improving fatigue life. The reviewer suggested that the project might need to look at corrosion resistance of the weld as well as the fatigue performance.

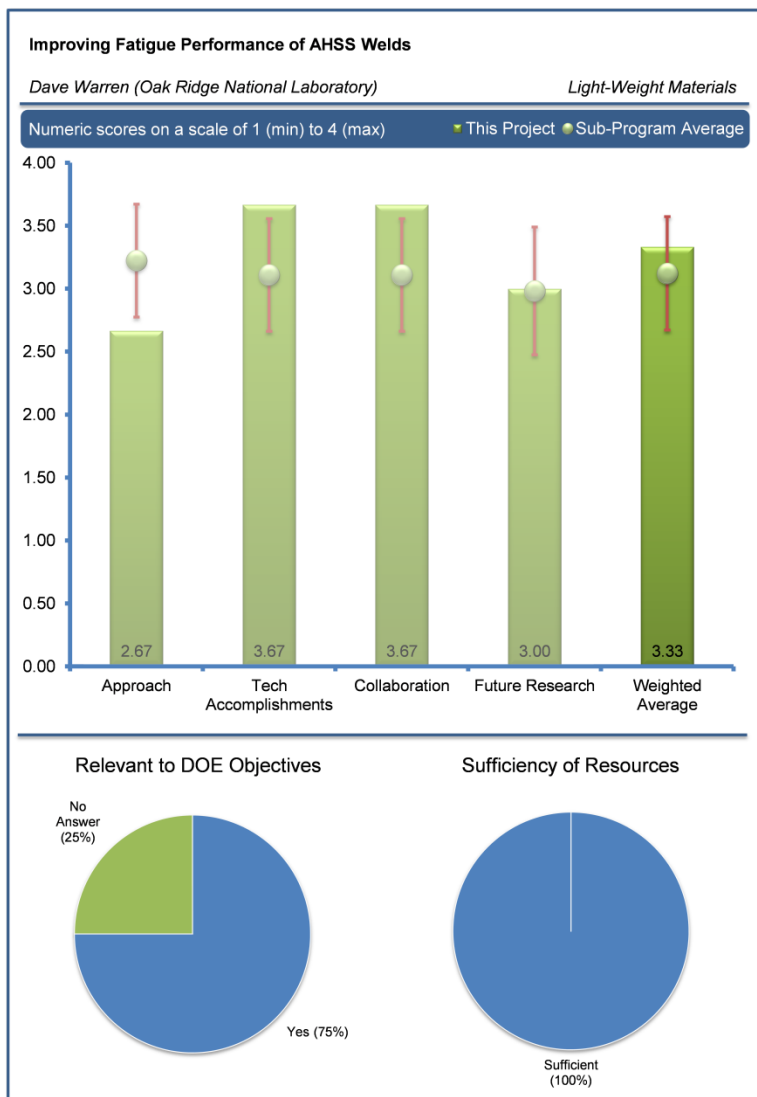
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that the project was a good accomplishment; the best is yet to evolve.

Reviewer 2:

The reviewer indicated that there appears to be good progress in developing new low transformation temperature (LTT) filler wires. The reviewer added that the investigator claims to have identified a new method to control the stress distribution at the weld beginning and end (but what the method is and its robustness are not explained).



Reviewer 3:

The reviewer stated that since the project timeline appears to have slipped by 7 months in the last 12 months since the 2012 AMR, the reviewer presumes the progress is less than half the expectation. At the 2012 AMR the Year 2 (3/12-2/13) milestones were already started and now in this 2013 AMR the Phase 2 (3/12-9/13) are the identical milestones and are listed as in progress. The reviewer pointed out that there is good evidence of some progress on residual stress measurement and some data on weld fatigue life testing. The reviewer said that the influence of the start and stop region is mentioned but not quantified. The reviewer said there are clearly issues with measuring the residual stresses in the weld toe. The reviewer concluded that the digital image correlation (DIC) information is not clearly identified as valuable.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer commended a great project team; the vertical structure always yields positive results.

Reviewer 2:

This reviewer stated that it appears the major participants have clearly defined roles and are actively participating.

Reviewer 3:

This reviewer indicated that the collaborators are certainly the correct gang to tackle this problem. The reviewer added there is insufficient information on the work at Colorado School of Mines so it is difficult to evaluate the effectiveness of the collaborations.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said the plan is great, execution and cost effective implementation are the next steps.

Reviewer 2:

This reviewer stated that the basic plan is sound to demonstrate technical feasibility; however, the reviewer felt it is overly optimistic to think that the project team will be ready to develop robust guidelines that could be applied widely in automotive body structure fabrication, based on what appears to be only coupon level and limited component testing.

Reviewer 3:

The reviewer stated that this is difficult to rate because the future work in this 2013 AMR are the identical tasks identified as future work a year ago at the 2012 AMR. The reviewer added that the task list sounds good, but there is little evidence of any effort or concepts addressing the welding process control aspects.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that this project incorporates a couple of novel approaches that will allow the auto companies to take more complete advantage of the added strength of AHSS. The reviewer added that this will enable more widespread use to reduce vehicle mass.

Reviewer 2:

This reviewer remarked that AHSS is a significant part of the multi-material architecture of the future.

Reviewer 3:

This reviewer said that fatigue capacity and residual stress control is critical.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer indicated that the money appears to be okay but the lack of progress over the last 12 months indicates to the reviewer that something is not going right. The reviewer stated the project leaders need to be forthright about the resources, technical difficulties or whatever has delayed progress.

Microwave Assisted Plasma Processing of Carbon Fiber: Felix Paulauskas (Oak Ridge National Laboratory) - Im069

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer commented that the approach is solid and attacks a key element of CF cost.

Reviewer 2:

This reviewer indicated that the microwave assisted plasma (MAP) process looks very promising; however, the potential for atmospheric processing should be the primary focus. The reviewer stated that this project is an excellent body of work and should be continued, with excellent science and parallel process development.

Reviewer 3:

The reviewer was not quite sure if working on this topic is justified; based on CF cost analysis, its total cost impact is 14 %

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that smart people always make good progress.

Reviewer 2:

The reviewer observed that assuming the properties presented are repeatable, this process offers a lot of potential for improved properties, supplementing the cost savings work, which is part of the LCCF projects at ORNL.

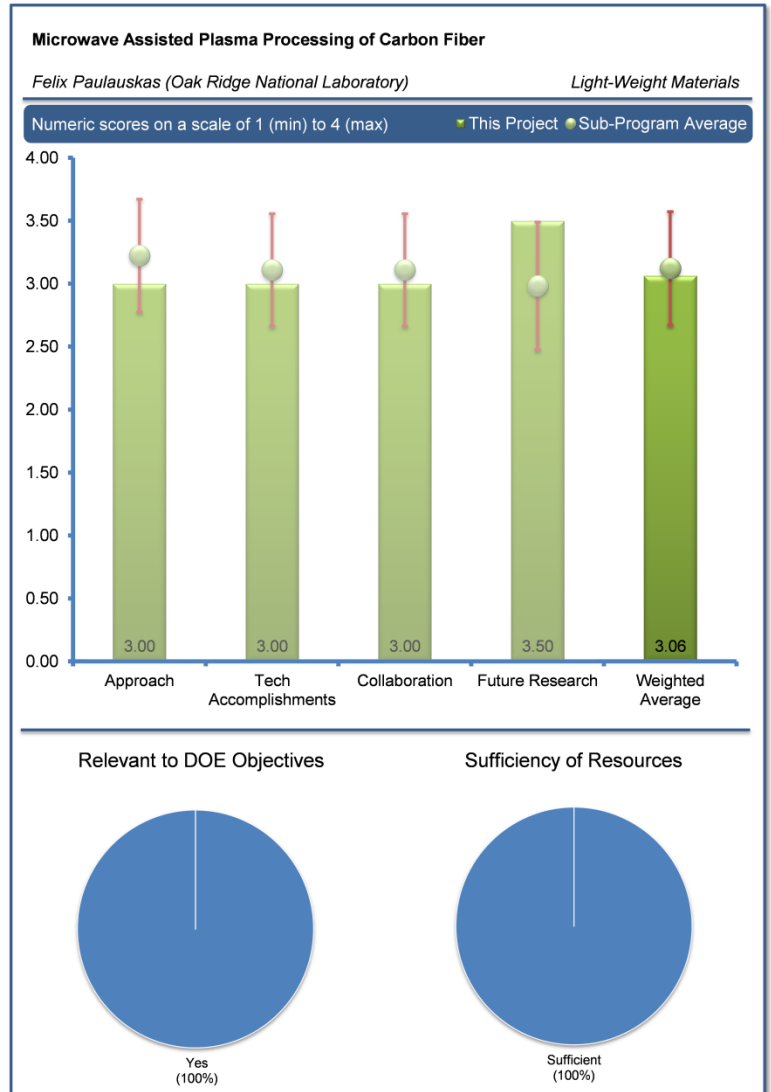
Reviewer 3:

The reviewer indicated that recent results appear promising, but there are still significant barriers that need to be addressed (i.e., varying tension in tows).

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that continued collaboration with plasma supplier should occur.



Reviewer 2:

The reviewer indicated due to export control, it is understood that collaboration is limited, but is still respectable.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that the outline of future work is right on track. The reviewer is looking forward to positive results from the next phase of the project.

Reviewer 2:

The reviewer stated that the project team should consider future funding to integrate this project into the CFTF, scaling this project is the next step and worth exploring.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer indicated that this project is in line with DOE's efforts to develop LCCF for lightweight structural applications for automotive and other industries.

Reviewer 2:

This reviewer observed that this project directly feeds the vehicle lightweighting initiatives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said this project looks to be well funded and should continue.

Vehicle Mass Impact on Vehicle Losses and Fuel Economy: Barney Carlson (Idaho National Laboratory) - Im070

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer indicated that many aspects were considered in setting up the experiments; care had been taken to account for variability and impact of many variables which can affect the results. Also, the reviewer stated even though the addition or removal of the weight is not explained properly the vehicle level was maintained closer for all weight conditions.

Reviewer 2:

The reviewer remarked that the experiment design was great. The reviewer emphasized the need to know versus believe.

Reviewer 3:

The reviewer stated that this project is a good parallel study to what the OEMs currently do, and it helped to confirm what is known about weight reduction for an internal combustion engine (ICE), hybrid, and battery electric vehicle (BEV).

Reviewer 4:

This reviewer noted this project was a very complicated topic to address.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

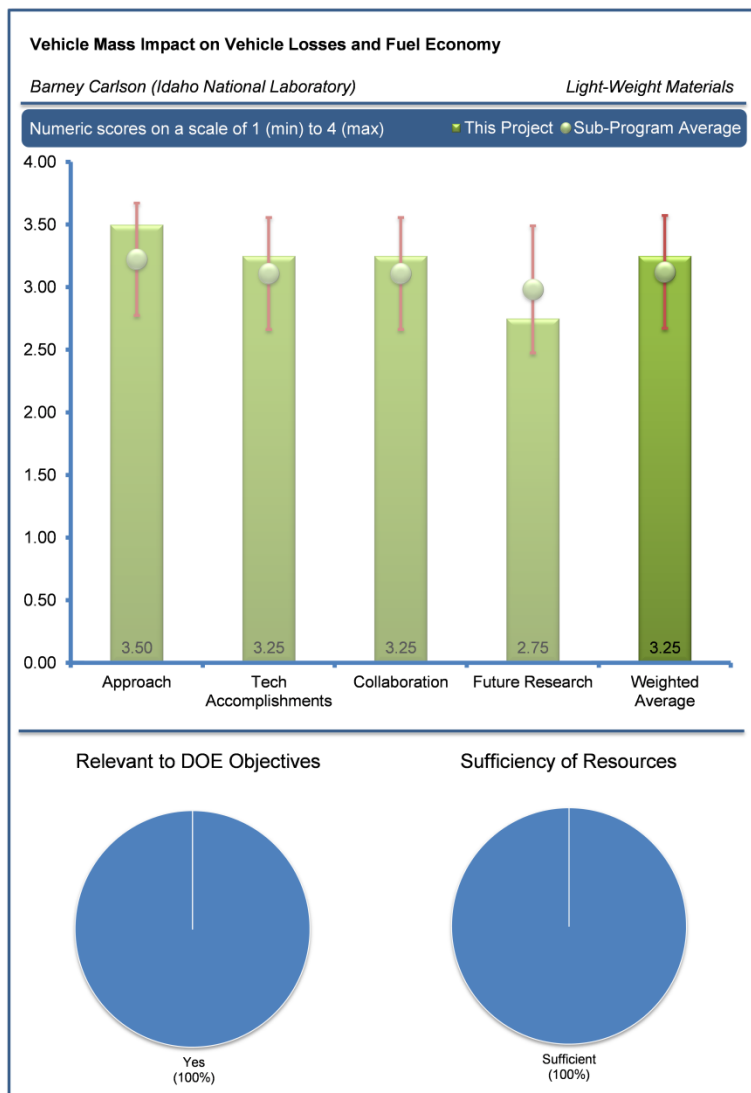
This reviewer commented that this project was a good body of work and met the DOE objectives.

Reviewer 2:

This reviewer said good effort.

Reviewer 3:

This reviewer commented that the results have proven the earlier empirical studies on the benefits of light-weighting. The reviewer that said it is significant to see even EV or hybrid powertrains can benefit from lightweighting even though less compared to ICE.



Reviewer 4:

The reviewer said the barriers were low but were overcome. The reviewer strongly encouraged determining the impact of transmission and rear axle fluid as well as the effect of ethanol.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated that a research study of this nature has involved many participants, including OEMs who had provided test tracks and facilities.

Reviewer 2:

This reviewer said good collaboration; however, these vehicles are now outdated, in other words, the fusions tested are the older versions, with the new one offering significantly better FE using engines that are downsized and boosted.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said that the project is complete and that no new funding is being requested.

Reviewer 2:

The reviewer strongly encouraged evolving the test protocol to determine the effect of temperature pre-conditioning of transmission and differential fluids. This is a significant contributor. The reviewer questioned why BMW uses radiator fluid to control transmission oil temperature. The reviewer noted that for BEVs we need built-in preconditioning of the drivetrain fluids. The reviewer stated that the impact may be as much as 12% increase in range or FE, specifically at highway speeds

Reviewer 3:

This reviewer remarked that the Idaho National Laboratory (INL) is encouraged to continue to develop expertise in accurate testing and measurements of FE, but discouraged from modeling and making forward product assumptions on FE, emissions, etc. The reviewer added the project team might want to consider these vehicles as benchmarked and accurately measured. The reviewer said to now use them to evaluate specific changes like use of low rolling resistant tires, air flow shutter, etc. (i.e., ancillary adds to a vehicle that should improve FE).

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said absolutely, with emphasis.

Reviewer 2:

This reviewer stated understanding the effect of many driving variables and light-weighting on the fuel/range efficiency is important. This will help policy makers to develop regulations reflecting reality.

Reviewer 3:

The reviewer commented that this project does contribute to our understanding of mass versus FE.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer stated that any additional funding should secure input from OEMs on what needs to be measured.

Analysis of Casualty Risks by Vehicle Type and Make: Tom Wenzel (Lawrence Berkeley National Laboratory) - Im071

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this was a good approach on comparing insights from two different, both reasonable, statistical studies. The reviewer noted that the project team needs more efforts in separating weight from footprint. The reviewer then asked since they are so well correlated in the fleet at this time, can the results be statistically separated with high confidence.

Reviewer 2:

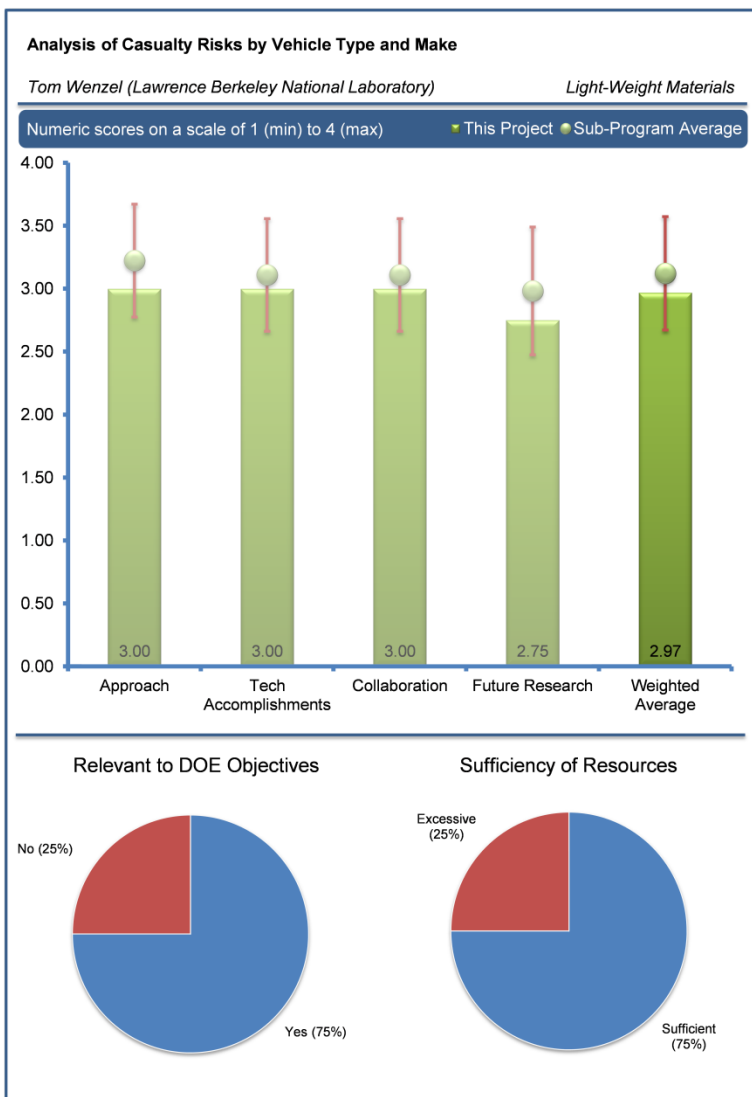
The reviewer said that the project is a statistical analysis to study the effect of light weight and fatalities. This reviewer noted that even though the data available is very limited the study concluded light-weighting has minimal risk, which is outweighed by other factors such as drivers, night driving, etc.

Reviewer 3:

Though the overall approach of the work is very good, the reviewer would have liked to see fewer variables. This reviewer explained that the more variables one has, the more multi-correlations one has, and the more difficult they are to give a clear picture of the sought-after effects. In the reviewer's mind, every effort should be made to limit the number of variables, and when a variable can be replaced by a measurement, then the measurement should be used as a parameter in the fitting. For instance, the reviewer does not understand why the weight should be a variable. The reviewer is convinced that there were other variables that could be replaced by parameters.

Reviewer 4:

This reviewer remarked that the methodology of this study does appear to be improved over the previous study; however, the reviewer failed to see how an estimate of how changes in weight and size of past vehicles will enable National Highway Traffic Safety Administration (NHTSA) and the U.S. Environmental Protection Agency (EPA) to set new vehicle standards that will encourage down-weighting of vehicles without affecting safety, or how such standards would encourage manufacturers to use advanced lightweight materials to reduce new vehicle weight without necessarily reducing size. Additionally, the reviewer noted that if the study did show a correlation between risk and reduced mass and/ or size, it would simply encourage consumers to buy larger, and/or heavier vehicles, which is contrary to DOE's desire to increase vehicle efficiency. The reviewer commented that if the study does not show a correlation (as is the case) it provides no motivation for consumers to buy smaller or lighter vehicles.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer remarked that the regression analysis is very systematic and thorough. The reviewer added that the results were confirmed by other studies and have been used for EPA regulation for future vehicles.

Reviewer 2:

The reviewer said that the project team made good progress completing the 2012 reports and updates. Additionally, the reviewer said the project is on track with the deliverables.

Reviewer 3:

This reviewer observed that much analysis has been completed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer remarked that the effort to collaborate with other agencies should be commended and encouraged.

Reviewer 2:

This reviewer stated that the project has worked or consulted with many regulating agencies, including EPA and NHTSA.

Reviewer 3:

This reviewer commented that the list of collaborators is strong. The reviewer would like to see more details on the deliverables and the gives and gets from each of the collaborators.

Reviewer 4:

This reviewer commented that although close work with NHTSA and EPA is cited, it is not apparent what those groups contributed to the project. The reviewer added that it appears that the work was done for them rather than with them.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer remarked that the proposed work for the last portion of the project appears to accurately address the most pressing needs. The reviewer wanted to see more details on what other statistical analyses could be done to illuminate the study of risk after vehicle redesign.

Reviewer 2:

This reviewer thinks that such a study should be continued with premises to be revisited.

Reviewer 3:

This reviewer stated that further analysis needs to be done to confirm or correct discrepancies.

Reviewer 4:

The reviewer pointed out that the study has shown that the effects of mass and/or footprint are negligible, especially in comparison to several other factors considered. Thus there is no apparent reason to continue a study that appears to be trying to create a simple (and assumed negative) correlation, where none actually appears to exist.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said absolutely, and further effort ought to be considered.

Reviewer 2:

This reviewer remarked that this project is an important adjunct question on how lightweighting effects society.

Reviewer 3:

This reviewer stated that it is necessary to know the implication of strict fuel efficiency rules which may call for lightweighting. The reviewer remarked that if lightweighting causes more fatalities it will be counterintuitive to call for such action. The reviewer commented that this study reveals no significant increase in risk of fatalities due to lightweighting by analyzing actual accident data.

Reviewer 4:

The reviewer described this study as a lose-lose proposition for DOE. The reviewer added that if the study did show a correlation between increased risk and reduced mass and/or size, it would simply encourage consumers to buy larger, and/or heavier vehicles, which is contrary to DOE's desire to increase vehicle efficiency. The reviewer said that if the study does not show a correlation (as is the case) it provides no motivation for consumers to buy smaller or lighter vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer said that the presenter did not complain about the level of funding (i.e., the funding is sufficient).

Reviewer 2:

This reviewer said resources appear to be sufficient.

Reviewer 3:

The reviewer opined that spending close to \$1 million on this study is not a reasonable use of funds that could have been better spent on researching technologies that could improve vehicle efficiency.

Multi-Material Lightweight Prototype Vehicle: Tim Skszek (VEHMA) - Im072

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the multi-material design is the way to go.

Reviewer 2:

The reviewer stated that there was a massive amount of information for delivery in 20 minutes. The reviewer added that the project team seems to know what they are doing and have people on board to cover all the technical areas. The reviewer likely would be able to give this a four if the reviewer had more information.

Reviewer 3:

The reviewer stated that it was outstanding; however, with such a huge program, the presenter could only keep summarizing the accomplishments, not only during the presentation but also in the slides. The reviewer remarked it would be better for DOE and the Principal Investigator (PI) to agree on a subject, i.e., say joining, and let the PI delve into that particular sub-subject.

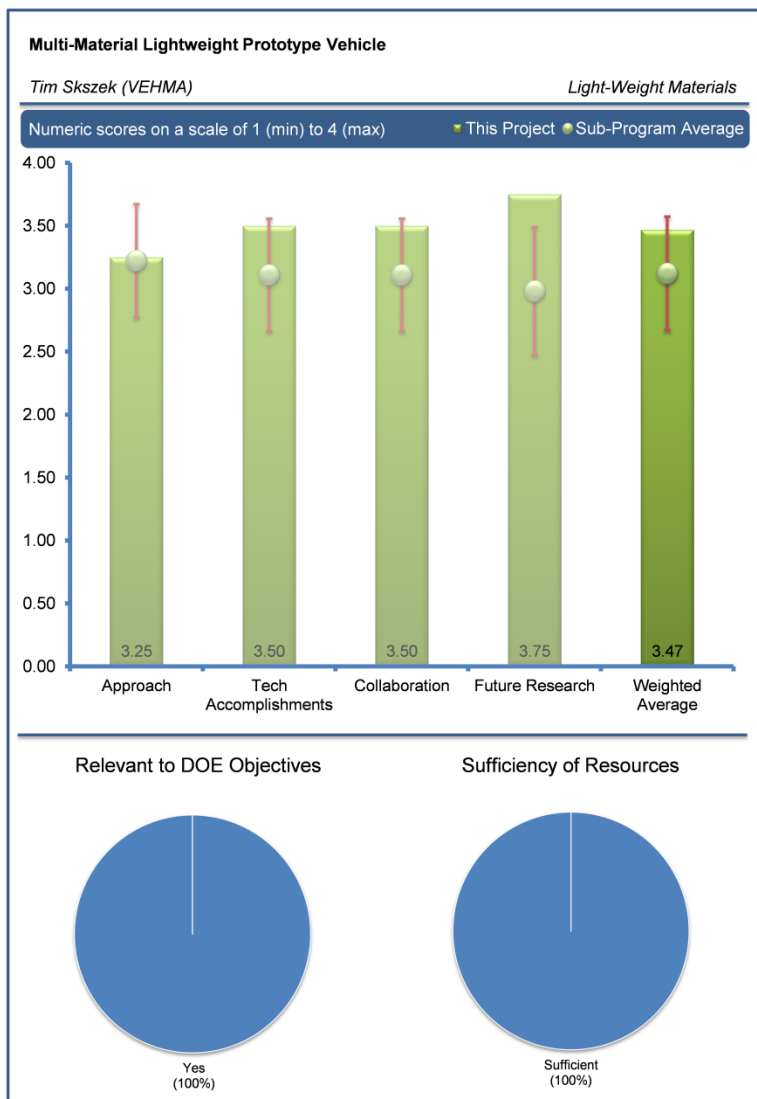
Reviewer 4:

This reviewer stated that while being a good and ambitious plan, demonstration of mass savings falls short of the 50% mass savings targeted in the original funding opportunity. Also, the reviewer said the Mach I design is aimed at only a 37-40% mass reduction. In addition, the project team has given themselves a 10-12% buffer due to using a 2012 vehicle as the starting point for the prototype. Thus, the target has been reduced to only a 25-30% mass reduction. The reviewer added that the Mach I also plans to use many current technologies (Al and AHSS materials, conventional joining methods, etc.) rather than pushing the technology envelope. The reviewer stated that there is no indication that the Mach II design (aimed at a 50% mass savings) will be anything more than a (concept) paper study. Thus, there will be no way to evaluate the accuracy of the projected weight savings or performance of that vehicle. The reviewer stated that such a study can be done today. The reviewer said that there was no mention of a cost assessment. If one is not included in the work plan, it should be added.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said that the project sounds very impressive.



Reviewer 2:

This reviewer indicated that Mach 1 only achieved 22% mass reduction. The reviewer added that the original Funding Opportunity Announcement (FOA) called for the build of 50% mass reduction vehicle. The reviewer stated that the current build of 22% is way below the original goal. The technologies chosen in Mach 1 build are essentially all in commercial production. Therefore, there is very limited learning in Mach 1 build and test. The reviewer then added that although the Mach 2 is targeted for 50% mass reduction, it will not be built and tested (unfortunately).

Reviewer 3:

This reviewer remarked that although much progress has been made in executing the project as designed, the basic plan is flawed in that it does not strive to demonstrate a 50% mass savings.

Reviewer 4:

This reviewer commented that if past performance indicates future productivity, the fact that the project team has met their marks so far is good. The reviewer observed that there was not much indication in the presentation or in the unbelievably dense overheads to be able to predict how well the project team will do going forward as things get more complicated. The reviewer commented that the project team seems to be making their marks. The reviewer was unaware of the scope of the project, specifically whether the project team needs to address if this one-off development needs to be demonstrated as viable for mass production, which would be a concern.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer stated that it was good to note that the project team reports no hang-ups due to collaboration issues and shortcomings.

Reviewer 2:

This reviewer indicated that the project appears to have well-coordinated and integrated activities at Ford and Vehma. The reviewer noted that it also appears there are numerous suppliers involved, but it is not clear to what extent they are contributing.

Reviewer 3:

This reviewer found it somewhat bothersome that only Ford is present as a participant. The reviewer stated that this probably reduces the extent of the overall finding for such a project. Also, the reviewer added that to be fair, DOE should consider similar projects with the other car makers.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer indicated that the project seems to be comprehensive and added that more information on the Mach 2 would have been useful.

Reviewer 2:

This reviewer stated that a logical and thorough plan has been laid out to deliver Mach I prototypes; however, the project fails to be aggressive enough to reach a 50% mass save as specified in the original Funding Announcement. The reviewer added that the plans do not appear to include an assessment of cost impact of the Mach I or Mach II lightweighting efforts. The reviewer suggested that it should include both to be complete.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer indicated that even a 25% mass reduction is significant in reducing energy consumption.

Reviewer 2:

This reviewer stated mass reduction.

Reviewer 3:

This reviewer said definitely, but as the car makers compensate the weight savings with comfort weight, one wonders.

Reviewer 4:

This reviewer commented that obviously for all the lightweighting work being done on various pieces, you need to put a whole car together to be able to address the various integration issues: dissimilar materials joining and corrosion, crash energy management, etc.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that the resources seem about right. The reviewer added that this project is going to be an expensive undertaking.

Reviewer 2:

This reviewer had no complaints, so it is adequate, but the reviewer is sure the project team could use more.

IR Heat Treatment of Hybrid Steel-Al Joints: Thomas Watkins (Oak Ridge National Laboratory) - Im073

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer commented that the project is aimed to measure the residual stress in a bimetallic component. The reviewer said that only one type of joint is considered and only one assessment technique, neutron diffraction, was considered. The reviewer added that it is better to test the freeform samples as well various process conditions to compare the stress development. The reviewer pointed out that another testing type needs to be used to confirm the validity of the new technique.

Reviewer 2:

This reviewer observed that the approach is missing a key aspect of incorporating bimetallic joints into lightweight vehicle design, corrosion. The reviewer remarked casting Al over steel has many strength advantages for mixed metal joining. The largest impediment has always been the corrosion performance of such a system.

Reviewer 3:

This reviewer stated that it is not clear what was done and what the findings have been. It appears that the entire purpose of the work was to exercise characterization tools formerly maintained by the High Temperature Materials Laboratory (HTML), without a vision for how the results would be used to increase the implementation of lightweight materials.

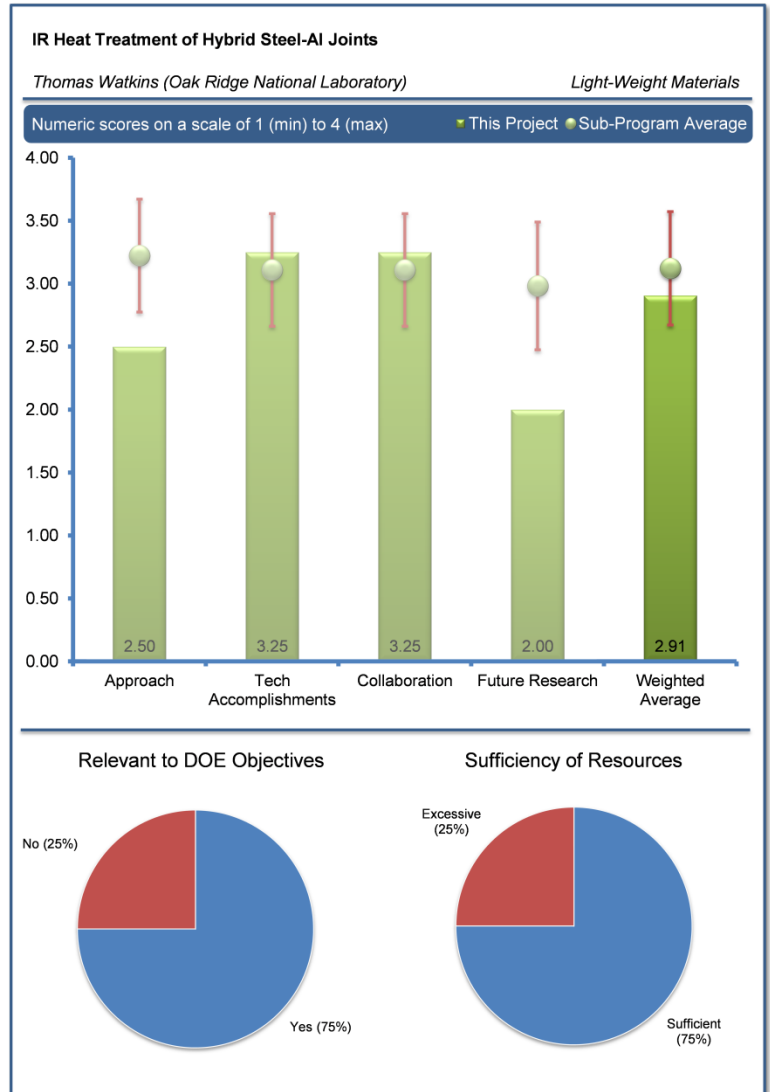
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer observed that strong progress has been made toward the stated goals. The reviewer stated that the neutron-based investigation of strains is particularly interesting. The reviewer wanted to see a bit more explanation, perhaps in the technical backup or reviewer slides of how the residual stresses were obtained. The reviewer pointed out that there should have been more information on the process for the high pressure die casting over the steel tube.

Reviewer 2:

This reviewer said that it is difficult to determine the progress from the limited information provided. This reviewer added that from comments during the Question and Answer (Q&A) it appears that it was determined that the Al is not simply a shrink fit on the steel tube, which could be a significant finding.



Reviewer 3:

This reviewer stated that the measurements are presented with some analysis. The reviewer added that comparing the results with another technique would be useful, and added that the effect of processing needs to be assessed.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer stated that the project team had good collaboration with their industrial partner.

Reviewer 2:

This reviewer stated that industry has provided actual test samples and that the interaction within the project team is good.

Reviewer 3:

This reviewer remarked that it appears that there was ongoing communication and coordination between Vehma and ORNL, but it is not clear how frequent the communications were. The reviewer said that because there are only two participants the reviewer would expect coordination would not be difficult.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer observed that insufficient information was provided to understand what additional modeling or joint characterizations will be done (or why or how).

Reviewer 2:

This reviewer said that no specific details were provided; if more testing methods were included, then it would have added value to the project.

Reviewer 3:

This reviewer remarked that it is not clear what the model development refers to. The presentation never discussed a model development or presented any model predictions. The future work on residual stresses is clear and necessary. The reviewer is curious why corrosion is not considered. The reviewer inquired if any work will address other bimetallic joints other than cast Al over steel sections.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer observed that bimetallic joints are a key enabler for lightweight designs.

Reviewer 2:

This reviewer stated that the manufacturing process can introduce defects or unwanted loading in the structures, which will influence the performance adversely. This reviewer pointed out that understanding the process and the structure conditions will help designers design good structures. Additionally, the reviewer said that bimetallic structures are necessary to reduce the mass of the vehicle structures, as this utilizes good properties of two different materials.

Reviewer 3:

The reviewer referenced the presentation, commenting that successful characterization of bimetallic joints will enable a 20% weight reduction relative to baseline steel, is not a realistic outcome of this project. The reviewer said that the ability to produce robust bimetallic joints may help reduce mass by easing the introduction of lighter-weight materials, but characterization of those joints will not reduce mass and will only be one small factor in introducing enough Al to enable a 20% mass reduction.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that resources appear sufficient for the study as described.

Reviewer 2:

This reviewer pointed out that \$1.4 million for characterization of a few joints, with no obvious path to using the method for anything but a laboratory exercise, is excessive.

SPR Process Simulation, Analyses, & Development for Mg Joints: Elizabeth Stephens (Pacific Northwest National Laboratory) - Im074

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer remarked that if heating is used for surface plasmon resonance (SPR), the reviewer would recommend working on Mg castings such as vacuum die cast AM60B, which the poor formability at room temperature is the limiting factor in SPR process.

Reviewer 2:

This reviewer indicated that the approach seems to take into account the major factors in the SPR process; however, the reviewer does not believe friction has been taken into account in the modeling. The reviewer added different rivet materials and/or rivet coatings will likely have different friction characteristics, which will influence such things as insertion force and joint performance. In addition, the reviewer stated that simply modeling the insertion process without modeling the performance of the joint will only answer half of the question of how good the joint is. Regardless of the aspects modeled, the project should include extensive testing to validate modeling predictions. The reviewer suggested that the project should also consider additional materials for the rivet and the materials to be joined. For example, Mg casting is much more prone to die-side cracking than is Mg sheet, which is the only material that currently appears to be modeled.

Reviewer 3:

This reviewer indicated the project needs to have more clearly defined objectives and deliverables. The general objective statement of, providing a reliable joining mechanism, and deliverable statement of, characterize the joint performance, is so broad it is difficult to judge the quality of the approach. The reviewer added that for SPR joints in Mg-to-Mg and also Mg-to-non-Mg stacks, a critical performance attribute is galvanic corrosion. In addition, the reviewer said that while the SPR process parameters are important to develop, a critical aspect of having SPR joints considered for automotive structures is the corrosion performance. The reviewer said that this must be explicitly described in the objectives, deliverables and approach.

Reviewer 4:

This reviewer stated that it was very hard to tell, as the project team has made so little progress doing actual work on the project. This reviewer added that the pretty pictures generated by finite element analysis (FEA) are fine, but reviewers have no way to know if the project team is on the right track even with this work.

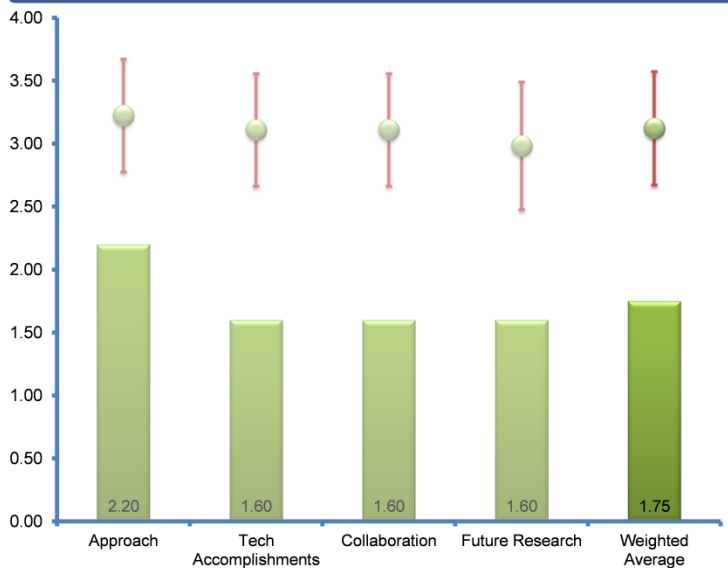
SPR Process Simulation, Analyses, & Development for Mg Joints

Elizabeth Stephens (Pacific Northwest National Laboratory)

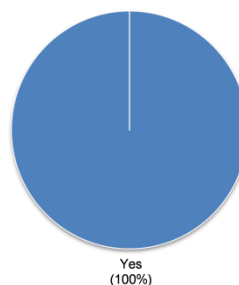
Light-Weight Materials

Numeric scores on a scale of 1 (min) to 4 (max)

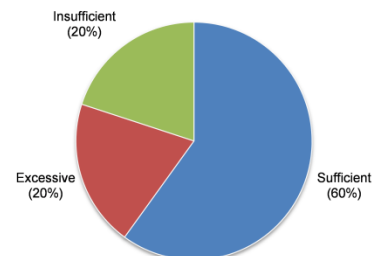
■ This Project ● Sub-Program Average



Relevant to DOE Objectives



Sufficiency of Resources



Reviewer 5:

This reviewer stated that the project team had a very poor approach.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said the project team had good progress in simulations and preliminary testing, for the limited time the project has been underway. This reviewer looks forward to seeing the results of Phase Two and the complete Phase One.

Reviewer 2:

This reviewer indicated that the accomplishments in this first year of efforts are strong in FEA models. The finite element method (FEM) analyses show that the SPR and clinching processes can be modeled effectively in LS-DYNA. The reviewer said that there is strong progress on the tools and initial efforts to characterize the process. The reviewer remarked that hopefully, the tool will correlate with the tail cracking. The reviewer advised that future efforts should also address the strength and fatigue performance of these joints. This reviewer further noted that the first room-temperature joints and observed tail cracking have been made. This reviewer said that there have been no accomplishments on the corrosion performance of the SPR joints. If corrosion is not part of the project, then this should be clearly stated. This reviewer considers corrosion a key aspect of the characterization of the joint.

Reviewer 3:

This reviewer said the project had only modeling results so far. The reviewer stated that heating mechanisms need to be defined as soon as possible.

Reviewer 4:

This reviewer pointed out that there was very little to report.

Reviewer 5:

This reviewer remarked that the project had a very slow start, which puts the whole timeline in jeopardy.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer pointed out that there is no explicit discussion of the collaboration. The reviewer added that as the project develops, it will be important to track the roles and responsibilities for process development, joint testing, joint analysis, strength predictions and testing, fatigue predictions and testing and corrosion predictions (hopefully) and testing.

Reviewer 2:

This reviewer noted Stanley and PNNL.

Reviewer 3:

This reviewer indicated that the work seemed to be very much dominated by PNNL. It is not apparent to what extent Emhart has been actively involved or contributing.

Reviewer 4:

This reviewer said that the project took a long time to reach a Cooperative Research and Development Agreement (CRADA).

Reviewer 5:

This reviewer indicated that a project where the two principals take two years, half the term of the project, to simply get a legal agreement in place, is extremely troubling. The reviewer added that doing clinching research where it is apparent that PNNL thinks that is a waste of time is doubly-so.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer remarked that the project team needs to include Mg castings, Mg-to-Al, and Mg-to-steel joining.

Reviewer 2:

This reviewer observed that the partner was considering clinching, which is outside the scope of SPR.

Reviewer 3:

This reviewer stated that the plan should be expanded to include prediction (and verification) of joint performance and influence of rivet coatings, more alternative rivet materials, and different materials to be joined. For example, different Mg forms and the addition of Al alloys.

Reviewer 4:

This reviewer said that the future work does not address what this reviewer sees as the critical aspects of SPR joints in Mg. The reviewer added that the process parameters are probably adequately addressed, though the future work slide is not clear on this point. However, the lack of even mentioning the strength, fatigue and corrosion performance is troubling.

Reviewer 5:

This reviewer stressed that everything appears to be in the future.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer stated that joining techniques that work between Mg and other metals are obviously going to be needed going forward.

Reviewer 2:

This reviewer remarked that SPR is a mainstream joining technique for joining many lightweight materials. This reviewer added that being able to model and optimize the rivet and die geometry and material temperature without extensive testing for each new joint configuration will enable much more widespread application of those lightweight materials.

Reviewer 3:

This reviewer said lightweighting with Mg.

Reviewer 4:

This reviewer observed that the joining of Mg components, especially to steel and/or Al components, is a critical enabler for further weight reduction in automotive body, chassis and interior components. The reviewer remarked that if this project is only to develop and validate a LS-DYNA model, then it is not as relevant as the objectives imply.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that there seems to be adequate funding and resources to attack this problem.

Reviewer 2:

This reviewer stated that the project seems to be scaled to fit the funding available rather than providing the funding that is needed to do a thorough job of being able to predict performance of SPR joints. Thus, the results will be limited to simply gaining some fundamental knowledge about how well the SPR (or clinch) flares and fills the die, which will have only limited influence on increasing the use of lightweight materials.

Reviewer 3:

This reviewer indicated that there are better ways to utilize the limited resources of the DOE labs.

High Speed Joining of Dissimilar Al Alloy TWBs: Yuri Hovanski (Pacific Northwest National Laboratory) - Im075

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer commented that this project is definitely one of the best projects of the 2013 AMR.

Reviewer 2:

The reviewer remarked that this is an excellent project with it representing the next generation to tailor welded blanks. The reviewer added that friction stir welding (FSW) is ideally suited for making tailor friction welded sheets and will have a significant impact on future Al usage in the automotive industry.

Reviewer 3:

This reviewer indicated that the approach to this project attacks the critical factors of joining dissimilar Al sheets. The reviewer added that the approach is staged to gain confidence on the easier joints and build on lessons learned to attach more difficult joints. The reviewer particularly likes the Task 3 and Task 4 efforts to get to a production capable system with an industrial supplier.

Reviewer 4:

This reviewer stated that the project team seems to have a good matrix for testing performance. The reviewer added that it would be great if the project team manages to down select one welding technique that will work at high speed production.

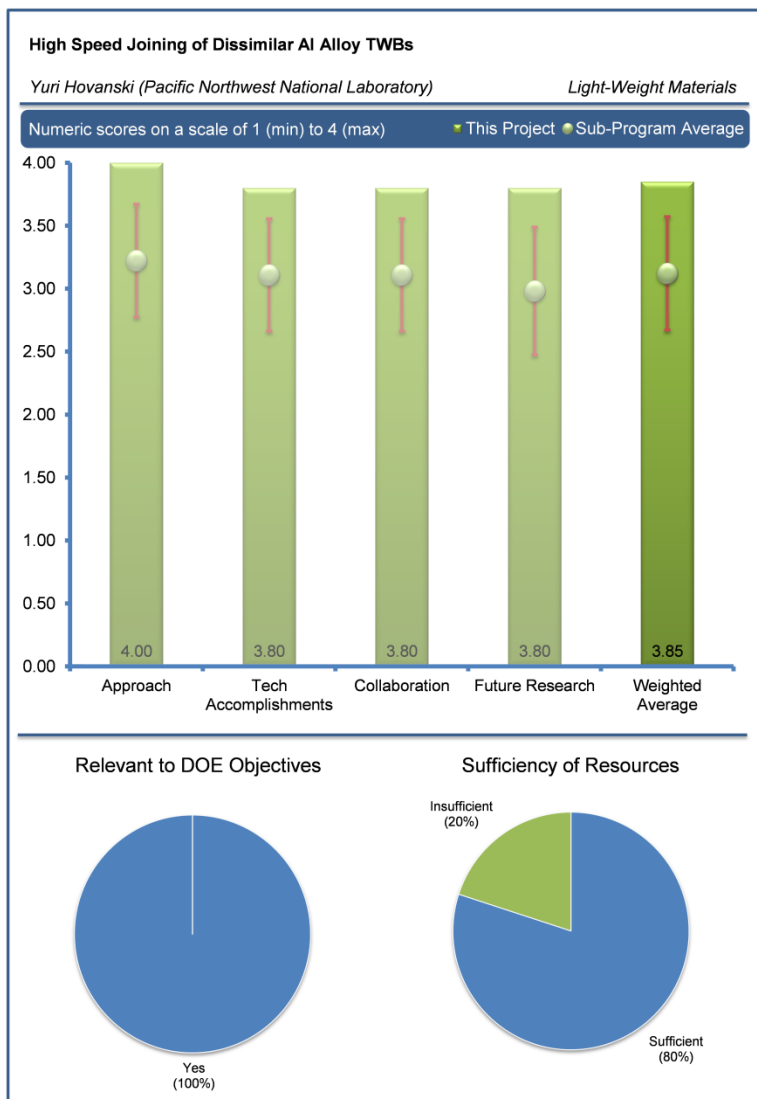
Reviewer 5:

This reviewer stated that it seems like a well-organized and focused project with a pretty realistic approach, although the reviewer wonders if the supplier cost modeling may be too optimistic.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer noted that the progress reported at this AMR is outstanding. This reviewer added that the dome testing and Taguchi Design of Experiment are combining to yield impressive results. The reviewer also said the characterizations of the weldments are also significant accomplishments.



Reviewer 2:

This reviewer observed that the scope and breath of materials, gages, and joining techniques is impressive and well throughout. The reviewer then said the post-testing at GM is an excellent verification of properties.

Reviewer 3:

This reviewer indicated that the project looks very good; hopefully, in the next phase the team can try to move beyond lab specimens and onto more production representative geometries.

Reviewer 4:

This reviewer stated the project is good so far.

Reviewer 5:

This reviewer said very good progress.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer observed an excellent vertical alignment of participants (i.e., OEM, PNNL, Material Supplier, and Tailor Welded Blank Supplier).

Reviewer 2:

This reviewer noted that the project looks very good from the reported activities. In addition, the reviewer stated that the non-destructive testing (NDT) work at Mississippi State University is very interesting and appears to show promise for better quality in production (always an issue in any welding-related process).

Reviewer 3:

This reviewer commented that there were clear, appropriate roles, responsibilities and deliverables from each of the collaborators.

Reviewer 4:

This reviewer stated that there was a bit of a disconnect (on purpose) on selecting welding technique, but perhaps that was for the best in that the partners stayed in their technical space.

Reviewer 5:

This is a CRADA and limited collaboration; however, the project has all of the right players in the mix to deliver this technology.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer noted that within the existing project plans, the current results and future plans are excellent. The reviewer suggested that the project team might consider adding sheet dimensional control after FSWing.

Reviewer 2:

This reviewer commented that the project team had an excellent plan for the future, and that the project team needs to consider an identical Mg program using ZEK100.

Reviewer 3:

This reviewer said the project looks good.

Reviewer 4:

This reviewer said that the project team had an ambitious schedule, and the reviewer hopes that all of the associated characterization is also going to be performed.

Reviewer 5:

This reviewer stated that the identified future work identically maps to the project plans.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer said absolutely, with emphasis.

Reviewer 2:

The reviewer commented that tailor welded blanks (TWB) are under-applied primarily because of the cost of the feedstock material, and if this project succeeds the project team will develop excellent insights into a viable high-volume production method.

Reviewer 3:

The reviewer stated that this welding process shows real promise for joining certain types of lightweight materials, and that will be crucial in the eventual adoption of these materials.

Reviewer 4:

This reviewer observed that the tailor welded Al blanks are a key enabler to further weight reduction in automotive body and closure stampings.

Reviewer 5:

This reviewer noted that this project contributes to the enabling of more Al closures of near term future vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer commented that the project was well-run and organized, hitting milestones and within budget.

Reviewer 2:

This reviewer pointed out that the money and resources appear sufficient to accomplish the project deliverables. With the demonstrated progress so far, there is confidence that the project is appropriately resourced.

Reviewer 3:

This reviewer observed no problems.

Reviewer 4:

This reviewer remarked that the match is growing, which implies that the project team underspecified the budget.

Understanding Protective Film Formation by Magnesium Alloys in Automotive Applications: Kinga Unocic (Oak Ridge National Laboratory) - Im076

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer commented that the project had very detailed work to identify corrosion mechanisms in Mg. A little too focused on micro-details, but excellent work. The reviewer added that the project team needs to expand the area of characterization and look at the micro-phases and grain boundaries to understand the microcell corrosion. The reviewer went on to say that industry has a good handle on bulk materials corrosion, so to get into impedance spectroscopy, supplement the focused ion beam (FIB) and transmission electron microscope (TEM) studies, and continue to help us understand Mg corrosion as a function of impurities.

Reviewer 2:

This reviewer said that the corrosion film formation on Mg was analyzed. It will be useful to start the database with the bare unexposed Mg surface. The reviewer added that this was not mentioned in the presentation. Also, comparing the film formation in Al will be beneficial.

Reviewer 3:

This reviewer stated that the approach lacks an idea and vision. The reviewer queried where the project is going.

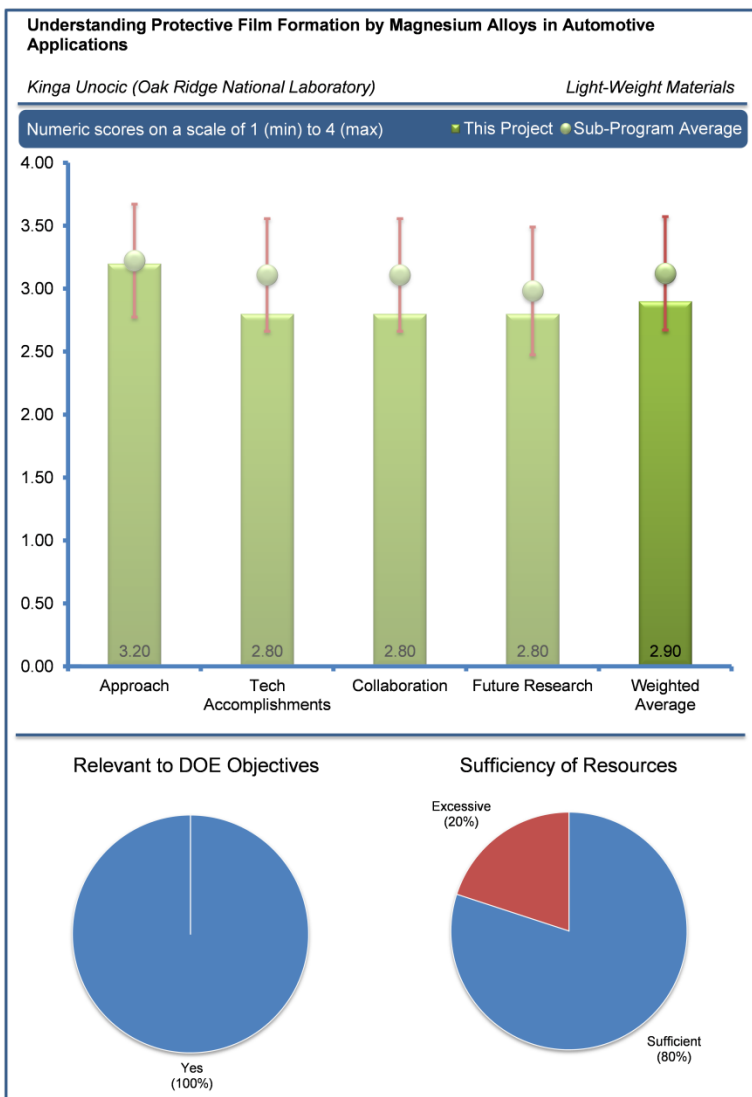
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer pointed out that the project team had excellent results and should consider expanding into impedance microscopy type analysis. The reviewer recommended not deviating from the current work, but focus on expanding characterization techniques. The reviewer also stated that the project team should consider Auger electron spectroscopy in addition to X-ray photoelectron spectroscopy (XPS).

Reviewer 2:

This reviewer noted that the project team has used multiple techniques to assess the surface film. The reviewer added that the project is quite elaborate and the information will provide understanding on the corrosion mechanism of Mg alloys. In addition the reviewer



said that the results are quite significant considering the project is only in initial stages; however, the interpretation needs to be more rigorous.

The following discussion is in reference to Slide 18. The reviewer noted that the top layer consists of magnesium oxide (MgO) and magnesium hydroxide (MgOH₂); this means the Mg is moving outwards from the metal surface as no Al or zinc (Zn) is detected here. The second layer is mixed with Al and Mg but no Zn. The reviewer questioned whether Zn diffuses inward as the corrosion process is progressing.

The reviewer stated it will be nice to see a non-corroded surface to compare the mechanism.

Reviewer 3:

This reviewer inquired about the reason for neodymium (Nd) segregation, and asked if this could be modeled. The reviewer also asked if models could be developed that could guide future development of Mg conversion coatings.

Reviewer 4:

This reviewer observed that it is early in the project, but results are minimal.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer commented that the collaboration was good, and that the project team should continue to solicit input from industry on what corrosion studies need to be undertaken and ultimately completed.

Reviewer 2:

This reviewer said that a material supplier is involved; for the basic research not many industrial partners are involved. The reviewer added that it may be useful to involve coating developers who may be interested to understand the mechanisms.

Reviewer 3:

This reviewer observed that the collaboration group is too small (ORNL and Magnesium Electron North America [MENA]).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer noted that continuing the current work is good. The reviewer said if bare Mg surfaces and some coated surfaces are included in the analysis, it will be useful for comparison purposes.

Reviewer 2:

This reviewer said that mechanistic understanding through modeling would be helpful. The reviewer added that the complex processes in this research are fertile ground for future research.

Reviewer 3:

This reviewer indicated that the project team needs to include a baseline of Al alloy and high pressure die cast (HPDC) Mg alloys (AZ91 and AM60) to understand the Al oxide film formation and effect of HPDC surface skin.

Reviewer 4:

The reviewer would like to see more baseline data on grain (matrix) corrosion, GAB corrosion, and then bulk materials corrosion. The reviewer stated that the project team should provide more information on starting grain size (GS), rolling direction and micro-alloy segregation, and the effects on MgO formation and corrosion.

Reviewer 5:

This reviewer commented that the goals and objectives were insignificant.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer commented that although indirect, this project allows a better understanding of corrosion, and thus find corrosion mitigation solutions that would enable more Mg materials application.

Reviewer 2:

This reviewer noted that Mg corrosion is an important issue to be resolved before it can be used extensively in vehicles.

Reviewer 3:

This reviewer stated that corrosion is a key roadblock for Mg applications.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer indicated that, for this level of detailed academic type of research, compared to other projects where tools are made, processes are developed, etc., this seems excessive for using existing characterization tools available.

Mg Intensive Vehicle Front End Sub-structure: Alan Luo (USAMP) - Im077

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer commented on the multi-material demo work, outstanding R&D plan, and very good comparison between high performance 6082 Al alloy and Mg alloy.

Reviewer 2:

This reviewer remarked that the project team has a good approach, but needs to show more focus on corrosion of joints and joining methods, such as the integration of International Computational Material Engineering (ICME) and use of demonstration component as a validation of ICME.

Reviewer 3:

This reviewer stated that while the overall approach is good, the linkages between different experimental and modeling efforts were not clear from the presentation.

Reviewer 4:

This reviewer noted that the tasks in creating a demo structure are fairly straightforward, and are well within the team's skill set. The reviewer would expect that some technical barriers will crop up, but the team seems aware of these and capable of overcoming them (maybe with some costly solutions if needed). The reviewer pointed out that critical issues for performance and life are being considered, including in the design of testing. In addition, the corrosion issues might need to be considered more carefully. The reviewer indicated that the joining issues are being considered, but no complete solution has been found. The reviewer stated that the long-term performance of these joints will be critical and is part of the project. The reviewer observed that the previous U.S. Automotive Materials Partnership (USAMP) projects (including many of the same partners) that have led to this project seem to have laid the necessary groundwork.

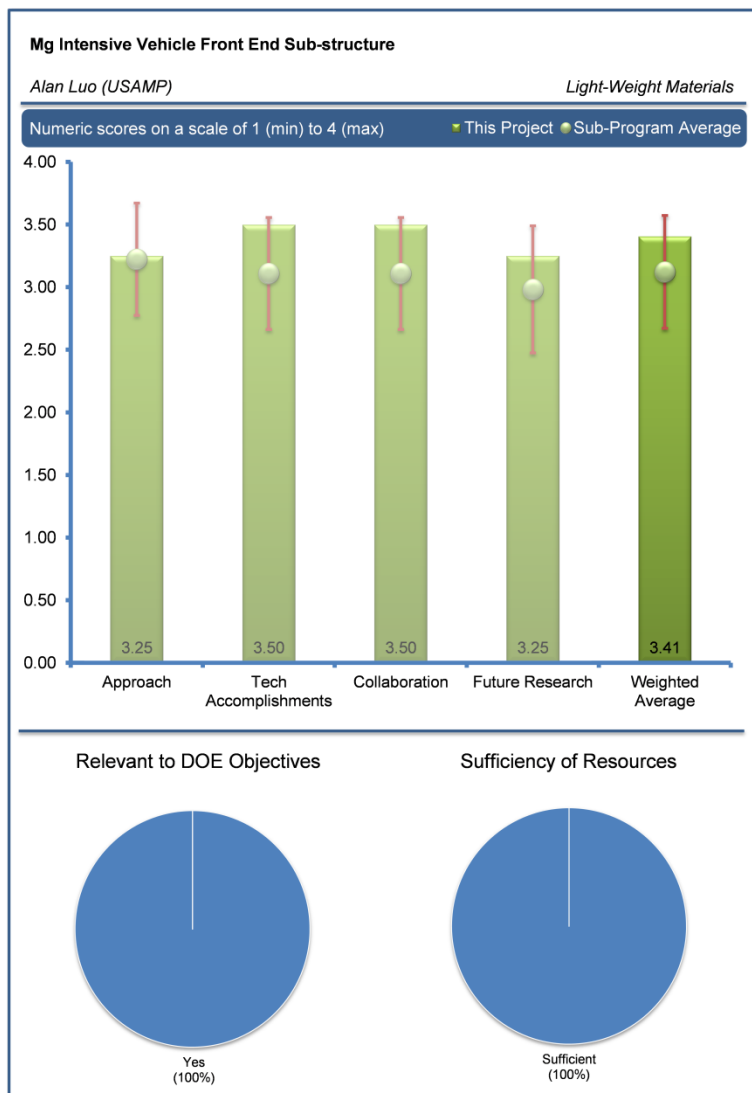
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer noted that the project seems to be ahead in the R&D plan and on target with budget.

Reviewer 2:

This reviewer said that as shown, the initial design is completed, and some of the coupon tests have been started.



Reviewer 3:

This reviewer indicated that some progress has been made, but mostly preliminary work. The reviewer added that this might just be a matter of careful planning that was being performed that shows little advancement of the goals for the amount of time spent, but will lead to large benefits as the project progresses. The reviewer said the actual joining process and methods still need to be solved this coming year.

Reviewer 4:

This reviewer stated that the project team needs to focus on corrosion of joints.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer noted that there was outstanding team and good international collaboration.

Reviewer 2:

This reviewer remarked that the team has long-term experience working together, and already has produced some parts for initial coupon testing.

Reviewer 3:

This reviewer commented that there was a large amount of partners, from OEMs to supply base to universities. This reviewer stated that the project team should be able to leverage partnerships in order to complete the scope, especially as there seems to be some scope growth.

Reviewer 4:

This reviewer said that there is an expansive collaboration listed, but the level of interactions was not well expressed.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that this project builds nicely on prior work and seems reasonable to complete. The reviewer said that an additional future work question that could be considered would be determining if there is any variation between suppliers, and if that will impact production.

Reviewer 2:

This reviewer noted that the proposed work for the coming year seems to be well-defined and appropriate; focusing on the coupon tests, joining issues, and fatigue. The reviewer said the ICME portion might be taking on too much, but would greatly benefit the overall goals of DOE. The reviewer stated that no specific decision points were presented, but some possible course corrections were given for the most likely problems.

The reviewer observed that the presenter seems to imply that new materials will be introduced. This reviewer warned that caution is required because dispersion implies shallowness.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said absolutely.

Reviewer 2:

This reviewer remarked that if the corrosion and multi-material challenges can be dealt with in a cost-effective way, this approach seems reasonable.

Reviewer 3:

This reviewer stated that the project is a practical step in the right direction to incorporation of multi-material structures into cars for lightweighting.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer indicated that the group seems to reach out to whoever is needed to answer relevant questions and has a broad contact base.

Reviewer 2:

This reviewer observed that, for the actual goals, the resources seem fine, but the ICME portion might eat some of the resources if not approached carefully.

Reviewer 3:

This reviewer has no complaint.

Reviewer 4:

This reviewer said that if the partnerships are leveraged appropriately that the project team should be able to accomplish milestones in a timely fashion. The reviewer would like to see how the partnerships are leveraged. The reviewer inquired as to who is contributing to what.

Aluminum Formability Extension through Superior Blank Processing: Xin Sun (Pacific Northwest National Laboratory) - Im078

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer observed that this was an excellent project and important for the manufacturing of Al.

Reviewer 2:

This reviewer noted that the project seems generally okay, but the reviewer would have appreciated an insight into the eventual applications of this work. The reviewer said that perhaps the level of the talk was pitched at too detailed a level for this review, but it may be that the reviewer was missing the point.

Reviewer 3:

This reviewer stated that the overall project seems okay and the modeling approach was clear, but the approach to integrate the modeling results to the experimental techniques was not very clear.

Reviewer 4:

This reviewer indicated that it was unfortunate that the details of how the geometry of the burr is being input into the model. The reviewer clarified that much of the technical details are not being presented.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

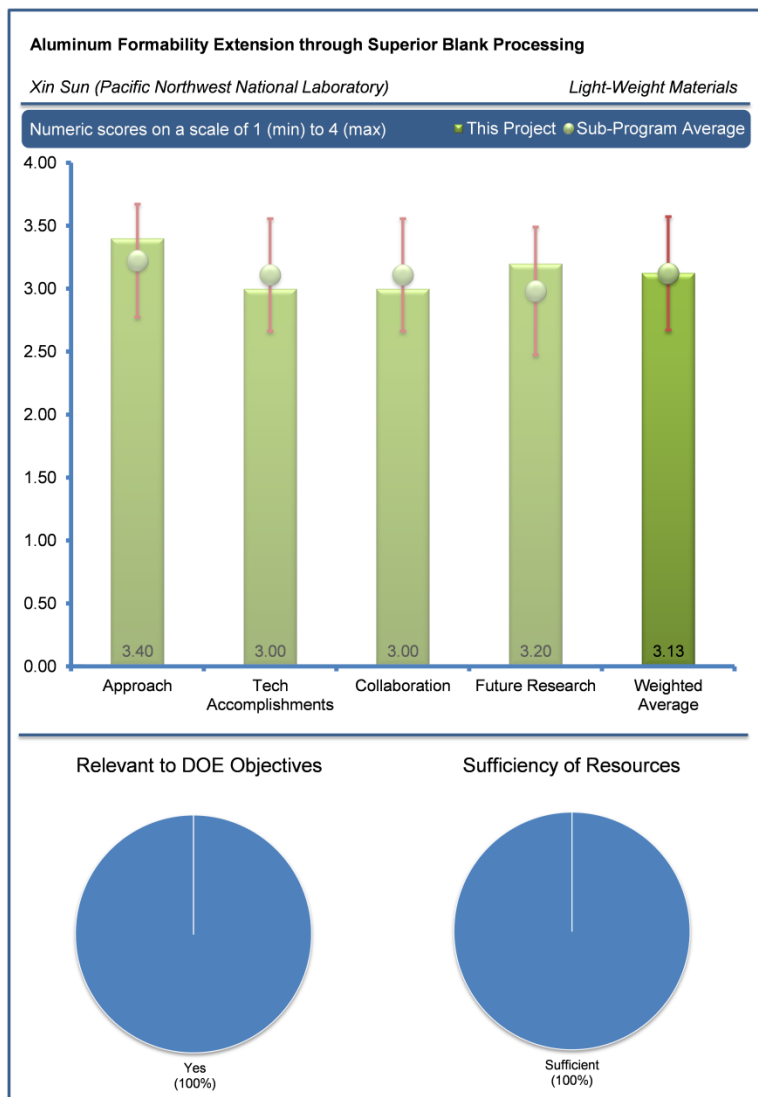
This reviewer indicated that there seems to be good technical progress to date (the presenter stated that project is ahead of schedule).

Reviewer 2:

This reviewer stated that the project was ahead of schedule and very detailed as far as results.

Reviewer 3:

This reviewer stated that there appears to be very positive patentable results. The reviewer added that this project should be a CRADA or Work for Others due to the content being proprietary information.



Reviewer 4:

This reviewer stated that the modeling efforts seem well integrated, but the reviewer has concerns that the resolution of the models may not be able to match the scale and complexity of the fracture surfaces.

Reviewer 5:

This reviewer stated it was difficult to assess the universality of the results and insights due to the lack of detail in the scientific process of putting the damage details into the model.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer said that it seems okay, but silo-ed.

Reviewer 2:

This reviewer indicated that collaboration is good, but it is regrettable that Ford is putting a lid on the results. The reviewer observed that, after all, a good part of the funding is done through public funding.

Reviewer 3:

This reviewer indicated that PNNL seems to be driving the efforts, but it did not feel like Oakland University and Ford were full partners.

Reviewer 4:

This reviewer said it seems okay. The reviewer added that the speaker kept alluding to other aspects of the progress but then did not discuss them, which was a bit tiresome.

Reviewer 5:

This reviewer said that the project appears to be a DOE subsidized research project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer stated that the project team is treating the important issues, but patent issues are getting in the way of doing a proper assessment.

Reviewer 2:

This reviewer stated that proposed future research was okay, but more emphasis on the eventual commercialization plan would have been worthwhile.

Reviewer 3:

This reviewer indicated that the future research seems well in line with the research that has been completed, but the details were not very explicit due to intellectual property (IP) concerns.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer observed that the link to petroleum displacement was not very explicit. The reviewer assumed the enhanced elongation will allow greater use, but this was not made clear to what degree.

Reviewer 2:

The reviewer noted there was a good analysis of a ubiquitous process.

Reviewer 3:

This reviewer said yes, no doubt about that.

Reviewer 4:

This reviewer said absolutely.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that there were no issues reported or observed.

Enhanced Room-Temperature Formability in High-Strength Aluminum Alloys through Pulse-Pressure Forming: Rich Davies (Pacific Northwest National Laboratory) - Im079

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer indicated that the project approach was very explicitly described and seems to line up with technical barriers.

Reviewer 2:

This reviewer noted that barriers have been identified, which is obviously important, but solutions to some of these barriers remain to be conquered. The reviewer stated that overall, the project appears to be using a good approach and making progress. The reviewer did not understand the reason for using a pre-forming approach. The reviewer doubted that a real part would ever use that method because of the poor control over final part geometry, and wondered if a more realistic approach would be to use a real die.

Reviewer 3:

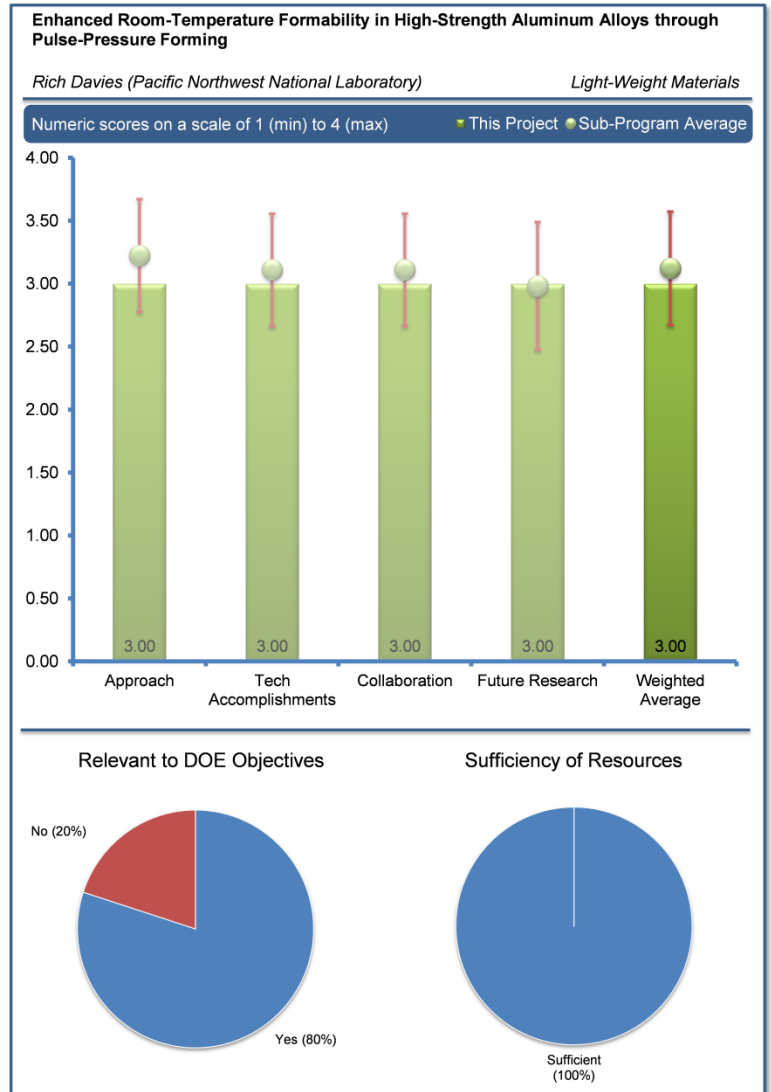
This reviewer indicated that pulse pressure forming using the dome test is interesting, but research to develop an understanding of high strain rate formability enhancement does not appear to have a real world application.

Reviewer 4:

This reviewer stated that this seems to be a proof of concept project, and it is not clear what the path is other than commercializing this form of pulse forming.

Reviewer 5:

This reviewer stated that there is a considerable amount of work in this field at some OEMs. This reviewer noted that this project is not about poor formability as much as an opportunity to enhance the formability of the high-strength (HS) Al alloys. The reviewer indicated that the project remains focused on formability analysis rather than process development. The reviewer stated the limiting factor in pulse pressure forming is the cost of the process and this is a much better project direction than to develop the formability studies.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said good progress.

Reviewer 2:

This reviewer said looks good, but some issues remain to be dealt with.

Reviewer 3:

This reviewer said with regard to the objectives, the project has focused on developing formability charts, but these already exist within some OEM's, for high strain rate formability. The reviewer advised the project team consider re-focusing future research on process development.

Reviewer 4:

This reviewer stated that alloy selection and process determination have been made, but it seems like most of the equipment seemed to be in place, so these seem like pretty modest goals.

Reviewer 5:

This reviewer stated that accomplishments are limited so far. This reviewer added that experimental setup is good, but nothing spectacular, and the project seems to be an assemblage of commercial off-the-shelf stuff.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer noted that the project had good engagement of selected OEMs that will learn from PNNL the limits of this process.

Reviewer 2:

This reviewer stated that the OEM, DOE Lab and material supplier are a well-rounded project team.

Reviewer 3:

This reviewer observed that the project seems okay; GM appears to be guiding the work effectively although some more words about the path to market would be helpful.

Reviewer 4:

This reviewer commented that it seems like the group has all of the personnel needed, but the interaction between groups was not as clear.

Reviewer 5:

This reviewer stated that collaboration was not terribly well-elaborated.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer stated that this points toward a database that can enable more use of AI, but again, the process needs development more than alloy formability characterization.

Reviewer 2:

The reviewer indicated that the project team seems to have an idea of the problems and experimental artifacts that the project team needs to chase down.

Reviewer 3:

This reviewer indicated that the speaker spoke briefly about the introduction of a real die, and this reviewer looks forward to that development.

Reviewer 4:

This reviewer stated that the design of prototype will likely have a strong influence on the success of the prototype. The reviewer thinks there should be a bit more work on these details.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer commented that this project is definitely a relevant piece of work as it will enable parts to be made out of light but strong alloys of Al.

Reviewer 2:

This reviewer noted that if it is possible to improve the forming of high strength Al, this will be useful, but the linkages could have been more explicit.

Reviewer 3:

The reviewer indicated that this project remotely enables the use of Al.

Reviewer 4:

This reviewer said that unfortunately, a potential application of this technology was not identified.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

This reviewer did not observe or identify any issues.

Reviewer 2:

The reviewer commented that this project is sufficiently funded for a material characterization project, but is borderline on over funded.

ICME Development of 3rd Gen Advanced High Strength Steels: Lou Hector (USAMP) - Im080

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

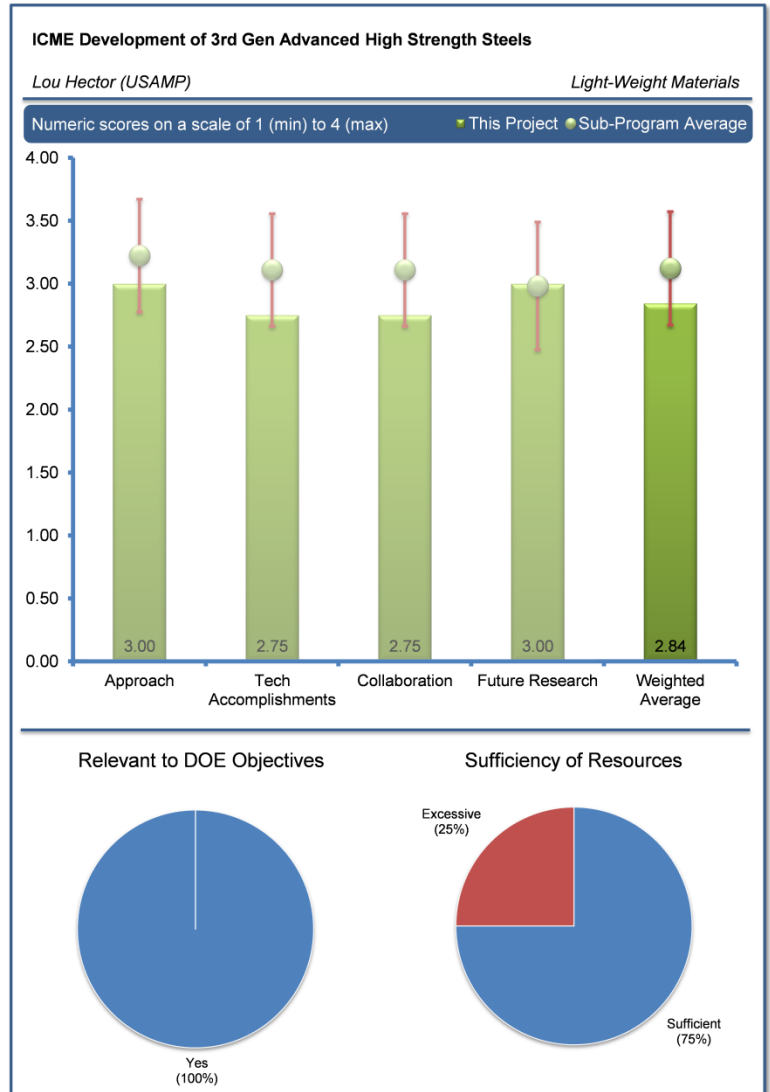
This reviewer stated that the project proposes a substantial and very difficult task in both meeting tough goals while simultaneously developing a fully integrated ICME process. The reviewer has doubts that the project will be fully successful, but the reviewer thinks the approach of the project is reasonable to advance the ICME field while achieving some limited success on the desired strain and strength targets. The reviewer added that the technical barriers to get the ICME models to output within 15% accuracy when the individual components are only validated to within 15% seem impossible.

Reviewer 2:

This reviewer indicated that this project was very, very complex and daunting.

Reviewer 3:

This reviewer said that the approach is not defined. The reviewer added that 19 participant groups will cause chaos.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer indicated that given nothing was expected at this point, well done.

Reviewer 2:

This reviewer commented that this project is in an early stage, too early to access accomplishments.

Reviewer 3:

This reviewer indicated that the project has just begun and that this question is not really applicable.

Reviewer 4:

This reviewer stated that as a new project, the technical accomplishment is the project plan itself and little progress is to be expected. The reviewer stated the project team does have a starting material that has been disseminated, but the next material is already in the pipeline, which might suggest the project team is doing too much at once or are just very aggressive at their task.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer said that collaboration and coordination is still being sorted out, but the pieces seem to be there.

Reviewer 2:

This reviewer noted that there are a lot of team members, and as pointed out the communication is critical. The effectiveness of the team will hinge on the necessary information being shared and used by each member. This falls on the two PIs, with little other options. This reviewer pointed out the fact that the project team has picked a material and disseminated it is positive, but the fact that a second material has already been ordered before any ICME could be performed causes the reviewer to worry that there was not real agreement on the initial material.

Reviewer 3:

This reviewer stressed that there were way too many participants, and noted 6 university groups, 11 industry groups, and 2 consortiums.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

This reviewer noted that the integrated nature and design of the project is quite good, but there is a lack of decision points. This could result in continuously changing local goals on different materials. The reviewer stated that there are no cut-off points to stop individual team members from continuing to work on an abandoned material, etc., that is interesting to them alone rather than moving the overall project forward.

The reviewer commented that the upfront work is logically geared to create experimental results for validation and refinement of the various models.

The reviewer indicated that the FY 2013-2014 plan to first determine how to make the experimental heats to produce the material for ICME iteration seems sound. The reviewer stated that the starting of later task items (tasks 3-5) at this stage seems a bit premature, but could be just an attempt to front-load the effort. This could lead to later efficiencies, or be a waste if effort. The reviewer concluded that there is no way to tell at this point.

Reviewer 2:

This reviewer indicated that the vision is good, but the probability of success is zero.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer noted that the validation of the models to be used for ICME and their interaction could be enabling for future light-weighting through material design while meeting performance requirements.

Reviewer 2:

This reviewer indicated that it is not clear how much weight saving one will get by using the grades of steel. Specifically, how much additional down gauging will occur beyond what is used from current hot stamped steel.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said the funding level is high, but the number of partners will result in spreading the funding thin. This reviewer wonders if the project is so large that the funding even with the contractor addition might not be sufficient.

Reviewer 2:

This reviewer observed there were too many participants and too few researchers.

GATE Lightweight Materials Center: Uday Vaidya (University of Alabama, Birmingham) - Im081

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that this project is a training/education effort. Involving community colleges will provide exposure to technologists on manufacturing processes.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

This reviewer said this is not a research project; training of future engineers for manufacturing industry is the objective. The reviewer added this is necessary as the manufacturing is increasingly technology-driven and proper knowledge on current technologies will increase the opportunities for the students.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer indicated that this is a training program, and many community colleges in and around the university are included.

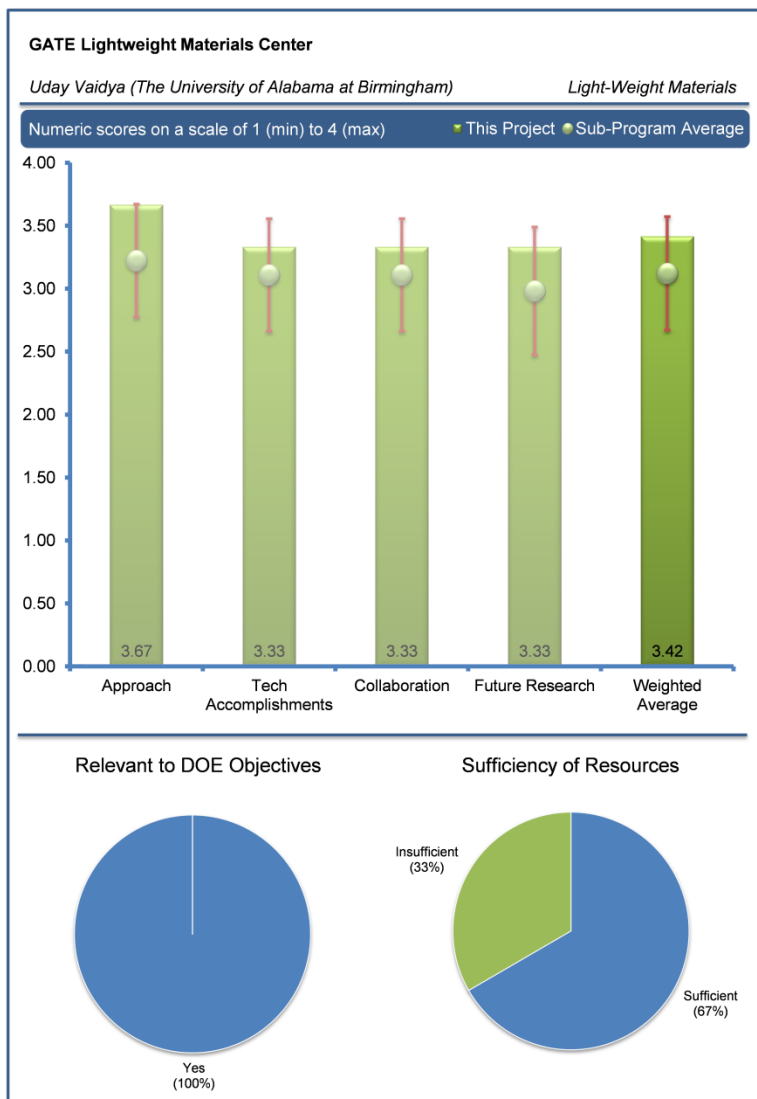
Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

No comments were received in response to this question.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer indicated that the education of future engineers in lightweight materials is the key to the future of the American manufacturing industry. The reviewer recommended that DOE should do more of these types of centers. The reviewer strongly emphasized that this project is a very important investment.



Reviewer 2:

This reviewer pointed out that trained personnel are required for the North American industry to revive manufacturing. The reviewer said currently manufacturing is more technology-driven and the workers need to understand the evolving processes to succeed.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that more funding would generate more returns, and that this project is a very efficient investment of the future.

Microstructure and Deformation Fundamentals in Advanced High Strength Steels: Xin Sun (Pacific Northwest National Laboratory) - Im082

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer said very good. The reviewer indicated that DOE is right to push for such a project due to the importance of the subject for the entire industry in general and the transportation industry in particular. The reviewer went on to say that in view of this importance, DOE ought to consider several groups on the same subject and the integration of all results from all groups is more likely to produce a result that the industry will accept.

Reviewer 2:

This reviewer stated that new steels are being designed, fabricated and tested. This reviewer added the project is a good start as some existing steels under production are being used for comparison.

Reviewer 3:

This reviewer observed that the approach is only being checked against two very similar materials (mat 1 and 2), which is likely to result in any conclusions having only narrow applicability. The reviewer stated that the project team wants to do 2-3 iterations of composition-characterization-modeling, which would hopefully include a more diverse selection of material. This reviewer added that the modeling results show high sensitivity to a property the project team admits measuring to be 2.9% by one method and then 23% by another. Even if the second method is more accurate, it is very difficult to perform (requiring Advanced Photon Source [APS] beam time). The reviewer stated the method of micro-pillars compression testing is likely no good for grains of nano dimension.

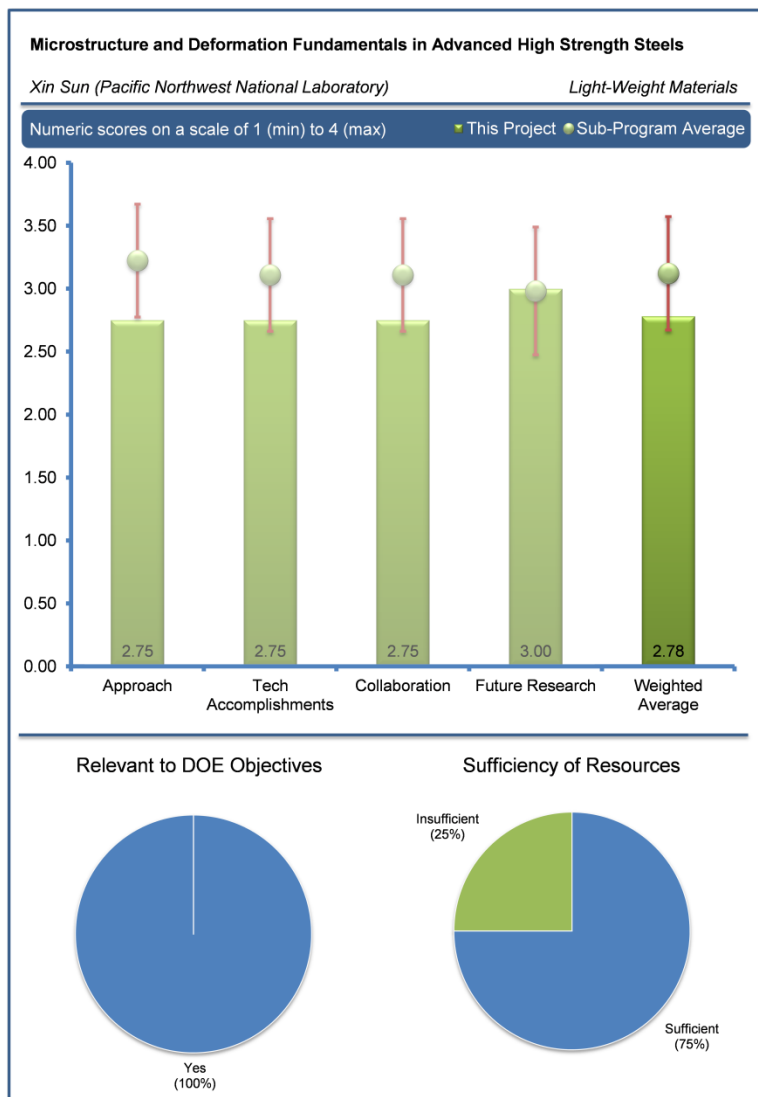
Reviewer 4:

This reviewer opined that the nanoindentation of nanoscale individual embedded phases is worthless. The reviewer then asked what the project team uses as the modulus, and what is below giving a composite response.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that furnace readiness is the reason why the project is being delayed.



Reviewer 2:

This reviewer indicated the presentation could have been clearer; four new compositions are made (heat 1 to 4) and two commercial steels are used (Bao Q&P / DP). A good labeling would be beneficial; the four experimental steels are labeled as Mat 1 / Mat 2 as well as Q&P steels.

The reviewer also pointed out that the focus is on developing specific microstructures, but inquired about what would happen if further processing changes these phases. The ICME approach should address this issue as well.

Reviewer 3:

The reviewer observed that questionable data is being compared to with limited success. The reviewer said that the method of micro-pillars compression testing is likely no good for grains of nano dimension. At this stage for just two materials the reviewer would expect the project to be further along. Additionally, the reviewer indicated that the project team has not gotten through their composition-characterization-modeling cycle even one time (but claim the project is 45% complete). This reviewer stated that the project was to add quantitative understanding, but the results seem more qualitative. As mentioned above, the modeling shows a high sensitivity to phase fraction of Austenite, which is known to be hard to accurately measure, suggesting the model may never work for the intended purpose.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

This reviewer stated that the academic nature of this research involves the university and the consortium of steel companies.

Reviewer 2:

The reviewer commented that this was hard to tell because there are only two partners, PNNL and Colorado School of Mines, with basically two separate tasks.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

This reviewer said to keep it up by any means.

Reviewer 2:

This reviewer stated that no decision points were presented. The reviewer added that the plan to continue as originally planned seems a bit misguided based on the results of the Austenite measurements (either 2.9% or 23%) and the size of the grains (too small for micro pillar measurements). The plan to try more materials seems correct. According to the reviewer, the project team does not know how it will perform the formability tests, but seem to be hoping it can be done at post technology.

Reviewer 3:

This reviewer said consideration should be given to whether it is necessary to complete all materials before the second iteration is started. The reviewer further questioned whether it is necessary to change the alloys, or whether just processing is enough for the second set of trials.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

This reviewer noted that the development of third-generation AHSS has been identified by the steel industry as a leading way for steel to address automotive light-weighting targets.

Reviewer 2:

This reviewer stated that new steels can significantly reduce the mass of vehicles. The reviewer then asked how thin the steel parts can be made before reaching the minimum useful thickness. This will address the maximum strength required.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer is sure that the project could use more.

Reviewer 2:

This reviewer said that most of the work seems left to be done; even the PI claims a generous 45% complete, but there is almost no funding in FY 2014.

Acronyms and Abbreviations

Acronym	Definition
3-DEP	Three Dimensional Engineered Preform
AHSS	Advanced High Strength Steel
Al	Aluminum
AMR	Annual Merit Review
APS	Advanced Photon Source
BEV	Battery Electric Vehicle
CF	Carbon Fiber
CFD	Computational Fluid Dynamics
CFTF	Carbon Fiber Technology Facility
Cr	Chromium
CRADA	Cooperative Research and Development Agreement
DIC	Digital Image Correlation
DOE	U.S. Department of Energy
EH&S	Environmental Health and Safety
EPA	Environmental Protection Agency
EV	Electric Vehicle
FE	Fuel Economy
FEA	Finite Element Analysis
FEM	Finite Element Method
FIB	Focused Ion Beam
FOA	Funding Opportunity Announcement
FSW	Friction Stir Welding
FY	Fiscal Year
GATE	Graduate Automotive Technology Education
GM	General Motors
GS	Grain Size
HPDC	High Pressure Die Cast
HS	High-Strength
HTML	High Temperature Materials Laboratory
IAC	International Automotive Components
ICE	Internal Combustion Engine
ICME	Integrated Computational Material Engineering
INL	Idaho National Laboratory
IP	Intellectual Property
IR	Infrared
L/P	Lignin/PAN Polymer Blend Precursor
LCCF	Low-Cost Carbon Fibers

Acronym	Definition
LTT	Low Transformation Temperature
MAP	Microwave Assisted Plasma
MENA	Magnesium Electron North America
Mg	Magnesium
MgO	Magnesium Oxide
MgOH₂	Magnesium Hydroxide
MOxST	Metal Oxygen Separation Technologies, Inc.
MW	Molecular Weight
Nd	Neodymium
NDE	Non-Destructive Evaluation
NDT	Non-Destructive Testing
NF	Nanofiber
NHTSA	National Highway Traffic Safety Administration
Ni	Nickel
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PACCAR	Commercial Vehicle Manufacturer (Kenworth, Peterbilt, DAF)
PAN	Polyacrylonitrile
PI	Principal Investigator
PNNL	Pacific Northwest National Laboratory
Q&A	Question and Answer
R&D	Research and Development
SMC	Sheet Molding Compound
SPR	Surface Plasmon Resonance
TEM	Transmission Electron Microscope
TWB	Tailor Welded Blanks
USAMP	U.S. Automotive Materials Partnership
VEHMA	Vehma International
VPSC	Viscoplastic Self-Consistent
VTO	Vehicle Technologies Office
XPS	X-ray Photoelectron Spectroscopy
Zn	Zinc

7. Materials Technologies: Propulsion Materials

Advanced materials are essential for boosting the fuel economy of modern automobiles while maintaining safety and performance.

Propulsion materials enable higher efficiencies in propulsion systems of all types. For example, many combustion engine components require advanced propulsion materials so they can withstand the high pressures and temperatures of high-efficiency combustion regimes. Similarly, novel propulsion materials may be able to replace the current expensive materials in electric motors and drivetrain components, thus lowering the cost of electric-drive vehicles.

Using lightweight components and high-efficiency engines enabled by advanced materials in one quarter of the U.S. fleet could save more than 5 billion gallons of fuel annually by 2030.

The Vehicle Technologies Office (VTO) collaborates with industry to improve materials that will increase vehicle efficiency while meeting consumer and industry expectations. It does this through multiple approaches, including working closely with other VTO technology areas to identify and meet requirements for materials needed to develop cost-effective, highly efficient, and environmentally friendly next-generation heavy and light duty power-trains.

The major research and development (R&D) goal for Propulsion Materials is:

- Develop high performance cost-effective materials that solve key challenges that currently limit the performance of propulsion systems (high-efficiency engines and electric drive, and compatibility with alternative fuels).

Subprogram Feedback

The U.S. Department of Energy (DOE) welcomed optional feedback on the overall technical subprogram areas presented during the 2013 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area who volunteered to provide subprogram overview comments responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1: Was the subprogram area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Question 3: Does the subprogram area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Office's needs?

Question 4: Other Comments.

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc., as reviewer responses were optional.

Subprogram Overview Comments: Jerry Gibbs (U.S. Department of Energy) – pm000

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer stated yes, yes, and yes, that all three questions were addressed. This reviewer added that this introductory presentation was perhaps the most solidly analytical overview of the materials challenges presented by the need to increase the fuel economy of vehicle engines. This reviewer emphatically noted a great job.

Reviewer 2:

The reviewer indicated that this sub-program was one of the most diverse, because it supported all of the other sub-programs. This was a good high-level overview.

Reviewer 3:

The reviewer felt that the presentation was informative.

Reviewer 4:

The reviewer remarked that the coverage of the sub-program was good. In general, the progress was well presented, though in some cases the challenges were not well defined. It would have been an improvement for project Gantt charts to be provided in a standard format.

Reviewer 5:

The reviewer commented that the program covered a wide range, including alternative powertrain materials. However, this reviewer noted fewer projects on the hybrid systems, and added that the new solicitations were on conventional internal combustion engine (ICE) powertrains. Hopefully in the future, the focus would be on materials for hybrid systems. As more and more vehicles were being moved to hybrid systems, materials needed to be developed for large-scale manufacturing and reliability.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Reviewer 1:

The reviewer pointed out that the plans for addressing issues and challenges were clearly identified and the approaches were laid out to address the materials limitation issues.

Reviewer 2:

The reviewer observed a good job describing the major challenges (increasing exhaust temperatures, timescales for implementing new technologies, etc.) as well as how the sub-program was handling them.

Reviewer 3:

The reviewer said that no gaps were noticed.

Reviewer 4:

The reviewer mentioned that the issues seemed to cover a wide range of applications and barriers, but that the program was handling focused research in a large number of different areas.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:

The reviewer mentioned that this sub-program was focused on an enabling technology for the overall DOE VTO. It was nice to see that the relations with this program were clearly identified, and the sub-program was well focused.

Reviewer 2:

The reviewer asserted that this sub-program was an enabler for the rest of the VTO and, as such, appeared to be very closely plugged into VTO's overall needs.

Reviewer 3:

The reviewer affirmed that it appeared to be focused and well managed. This reviewer added that the diversity in programs seemed rather limited to a select number of groups.

Reviewer 4:

According to this reviewer, this sub-program was very well focused, well managed, and effective in addressing the DOE VTO needs. Unfortunately, resources (funding) were clearly inadequate to cover the needs identified or to accelerate development of new material compositions in a timely fashion. This reviewer added that it usually took about 10 years to develop a new alloy composition and get it qualified for specific usages. Without adequate resources, this timeframe could be delayed by as much as four years.

Question 4: Other Comments**Reviewer 1:**

The reviewer expressed that Gibbs had done a great job as session chair. He managed time well and made sure that all of the questions were answered. The presentations were grouped in a logical order, and this was a very enjoyable session.

Reviewer 2:

The reviewer suggested that it might be useful to see the full portfolio of projects, and added that every year only a portion of the project portfolio was being reviewed.

Reviewer 3:

The reviewer warned that starving the materials development effort would lead to several-year delays in the commercial development of higher fuel economy engines, transmissions, and other vehicle components.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, as well as numeric scoring responses (*on a scale of 1 to 4*). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Novel Manufacturing Technologies for High Power Induction and Permanent Magnet Electric Motors (Agreement ID:23726)	Glenn Grant (Pacific Northwest National Laboratory)	7-5	3.29	3.14	3.14	3.00	3.16
Materials Issues Associated with EGR Systems (Agreement ID:18571)	Michael Lance (Oak Ridge National Laboratory)	7-11	3.60	4.00	4.00	3.20	3.80
Durability of Diesel Engine Particulate Filters (Agreement ID:10461)	Thomas Watkins (Oak Ridge National Laboratory)	7-14	3.00	3.33	3.33	2.50	3.15
Thermoelectric Mechanical Reliability	Andrew Wereszczak (Oak Ridge National Laboratory)	7-17	2.67	3.67	3.67	2.83	3.31
Thermoelectrics Theory and Structure	David J. Singh (Oak Ridge National Laboratory)	7-21	3.50	3.33	3.33	2.83	3.31
ORNL: Low-Cost Direct Bonded Aluminum (DBA) Substrates (Agreement ID:23278)	Hua-Tay Lin (Oak Ridge National Laboratory)	7-25	3.00	2.50	2.50	2.83	2.67
Improved Organic Dielectrics for Power Electronics and Electric Motors (Agreement ID:23279)	Andy Wereszczak (Oak Ridge National Laboratory)	7-29	3.33	2.83	2.83	3.00	2.98
Advanced High Temperature Aluminum Alloys for Propulsion Applications (Agreement ID:24034)	Mark Smith (Pacific Northwest National Laboratory)	7-33	3.20	3.00	3.00	3.20	3.08
Non-Rare Earth magnetic materials (Agreement ID:19201)	Michael McQuire (Oak Ridge National Laboratory)	7-36	3.29	2.57	2.57	2.86	2.79
Mechanical Reliability of Piezo-Stack Actuators (Agreement ID:13329)	Hua-Tay Lin (Oak Ridge National Laboratory)	7-41	2.60	3.40	3.40	2.60	3.10
Materials for HCCI Engines (Agreement ID:11752)	Murali Muralidharan (Oak Ridge National Laboratory)	7-44	3.50	3.00	3.00	3.00	3.13
Tailored Materials for Improved Internal Combustion Engine Efficiency (Agreement ID:23725)	Glenn Grant (Pacific Northwest National Laboratory)	7-48	2.60	3.40	3.40	3.20	3.18
Catalyst Characterization and Deactivation Mechanisms (Agreements 9130 and 9105)	Thomas Watkins (Oak Ridge National Laboratory)	7-51	3.00	3.20	3.20	2.60	3.08
Catalysts via First Principles (Agreement ID:10635)	C.K. Narula (Oak Ridge National Laboratory)	7-55	3.17	2.33	2.33	2.67	2.58
Overall Average			3.13	3.12	3.12	2.88	3.09

Novel Manufacturing Technologies for High Power Induction and Permanent Magnet Electric Motors (Agreement ID:23726): Glenn Grant (Pacific Northwest National Laboratory) - pm004

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the project design showed a thought-out approach, including how the first two tasks specifically feed into the third, and that the approach focused specifically on several key needs/elements.

Reviewer 2:

The reviewer remarked that friction stir welding (FSW) approach for manufacturing of copper (Cu) alloys and components from dissimilar materials offered a promising approach to reducing material costs.

Reviewer 3:

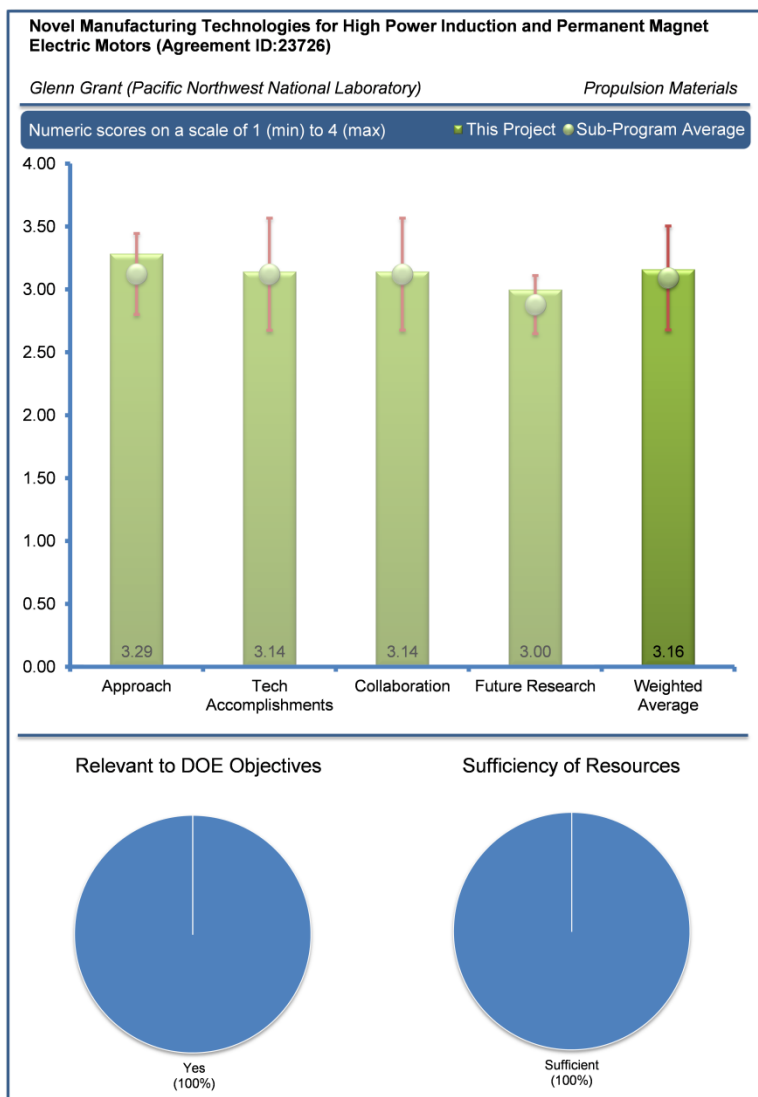
The reviewer considered this project to have a good mix of laboratory development and eventual performance testing of the fabricated components. The reviewer stated that FSW approach was being used to join similar [Carbon (C)/ Cu] and dissimilar (Aluminum [Al]/ Cu) parts to fabricate components for rotors and stators, and to produce low-cost bulk soft magnetic materials for rotor core.

Reviewer 4:

The reviewer judged the approach to be well-designed based upon the intended application, and expressed that the results thus far appeared to effectively demonstrate the feasibility of the research for distinctly practical purposes. The reviewer revealed that the relationship between the FSW zone and the end cap/shorting bar contact area was not completely clear, however. The reviewer reported the assumption was that it must be fully electrically conductive, although the weld zone does not completely fuse the contact area. The reviewer asked if there was a potential for motor efficiency loss over time with a contact fit between dissimilar metals, and if this was a concern.

Reviewer 5:

The reviewer maintained that the approach appeared to have been well thought-out, as the FSW method appeared to be superior to any of the several other joining techniques that have been investigated. The reviewer wondered, however, if the FSW method were to ultimately not succeed, what the fallback position would have been.



Reviewer 6:

The reviewer declared that the project addressed the development of FSW for solid-state joining of high-power electric motor components used in automotive applications. The reviewer thought that the barriers and issues associated with current manufacturing processes should have been addressed in greater detail; electric motors are produced today without FSW. The reviewer wondered what barriers were being addressed. This reviewer suggested that perhaps the cooperative research and development agreement (CRADA) partner, General Motors (GM), could provide a better rationale for the development of FSW and, if successful, could clarify what the benefits would be in terms of cost, reliability, energy efficiency, enabling hybrid electric vehicle (HEV) technologies. The reviewer would like to see quantitative benefits on weight savings, higher performance, and lower cost estimates.

Reviewer 7:

The reviewer deemed the concept behind this project to be sound and of technical value, with a strong corporate partner. The reviewer further judged the joining research in Tasks 1 and 2 to be well designed, but deemed the link to the bulk materials processing in Task 3 to be unclear, and was not clarified during the presentation. The reviewer disclosed that the motivation and justification for soft magnetic materials fabrication in Task 3 was omitted, other than a statement that Advanced Research Projects Agency-Energy (ARPA-E) work was being leveraged. The reviewer reflected that it would have been good to let the reviewers know if that proposed effort was based on some prior results, suggesting this manufacturing route would be effective; and if so, to provide at least a sentence or figure supporting the prior observation.

The reviewer also stated that the presentation of progress of the Task 1 and 2 efforts would have been further strengthened and clarified by adding quantitative comparisons of the FSW weld joint properties versus other methods or earlier FSW approaches, perhaps on standardized test coupons in addition to rotor assemblies. The reviewer thought that this was particularly true where there were dissimilar metals being joined, as in Task 2. The reviewer pointed out that Slide 18 states that there are mechanical properties metrics established by the team, but provides no insight to those metrics, or how near the project is to achieving them.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer found that substantial progress had been made in developing the FSW process to optimize production of copper welds. The reviewer observed that adaptive controls for temperature stabilization appeared to work well.

Reviewer 2:

The reviewer characterized the progress on the project as good, and cited the fabricated rotor component qualified the screening test.

Reviewer 3:

The reviewer saw that progress appeared adequate, given the level of resources.

Reviewer 4:

The reviewer observed that the project team had found shortcomings with existing attempts, but had also clarified necessary parameters for successful processes, particularly in the area of tool design evolution. In addition, the reviewer noted that the project team began to develop methods to address the impact of heat on the process, and how to control it. The reviewer agreed that the fabrication process appeared to pass testing.

Reviewer 5:

The reviewer felt that the accomplishments provided a clear picture of the objectives, the shortcomings/barriers, and how each has been addressed or met. The reviewer agreed that the technical merit of the research was significant based upon the intended end use. The reviewer noted the unclear association between the specific joining study and the objective of developing new alloys as a part of this program.

Reviewer 6:

The reviewer disclosed that the project had three major tasks: Cu-Cu joining; Cu-Al joining; and friction stir processing (FSP) of novel soft magnetic materials. The reviewer declared that the project had demonstrated significant progress relative to the project team's 2012 Annual Merit Review (AMR) report, but was concerned about the progress on the latter two tasks, as it was not as evident in the 2013 report. The reviewer wondered if there will be sufficient time to address the latter two tasks in the three-year project timeframe.

Reviewer 7:

The reviewer observed that the project seemed to be making some progress, but also seemed to either be behind schedule or had somewhat of an unrealistic schedule, because Task 3 had not yet begun. The reviewer revealed that the original target date for beginning Task 3 was not identified, although the presentation stated that it would begin in late 2013, which meant it would begin sometime in the third year of a three-year project. The reviewer reflected that it seemed practically unrealistic that development of a new soft magnet material, using a new manufacturing process, would be given one year or less of development effort. The reviewer further found that, on Page 25, it was stated that implementation of the new soft magnet materials developed in Task 3 would require collaboration with others who were not part of the current project. The reviewer commented that it seemed that this task was not being given adequate time or attention to achieve the stated goals, which led the reviewer to question whether realistic goals had been set for Task 3. The reviewer reported that it was stated that risks of Task 3 will be mitigated by performance gates, but pointed out that there has been no activity here yet, and higher risk efforts often take more time for success. [DOE: Program Clarification: It should be noted that the proposed future work discussed by the presenter is outside the scope of the project.]

The reviewer's primary overall concern was that the presentation showed very few actual results from this project, and the results that were shown were primarily non-quantitative or somewhat vague. It was not made clear to the reviewer if that was due to the CRADA partner restricting results, or whether there just were not yet many results to present. To this concern the reviewer cited an example; on Slide 18 it was stated that the following milestone had been completed: Characterize the microstructure and mechanical properties of Cu-Cu joints. Yet, there were no mechanical properties or successful Cu-Cu joint microstructures shown anywhere in the presentation. The reviewer reported that only microstructures with gaps and voids in the joint were shown on Slides 11 and 14, and it was not made clear if those are Cu-Cu joints from this specific study. The reviewer concluded that a slide emphasizing the properties and microstructure of that successful Cu-Cu joint and contrasting it with other non-successful welds would have been a helpful confirmation of progress.

The reviewer further observed that the presentation stated that the first Go/No Go gate had been achieved through an unidentified custom screening test, but qualified that result by stating that the rotor tested was machined from a design that will not be the prototype due to manufacturing considerations. That did not sound to the reviewer as if the originally intended goal was fully achieved, even though the authors made clear that the test was accepted as passing the gate. Again, this is where some more quantitative test or more detailed description of the custom test, or success metrics would have been helpful in assessing progress. The reviewer thought that it would have been better to present what the metrics for success were, and how close the current manufacturing process is to achieving those goals.

The reviewer agreed that the adaptive control technology is a good approach to solving the temperature control issues. However, the results shown on Slide 17 are for 6061 T6, not Cu-Cu or Cu-Al. The reviewer also suggested that the presentation would have been strengthened significantly by providing results related to Cu-Cu joining from the present study.

The reviewer saw that the actively cooled fixture seemed to be a successful response to a manufacturing barrier, but even that effort would have been more effective with some results to demonstrate its impact on Cu-Cu or Cu-Al joining. The milestone on Slide 18 states that it was developed, fabricated, and tested to allow FSW or Cu and Al rotor parts. However, the reviewer pointed out that no results were shown related to testing of that fixture, and asked what was tested, what was the outcome, and why were those results not shared.

The reviewer expressed concern that at the 50% point of the project there is not yet a FSW production process robust enough to join Cu-Cu (Slide 20). That result suggested that the prospects for joining Cu-Al were going to be even more difficult, although no results were presented related to Task 2, although Task 2 was stated to be on schedule on Slide 18.

In closing, the reviewer summarized the project as being very interesting work, but suggested that future presentations be more specific or explain why the project team cannot do so, and to include more materials-specific metrics and results from the current materials of interest.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer assessed that the CRADA with GM provides a useful distribution of capabilities between the National Laboratory and industry. Fabrication techniques and process development by Pacific Northwest National Laboratory (PNNL) with testing by industry partner is effective and should lead to good results.

Reviewer 2:

The reviewer observed that the project had a very close coordination with GM under a CRADA, and GM was also working on fabrication processes. The rotor fabricated under this project will go to GM for testing. The reviewer cited the fact that the CRADA was established as a 50-50 cost share as evidence of this close coordination, with GM providing at least half of the funding (largely through in-kind contributions of facilities, labor, and testing).

Reviewer 3:

The reviewer felt that industrial partnership has been excellent in terms of the component testing and potential eventual commercialization of the technology. However, it was not clear to the reviewer how and in what form the CRADA partner is contributing. It appeared 50% in kind share was excessive for performing a screening test.

Reviewer 4:

The reviewer reported that the study had borrowed specific fabrication requirements and parameters from the industrial partner (GM). The results of the research indicated to the reviewer a tollgate level that is, for all intents and purposes, ready for deployment on an industrial scale.

Reviewer 5:

The reviewer judged collaboration with GM to be adequate for this stage of the project, although it appeared from Slide 19 that the bulk of GM's participation would come in the motor component testing and commercial development in the later stages of the project.

Reviewer 6:

The reviewer thought collaboration with industry partner appeared sufficient to continue progress toward the goals.

Reviewer 7:

The reviewer found limited collaboration, and wondered about the CRADA with GM – if GM will buy these components from a supplier (e.g., Delphi), or if GM might actually manufacture these components. The reviewer recommended that if GM intends to go through a supplier, then there should have been a supplier on the project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the plans build upon past progress and generally address overcoming barriers. Progress to date gives confidence that the project will succeed with a high degree.

Reviewer 2:

The reviewer found that the project was moving forward based upon the 2012 results. The reviewer expected the schedule to be a challenge to complete on time, but the principal investigator (PI) indicated he expects to be able to get the rotor to GM for testing within the required schedule.

Reviewer 3:

The reviewer thought there was a good description of issues that need to be addressed for the Cu-Cu joining, but revealed there was little discussion of future plans for the Cu-Al and soft magnetic fabrication tasks.

Reviewer 4:

The reviewer was concerned about the timing of Task 3, since it was not scheduled to begin until sometime within the last year of the project. The active controls approach was good, as was the implementation of the cooled fixture.

Reviewer 5:

The reviewer observed that one of the remaining objectives that had not been addressed in detail was the solid-state processing of rotor-stator core materials. The presentation did not clarify how past progress was connected this future work, or the inherent barriers to success. The reviewer noted that general expertise in FSW processes to facilitate this research seemed to be the consistent thread, and that particular progress had been commendable.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer saw that substantial weight reduction and improved efficiency appear possible and are directly in line with objectives of cost reduction and maintaining performance. Advances in adaptive control of friction stir welding process may be applicable to other production goals.

Reviewer 2:

The reviewer observed that the association between efficient and cost-effective manufacture of lightweight and reliable electric motors is inarguably clear.

Reviewer 3:

The reviewer pointed out that electric motors are critical to increased electrification of vehicles, and this project is focused upon improved cost, performance, and weight.

Reviewer 4:

The reviewer declared that vehicle electrification contributes strongly to the DOE petroleum displacement objective.

Reviewer 5:

The reviewer disclosed that high power electric motors are critical for HEVs.

Reviewer 6:

The reviewer agreed that the project addressed the development of low cost, lightweight components for the motors for HEVs and hence the displacement of petroleum use.

Reviewer 7:

The reviewer declared that, if successful, the project will help to lower the cost and weight of electric motor assemblies, thus providing an enabling step toward mass vehicle electrification.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer thought resources appeared sufficient to achieve the stated milestones.

Reviewer 2:

The reviewer found that resources appeared to be sufficient, and included 50-50 cost-share from GM.

Reviewer 3:

The resources seemed to the reviewer to be sufficient for the described effort.

Reviewer 4:

The reviewer thought that, as the focus shifts considerable from joining techniques to materials processing, it would be difficult based upon past work to determine whether the budget is sufficient. The reviewer anticipated that it will be assumed that the research group has been thorough in assessing the needs of the upcoming work, and a relatively large budget amount has been earmarked for this work.

Materials Issues Associated with EGR Systems (Agreement ID:18571): Michael Lance (Oak Ridge National Laboratory) - pm009

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer declared that having a DOE lab conduct round-robin style evaluations and proposing remediation options with industry participation was a very functional approach and great role for the federally funded research and development center (FFRDC).

Reviewer 2:

The reviewer thought there was a good description of the problem and approaches to address the issues.

Reviewer 3:

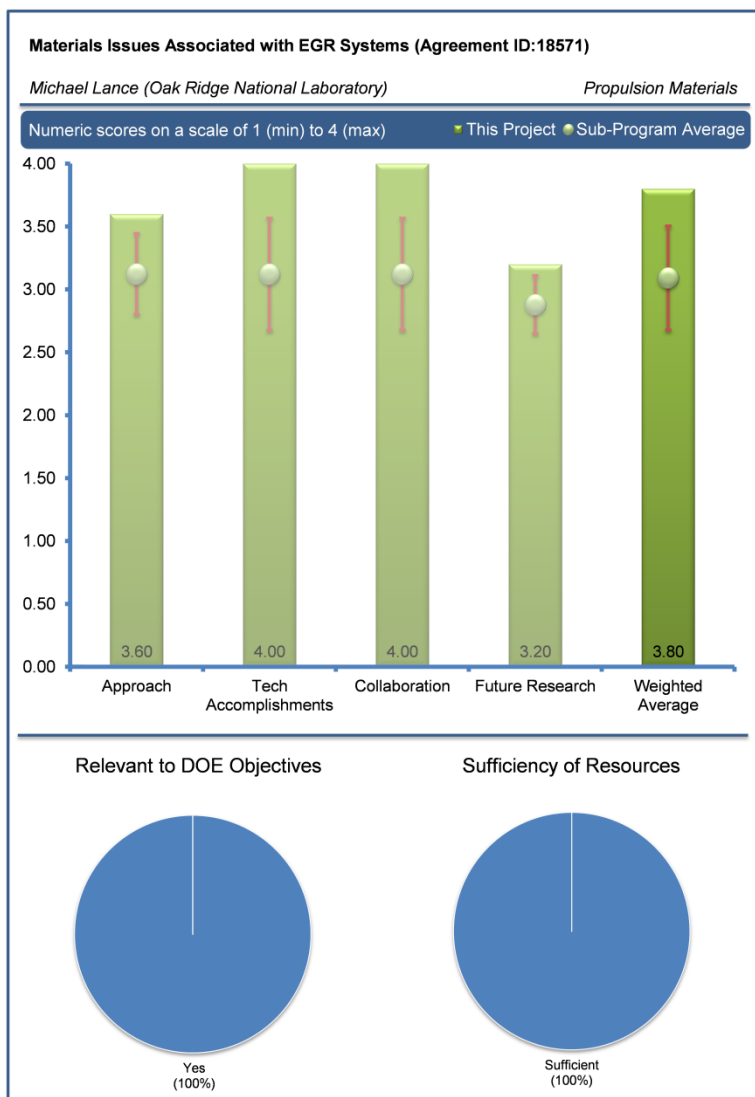
The reviewer pronounced that the technical barriers to developing a strategy to mitigate exhaust gas recirculation (EGR) fouling were clearly defined. By involving all OEM's in supplying samples the problem is clearly defined. The reviewer stated that the chosen analysis methodology will lead to proposals to define solutions for the given problem.

Reviewer 4:

The reviewer held that the work has proved why high load operation can regenerate EGR by showing the changes occur in the coating. However, the approach can be improved by studying the interface of the deposit/base metal. The reviewer concluded that this will provide insight at the deposition mechanism, and ways to remove it.

Reviewer 5:

The reviewer reported that the project addresses fouling of EGR systems and the development of strategies to refresh/regenerate EGR in-situ. The approach selected focused solely on operational protocols and did not address material approaches. The reviewer questioned whether the PIs had ruled out application of materials that are resistant to fouling. The reviewer did not see any indication that the PIs understood the mechanisms involved in the fouling process. The reviewer went on to express that a good understanding of the mechanisms involved, and the impact of physical properties, the mechanics of fouling, and in-situ regeneration would greatly benefit the project team's efforts to develop protocols to clean the systems.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed that several mechanisms were identified that suggest deposit removal can occur or conditions can be established to reduce adherence of deposits on metal surfaces. The reviewer felt that good progress had been made on understanding the formation of troubling deposits and insights on how to avoid.

Reviewer 2:

The reviewer commented that a good understanding of the fouling process was achieved, but noted that the mitigation strategies still have to be evaluated. The claimed fuel penalty for a fouled EGR is 1-2%. In case of active regeneration care has to be taken that there will be no net fuel penalty (in case of frequent regeneration). The reviewer reflected that coating with catalytic materials (provided low temperature catalytic materials exist) could be a good alternative, but noted that this was not taken into consideration.

Reviewer 3:

The reviewer remarked that the project revealed the nature of the deposits in the EGR coolers and explained the differences due to the operating conditions. Also, the mechanism of regeneration of the plugged in EGR has been explained. The reviewer reported that the nature of deposit was studied but the interaction with the surface still needed to be clarified. The deposits do not have any permanent adherence to the surface. The reviewer recommended that understanding this can help developing surface treatments to reduce deposition.

Reviewer 4:

The reviewer disclosed that the PIs appeared to have performed a number of detailed studies on the use of turbulent flow/high temperature spallation and low-temperature condensation, but that the results to the point of presentation were not sufficiently compelling to indicate their approaches will succeed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer felt that there was excellent involvement with industry. The reviewer saw that industry had input on defining most important issue for EGR cooling and performance and recommending project direction.

Reviewer 2:

The reviewer declared that the project was working with great and relevant industry partners.

Reviewer 3:

The reviewer thought the project had a strong participation/support from the whole heavy duty industry. The reviewer also noted that results are shared at appropriate level with the partners optimizing the chance of getting the results implemented.

Reviewer 4:

The reviewer reported that the PIs have on-board a number of OEMs that are providing components for analysis.

Reviewer 5:

The reviewer noted that many manufacturers and users were involved.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer felt the proposed plans for future research were clearly built on the analysis of the fouling and the model developed for the fouling process.

Reviewer 2:

The reviewer recommended that computational fluid dynamics (CFD) should be a good approach to investigate geometry effects on flow velocities. The reviewer asked if experiments to date have helped to identify criteria that will be used to model the tendency for deposits to adhere, or velocity at the wall to either reduce deposit adherence or remove existing deposits. The reviewer further noted that several concepts had been identified for further research.

Reviewer 3:

The reviewer would like to see how the information on the composition will be applied in the development of the test protocols.

Reviewer 4:

The reviewer revealed that the plan did not include characterization of the interface at deposit/tubes, and suggested that it would be worthwhile to study the interface as it can reveal ways to prevent deposit building up.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that, as many of the future vehicles will use EGR to improve the efficiency, it is imperative that the efficient operation of this system is well-understood. This will help increased use of this technology

Reviewer 2:

The reviewer believed that the project would lead to an overall fuel consumption improvement of 1-2% for the heavy-duty vehicles.

Reviewer 3:

The reviewer noted that EGR performance has a direct impact on engine efficiency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer judged that the stated results should be achievable within the remaining time, but also noted that the project suffered from a reduction in funding.

Durability of Diesel Engine Particulate Filters (Agreement ID:10461): Thomas Watkins (Oak Ridge National Laboratory) - pm010

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that this is a mature project with ongoing funding since 2004, possibly, which is relevant to the VTO goals. The project is providing valued data to a commercial partner to improve material properties, develop new properties, and modify regeneration protocols for diesel particulate filters (DPFs). The reviewer judged the approach to determining relevant physical and mechanical properties to be sound.

Reviewer 2:

The reviewer reported that the approach utilized existing advanced technology from Oak Ridge National Laboratory's (ORNL) High Temperature Materials Laboratory (HTML) to provide an elegant level of depth and accuracy using digital image correlation (DIC) to a relatively simple stress rig. The reviewer remarked that this, among other techniques, was an indicator of the practical and straightforward approach taken to produce useful results. The reviewer suggested that to achieve outstanding marks might involve more technologically ground-breaking test development and associated approaches.

Reviewer 3:

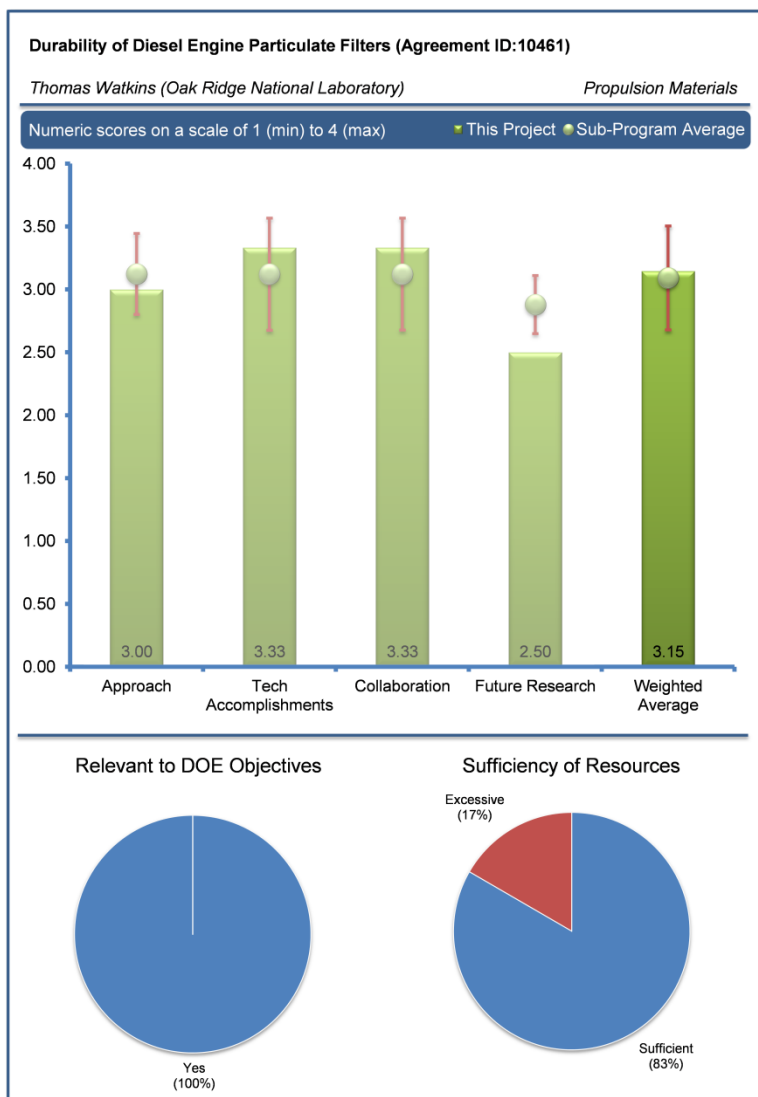
The reviewer characterized the project as establishing important material characterization of the different DPF materials and understanding the failure mechanisms. The reviewer noted, however, that the measuring of important properties will be needed to improve modeling.

Reviewer 4:

The reviewer disclosed that there is work being done which seems to be directed by Cummins. The reviewer asked if this is the best approach to solving the important problems.

Reviewer 5:

The reviewer reported that the project utilized a miniature tensile rig to examine materials properties such as fracture and moduli. While this information has some utility for manufacturers as they investigate various packaging and mounting strategies, the type of measurements are routine. The reviewer was left to wonder whether these types of tests are most efficiently done at a National Laboratory rather than a more cost effective contract firm.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer judged that the technical accomplishments were in line with the directed efforts.

Reviewer 2:

The reviewer commented that the approaches were not overly complex, but met the needs of the customer and project goals. With a refinement in test protocols and evaluation methods, it would be very favorable to open up a study like this to a much larger matrix of candidate materials, which the reviewer suggested would be an appropriate topic for future work.

Reviewer 3:

The reviewer reported that the test machine and procedures were established to evaluate mechanical properties, and that the modulus appears to greatly impact the life prediction from the models. It appeared to the reviewer that the modulus can be difficult to consistently measure. The reviewer went on to ask how much measurement error there is in the process, and how much variation there is in the actual DPF filters due to manufacturing variations.

Reviewer 4:

The reviewer stated that the researcher presented information on microcracks and the dependency on material type, some strain maps, and a discussion on moduli but did not tie the information together into conclusions which elucidate failure mechanisms or phenomenon. The results seemed to the reviewer more in the way of observations rather than serious scientific inquiry. The reviewer remarked that the project team did not answer the question of so what.

Reviewer 5:

The reviewer felt that development of the microtesting rig combined with digital image correlation to derive Young's modulus on DPFs was a useful accomplishment. There appeared to be considerable work remaining to understand thermal properties on additional materials, however. It was not apparent to the reviewer from the presentation what progress had been made on predictive modeling. The reviewer went on to speculate that this may be due to the confidential nature of the relationship with Cummins.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the collaboration and coordination with other institutions was probably somewhere between good and outstanding, but the reviewer limited the response to good because it was unclear (due to CRADA restrictions) what specific input to technical direction that Cummins might be providing. It appeared to the reviewer that ORNL is working well with Cummins to follow an evaluation path that is focused on the critical parameters.

Reviewer 2:

The reviewer remarked that collaboration with Cummins must be reasonably good.

Reviewer 3:

The reviewer assessed the collaboration with Cummins as good. The researcher presented the importance of the data generated on the analysis work performed at Cummins to develop DPF products.

Reviewer 4:

The reviewer felt that collaboration with Cummins demonstrates a strong industrial interest and drives the characterization research, since it appears that Cummins is providing the modeling component.

Reviewer 5:

The reviewer reported that this project appeared to be a longstanding collaborative with Cummins going back nearly ten years. It was not clear why this project has been going for so long, nor what had been accomplished over this timeframe. The reviewer suggested

that it would have been most helpful to see an overall timeline with milestones, deliverables and decision points. The reviewer wondered what would constitute success, as well as when the project will be complete and why.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that work on additional materials must be driven by the CRADA partner. The reviewer presumed that Cummins will continue to be interested in the development of new DPF materials.

Reviewer 2:

The reviewer observed that the future work seems to follow the same (or similar) established path - with an eye toward improving existing test techniques and adding new materials to the test matrix.

Reviewer 3:

The reviewer suggested that this project is in need of evaluation as to whether these resources should be used in a CRADA benefiting one company versus general re-application to other problem areas.

Reviewer 4:

The reviewer wondered why the CRADA is being renewed, and asked what the ultimate objectives and outcomes are. The reviewer noted that the stated work on characterization appears to be routine measurement work.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer felt that there was an established clear relationship between the development of clean diesel technologies and reducing petroleum consumption due to improved efficiency of the diesel engine.

Reviewer 2:

The reviewer pointed out that the program assists in overcoming the present concern over larger-scale use of efficient diesel engines (i.e., soot generation), and that more widespread use of reliable clean diesel technology supports the DOE goal.

Reviewer 3:

The reviewer's assessment was that the project supports goals of reducing fuel consumption through development of more efficient use of DPFs and regeneration techniques.

Reviewer 4:

The reviewer thought that the project could possibly support DOE goals. The reviewer considered it to be a stretch, in that it only involves using alternative fuels and controlling the particulate emissions.

Reviewer 5:

The reviewer commented that the argument for petroleum displacement is thin at best. One can see an argument for durability and cost reduction, but it was difficult for the reviewer to see how these materials studies tie back to reduced backpressure, passive regenerations, or reduced active regeneration events which have a more direct argument to fuel use.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer pointed out that the program is not reliant on new or exceptional capital equipment, and appears poised to continue refining techniques within the realm of experimental approaches that the project team has developed.

Thermoelectric Mechanical Reliability: Andrew Wereszczak (Oak Ridge National Laboratory) - pm012

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer declared that this represents an ambitious three-pronged program, covering CRADA efforts (focused on determining performance of Marlow materials), International Energy Agency (IEA) activities (round-robin testing and coordination on testing techniques), and cross-cutting R&D. The reviewer saw that this appears to really represent multiple projects presented as one. The project seems to correctly rely upon first performance (property) testing and supportive materials work, and then round-robin testing through IEA (including development of testing procedures), leading to needed standardization. The reviewer noted that additional efforts were included to specifically aid other researchers in this area (such as through development of appropriate reports).

Reviewer 2:

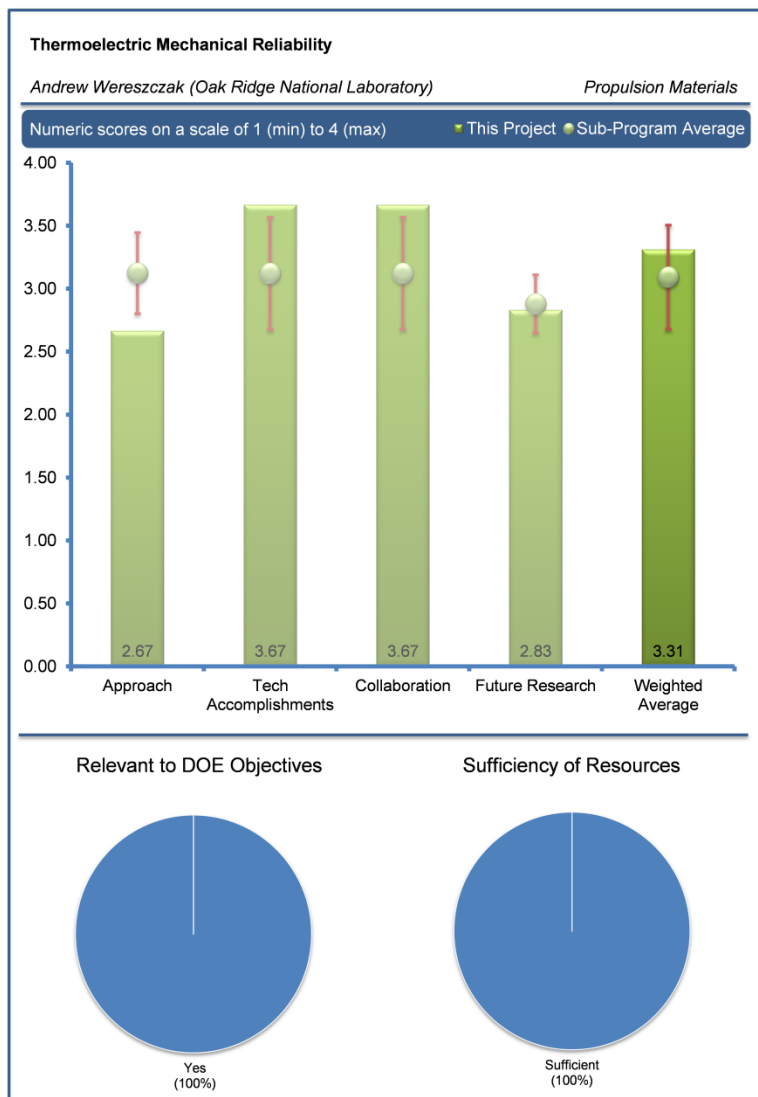
The reviewer remarked that overall, the approach to the project was adequate in that it addressed the needs to enhance the mechanical/performance reliability for thermoelectric materials being developed for vehicles. The project entailed stress analysis and variety of mechanical, thermal, and electrical characterizations. The reviewer noted that these characterizations are a key component to develop a reliable thermoelectric system. Further, there are additional activities such as participation in a round-robin study on the thermoelectric property evaluation and development of a fatigue test method.

Reviewer 3:

The reviewer felt that the research took an intelligent approach, which builds upon the knowledge base of Structural Ceramics. The reviewer noted that this database of mechanical properties, developed to enable high temperature ceramics for heat engine applications, is now being mined for electronic properties as well.

Reviewer 4:

The reviewer concluded that mechanical durability was the main issue, but that it is heavily dependent on how the thermoelectric materials (TEMats) are built in. In order to produce any significant amount of electricity a significant amount of heat has to pass through it. The reviewer reported that the TEMats must be a part of a dedicated heat exchanger for that to happen, and that there has to be secondary heat transfer surfaces on both sides to achieve any significant performance. Considering this, the reviewer reasoned that the integration of the TEMats with the heat exchanger surface is needed to understand the mechanical boundary conditions.



Reviewer 5:

The reviewer found that his project focused on evaluating of transport properties and mechanical reliability of thermoelectric (TE) materials/devices. Little or no technology development/innovation is evident in the project - it focuses primarily on providing a service to the industrial partners

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

Given the modest level of resources, the reviewer found progress toward overcoming barriers to meet the objectives of the work appeared to be on track. The reviewer noted that, interestingly, despite the brittleness of the thermoelectric materials, some of the earlier work carried out by DOE and Caterpillar to place a 500 watt thermoelectric generator (TEG) on a gravel hauler truck indicated that, if properly done, the TEG would survive on the order of 500,000 miles with no interruption in output.

Reviewer 2:

The reviewer saw good progress on property measurement, but would have liked to see how this information was being used or applied by the industrial partners.

Reviewer 3:

Overall, the reviewer thought the project seemed to have accomplished a lot for a small amount of funds, even taking into account the IEA involvement (where members' countries fund their own activities). The reviewer reported that all identified milestones for 2012 were completed, and it appeared that 2013 ones are on schedule. A great deal of characterization work and testing has been completed, including development of testing procedures.

Reviewer 4:

The reviewer said that the project identified the mechanical problems with TEMats, but that characterization of thermoelectric devices (TEDs) is a somewhat fuzzy goal

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer felt the project had excellent leverage of IEA, as well as CRADA partnership with Marlow and GM involved as original equipment manufacturer (OEM).

Reviewer 2:

The reviewer agreed that collaboration with industry (part of a CRADA) and IEA has been quite effective.

Reviewer 3:

The reviewer noted that the project involved a CRADA with Marlow, as well as direct and indirect coordination and collaboration with GM (indirect through Marlow, which serves as a contractor to GM under a CRADA for development of thermoelectric devices). Plus, IEA participation ties to international interest in the project. The reviewer reported that under the IEA portion, the project is also involving universities, additional industry partners, and other government research organizations.

Reviewer 4:

The reviewer observed large participation by GM team and international collaborators.

Reviewer 5:

The reviewer declared that the whole project approach was built on supporting stakeholders, and that the project is supporting other stakeholders with characterization work.

Reviewer 6:

The reviewer suspected that the level of collaboration and coordination with industry partners could be improved by adding other potential suppliers besides Marlow, as well as end users. There appeared to the reviewer to be little interest in mechanical properties of thermoelectric materials research by the auto industry despite their increasing interest in thermoelectric technologies.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that there is not that much left to do, since much of the project is scheduled to end soon. Remaining efforts planned seem important, including getting the word out on design approaches and concerns. The reviewer was concerned about whether the remaining time is sufficient to complete all planned tasks.

Reviewer 2:

The reviewer reported that the project is about 93% complete. The future work presented appears to be completion of the on-going activities in the various areas of characterizations, fatigue test method, and participation in the round robin study.

Reviewer 3:

The reviewer judged the future work to be more of the same, but that the 500°C work was important because it has the biggest potential to support petroleum displacement targets.

Reviewer 4:

The reviewer felt that it would be useful to see what metrics, goals, and targets are available for the different designs. The reviewer asked what the minimum mechanical strength requirements were, and if the devices being studied were meeting these goals.

Reviewer 5:

The reviewer observed that this work is nearing completion, and yet it is not clear what next steps need to be taken to ensure industrial application of these materials.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer's assessment was that durability and reliability would be critical for successful implementation of TE devices, as mechanical properties are critical in the design stage of TE devices.

Reviewer 2:

The reviewer found that the project focused on improvements of materials for thermoelectric applications, and reported that thermoelectrics are expected to help improve efficiency of vehicles significantly.

Reviewer 3:

The reviewer evaluated the 500°C work to be important since that has the biggest potential to support petroleum displacement targets.

Reviewer 4:

The reviewer believes that enabling the use of TE to harvest waste heat will improve vehicle fuel economy, if only a few percent. Such usage will support the overall objectives of DOE for petroleum reduction in vehicles.

Reviewer 5:

The reviewer observed that the impact of on-board electrical power generation on petroleum displacement was inferred but never directly quantified or even projected for ICE, Hybrid, or electric vehicle (EV).

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that it seemed like DOE is getting a lot of bang for the buck from this project, even taking into account the testing funded by others through IEA.

Reviewer 2:

The reviewer thought that resources for this project appeared adequate to achieve the stated milestones in a timely manner.

Reviewer 3:

The resources provided appeared to the reviewer to be sufficient for the completion of the milestones in the suggested time frame.

Reviewer 4:

The reviewer found it difficult to judge the adequacy of resources for this project.

Thermoelectrics Theory and Structure: David J. Singh (Oak Ridge National Laboratory) - pm013

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found the approach to be exactly right. Thermoelectrics do not exhibit the cost/performance required for vehicle applications by far. The reviewer felt that this work addresses these issues in the correct way.

Reviewer 2:

The reviewer thought that there was an excellent approach that has defined targets [figure of merit (ZT) greater than 2 for heat recovery; greater than 1 for cooling], and includes fundamental of TE performance (Seebeck) based on first principles.

Reviewer 3:

The reviewer reported that this work is in the early stages of development and is quite basic in nature, but agreed that this is exactly the type of research that the federal government should be supporting.

Reviewer 4:

The reviewer reported that much of the effort under this project is focused upon the first detailed look at certain materials for thermoelectric applications, and could lead to significant improvements in materials utilized for these applications. The specific focus for this project is to identify materials, but leave the validation to others.

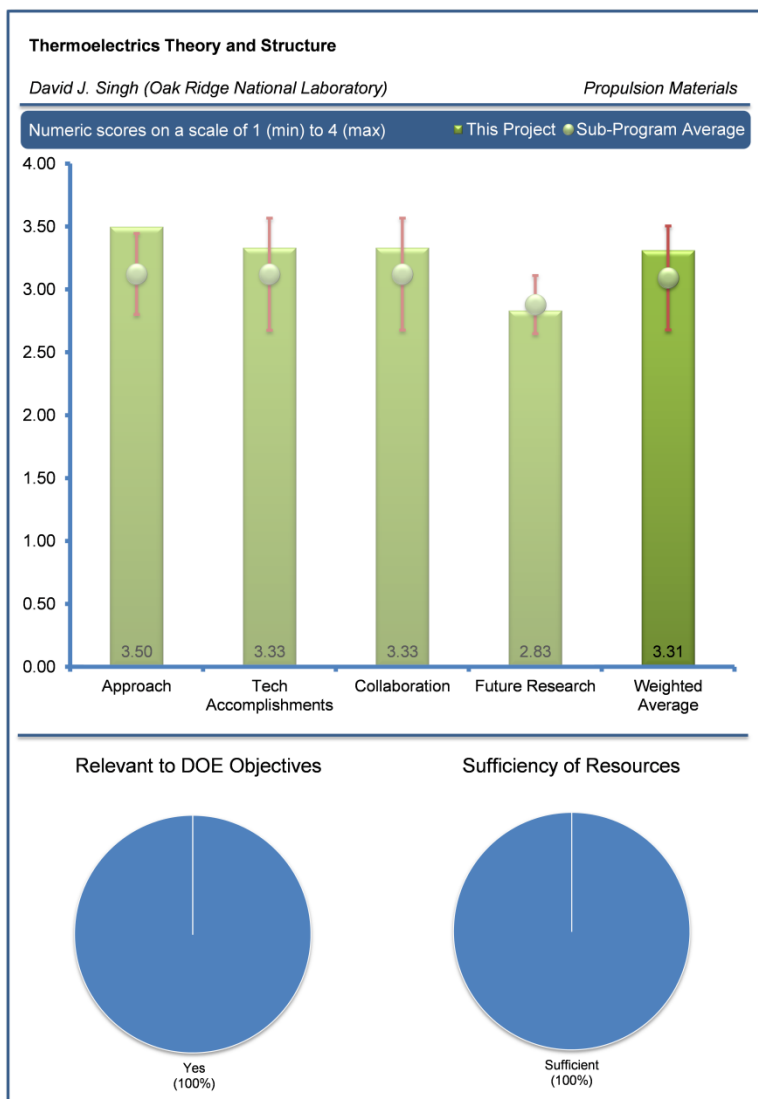
Reviewer 5:

The reviewer observed that the project addresses a very important problem of waste heat recovery using novel thermoelectric materials. This computational study is important in designing new materials and predicting their properties. However, the end goal of the study is not clear. The reviewer asked if this work relates to any experimental thermoelectric material development, since it seems that the fundamental work needs to be related to thermoelectric material development to realize the target goals of ZT and cost. Further, the reviewer wondered if the proposed materials are easily fabricated, what their material properties are, what the costs are, etc. The reviewer finally suggested that practical viability of the material needs to be discussed.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that the project has identified big potential improvements.



Reviewer 2:

The reviewer noted that the project team had expected to identify one low-cost material for 300-600°C operation, but ended up identifying three. Also identified were two promising materials for room temperature operation. Finally, the project identified a high-performance material that had been previously overlooked. Overall, the reviewer felt that the project team seemed to have not only found good materials, but figured out why these materials performed better.

Reviewer 3:

The reviewer judged that the identification of potential new thermoelectric materials which lack toxic or expensive/rare elements is a very worthy goal. The reviewer saw that so far significant progress is being made toward this objective of identifying new potential material compositions which exhibit thermoelectric capabilities.

Reviewer 4:

The reviewer reported that there was good progress on new novel compounds. The reviewer noted, however, that no mention is made of the Mo₃Sb₇ compound identified in Fiscal Year (FY) 2011/2012. It was not clear to the reviewer why no mention was made, and raised the questions of why this was apparently abandoned. In FY 2013 review, the reviewer reported that the project team has three new materials.

Reviewer 5:

The reviewer wondered what the implications might be of using the two identified materials, which both have lead, a toxic metal. The reviewer was also not sure what the implications were that all external collaborations have been discussions or communications. The reviewer asked if anyone was fabricating a device based on these materials or if this was just an academic exercise.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer reported that the research was published which was a good way to make an impact. The reviewer remarked that since thermoelectrics is in such an early stage, it is truly precompetitive and the right way to collaborate.

Reviewer 2:

The reviewer noted that the project team was working with the automotive industry (including multiple manufacturers), universities, and other research organizations (including the Naval Research Laboratory). The reviewer thought that this approach should really help to get the word out on results, which will be key to the value of this project.

Reviewer 3:

The reviewer found that the investigators had assembled a diverse project team for a primarily fundamental study on thermoelectric properties including both significant industrial partners (OEMs) and reputable academic institutions.

Reviewer 4:

The reviewer felt that collaboration and coordination with other institutions could be improved, but since the work appears to be rather fundamental, it may be too soon for such detailed collaboration.

Reviewer 5:

The reviewer was left unclear on the role of the collaborators the project, and asked the presenter to please be more specific on their roles.

Reviewer 6:

The reviewer commented that specific details of the various collaborations needed to be discussed.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer felt that focusing on low cost was the right thing to do.

Reviewer 2:

It seemed to this reviewer that the project had a lot planned for the remaining 16 months or so to go, particularly compared to what has been accomplished so far. The reviewer was definitely concerned about the project meeting schedule requirements. Also, most of the future efforts are simply focused upon identifying potential materials, not on the experimental results (for validation by others).

Reviewer 3:

There appeared to the reviewer to be a lack of connectivity or transition from this theoretical work and a strategy to develop a practical usable material.

Reviewer 4:

The reviewer thought that future research planned needed to be made more explicit. For example, if the atomic structure of these new material compositions is not well established, then the work should be done to determine what that structure is and how best to formulate their production.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer found this project to be highly relevant - to improve vehicle efficiency, high efficiency thermoelectrics are needed, and to get that efficiency from thermoelectrics, better materials are required. That is exactly what this project is aimed at. The reviewer declared that many industry members are looking to incorporate thermoelectrics, so there is strong potential for petroleum savings if efforts are successful.

Reviewer 2:

The reviewer suspected that extensive usage of thermoelectric materials will necessitate the ability to manufacture greatly increased quantities of these materials; and therefore it is incumbent to develop the means to do so. Before that can be accomplished, it is necessary to have a validated database of materials composition and thermo-mechanical properties. In particular, the new materials must have no toxic or expensive elemental components. The reviewer judged that usage of thermoelectrics to harvest vehicle waste heat or to provide occupant comfort will support the overall DOE objective of petroleum reduction.

Reviewer 3:

The reviewer said that, yes, there are a few applications where thermoelectrics make sense for petroleum displacement. For example, waste heat recovery (WHR) for the EGR circuit – many of the future downsized engines will have EGR coolers. The reviewer cited this as the ideal application since there is a temperature difference big enough to give a significant output. There is also already a cold sink in place today so the added cost, weight and complexity is manageable. The reviewer noted that other WHR systems are far too expensive for cars. However, the reviewer did not see the relevance for air conditioning, since the efficiency of an air conditioning system is above one if designed for efficiency. Thermoelectrics have an extremely low efficiency at air conditioning temperatures in comparison.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that resources appeared sufficient for now, though the project team would clearly continue to evaluate additional materials if it received additional funding (and time).

Reviewer 2:

The reviewer felt the resources seemed appropriate but could not really judge the effort, although the reviewer also thought there were an impressive number of publications for the money.

Reviewer 3:

It was the reviewer's view that at this stage of the work, there is no strong imperative to increase funding, and therefore resources appear adequate to achieve the stated milestones.

ORNL: Low-Cost Direct Bonded Aluminum (DBA) Substrates (Agreement ID:23278): Hua-Tay Lin (Oak Ridge National Laboratory) - pm036

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found that the program addressed all relevant issues including strength, thermal conductivity, and cost with benchmarking against commercially available direct bonded aluminum (DBA) and direct bonded copper (DBC). To support future high temperature wide bandgap (WBG) electronics, an assessment of the reliability of these substrates to long-term high temperature operation and thermal cycling should be conducted. It was not clear to the reviewer what the cost targets were or what savings might be realized from the ORNL-developed technologies.

Reviewer 2:

The reviewer thought that the initial approach to assessing the market, performing tests on low-cost substrates and benchmarking were reasonable. The reviewer felt, however, that there was insufficient discussion on the approach towards developing material parameter improvements in silicon nitride (Si_3N_4) compositions.

Reviewer 3:

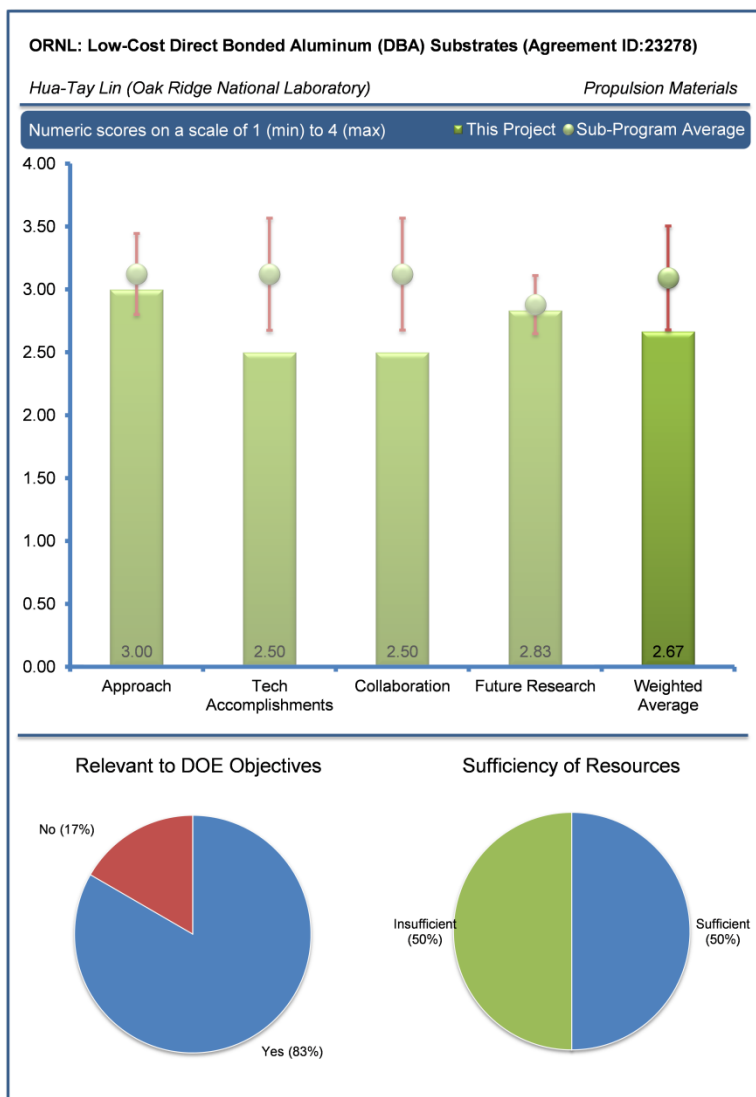
The reviewer said that this was interesting work but there were unanswered questions about residual stresses perhaps imparted during the bonding process. The reviewer felt that the work may be a solution looking for a problem: This means that the work seems to be like a product improvement project that industry might be able to do on its own.

Reviewer 4:

It was the reviewer's view that the project addressed a critical problem of DBA for power electronic applications. With higher power density electronics being developed, need is for more reliable joints with appropriate thermal conductivity materials. The reviewer reported that the project is investigating DBA fabrication with various ceramics, and that the project is actively seeking low-cost, large scale manufacturing approaches for DBA fabrication.

Reviewer 5:

The reviewer cautioned that the technical approach to using high-vacuum to process alumina-forming alloys was going to be an uphill battle from the beginning unless involving reactive brazing or reducing atmosphere processing.



Reviewer 6:

The reviewer felt that a significant barrier at this point may be time – for a project in the final planned funding year there is still a considerable amount of valuable work being proposed, particularly with regard to the optimization of the Si_3N_4 . Much of this work is planned for completion in FY14, although this particular project ends in 2013 – presumably there is another source of funding for this work.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer thought the progress on the project has been on track per the proposed milestones. Various brazing materials have been investigated. Silicon nitride-based substrate materials with optimized properties have been developed. The reviewer found the strategy to develop silicon nitride ceramics which optimize thermal conductivity using appropriate sintering elements to be excellent.

Reviewer 2:

The reviewer saw that, while the work being performed was significant, the technical challenges with substrate bonding for various systems appear not to have been overcome. The reviewer deemed promising some studies that are planned to improve this, but little in the way of accomplishment thus far (this could change significantly over the remainder of the program). The reviewer found that the largest breakthroughs seem to be in the area of the mechanical performance of the Si_3N_4 , and the qualities being presented are intriguing. This appeared to the reviewer to be a direct follow-on on earlier work, however, and not necessarily an outcome of this program; the mechanical properties listed on Slide 17 are attributed to work published in 2010, which was before this specific program was funded.

Reviewer 3:

It appeared to the reviewer that the accomplishments to date were largely in the area of trial of unsuccessful bonding techniques and assessment of key thermal and mechanical properties of existing materials. The reviewer felt that this is a good start on bounding the issues associated with development of improved substrates.

Reviewer 4:

The reviewer felt that progress has been good. It was unclear to the reviewer what the ultimate objectives (quantitative) were, leading the reviewer to ask how the reviewers will know when the work is done.

Reviewer 5:

The reviewer warned that milestone three may not be completed due to budget changes.

Reviewer 6:

The reviewer stated that if the objective was lowering the cost of DBA manufacturing, then progress has been poor. The reviewer went on to say that although a shift to Si_3N_4 and DBC may be a more fruitful pursuit, it seems to be a re-direction of the intended purpose of the project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer saw that collaboration with the Advanced Power Electronics and Electric Machines Program (APEEM) team members and industrial partners/suppliers appeared to have been quite fruitful for the project. Benchmark testing using Marlow DBA substrate is particularly important task. The reviewer went on to suggest that potential licensing of the DBA for silicon nitride ceramics to industry exists.

Reviewer 2:

The reviewer found ample evidence to suggest that the program has engaged outside entities to support the work, as the collaboration with Marlow has been established. The reviewer noted that direct contribution from Marlow appeared limited to the supply of material for benchmarking, so this collaboration (along with others) should be pursued more aggressively.

Reviewer 3:

The reviewer reported that this seems to be primarily a team within ORNL and industry involvement is limited to Marlow and Materion providing material.

Reviewer 4:

The reviewer expressed that collaborations appeared limited to obtaining materials from vendors, and was unclear what the relationship was with the National Transportation Research Center (NTRC).

Reviewer 5:

The reviewer said that, other than supplying components or materials for some aspects of the work, it was unclear the extent of collaboration with other industrial partners.

Reviewer 6:

The reviewer recommended that the project expand partnerships with industry and universities [e.g., Virginia Polytechnic Institute Center for Power Electronics Systems (CPES)].

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer thought the difficulties encountered with successful bonding and the shortcomings of DBA-type systems had been presented adequately. The reviewer stated the future research path has the potential to overcome a number of these issues.

Reviewer 2:

The reviewer relayed that enhancements to present properties of Si_3N_4 ceramics are possible and the proposed approach for attaining improvements seemed reasonable. The reviewer concluded that completing the evaluation of tape casting products will support the overall benchmarking effort.

Reviewer 3:

The reviewer found that future work adequately addresses the milestones and deliverables of the project. However, it was not clear to the reviewer how low-cost silicon nitride ceramic will be developed using a high purity silicon powder. This seemed to be counterintuitive.

Reviewer 4:

The reviewer reasoned that since bonding of ceramics and other materials seem to fail in the region adjacent to the joint, it is important to determine if the process imparts large residual stresses in this region. There are models which seek to predict these residual stresses, which should at least be investigated for applicability.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer thought that this project addressed an enabling technology for the reliable thermal management of high power density electronics for HEVs or EVs, thus leading to significant petroleum displacement.

Reviewer 2:

The reviewer claimed that, yes, high performance substrates are critical for future WBG electronics that will have significant impact on efficiency, mass, and cost.

Reviewer 3:

The reviewer observed that lighter-weight, more efficient and reliable DBAs could lead to less costly power modules in EVs, thus pushing down the costs. It was not clear to the reviewer how much cost savings was possible, although it appeared to be minimal.

Reviewer 4:

The reviewer saw that the relationship between this program and petroleum displacement seemed to exist through efficiency and reliability of electronics, but remarked that the direct path between the concepts was not clearly presented.

Reviewer 5:

The reviewer thought there was small relevance to the DOE objective of petroleum displacement (e.g., bonding on ceramic engine valves), but it was unclear how much this contributes to engine powertrain efficiency improvement.

Reviewer 6:

The reviewer reported that the impact on petroleum displacement was not discussed. The power electronics application was not even mentioned until the summary slide. In the reviewer's opinion the case for relevance was not made in the presentation.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that overall the resources appeared to be sufficient but suggested that perhaps the industry partners could contribute a higher percentage of the project cost.

Reviewer 2:

The reviewer relayed that it was acknowledged in the early slides that budget changes may alter a FY 2013 milestone.

Reviewer 3:

The reviewer declared that additional resources will be needed to support substrate needs of future WBG electronics.

Reviewer 4:

The reviewer found that funding was not sufficient to support proposed work.

Improved Organic Dielectrics for Power Electronics and Electric Motors (Agreement ID:23279): Andrew Wereszczak (Oak Ridge National Laboratory) - pm037

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought that this was a nice piece of work; well thought-out and planned. The reviewer also thought that this appears to be a good return on investment.

Reviewer 2:

The reviewer felt that the project would return a solid set of conclusions on the relative strengths of different approaches, because the test matrix encompasses a large number of candidate fillers. It was not entirely clear to the reviewer why other classes of materials (outside of oxides) were not a significant part of the evaluation; as it might have been more transformational in nature for the intended applications due to much higher levels of thermal conductivity.

Reviewer 3:

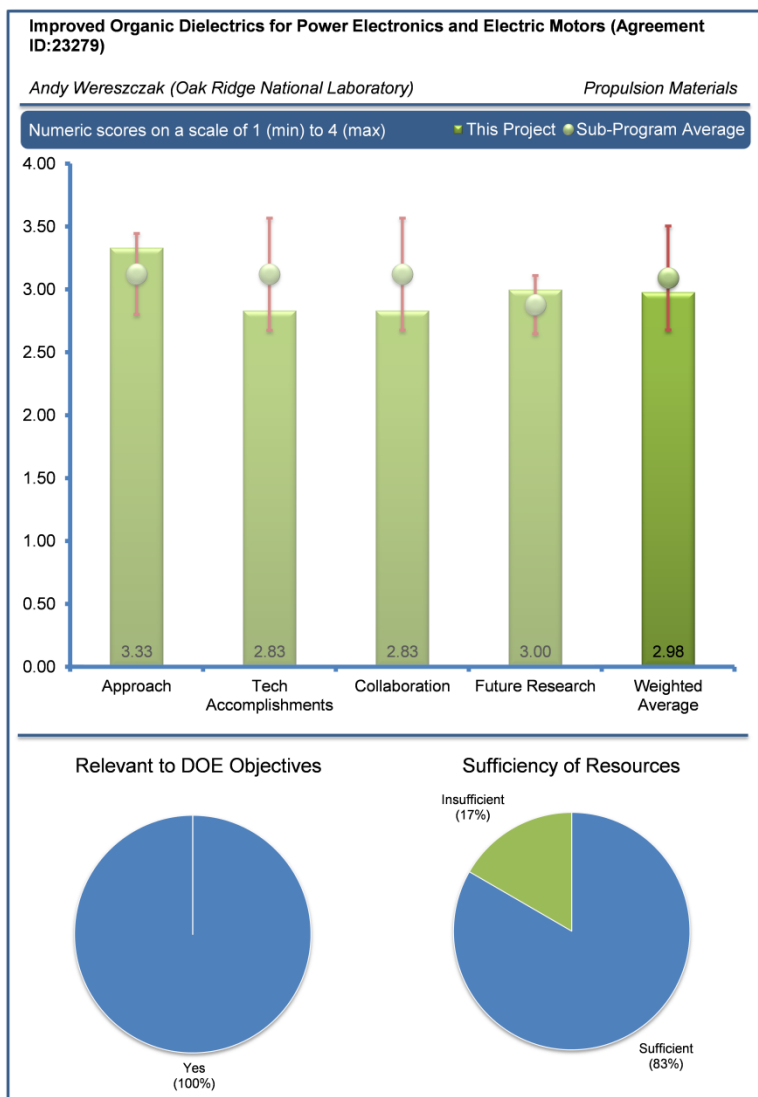
This work seemed to the reviewer to be closer to basic applied research, which is very appropriate for federal funding. The approach is very straightforward but perhaps too heuristic. The reviewer asked if there was any theoretical work which might contribute to faster progress to finding better materials.

Reviewer 4:

The reviewer reported that the project is related to developing thermal management strategies for power electronic devices using thermally conductive molding compounds. Increased heat dissipation can lead to reliable performance of the power modules and longer lifetimes, thus contributing to cost savings. The reviewer relayed that different conductive filler materials added to the epoxy materials to enhance thermal conductivity are being investigated.

Reviewer 5:

The reviewer disclosed that the project used magnesium oxide (MgO) as filler in epoxy to improve thermal performance, and presented a wide range of fillers and cost estimates. The reviewer also noted additional work on durability and impact on life due to thermal cycling, mechanical forces, and vibration before these materials are suitable for use in production motors and power modules.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer felt there was an excellent review of candidate materials, with a good combination of predictive modeling and experimental results. The reviewer also reported that the target of 3 W/mK (watts per millikelvin) achieved through a process of material evaluation, modification, modeling and cooperation with industry.

Reviewer 2:

The predictive models are effective, and the approach to determining the relative effectiveness of each filler distribution and type is adequate. More in-depth testing based upon actual usage conditions appears to be slated for future efforts.

Reviewer 3:

The reviewer felt that progress and technical accomplishments were moving forward to the objective of greater than 5 W/mK, but the reviewer was still not clear what the barriers might be to achieving this goal from the 3 W/mK level achieved.

Reviewer 4:

The reviewer saw that good progress was being made, but observed that some results appear to be identical to results presented last year (i.e., Slides 8 and 10).

Reviewer 5:

The reviewer deemed progress on the project to be adequate. Epoxy formulations have been developed with thermal conductivities of 3 W/mK from the baseline value of 0.2 W/mK. Synthesis and process strategies have been developed. Models have been developed to assess the temperature reductions in various electronic modules by using the conductive polymers. The reviewer reported that tests conducted on the magnetic and electrical characteristics of the developed formulations shows their acceptable performance. However, the reviewer wondered if these materials perform under long-term exposure to natural elements such as moisture, etc., or if thermal cycling affects the performance. It was not clear to the reviewer why the thermal conductivity goes up and not the electrical conductivity in these formulations.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer judged, based upon the budget, that the right collaboration level appeared to be in place. The collaborative role of the MgO supplier did not appear to be significant outside of providing filler materials.

Reviewer 2:

The reviewer noted that collaboration with a key industrial partner, SolEpoxy, was likely providing useful data for both the manufacturer and the researchers.

Reviewer 3:

The reviewer reported that collaboration with the industrial partner that is a supplier to the electrical and motor component manufacturers is important, and noted that this will certainly help in the technology commercialization and adaptation.

Reviewer 4:

The reviewer would have expected greater involvement of more industrial partners, given the importance of this work to electric and hybrid vehicle propulsion systems.

Reviewer 5:

The reviewer rated partnerships with the feedstock material suppliers to be good, but there was no direct connection, and thus technology path, to industry. The NTRC was referenced as an end-user/industrial partner which is another research institution (via ORNL), not a true industrial user.

Reviewer 6:

The reviewer recommended that collaboration with motor and power module manufacturers would provide valuable feedback from end user on durability and other issues.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer found that the future work being proposed was an effective mix of building upon past work and refining the evaluation protocols. The scope still seemed to the reviewer to be relatively limited, but the budget allocation may be restricting this.

Reviewer 2:

The reviewer reported clearly defined future work.

Reviewer 3:

The reviewer stated that future work includes further increase in thermal conductivity up to 5 W/mK, and demonstrating the heating effects of the molding compound. Further, the material is planned for implementation on an electric motor component. The reviewer questioned whether all these activities could be completed in the remaining fiscal year.

Reviewer 4:

The reviewer recommended that basic research on new low-cost filler materials with superior thermal/electrical/dielectric properties should be pursued as an adjunct to this work.

Reviewer 5:

The work did not appear the reviewer to be focused on identifying and addressing the barriers to achieving the goal.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer thought this project was very relevant, since improved thermal performance will lead to higher power density in electric drive system components.

Reviewer 2:

The reviewer concluded that this project addressed an enabling technology for the reliable thermal management of high power density electronics for HEVs or EVs, thus, leading to significant petroleum displacement.

Reviewer 3:

The reviewer found that the direct support was not as significant as other programs, but increased efficiency and reliability of electric components still played a role in reducing energy consumption, which invariably includes petroleum.

Reviewer 4:

The reviewer stated that vehicle electrification contributes strongly to the DOE petroleum displacement objective.

Reviewer 5:

The reviewer relayed the project improved the thermal reliability of power electronics.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer recommended additional resources to include research on improved filler materials.

Reviewer 2:

It was unclear to the reviewer whether funding would be sufficient in FY 2013 to complete the tasks listed in Future Work slide. The reviewer expected that additional funding in FY 2014 would provide additional funds needed.

Reviewer 3:

The reviewer thought the resources seemed sufficient based upon the proposed scope, but the relative allocation for FY 2013 is quite small compared to earlier years in the program.

Reviewer 4:

The reviewer judged that the resources appeared to be sufficient to continue timely progress.

Advanced High Temperature Aluminum Alloys for Propulsion Applications (Agreement ID:24034): Mark Smith (Pacific Northwest National Laboratory) - pm044

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought the team had a good approach to developing an alloy, and a manufacturing process to produce it.

Reviewer 2:

The reviewer declared that development of new alloys is not a simple task. The reviewer judged the current approach to be good, concentrating on one system with small variations; however, the reviewer would have liked to see justification of why a particular alloy system was chosen.

Reviewer 3:

The reviewer reported that the original goal was to reach 300 MPa (megapascal) tensile strength at 300°C, but that this goal had been changed to 250 MPa, and as a result not all technical barriers were tackled in phase 2 of the project. The reviewer concluded that the approach was solid and scientifically well chosen. The microstructure of this material is quite different from standard Al, which makes it desirable to have a broader evaluation of the material characteristics, like corrosion resistance.

Reviewer 4:

The reviewer found it strange that Transmet was not involved from the beginning, as Transmet and Cummins are both based in Columbus, and Transmet specializes in this very technology. The reviewer stated that it should have been advantageous if Transmet had been a bigger partner in this work, and that it should also have been advantageous to have a few components identified upfront with given requirements to meet.

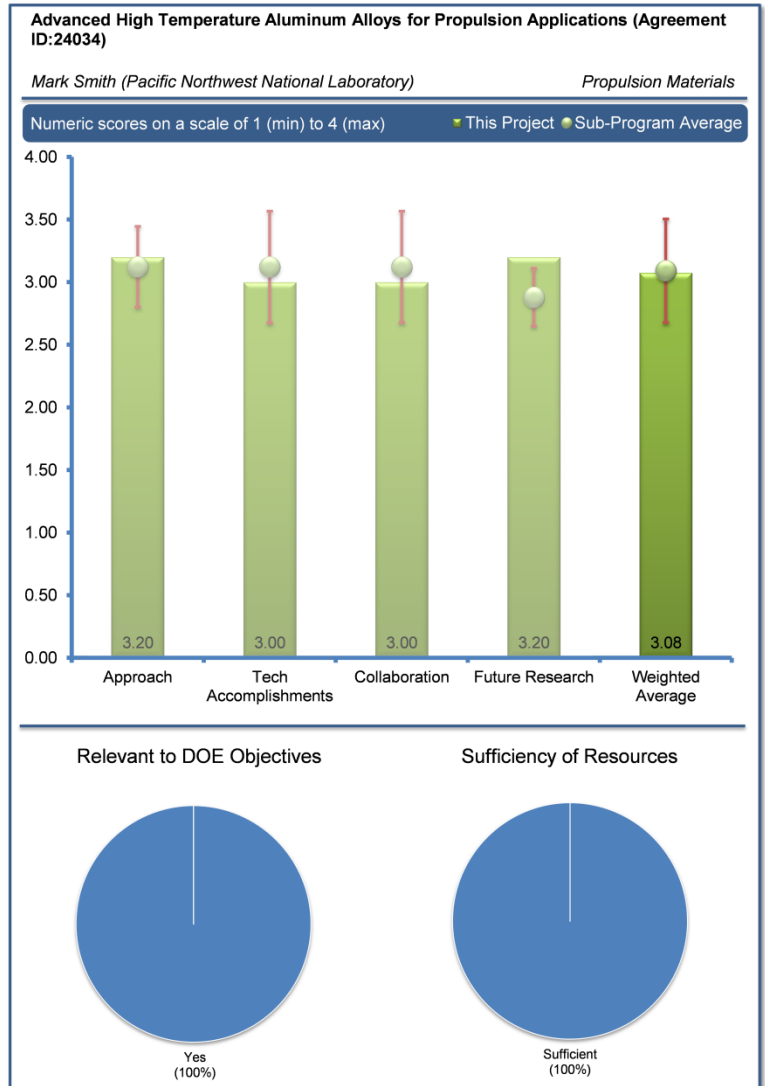
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed excellent process towards developing something that could be commercialized in the near future.

Reviewer 2:

The reviewer found very good progress with the alloys showing good properties at 300°C. Even though the extruded structure is not quite uniform with large scale segregation of phases the properties are significant. The reviewer recommended that efforts should be



made to assess the effect of long time holding at high temperatures on the structure. Also, the high-temperature corrosion behavior of the new alloys needs to be evaluated.

Reviewer 3:

The reviewer reported that the project was being executed according to plan. In the original plan Kaiser Aluminum had a role as material provider this was taken over by Transmet. During the presentation evidence was provided that this should not influence progress. The reviewer found the progress towards DOE goals difficult to evaluate since it is unknown for what part this is used and as such it is not possible to establish the potential fuel economy benefit.

Reviewer 4:

The reviewer commented that the need for a stronger extrusion machine was identified, which indicated a potential wear problem for the extrusion machine. The reviewer would have expected more results considering the funding size. This lack of results indicated to the reviewer a number of failures that have not been reported. Also failures are worth reporting. That is what we learn from. The reviewer commented that this was a sound project addressing the need to reduce weight to save fuel.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer found that there was good collaboration with industry partners. It was clear to the reviewer that a good relationship had been built with Transmet.

Reviewer 2:

The reviewer judged there to be a good, well-coordinated, collaboration with industry, but suggested that cooperation with universities could have been beneficial to have a basic evaluation of a wide variety of this material's characteristics.

Reviewer 3:

The reviewer reported that the entire process team was included; this will make commercialization quite easy.

Reviewer 4:

The reviewer reflected that collaboration was limited to three partners. The reviewer suspected that others are probably watching and will participate based on favorable materials research and cost to produce.

Reviewer 5:

The reviewer stated that an Al processing company should have been identified from the start.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pronounced that there were solid plans in place for future development toward the possible commercialization of this material.

Reviewer 2:

The reviewer felt that the plan was clearly described in milestones, and that there was a clear focus on producing an engine component.

Reviewer 3:

The reviewer relayed that there was a plan for large-scale production and field testing; this is good progress. However, the reviewer recommended that the corrosion at high temperature be evaluated before commercialization, and pointed out that this is not currently included in the future plan.

Reviewer 4:

The reviewer reported that the project is on the path to conclude in calendar year (CY) 2014, and there were no indications of follow-on work, or of any manufacturing interest to date. The reviewer suggested a marketing strategy to determine what company may be interested in producing bulk alloy.

Reviewer 5:

The reviewer said that this seems to be trial and error, performing some tests and seeing where this is going. The reviewer felt that targets, components, and requirements were not identified.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer expected that as the new powertrain is expected to perform at higher temperatures, conventional Al alloys may not perform well. Replacing them with titanium may increase the cost and weight. The reviewer concluded that development of new Al alloys with high temperature capability will help in maintaining the weight while increase the performance.

Reviewer 2:

The reviewer agreed that reduced weight is very important.

Reviewer 3:

The reviewer stated that higher allowable temperatures in general lead to higher fuel efficiency. The reviewer had to guess that this will actually be the case, since the applications were not disclosed.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer judged the resources to be in line with the requested work volume.

Reviewer 2:

It was not clear to the reviewer what the contribution from Cummins was in the project.

Non-Rare Earth magnetic materials (Agreement ID: 19201): Michael McGuire (Oak Ridge National Laboratory) - pm045

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer felt that the team had an excellent pragmatic approach to new materials development, combining chemical intuition, supplemented with first-principles computation, followed up with synthesis and characterization. It is easy for this type of exploratory work to wind up in the weeds, but this project is mostly staying focused on promising directions.

Given the relatively small global supply of hafnium, it was not entirely clear to the reviewer that magnet chemistries based on hafnium would be such a great advance compared to rare earth chemistries. This is particularly true if the measured energy products of the hafnium-based magnets are closer to Alnico than to rare-earth magnets. Considering this, the reviewer reported that the team has identified directions to address these issues (possible substitution of zirconium (Zr) for hafnium (Hf), and improved processing to increase the energy product) as work items for FY13.

Overall, the reviewer was not fully convinced that pursuing hafnium-based chemistries is preferable to improving existing chemistries such as Alnico.

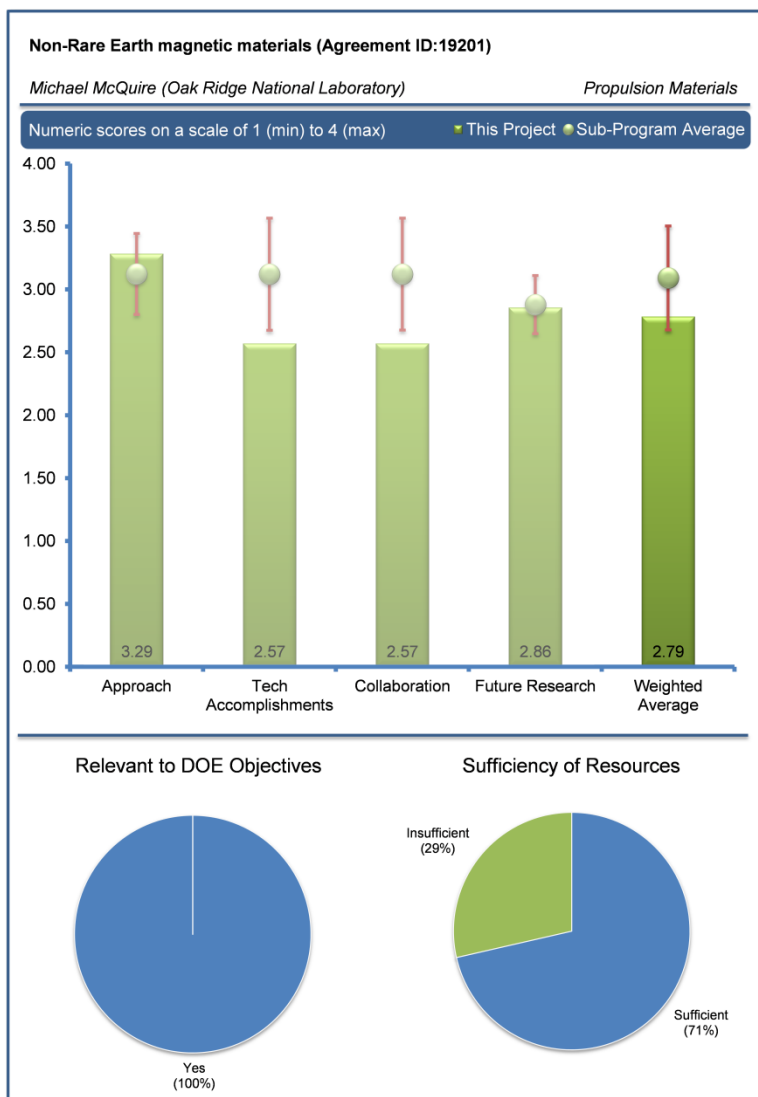
The reviewer felt that the most promising direction to achieve energy products comparable to rare-earth magnets using lower-cost materials seems to be the thermomagnetic stabilization of L1₀ iron (Fe)-palladium (Pd)-nickel (Ni). The initial progress on this front is encouraging. The reviewer thought it would be interesting to see the outcome of the FY13 work.

Reviewer 2:

The reviewer saw that the project appeared to be well thought-out, relevant to the objectives and directly targeting technical barriers largely through the attempts to develop new, non-rare-earth based magnetic materials.

Reviewer 3:

The reviewer relayed that this project addressed the development of non-rare earth magnetic materials for automotive applications. The project focused on identification of heavy transition metals as potential replacements for rare-earth magnets. The reviewer thought that there were well-defined targets and barriers are presented.



Reviewer 4:

The reviewer reported that the project approach included both theoretical and experimental activities to develop low-cost permanent magnet materials. The project was multi-disciplinary and involved theory/computations, processing, and characterizations. The reviewer observed that use of high magnetic fields to stabilize ferromagnetic phases has been shown to be successful.

Reviewer 5:

The reviewer considered the research to be important, and reflected that the potential dependency on rare earths in large supply is somewhat frightening. Unfortunately, the reviewer felt the approach and selection of the range of systems did not clearly come across. The reviewer was left wondering what the relative cost of an advanced iron-based system versus Hf-cobalt (Co)-boron (B) was, and how this compared with fractional differences or orders of magnitude, as cost is a critical driver to this research. The reviewer reported that there were promising results on the Hf-Co-B system that would be continued with substitutions for more common elements, so the focus was not absent.

Reviewer 6:

The reviewer declared that one of the primary technical barriers was cost, and the cost component was not addressed during the presentation.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that, given the exploratory nature of this project, the goal was rather broad in nature, citing the entire goal as to identify alternative hard ferromagnetic materials which do not contain rare-earth elements and are relevant to permanent magnet (PM) motor technology. The team is making good progress towards what is clearly a long-term goal. The reviewer felt the team was producing useful findings, both in terms of the physical metallurgy of these materials, as well as their processing. The reviewer concluded that promising chemical systems have been identified for further study.

Reviewer 2:

The reviewer judged that the presentation clearly showed the progress being made on different alloy systems. The end goal for the program seems to be to have evaluated numerous categories of potential PM materials without a particular emphasis on perfecting a single system. The reviewer thought this might be considered a strength (wide range of potential material) and a weakness (if the conclusions do not move us significantly toward a more mature tollgate). The reviewer was not completely clear whether there is a planned downselection of promising PM systems, although it would be relevant when the evaluations cover a wide range of conceptual materials.

Reviewer 3:

The reviewer felt that good progress was being made towards program goals; however, significant work remains before viable replacements for rare earth-based magnets are developed.

Reviewer 4:

The reviewer deemed technical accomplishments to be adequate. However, the reviewer was concerned that after almost four years into the project, the focus is on the material development. Further, it was not clear whether the hafnium-based material would be cost-effective material. A simple cost analysis would provide some indications. The reviewer reported that substituting zirconium for hafnium has been suggested, but no plans for conducting that work are presented.

Reviewer 5:

The reviewer relayed that this project has been ongoing since 2009 and is slated to end in 2015. During that time the project team identified several new ferromagnetic compounds and is in the process of characterizing their properties. The reviewer thought it would be useful for the PIs to compare the current level of performance against automotive needs and state-of-art magnet technology.

Reviewer 6:

The reviewer revealed that a new material has been identified and initially characterized that has the potential to provide desirable magnetic parameters comparable to and possibly in the long run competitive with rare earth magnets. The reviewer thought that the melt spun technique appeared fruitful, and that follow-on work with zirconium would be a reasonable next step. The reviewer reported that the efforts with phosphides (listed as FY 2013 milestone) were not adequately addressed in presentation.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer concluded that collaboration has provided an efficient means to achieving technical progress and has resulted in peer-reviewed publication.

Reviewer 2:

The reviewer expressed that the bulk of the work is clearly ORNL-centric (collaborations with the University of Tennessee are somewhat inevitable); but that complementary studies carried out by other groups (Georgia Institute of Technology) appear to support the work.

Reviewer 3:

The reviewer reported that there was collaboration with University of Tennessee and Georgia Tech Research Institute (GTRI) and coordination with the Ames Lab effort.

Reviewer 4:

The reviewer stated that current collaborators and partners are involved in the technical aspects of the project. The reviewer suggested that it may be useful to establish collaborations with electric motor manufacturer to gain insights into feasibility of the material being developed as a commercial product.

Reviewer 5:

The reviewer commented that, because of its nature, this project has limited collaboration with industry or supply chain. The reviewer commented primarily a fundamental research project with collaboration limited to other FFRDC and academia (i.e., Ames and universities).

Reviewer 6:

The reviewer observed that there were minimal collaborations, primarily within the ORNL/University of Tennessee complex. The reviewer was unclear on the role that Georgia Tech plays.

Reviewer 7:

The reviewer reported that, as the presenter noted, there is significant work being done on non-rare-earth magnets. The reviewer listed this work as including ARPA-E REACT, U.S. DRIVE (U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability), BREM, etc. In particular, ARPA-E is funding work at Northeastern University on stabilized L1₀ phases (i.e., <http://arpa-e.energy.gov/?q=arpa-e-projects/iron-nickel-based-supermagnets>). The reviewer commented that there should be greater collaboration in this work.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer saw that the team has clear directions for future work. the reviewer listed cost-reduction of the Hf-based chemistries by substitution of Zr for Hf; enhancing the performance of the Hf-based chemistries through improved processing; and further exploration of stabilized L1₀ iron-nickel intermetallics. These directions address the barriers and limitations of past work.

Reviewer 2:

The reviewer deemed the plans for Hf-Co-B to be well laid out and reasonable, as are the Fe-Pd-Ni efforts. The reviewer noted, however, that phosphide development work was not well covered in the presentation.

Reviewer 3:

It was clear to the reviewer that use of hafnium-based compounds will be quite expensive; hence substitution of hafnium with other elements would be required. The reviewer reported that one suggestion made was for use of zirconium, however, there was no mention of synthesizing and evaluation of zirconium-based compounds. Further, the reviewer relayed that there was limited reference to how the work being conducted as part of the project will transition into a commercial product.

Reviewer 4:

The reviewer found that the path to the next step was not entirely clear, although it all falls under the new materials for PMs category. Maybe this could use a bit more emphasis, but the step from one materials type to the next does not always seem to build upon past discovery. The reviewer asked if the next up would be studies on phosphides, and wondered if this was natural extension of the Hf-Co-B work. Also, the reviewer questioned what of that work was based upon L1₀ or earlier iron-based ferromagnetic work.

Reviewer 5:

The reviewer reported that the 6.7 MgO max energy product shown, not clear how higher-energy products would be achieved. Much work remains.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer declared that this is a tremendously relevant topic. The importance to the nation is hard to exaggerate. The reviewer sees reducing dependence on rare earths as a national challenge and on the same level as reducing dependence on petroleum. Although this is clearly not the only work DOE is doing in this regard, the reviewer thought the type of long-term exploratory work embodied by this project is highly important.

Reviewer 2:

The reviewer considered that the main principle of the study (i.e., reducing the inherent cost of electric propulsion systems) certainly supports the objectives. The development of efficient electrical propulsion systems naturally reduces the dependency on petroleum, while the goal of reducing the dependency on rare earth elements provides an even more important contribution, thereby making electric propulsion an affordable alternative to ICEs.

Reviewer 3:

The reviewer reported that the project's goal is to reduce costs for the permanent magnets by using non-rare earth materials, which is bound to reduce the costs and meet DOE cost targets for power electronics for 2020. The reviewer predicted that if the cost target is met, then large-scale viability of HEVs and EVs will be reasonable, which will in turn lead to significant petroleum displacement.

Reviewer 4:

The reviewer found elimination of rare earth materials to be critical to efficient and low cost electric drives for EV/hybrid applications.

Reviewer 5:

The reviewer stated that the project supports goals of lower-cost EV development.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer deemed that, as new magnet materials are critical to vehicle electrification efforts, additional resources should be allocated to speed the development of these materials.

Reviewer 2:

The reviewer saw that the team appeared to be functioning well at current resource levels, but given the importance of this work, suggested that resource levels should be increased, and greater integration with other DOE efforts should be encouraged.

Reviewer 3:

The reviewer commented that ORNL and its collaborators appeared to have sufficient resources in terms of highly qualified personnel, laboratories and equipment.

Reviewer 4:

The reviewer judged resources in terms on manpower and facilities to be adequate for the project.

Reviewer 5:

The reviewer found that the resources were sufficient based upon a confidence that the research group knows what it will need - the focus shifts significantly enough for future endeavors that it is difficult for an outside reviewer to make a direct judgment.

Mechanical Reliability of Piezo-Stack Actuators (Agreement ID:13329): Hua-Tay Lin (Oak Ridge National Laboratory) - pm046

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer characterized the approach as the typical approach of make, test, evaluate and improve the material to address any failures.

Reviewer 2:

The reviewer asked if material constitutive models and failure mechanisms were being developed from experimental test for use in finite element analysis (FEA) design efforts. The reviewer reported thorough experimental testing to characterize material behavior under various conditions in order to prioritize material selection. The reviewer wondered if the results being obtained were being transferred to FEA to complete design optimization by project completion.

Reviewer 3:

The reviewer reflected that the fifth year of a six-year project is rather late in the program to be developing new techniques, and the PIs are reporting on the development of lab techniques to characterize high temperature properties. The reviewer thought that it would have been more prudent for the project team to wrap up previous studies and propose a new project. The reviewer asked what the rationale was for studying the effect of humidity on performance instead of fuel vapors and noted that these elements will operate in a fuel injector where they will be exposed to fuel vapors.

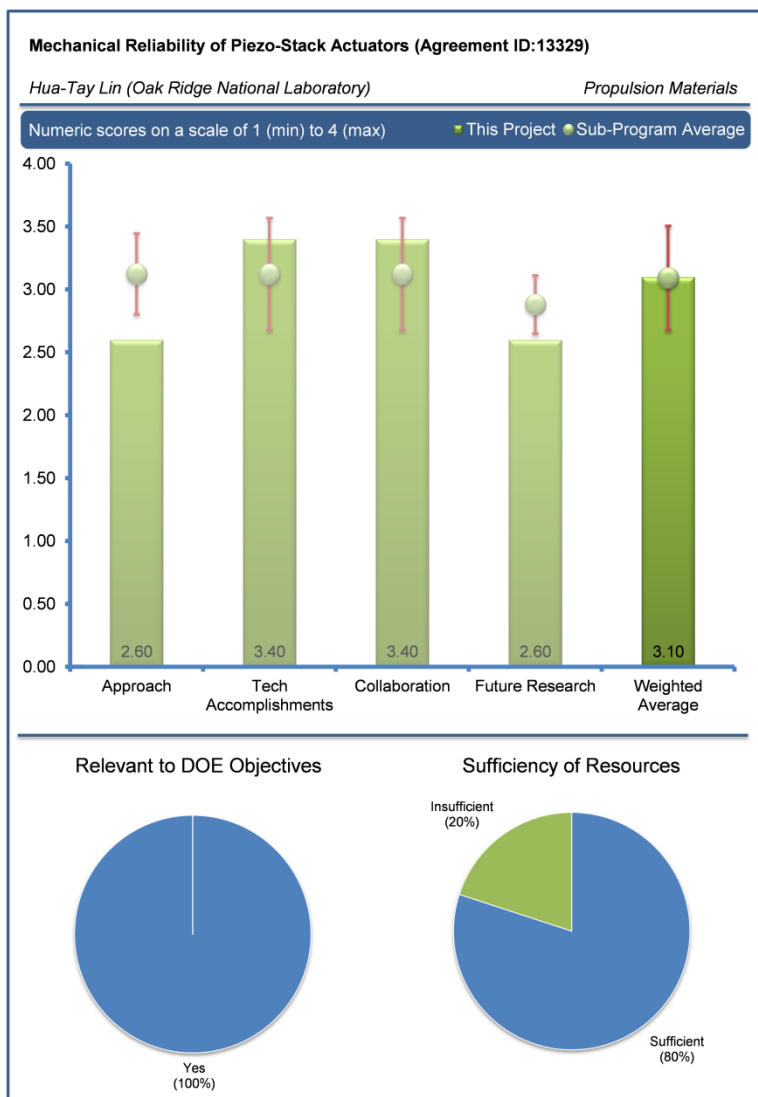
Reviewer 4:

The reviewer felt that the technical barriers were not well-defined. The project focused on characterizing the material and there is little information on the requirements to be reached to reach the goal of 2800 bar fuel injection pressures.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that technical progress was good, but suggested that since this work seems to fall under the label of Product Improvement, perhaps future work should be conducted under a Work for Others (WFO) CRADA where the industrial partners pay for the use of ORNL capabilities.



Reviewer 2:

The reviewer found that the progress was good compared to the goals, and that the project was being executed according to the plan. The main objective is to characterize the PZT (lead zirconate titanate) materials. It was not clear to the reviewer how the results of this project contribute to the overall mentioned goal of 55% engine thermal efficiency. It was difficult for the reviewer to evaluate to what extent barriers were/need to be overcome.

Reviewer 3:

The reviewer thought there were good experiments conducted to understand material behavior and aging effects. Several years into a project it would be expected to have material property requirements understood when evaluating and reporting experimental results. The reviewer wondered if target property requirements have been established for heavy-duty (HD) engine fuel injectors. The reviewer asked if the materials being investigating were showing promise for meeting objectives or not.

Reviewer 4:

The reviewer revealed that progress during the prior years was not reported and thus it was difficult to judge overall progress that the project was making on identifying the impact of environmental factors on performance.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer stated that since this work is being conducted under a CRADA, collaboration appeared to be excellent.

Reviewer 2:

The reviewer agreed that there was excellent commitment from industry and a material supplier.

Reviewer 3:

The reviewer saw good collaboration with fuel injector and engine OEMs.

Reviewer 4:

The reviewer remarked that there was a good cooperation with industry, and foresaw a clear path to implementation.

Reviewer 5:

The reviewer found there to be equal funding with Cummins, but found unclear what Cummins' contributions to the project were to date.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reasoned it likely that the barriers would be overcome, especially since the goal is to optimize the component design through probabilistic component design.

Reviewer 2:

The reviewer judged that future research clearly defined future experimental plans to further characterize material. It was not as clear to the reviewer how knowledge gained is being transferred to design and development of target applications, leading the reviewer to ask if the fuel injector concept using these materials has overcome the barriers.

Reviewer 3:

The reviewer recommended that future work of this kind should be conducted under a WFO CRADA.

Reviewer 4:

It appeared to the reviewer that the future activities would not be achieved with the current budget constraints being imposed on the PM program.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer discussed that a higher injection pressure and closer control of the injection cycle will result in reduced fuel consumption, and confirmed that this project will be an enabler for this.

Reviewer 2:

The reviewer reasoned that improving heavy duty injectors does support the overall DOE objective of saving petroleum.

Reviewer 3:

The reviewer agreed that fuel injector technology is important for achieving fuel economy and emission requirements.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

It appeared to the reviewer that resources were adequate to achieve the milestones in a timely manner, although there was no guarantee that the overall performance of the materials in-situ would be improved.

Reviewer 2:

The reviewer agreed that the budget is in line with the provided results.

Materials for HCCI Engines (Agreement ID:11752): Murali Muralidharan (Oak Ridge National Laboratory) - pm047

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented this project exhibited what National Labs do best, which is research using advanced methods on fundamental engineering problems.

Reviewer 2:

The reviewer commented that to start with integrated computational materials engineering (ICME) was a good approach to have guidance on the potential composition of the new alloys. This was followed by a limited number of alloys produced for further evaluation.

Reviewer 3:

The reviewer reported that technical barriers that were considered have been well defined, but noted that all technical barriers have not been fully investigated, such as temperature aging and corrosion.

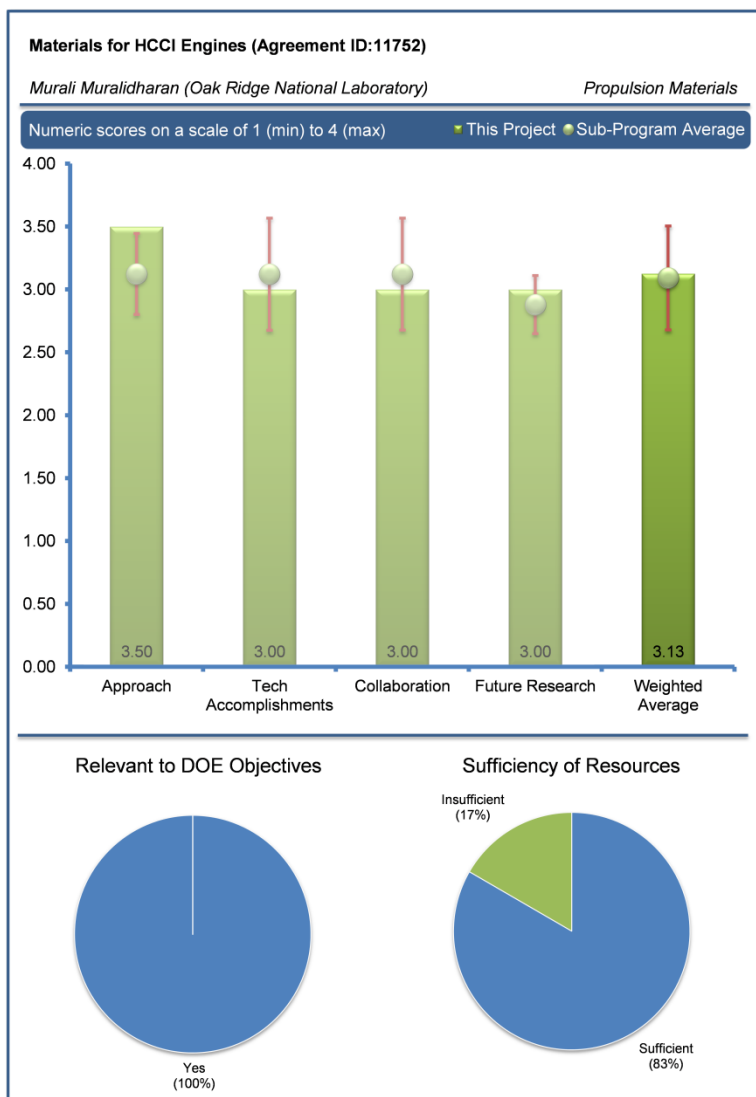
Reviewer 4:

The reviewer relayed that there has been alloy development using first principles and ICME, and recommended that the trial should be recorded so that future efforts can be improved upon. Even though the effort is based on ICME, many trials were needed. The reviewer thought it would be useful if some information or estimate could be provided on what would have been the physical efforts, if the ICME route is not followed.

Reviewer 5:

The reviewer asserted that the goal of this project is very clearly defined on Slide 6 [i.e., improve fatigue life at a temperature of 870°C, 35 kips per square inch (ksi) stress while maintaining the lowest possible cost (lowest Ni additions)]. The reviewer thought there was a solid approach to meeting this goal; by identifying a target microstructure and using thermodynamic/kinetic modeling to identify possible routes to achieve this microstructure, then making samples and performing microstructural characterization/fatigue testing.

However, the reviewer also commented that this goal was very narrow. There are many properties that are needed in an exhaust valve, of which fatigue life at 870°C and 35 ksi stress is only one. The reviewer recommended that creep, among other phenomena, also needs to be considered in order to meet the broader objective of this project, as stated on Slide 3 (i.e., develop cost-effective exhaust valve materials suitable for operating at higher temperatures [870°C versus current 760°C] for use in advanced engine concepts).



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer reported that this project has successfully developed a family of alloy with higher strength (30-80%) and lower cost (25-40%) than the current commercially-used alloy, in a relatively short period of time (seven years). The reviewer considered this a significant achievement, and demonstration of the validity of the approach.

The reviewer commented that the limitations of these findings (i.e., properties and cost depend on processing, which was not optimized in this project) were also clearly identified by the presenter.

Reviewer 2:

The reviewer remarked that the alloys have been assessed as worthwhile for IP (intellectual property) protection, which itself is an achievement, even if most of the time compositions cannot be effectively protected. The reviewer reported that the work has been completed on basic assessment, but thought more experiments, such as corrosion at high temperature, need to be carried out.

Reviewer 3:

The reviewer relayed that materials with improved properties have been successfully identified. Tradeoff studies have been conducted to improve ductility with minimal loss in strength. It appeared to the reviewer that materials were an improvement over baseline alloy. Fatigue properties at higher stress levels could be an issue for higher performance engines.

Reviewer 4:

The reviewer found that the project produced a number of potential lower cost alloys as compared to the current material. Although there was a significant improvement in fatigue strength at 870°C it was not clear to the reviewer if this was sufficient for application of this material in an engine valve application. Next to fatigue strength thermal conductivity at the targeted temperature is an important material characteristic. Although the reviewer expected improvements based on composition, an indicative measurement would be supportive.

Reviewer 5:

The reviewer stated the project had test results demonstrating goals, and suggested that as a next step need a commercial partner.

Reviewer 6:

The reviewer called the project a concluding line of research.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer judged there to be a good collaboration in the supply chain of this material, and noted that there was no collaboration with other institutions or universities.

Reviewer 2:

The reviewer reported that there were some discussions with potential alloy manufacturers, but no indication of any significant end user interest. The reviewer noted possible participation if alloy is available in quantity at low cost.

Reviewer 3:

The reviewer stated that there was involvement from material and valve manufacturers. The reviewer thought that it would be good to directly involve engine manufacturer to consider actual loading conditions a valve experiences during operations and definition of all property requirements in order to satisfy all functional requirements.

Reviewer 4:

The reviewer relayed that targets had been discussed with a manufacturer.

Reviewer 5:

The reviewer commented that greater collaboration from Eaton in better identifying the properties needed for an exhaust valve would be valuable. The reviewer thought the stated goal defines too narrowly the requirements for an exhaust valve.

Reviewer 6:

The reviewer felt that, even though discussion was carried out with many material suppliers, not many were involved, the work was very basic and no commercial interest was driving this project.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer declared that there is a need to get a more comprehensive understanding of the fatigue curve shape for the high potential alloy candidates.

Reviewer 2:

The reviewer noted that the project is close to its finalization, and that remaining activities are well described and planned.

Reviewer 3:

The reviewer felt that it was not obvious how the plan was followed, but the method seemed to work. The project is almost finalized (99%).

Reviewer 4:

The reviewer called this a concluding project.

Reviewer 5:

The reviewer relayed that no new work is proposed, and at the end of funding for the project.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer advised that enhancing the temperature of operation in powertrain will improve the fuel efficiency, which is one of the objectives of VTO.

Reviewer 2:

The reviewer saw that the developed material would allow higher temperatures in the combustion chamber, and this will lead to higher thermal efficiency of the engine and will reduce fuel consumption.

Reviewer 3:

The reviewer observed that the project meets a clear industry need. As exhaust temperatures continue to increase, industry will need materials that can withstand the higher temperatures, without incurring an unacceptable cost penalty. The reviewer felt this project was a good first step, although there is clearly much more work to do.

Reviewer 4:

The reviewer observed an enabler (among many others) for engines with higher efficiencies.

Reviewer 5:

The reviewer stated that engine valve materials are a known constraint to cost effectively achieving high performance and efficient engines.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The project appeared to the reviewer to be complete and not receiving funding, but testing is ongoing.

Reviewer 2:

The reviewer concluded that the project is finished based on the provided budget, and that results were achieved.

Reviewer 3:

The resources appeared to be sufficient to achieve the fairly limited goals of this project. However, the project could have benefited from greater resources, in order to address the broader topic of developing suitable alloys for HCCI applications. Hopefully, this project will continue in some form or another.

Reviewer 4:

The reviewer could not judge the appropriateness of the resources.

Tailored Materials for Improved Internal Combustion Engine Efficiency (Agreement ID:23725): Glenn Grant (Pacific Northwest National Laboratory) - pm048

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought that this seemed to be a cost-effective technology with many different possible applications. Due to that it is good to see the close cooperation with GM.

Reviewer 2:

The reviewer expressed that the approach for improving the strength of Al alloys was a straight forward approach and will have the potential to overcome the technical barriers. However, the reviewer found that the approach for the second task was not clear. FSW is a process to optimize cast microstructures. In this case it looked as if an attempt is made to optimize the structure of forged material. The reviewer relayed that during the presentation it was confirmed that this has a little change of success and that the focus should be on iron cast crankshafts. The reviewer advised that, for this, it is necessary to do tests on cast iron material and not on rolled material.

Reviewer 3:

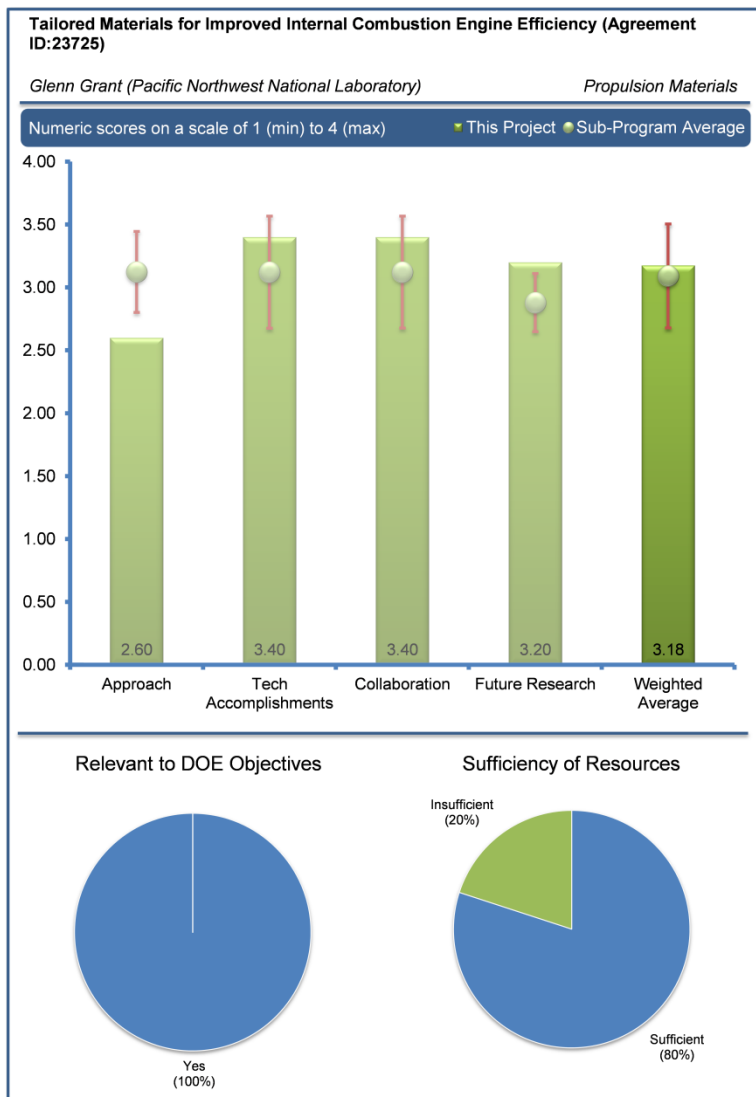
The reviewer thought the title was not representative of the project objectives. The work is to improve properties of surfaces through FSP. Two different materials are being processed to change the surface micro structure to improve high temperature stability or fatigue resistance.

Reviewer 4:

The reviewer felt that the objective of this project was rather loosely defined: employ FSP to improve the performance of engine components. The reviewer pronounced that more specific and measurable goals would help to make this project more successful.

For Task 1 (FSP of Al castings), the goal of a 10% improvement in room-temperature fatigue performance seemed to the reviewer to be excessively modest, especially given Jana's previous (2010) work showing a 5x improvement for investment-cast F357. The reviewer did not see any other quantitative goals. Thermal fatigue improvement, which is a major part of Task 1, did not have its own subtask assigned. Creep-fatigue was discussed, but there did not appear to be a clear plan of how creep-fatigue will be addressed.

The reviewer observed from the reviewer-only slides that Task 2 (FSP of steel forgings/castings) had not yet started, and needed to be worked out in greater detail to determine whether it was even worth pursuing. The reviewer thought that FSP was unlikely to provide any measurable benefit for forged crankshafts.



Given that there has been a significant body of work on modeling of microstructural evolution during FSP, the reviewer was disappointed that this project apparently did not include a modeling component. The approach so far appeared to the reviewer to be purely experimental. Also, this project did not appear to contain any fundamental work to advance understanding of FSP in general. The reviewer felt that this limits the broader value of the work.

The reviewer suggested that it would be beneficial to re-focus this project on FSP of Al castings only (i.e., eliminate Task 2), and develop a more focused plan around Task 1, incorporating clearly-defined quantitative performance improvement goals, better understanding of fundamental mechanisms, and computational modeling.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed that the progress in Task 1 was very good, and that deliverables were met. The process was developed and showed good results for the microscopic structure of the material. The reviewer noted that in Task 2 no progress has been reported, but wondered if this could be in line with the planning, since no Gant chart was provided.

Reviewer 2:

The reviewer advised that the project was still waiting for results on hot engine components.

Reviewer 3:

The reviewer reported that the effect of stir processing on the micro structural change and improved properties were discussed. As the Al alloy is stir processed a fine grained structure is obtained, which will have improved crack arresting capability. However, the reviewer explained that fine-grained structure is known to suffer from creep and long-term exposure to high temperatures may accelerate this failure mechanism. Also, the interface between the FSP and base metal will be weak point at high temperatures. The reviewer thought that these effects need to be addressed before commercialization is tried.

Reviewer 4:

The reviewer was concerned that the project is only 30-40% complete, given that nearly 60% of the project time has passed. Task 2 has not been started yet, and key components of Task 1 are still not clearly defined. The reviewer recommended that the goals and timeline for this project should be re-evaluated.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed very good cooperation with GM.

Reviewer 2:

The reviewer saw definite manufacturing and production incorporation interest, and thought there was potential for transition to end users.

Reviewer 3:

The reviewer found there to be a good collaboration between industry, PNNL, and the University of North Texas. The cooperation could be called outstanding if the goals for Task 2 were clearer.

Reviewer 4:

The reviewer thought the corporate partner (GM) appeared to be providing solid support for this project. However, the reviewer wondered if the apparent lack of focus in this project is a result of GM having unclear expectations. It was difficult for the reviewer to determine.

Reviewer 5:

The reviewer reported that an OEM is actively involved and agreed to conduct field trials on components. This reviewer felt this was quite significant as it makes the technology transfer very effective.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer found that future plans are in line with the outcome of previous activities.

Reviewer 2:

The reviewer thought that addressing hot engine parts is next step.

Reviewer 3:

The reviewer relayed that the effort will move on the steel structure and fatigue resistance of the stir processed surface. However, the reviewer maintained that the effect of fine grain structure on the creep performance needs to be evaluated for Al alloys; also the interface or process affected zone need to be characterized.

Reviewer 4:

The reviewer remarked that future work was not well-defined because the goals of the project as a whole are not well-defined. The reviewer concluded that the goals and timeline for this project should be re-evaluated.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer felt that this project is potentially of significant value in enabling the use of lightweight materials and advanced combustion technologies.

Reviewer 2:

The reviewer agreed that, yes, it is one enabler among many for higher engine efficiency.

Reviewer 3:

The reviewer discussed that improved high temperature strength in cylinder heads will enable higher thermal efficiency of the engine.

Reviewer 4:

The reviewer reported that selective reinforcement or modification of surface is an optimized process to use current materials in more demanding applications. The reviewer saw that this could reduce the cost of developing new materials and make the process economically viable.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reasoned that, given the importance of this project and the slow progress, more resources are needed. Computational resources, in particular, would be of value to this project.

Reviewer 2:

The reviewer felt that simple equipment was used so resources are sufficient.

Reviewer 3:

The reviewer said that the budget is sufficient to reach the goals.

Catalyst Characterization and Deactivation Mechanisms (Agreements 9130 and 9105): Thomas Watkins (Oak Ridge National Laboratory) - pm049

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought the approach to the 9130 project was good, and gave it a rating of three. The reviewer felt that a better understanding of benefit and limitation of ammonia oxidation (AMOX) catalyst was important to develop AT control mechanism and maximize long-term nitrogen oxide (NO_x) efficiency over selective catalytic reduction (SCR); however, selecting platinum (Pt) as an AMOX catalyst was not a good approach as the particular metal can convert ammonia (NH₃) into NO_x. The reviewer added that not having a detailed performance measurement plan in the approach was the weak point.

The reviewer thought the approach to the 9105 project was outstanding, and gave it a rating of four. The reviewer felt the approach using a gas-reaction holder for in-situ transmission electron microscopy (TEM) was very unique and the presented technique could provide features that others could not investigate automotive catalytic materials with during the thermal and chemical deactivation.

Reviewer 2:

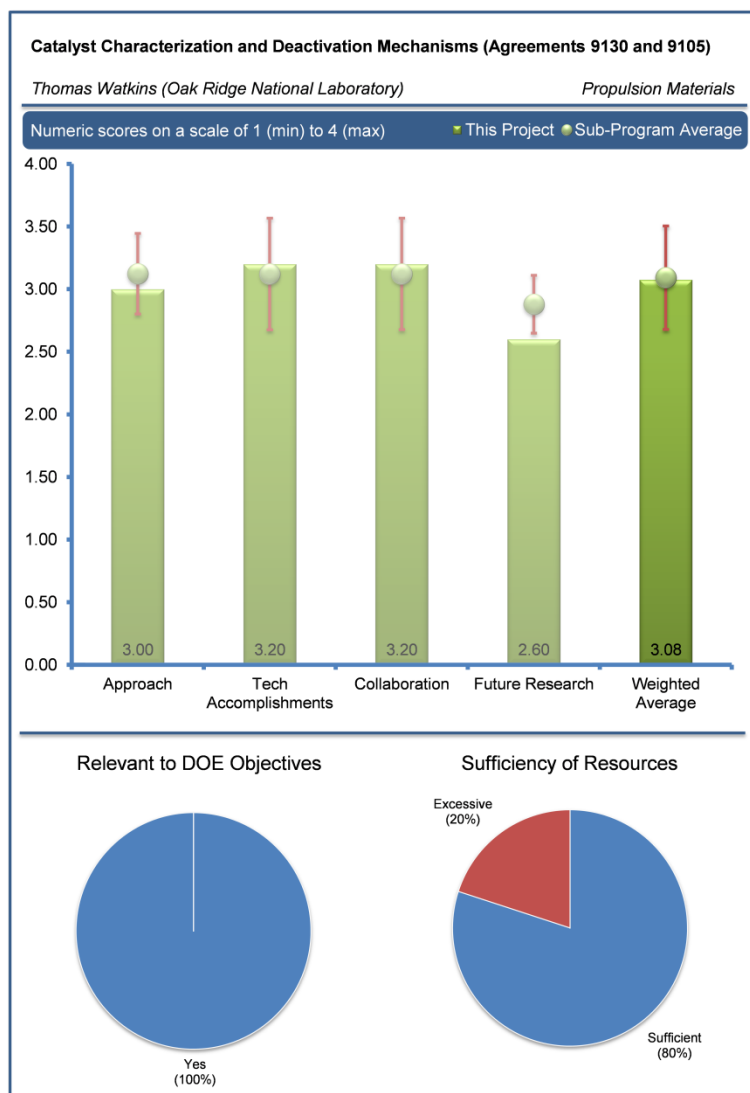
The reviewer stated that the application of methodologies was good.

Reviewer 3:

The reviewer disclosed that this is a very mature (more than 10 years) project focused on advanced characterization techniques of catalysts most recently employing in situ heating and gas flow capabilities. As exhaust temperatures change, there is value in providing the ability perform characterization at operating temperatures with experimental gaseous mixtures. This project appeared to the reviewer to be more service oriented than research oriented. ORNL is providing a valuable resource for collaborators interested in testing a variety of potential catalysts.

Reviewer 4:

It was difficult for the reviewer to find fault with the development of advanced techniques that provide a clearer understanding of catalyst response at atomistic length scales.



Reviewer 5:

The reviewer reported that the project proposed to experimentally characterize AMOX catalysts and SCR materials in various states of use from fresh to aged. The characterization involves microscopy and elemental analysis. The reviewer observed that results were shown yet no clear results were articulated. Pt particle growth in AMOX catalyst with increasing temperature is known and expected. The reviewer was left wondering what new insights or conclusions had been reached; likewise, with the elemental analysis, the reviewer asked what insight or actionable conclusions could be reached from the knowledge of non-homogeneous distributions of Zr and Cu.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

For the 9130 project, the reviewer gave a rating of two. The reviewer commented that accomplishments were very disappointing, producing no new information on Pt degradation under hydrothermal aging conditions. The reviewer reported that there are hundreds of references out in the public domain about how Pt grows under high temperature (greater than 700°C). Slide 10 does not show any information; zirconium dioxide (ZrO₂) may be from the binder for washcoat process. Also, the reviewer wondered if BASF is involved in this project, because the PIs cited a patent filed by BASF. The reviewer also noted that in-situ X-ray diffraction (XRD) data is also from a reference done by other group.

The reviewer thought the progress on the 9105 project was outstanding, and gave it a rating of four. The reviewer thought that it was a brilliant idea to have a microscale gas channel in vacuum chamber for the in-situ work. The reviewer was looking forward to seeing more progress next year.

Reviewer 2:

The reviewer gave progress a positive grade, but thought that it may seem a bit harsh based upon the development and employment of new technology to provide advanced characterization capabilities. An alternate general synopsis might be summarized as follows: The group collaborated on a new characterization technique, and then utilized it. The reviewer felt that without an in-depth analysis of the justification or hypotheses concerning the observed behavior and an elucidation of these hypotheses on future work, some room for improvement of an otherwise very successful program exists and an outstanding grade is not necessarily warranted. The reviewer concluded that the work is impressive and the goal is catalyst characterization, but some employment of this clear expertise beyond what was observed for a particular set of conditions would be an improvement.

Reviewer 3:

The reviewer stated that development of advanced characterization capabilities and use of instrumentation for characterization of new materials has enabled improved understanding for collaborators.

Reviewer 4:

The reviewer thought that the applications seemed to be less at the forefront of the technology. These catalysts are out there in use, leading the reviewer to question whether the PIs should be addressing new generations, or new problem areas.

Reviewer 5:

The reviewer observed technical accomplishments related to characterization, but noted that characterization, in isolation, is of limited value. Instead, characterization coupled with performance data and/or parametric studies would help answer critical questions of relevance to the broader community. The reviewer felt the project needed to set clear objectives as to the critical questions being answered, how the test is designed to get those answers, and then a concise presentation of the results. One of these projects has been ongoing for 11 years. The reviewer asked what the overall mission has been, and where the timelines, milestones, decision points were.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer observed that collaboration and support of industry (Ford, Cummins) appeared to be very useful. Collaboration with Protochips to advance capabilities of the electron microscope has also been fruitful, the reviewer noted.

Reviewer 2:

The reviewer believed that collaboration must be acceptable from Cummins side.

Reviewer 3:

The reviewer relayed that the role of Cummins appeared to be assisting in establishing specific parameters for observation, and that the developments with Protochips were a significant accomplishment.

Reviewer 4:

The reviewer felt that both branches of the project showed fair collaboration, and gave them a rating of two. For the 9130 project, it was not clear to the reviewer what the contribution from Cummins was. The reviewer wondered if there any vehicle level achievement available, and noted that it was not necessarily a set of data if it is proprietary information. For the 9104 project, it would have been great if the newly developed technique was available for other groups such as fuels and emission groups at ORNL.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.**Reviewer 1:**

The reviewer saw that the future work seems to follow the same (or similar) established path, with an eye toward improving existing test techniques and adding new materials to the test matrix.

Reviewer 2:

The reviewer reported that proposed future work is to continue along the lines of characterization of materials for collaborators.

Reviewer 3:

The reviewer felt that both branches of the project proposed good future research, and gave them a rating of three. For the 9130 project, the proposed future work was very well listed; however, the reviewer noted those are all work to be done at ORNL not Cummins. For the 9105 project, the future scope was not very clear about what will be the next scope in material characterization, although it is well explained on the hardware side.

Reviewer 4:

The reviewer felt that this should be re-visited in terms of whether these resources might be better employed in other projects rather than on this selective CRADA.

Reviewer 5:

The reviewer questioned why these projects would be renewed; and wondered what the ultimate objectives and outcomes would be. The reviewer was extremely concerned at the presenters comment that the project has no metrics or targets. The reviewer could not see how the DOE mission was being furthered, or what value was being added.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer remarked that both projects support the DOE effort on optimizing fuel-efficient vehicle technologies.

Reviewer 2:

The reviewer stated that characterization of catalysts at realistic gas temperatures and pressures would provide valuable information for development of new catalysts.

Reviewer 3:

The reviewer revealed that although the research is fundamental in nature, it does lend credibility to developments in clean diesel technology, which provides reduced petroleum consumption if deployed on larger scales relative to gasoline combustion engines.

Reviewer 4:

The reviewer found the argument that this research supports DOE goals to be a bit of a stretch, and pointed out that automotive emissions issues involve fuels and fuels may be something other than petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer said the future work appeared to be a continue-as-before approach for the most part, involving a wider range of catalyst conditions.

Reviewer 2:

The reviewer judged resources on both projects to be sufficient and well-allocated, and noted that the progress for the project 9130 is not sufficient compared to the level of funding the project received. The project 9105 may need more funding to improve and standardize the unique in-situ characterization technique.

Reviewer 3:

It appeared to the reviewer that this project has been adequately funded by government and industrial sources for an extended period of time. It is not clear if future funds will be adequate to continue to cover system development and characterization activities.

Reviewer 4:

The reviewer recommended that re-deployment should be considered.

Catalysts via First Principles (Agreement ID:10635): C.K. Narula (Oak Ridge National Laboratory) - pm050

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought that there was a very well-defined effort on both theoretical and experimental studies. The PI was very knowledgeable on the fundamental catalysis.

Reviewer 2:

The reviewer judged that the project had a well-conceived blend of modeling and experiment.

Reviewer 3:

The reviewer stated that the project approach utilized a blend of first principles modeling with experiments and characterization.

Reviewer 4:

While the objectives seemed to the reviewer to be well-defined, the barriers being presented on Slide 3 did not seem to have any particular focus on first-principles advantages to practical research in this field. Slide 5, however, accomplishes this specific focus in very clear fashion. The reviewer concluded that the approach was well-established and the utility of simulation-based atomistic selection of ideal catalysts is a significant body of work.

Reviewer 5:

The reviewer reported that this project is apparently a perennial project. The reviewer expressed that Pt on alumina is old work to be expending resources upon. Copper chabazite is already in commercial use, and the modeling link-up is tenuous at best.

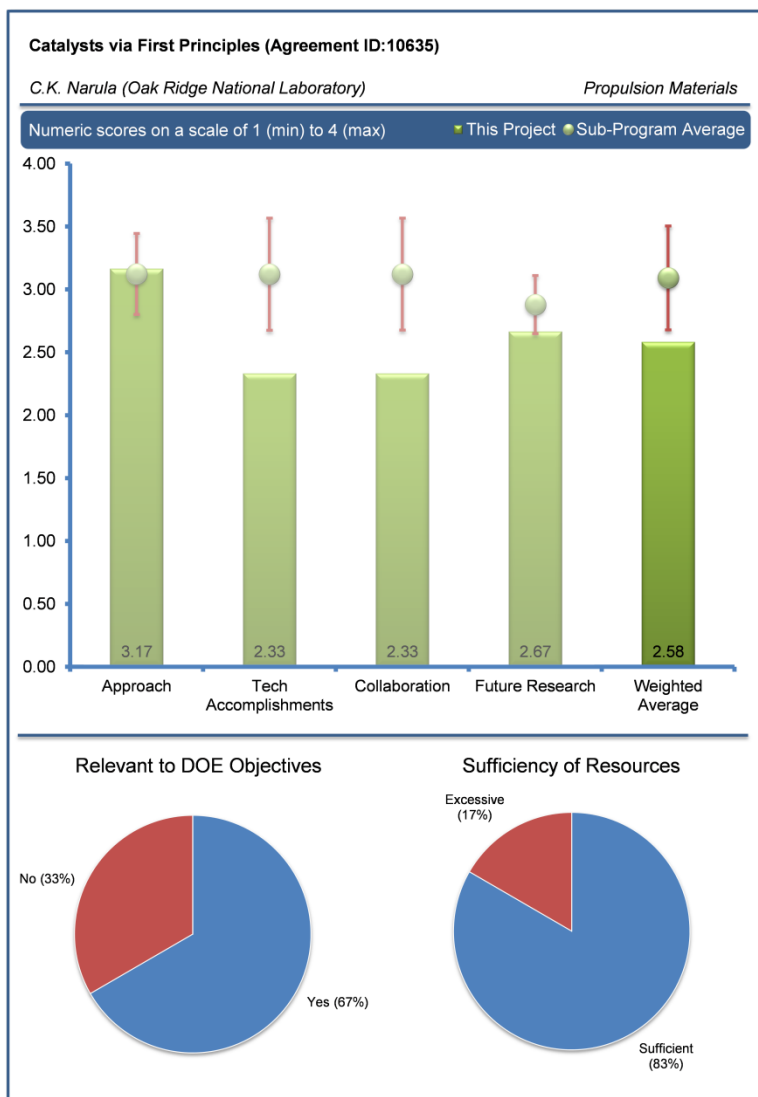
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer thought the work on single atom oxidation of CO (carbon monoxide) and NO (nitric oxide) was interesting, and that the work on low temperature CuFe zeolites was timely and relevant.

Reviewer 2:

The reviewer saw promising progress so far, and declared that engine testing is warranted based on prior results.



Reviewer 3:

The reviewer reported that addition of iron for CuFe-ZSM-5 zeolite catalyst appears to meet low temperature catalyst goal. An 80% NO conversion at 150°C was achieved. The reviewer stated that understanding was gained that single Pt atoms are active catalysts for CO but not for NO_x.

Reviewer 4:

The reviewer relayed that, although it was hard to judge the progress without the previous work available, this project seemed to have stayed focused on identifying the active sites for low temperature emission control.

Reviewer 5:

The reviewer was impressed by the overall development of the calculations-based selection process for effective catalyst reactions. However, the reviewer found the work centered on single Pt atoms to be somewhat confusing, and stressed that this does not mean that it lacks accuracy. The reviewer queried whether it is being suggested that a high-angle annular dark-field (HAADF) detector is imaging single atoms, and would like to know by what mechanism (e.g., simple scattering). The reviewer stated that a Bragg condition would certainly not be satisfied. Supporting evidence of this phenomenon would be helpful in cementing this observation, even if simply limited to an atom count based upon the estimated imaged volume to see if the atomic fraction of Pt matches the observations. The reviewer concluded that even minor clustering could be discounted if the atom fraction matches reasonably well.

Reviewer 6:

The reviewer felt that these were not very distinguished results. Pt crystal growth is well known and old knowledge.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer saw that collaboration with industry (John Deere) is good.

Reviewer 2:

The reviewer felt that the collaboration efforts with John Deere were not entirely clear outside of off-road degreening and testing protocols, and asked if they provided conditions alone or actual engine testing, or if the entirety of engine testing was to be undertaken later in FY 2013.

Reviewer 3:

The reviewer noted that John Deere was to provide engine testing support, but wondered who was providing automotive engine testing support for CO catalyst development.

Reviewer 4:

The reviewer observed that the project involved one heavy-duty engine manufacturer (John Deere), and that there could be a synergy if more light-duty OEMs were involved, especially for low temperature challenges.

Reviewer 5:

The reviewer thought that the project would have greatly benefited from additional partners, and recommended that the interest from Chrysler and/or Cummins be actively pursued.

Reviewer 6:

The reviewer found that collaboration was not memorable as described.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer thought that future research was very well-defined; however, it would have been excellent if a catalyst supplier or their samples can be involved for the future plan.

Reviewer 2:

The reviewer reported that activities for next year appeared to be consistent and reasonable.

Reviewer 3:

The reviewer felt thought that developments in calculation- or simulation-based materials selection in almost every sense have widespread future applications. However, the reviewer also cautioned that the future research being proposed does not go into nearly enough detail to take credit for the progress to date.

Reviewer 4:

The reviewer asked if there are leading contenders to replace Pd as a lower-cost solution for Pt stabilization.

Reviewer 5:

The reviewer concluded that engine testing is a logical and critical next step.

Reviewer 6:

The reviewer recommended that this project be re-evaluated.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer found that this project would support the low temperature after treatment activity that DOE emphasizes for harmonizing future advanced combustion systems.

Reviewer 2:

The reviewer thought that the direct application may not be immediately clear (presently focused on off-road applications), but reasoned by inference that the developments have much more widespread application.

Reviewer 3:

The reviewer felt thought this project seemed entirely focused on emissions reduction and not on petroleum displacement. The reviewer did not see any linkage presented on engine efficiency.

Reviewer 4:

The reviewer stated the project was reducing emissions of high-performance gasoline and diesel engines.

Reviewer 5:

The reviewer said that it was not very evident if the program supported DOE goals.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the project was very well planned and allocated resource and activities.

Reviewer 2:

The reviewer reported that no specific barriers to progress seemed to exist to meet the objectives.

Reviewer 3:

The reviewer recommended to re-evaluate and re-deploy.

Acronyms and Abbreviations

Acronym	Definition
°C	Degrees Celsius
Al	Aluminum
AMOX	Ammonia Oxidation
APEEM	Advanced Power Electronics and Electric Machines Program
ARPA-E	Advanced Research Projects Agency-Energy
B	Boron
C	Carbon
CFD	Computational Fluid Dynamics
Co	Cobalt
CO	Carbon monoxide
CPES	Virginia Polytechnic Institute Center for Power Electronics Systems
CRADA	Cooperative Research and Development Agreement
Cu	Copper
CY	Calendar Year
DBA	Direct Bonded Aluminum
DBC	Direct Bonded Copper
DIC	Digital Image Correlation
DOE	U.S. Department of Energy
DPF	Diesel Particulate Filter
EGR	Exhaust Gas Recirculation
EV	Electric Vehicle
FEA	Finite Element Analysis
FFRDC	Federally Funded Research and Development Center
FSP	Friction Stir Processing
FSW	Friction Stir Welding
FY	Fiscal Year
GM	General Motors Corporation
GTRI	Georgia Tech Research Institute
HAADF	High-Angle Annular Dark-Field
HCCI	Homogeneous Charge Compression Ignition
HD	Heavy-Duty
HEV	Hybrid Electric Vehicle
Hf	Hafnium
HTML	High Temperature Materials Laboratory
ICE	Internal Combustion Engine
ICME	Integrated Computational Materials Engineering
IEA	International Energy Agency
IP	Intellectual Property
KSI	Kips per Square Inch

Acronym	Definition
MgO	Magnesium oxide or Magnesite
MPa	Megapascal
NH₃	Ammonia
Ni	Nickel
NO	Nitric Oxide
NO₂	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
NTRC	National Transportation Research Center
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
Pd	Palladium
PI	Principal Investigator
PM	Permanent Magnet
PNNL	Pacific Northwest National Laboratory
Pt	Platinum
PZT	Lead Zirconate Titanate
R&D	Research and Development
SCR	Selective Catalytic Reduction
Si₃N₄	Silicon nitride
TE	Thermoelectric
TED	Thermoelectric Devices
TEG	Thermoelectric Generator
TEM	Transmission Electron Microscopy
TEMats	Thermoelectric Materials
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability
VTO	Vehicle Technologies Office
W/mK	Watts per Millikelvin
WBG	Wide Bandgap
WFO	Work for Others
WHR	Waste Heat Recovery
XRD	X-ray Diffraction
Zr	Zirconium
ZrO₂	Zirconium dioxide
ZT	Thermoelectric Figure of Merit

8. Technology Integration

The Technology Integration subprogram accelerates the adoption and use of alternative fuel and advanced technology vehicles to help meet national energy and environmental goals and accelerate dissemination of advanced vehicle technologies through demonstrations and education. This subprogram's efforts logically follow successful research by industry and government and help to accelerate the commercialization and/or widespread adoption of technologies that are developed in other Vehicle Technologies Office (VTO) program areas. Deployment activities linked to research and development (R&D) also provide early market feedback to emerging R&D.

Subprogram functions include both regulatory and voluntary components. The regulatory elements include legislative, rulemaking, and compliance activities associated with alternative fuel requirements identified within the Energy Policy Acts of 1992 (EPAct 1992) and 2005 (EPAct 2005), as well as the Energy Independence and Security Act of 2007. Voluntary efforts include demonstration of advanced technology vehicles to verify market readiness and public information, education, outreach and technical assistance efforts. VTO works with public/private partnerships between the U.S. Department of Energy (DOE) and local coalitions of key stakeholders across the country (such as through Clean Cities) to implement strategies and projects that displace petroleum. In addition, the annual DOE/U.S. Environmental Protection Agency (EPA) Fuel Economy Guide publication and related data dissemination efforts (required by law) are produced, along with the website www.fueleconomy.gov.

Education aids in overcoming institutional barriers to widespread use of advanced vehicle technologies and alternative fuels, and serves to train the next generation of participants in this technology sector. Activities such as the Advanced Vehicle Competitions (EcoCAR) and Graduate Automotive Technology Education (GATE) encourage the interest of university student engineers and engage their participation in advanced technology development.

EcoCAR 2: Plugging In to the Future: EcoCAR 2 is the successor to EcoCAR: The NeXt Challenge. Established by DOE and General Motors (GM), EcoCAR 2 is a three-year collegiate engineering competition and the only program of its kind. The mission of EcoCAR 2 is to educate the next generation of automotive engineers through an unparalleled hands-on, real-world engineering experience. The competition challenges 16 North American universities to reduce the environmental impact of vehicles without compromising performance, safety and consumer acceptability. EcoCAR 2 requires students to explore a variety of powertrain architectures and follow a real-world engineering regimen modeled after GM's Global Vehicle Development Process. EcoCAR 2 teams will utilize a Chevrolet Malibu, donated by GM, as the integration platform for their advanced vehicle design.

EcoCAR: The NeXt Challenge: EcoCAR is the successor to Challenge X and is also a three-year engineering competition sponsored by VTO and GM. EcoCAR, started in 2008 and ending in 2011, challenges students to reengineer a 2009 Saturn Vue. The Challenge is to engineer a system that reduces fuel consumption and lower emissions by using advanced fueling technologies, such as: hydrogen fuel cells, plug-in hybrid technology, hybrid technology, diesel technology and other advanced fueling technologies. EcoCAR also is introducing hardware-in-the-loop and software-in-the-loop training for its competition students. This is state-of-the-art training and allows students to mirror the real-world development process used by GM and other auto manufacturers from around the world.

Automotive X Prize: DOE has partnered with the Automotive X Prize (AXP) to develop an educational outreach program aimed at engaging students (kindergarten-12) and the public in learning about advanced, energy-efficient vehicles. DOE is providing \$3.5 million over 3 years for the outreach effort. The Automotive X Prize is an open competition with the goal of inspiring a new generation of super-efficient vehicles that dramatically reduce oil dependence and greenhouse gas (GHG) emissions. The Automotive X Prize Education Program is comprised of three integrated activities: 1) an on-line knowledge center; 2) development of a vehicle telemetry package and integration of that package with the AXP online knowledge center; and 3) launch of a national contest to harness student creativity.

Graduate Automotive Technology Education: DOE established the GATE Program Centers of Excellence to provide future generations of engineers and scientists with knowledge and skills in advanced automotive technologies. By funding curriculum development and expansion as well as laboratory research, GATE allows higher education institutions to develop multidisciplinary

training. As a result, GATE promotes the development of a skilled workforce of engineering professionals who will overcome technical barriers and help commercialize the next generation of advanced automotive technologies. To that end, 10 GATE Centers were originally established in 1998 at 9 universities. In 2005, DOE held a second competition to form new, or expand, existing GATE Centers of Excellence. Award recipients received funds to support graduate research and/or expand course study and laboratory work. These improvements supported graduate engineering degree programs with a focus or certificate in critical automotive technology areas. Eight universities received awards in 2005 for programs focused on hybrid propulsion systems, fuel cells, advanced computation and simulation, energy storage systems, biofuels, and lightweight materials. In late 2011, the GATE initiative awarded \$6.4 million over the course of five years to support Centers of Excellence at American colleges, universities, and university-affiliated institutions. The awardees will focus on three crucial automotive technology areas: hybrid propulsion, energy storage, and lightweight materials.

EPAct Transportation Regulatory Activities: VTO manages several EPAct transportation regulatory activities that aim to reduce U.S. petroleum consumption by building a core market for alternative fuel vehicles (AFVs).

Clean Cities: Clean Cities advances the nation's economic, environmental, and energy security by supporting local actions to reduce petroleum consumption in transportation. A national network of nearly 100 Clean Cities coalitions brings together stakeholders in the public and private sectors to deploy alternative and renewable fuels, idle-reduction measures, fuel economy improvements, and emerging transportation technologies.

In August 2009, DOE announced the selection of projects supporting two program areas under the American Recovery and Reinvestment Act (ARRA): transportation electrification education; and clean fuels, vehicles and infrastructure development. With funding totaling \$39 million, the 10 ARRA-funded Advanced Electric Drive Vehicle Education activities support educational programs to substantially reduce petroleum consumption. Activities under this program include engineering degree and certificate programs, emergency responder and safety training, consumer and K-12 educational outreach, developing and providing teaching materials, and training service personnel, vehicle mechanics, and supporting infrastructure.

Additionally, DOE announced the selection of 25 projects totaling nearly \$300 million that will speed the transformation of the nation's fleet. These projects will place more than 8,000 alternative fuel and energy efficient vehicles on the road, and establish hundreds of refueling locations/recharging sites across the country, which are both activities that support efforts to reduce petroleum consumption. Activities include development of alternative fuel infrastructure and alternative fuel corridors; AFV deployment, including deployments of light-duty AFVs and vehicle conversions; upgrades to existing alternative fuel infrastructure; technical training; and education and outreach.

Subprogram Feedback

DOE welcomed optional feedback on the overall technical subprogram areas presented during the 2013 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area who volunteered to provide subprogram overview comments responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1: Was the subprogram area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Question 3: Does the subprogram area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Office's needs?

Question 4: Other Comments.

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc., as reviewer responses were optional.

Subprogram Overview Comments: Dennis Smith, Connie Bezanson (U.S. Department of Energy) – ti000

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer commented that the program area was adequately covered, and the important issue of achieving petroleum displacement when technology R&D was complete had been identified. Progress in terms of petroleum displacement by the Clean Cities efforts was clearly defined. The reviewer added that new initiatives were discussed appropriately.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Reviewer 1:

The reviewer stated that Clean Cities covered the broad range of petroleum displacement methods (alternative fuels, fuel efficiency, etc.). There did not appear to be gaps in the project portfolio, but the level of support for individual technology deployments varied from year to year. This reviewer added that the current focus was on electric vehicles (EVs), and encouraged Clean Cities to maintain efforts across that broad range of technologies to ensure DOE had a solution ready no matter what the national need might be.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:

The reviewer said that the Technology Integration program did indeed support the needs of the VTO, and appeared to be focused and well-managed by a team of experienced professionals who were very familiar with the needs of the program and VTO.

Question 4: Other Comments

Reviewer 1:

The reviewer hoped that the VTO would maintain its support for these important efforts, adding that, without deployment and outreach efforts, technologies would not be ready when the country needed them.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, as well as numeric scoring responses (*on a scale of 1 to 4*). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
EcoCAR 2 Plugging into the Future	Kristen De La Rosa (Argonne National Laboratory)	8-6	4.00	4.00	4.00	3.83	3.98
Center for Electric Drive Transportation at the University of Michigan - Dearborn	Chris Mi (Regents University of Michigan)	8-10	3.17	3.67	3.67	2.83	3.44
Innovative Drivetrains in Electric Automotive Technology Education (IDEATE)	Gregory Plett (Regents University of Colorado)	8-14	3.00	2.83	2.83	2.67	2.85
GATE: Energy Efficient Vehicles for Sustainable Mobility	Giorgio Rizzoni (Ohio State University: GATE)	8-18	4.00	4.00	4.00	3.00	3.88
Hoosier Heavy Hybrid Center of Excellence	Gregory Shaver (Purdue University)	8-21	3.00	3.00	3.00	2.80	2.98
GATE Center of Excellence in Sustainable Vehicle Systems	Imtiaz Haque (Clemson University)	8-25	3.80	3.60	3.60	3.40	3.63
IN-VEHICLE, HIGH-POWER ENERGY STORAGE SYSTEMS	Joel Anstrom (Pennsylvania State University)	8-28	3.20	3.00	3.00	3.00	3.05
GATE Center of Excellence in Lightweight Materials and Manufacturing Technologies	Uday Vaidya (The University of Alabama at Birmingham)	8-31	2.80	3.80	3.80	2.00	3.33
EV Community Readiness projects: American Lung Association of the Southwest (CO); Oregon Business Development Department (OR, WA)	Kay Kelly (DOE GFO)	8-34	3.50	3.50	3.50	2.86	3.42
EV Community Readiness projects: New York City and Lower Hudson Valley Clean Communities, Inc. (NY, MA, PA); NYSERDA (ME, NH, VT, MA, RI, CT, NY, NJ, PA, DE, MD, DC)	Mike Scarpino (National Energy Technology Laboratory)	8-44	3.38	3.25	3.25	3.29	3.29
EV Community Readiness projects: SCAQMD (CA); University of Hawaii	Brett Aristigui (National Energy Technology Laboratory)	8-54	3.38	3.63	3.63	3.29	3.52
EV Community Readiness projects: Delaware Valley Regional Planning Commission (PA); Metropolitan Energy Information Center, Inc. (KS, MO)	David Kirschner (National Energy Technology Laboratory)	8-65	2.75	2.88	2.88	2.43	2.79
EV Community Readiness projects: Center for the Commercialization of Electric Technologies (TX); City of Austin, Austin Energy (TX)	Neil Kirschner (National Energy Technology Laboratory)	8-75	3.29	3.29	3.29	3.29	3.29
EV Community Readiness projects: Clean Energy Coalition (MI); Clean Fuels Ohio	Erin Russell-Story (National Energy Technology Laboratory)	8-82	3.57	3.57	3.57	3.43	3.55
EV Community Readiness projects: South Florida Regional Planning Council; Virginia Department of Mines, Minerals	Darren Stevenson (National Energy Technology Laboratory)	8-89	3.00	2.71	2.71	2.86	2.80

and Energy							
EV Community Readiness projects: Center for Transportation and the Environment (GA, AL, SC); Centralina Council of Governments (NC)	Trev Hall (National Energy Technology Laboratory)	8-97	3.29	3.57	3.57	3.14	3.45
Overall Average			3.32	3.39	3.39	3.01	3.33

EcoCAR 2 Plugging into the Future: Kristen De La Rosa (Argonne National Laboratory) - ti013

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that the replication of an auto industry multi-year vehicle development process in a university setting provides students with invaluable real world engineering experience prior to graduation. In addition to automotive engineering experience, teams also gain practical experience in project management, budgeting, risk analysis as well as outreach and public relations. The reviewer noted that overall, the program is an outstanding opportunity for students.

Reviewer 2:

The reviewer stated that the project directly addresses the technical barriers that the project team has identified in the market place. This is a highly valuable project that will provide the participating students the equivalent of a few years of original equipment manufacturer (OEM) work experience.

Reviewer 3:

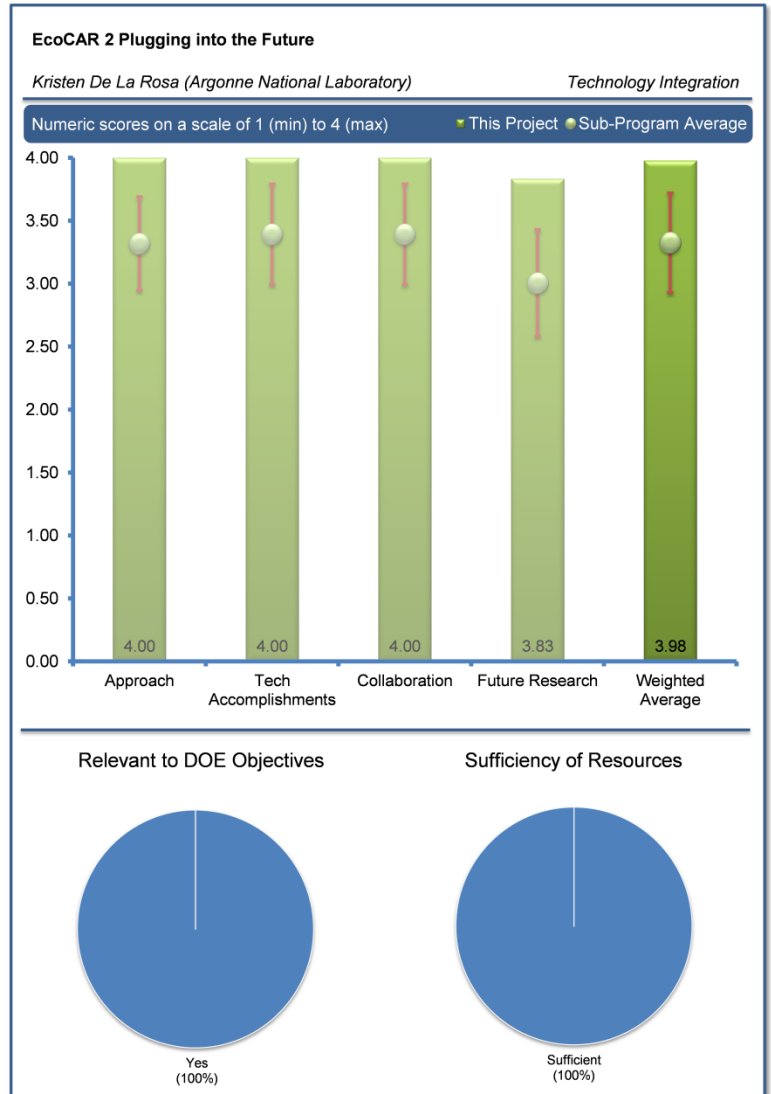
The reviewer remarked Argonne National Laboratory (ANL) has a very well-managed program and a very dedicated staff that steps in and helps execute business plans for each individual program participant. The outreach program is very effective and number of partners is impressive. The reviewer observed that the program is well-integrated with other OVT programs.

Reviewer 4:

The reviewer remarked that this and the other similar student automotive competitions are propelling the U.S. industry forward. The reviewer recommended to keep refining it, and that no strategy changes were needed.

Reviewer 5:

The reviewer summarized that the project relies upon a time-proven approach, focusing on emphasizing placing students in project development team environments. This approach has been developed in close coordination with industry. Many students have been hired by industry, National Laboratories, or even DOE. In fact, stated the reviewer, auto manufacturers in particular appear to use competition events as opportunities to recruit new engineers. GM has indicated half of its hires from the student competition program have patents within the first two years on the job. According to the reviewer, this project is typically limited in number of teams chosen for competition, which is good, so that the program does not over-reach. The student competition program's strength has been in its ability to follow its well-proven approach, which could be compromised if competition were expanded. The reviewer concluded



that this project also focuses on providing opportunities for a number of advanced vehicle technologies and is explicitly not limited to any specific winner, which expands the opportunities for experience and solutions.

Reviewer 6:

The reviewer commented that promoting an interdisciplinary approach is a key to the success of the competing team.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the number of students graduating from DOE's Advanced Vehicle Technology Competition Program is impressive and attests to the long-term impact and success of the program.

Reviewer 2:

The reviewer commented that while the process overall was simplified, the focus on safety is being emphasized even more. The reviewer also stressed that there have been no recordable incidents in 25 years. All systems are clearly defined. This reviewer remarked that what is even more impressive is that the program targets not only engineers, but business managers.

Reviewer 3:

The reviewer observed that barriers were being blown through.

Reviewer 4:

The reviewer reported that the year two competition is underway now and that vehicle components are required to be operational, though entire vehicles are not yet required to be. It appeared to this reviewer that the teams have accomplished a great deal, utilizing not only advanced technologies, but also extensive advanced modeling and controls software. The teams have demonstrated truly innovative solutions and approaches. The reviewer concluded that the project also included a strong emphasis on ensuring safety throughout the duration of activities.

Reviewer 5:

According to the reviewer, ensuring that participants are fully-supported by the Principal Investigator (PI) was no trivial task. Having an annual progress evaluation has been an effective audit management process. The reviewer observed a job well done.

Reviewer 6:

This reviewer suggested that the only area for improvement would be to conduct outreach to other technical universities to expand the program.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the level of collaboration and coordination is outstanding. The EcoCAR 2 program not only involves students from 15 different universities, but also garners support from a network of more than 30 government and industry sponsors.

Reviewer 2:

The reviewer observed that the cost-share was an impressive leveraging of DOE funds. The success of this program is clearly dependent upon the partners to EcoCAR, as it should be, as the engineers who participate have a strong likelihood of continuing in an automotive career after graduation.

Reviewer 3:

The reviewer observed an excellent ability to attract partners and sponsors, and leverage government funding.

Reviewer 4:

The reviewer stated that the project included strong collaboration with a large number of industry and government organizations (approximately 30), resulting in increased opportunities for technology transfer. This also has resulted in substantial financial contributions.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the milestones are well-defined and challenging.

Reviewer 2:

The reviewer commented that year three of the competition is clearly planned out, as well as the selection process for the EcoCAR 3 competition. During year three of EcoCAR 2, teams will move from integrated components to fully-functional vehicles, resulting in the final competition in Spring 2014.

Reviewer 3:

The reviewer commented that the EcoCAR 3 program is in the initial stages, but appeared to be well-planned and builds on past progress.

Reviewer 4:

According to the reviewer, preparation of EcoCAR 3 appeared to be well-formulated upon a successful model. This reviewer, however, did not recall any description of how this program markets for participation.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer praised the program, as it may be one of the most important investments that DOE makes in future automotive engineers.

Reviewer 2:

The reviewer remarked that this project was highly relevant, as it has resulted in another generation of graduates trained in advanced vehicle technologies as well as providing useful information on, and experience with, these technologies.

Reviewer 3:

The reviewer commented that this program will create an engineering workforce that could immediately contribute at an automotive OEM, which should translate into improved productivity for auto manufacturers, because the project will spend less time training their new engineers.

Reviewer 4:

According to the reviewer, the practical hands-on experience that students gain in the development of advanced vehicle technologies in the EcoCAR program fully supports DOE's petroleum reduction goals.

Reviewer 5:

The reviewer observed that there is an obvious shortfall in the workforce in the field, and that this program was well-designed and effective to overcome this barrier.

Reviewer 6:

The reviewer observed that many, if not all, of the vehicle power systems used reduced or non-petroleum fuels.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that funding seemed adequate, and that leveraging of DOE funding with external industry and academic sources has been very successful.

Reviewer 2:

The reviewer commented that resources appeared sufficient for maintaining the program at its current levels. Funding is being leveraged 90:1 through industry contributions of cash, equipment, and in-kind support.

Reviewer 3:

The reviewer remarked that the project appeared to have sufficient resources.

Reviewer 4:

The reviewer suggested that ANL might want to assist other teams in the Technology Integration Program to be more efficient.

Center for Electric Drive Transportation at the University of Michigan - Dearborn: Chris Mi (Regents University of Michigan) - ti020

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found that working with industry partners to train employees was a great approach to promote DOE objectives.

Reviewer 2:

The reviewer commented that the University of Michigan (UM)-Dearborn GATE Center is a well-designed program and provides good opportunities to involve students in advanced technology research.

Reviewer 3:

According to the reviewer, designing course work directly at what is perceived as a barrier is a good method at developing a skillset to overcoming a deficiency. Also, the ability to have relevant industry partners on the Industry Advisory Board (IAB) should help steer the curriculum over time so that it remains relevant to the constantly evolving needs of this industry. However, according to the reviewer, a laboratory component to the curriculum with physical hardware could also provide an additional level of understanding of the material.

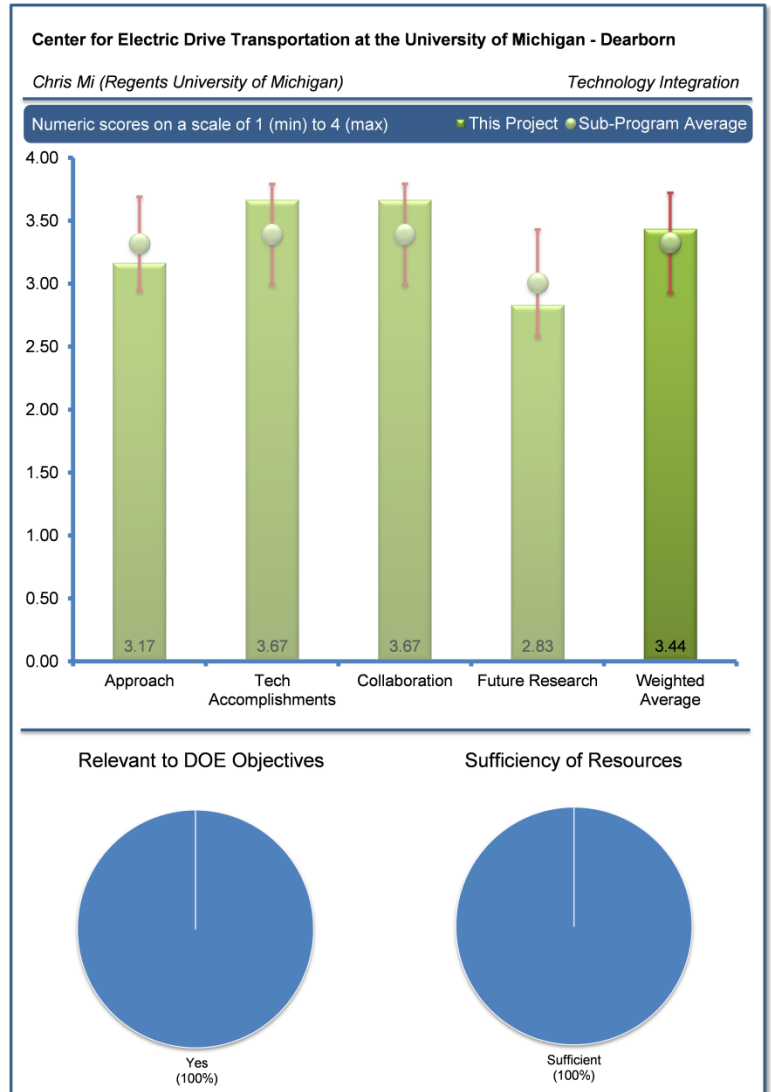
Reviewer 4:

The reviewer commented that the project seems like it has a well-planned-out approach to curricula development. This approach was focused on ramping up quickly in the first two years, but a concern might be that future years appear largely focused on simply implementing/supporting efforts from the first two years, rather than much new. The reviewer noted that the university appears to be hoping to increase research through partnerships with industry, though not much was identified specifically as to how.

According to the reviewer, the recruiting approach, particularly for fellowship candidates, appeared to be a bit weak, as it focused mostly on flyers, a website, and mentioning the program at conferences. The reviewer suggested that the university could use a more active approach to bringing potential candidates in to talk about program, and once more students have been through the program, to utilize them to discuss the benefits of the program.

Reviewer 5:

According to the reviewer, the fundamental approach seemed to be sound. The reviewer noted there was difficulty overcoming the inertia of starting up the program. The project's strategy seemed to be a bit fuzzy from the outside, and the reviewer questioned whether it was the intent to train the working professionals in the vicinity, train full-time students, or both. The reviewer suggested



that it seemed that most full-time students would more likely go to one of the established universities instead. The reviewer suggested the project consider focusing on the working professionals only.

Reviewer 6:

The reviewer observed good effort on development of the academic activities, but noted that the project needed more effort on marketing.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed that the university appeared to have met its planned milestones during year one, and had already met most of them for year two. The university appeared to the reviewer to have ramped up activities quickly, to complete most of activities during the first two years.

Reviewer 2:

According to this reviewer, the technical accomplishments were impressive, since the curriculum had been designed and the students were on a path towards graduation. The reviewer stated that the true measure of the program's success will be measured once the students enter the workforce and industry is able to provide feedback on the ability of the graduates of this program to contribute.

Reviewer 3:

The reviewer remarked that the program has a well-formulated structure to keep the GATE program relevant to industry needs.

Reviewer 4:

The reviewer remarked that progress appeared to be good, with curriculum being established and students coming onboard.

Reviewer 5:

The reviewer observed that the UM-Dearborn program had made good progress toward curriculum development and also had shown excellent success in garnering support from industry partners. The program has also been successful in meeting goals to recruit GATE Fellowship graduate students thus far, but according to the reviewer, additional efforts may be required to meet future goals.

Reviewer 6:

The reviewer observed good progress, and suggested that the project needed a more concerted effort in attracting talent. The reviewer suggested that the project might want to have students in the MBA program assist.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer asserted that the collaboration page speaks for itself; the program has covered automotive OEMs, Tier 1 suppliers, and modeling & simulation software companies.

Reviewer 2:

The reviewer observed that there appeared to be significant industry participation in the program.

Reviewer 3:

The reviewer commented that UM-Dearborn had been very successful at developing a wide variety of industry partnerships. These partners serve on the Industrial Advisory Board and also provide funding for student research.

Reviewer 4:

The reviewer commented that the university appeared to have a strong list of collaborators within the industry, including automakers, Tier 1 suppliers, and others. The program included a specific structure including industry partners into activities, including through an IAB. The reviewer noted that the industry partners also provided funding through dues and projects.

Reviewer 5:

The reviewer observed that the project appeared to have good partnerships; however, the cost-share ratio was a little low compared to other more-leveraged GATE programs.

Reviewer 6:

The reviewer remarked that the project had made good efforts, but needed to have a more involved advisory board that actually was active and was helping towards objectives.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the proposed work was appropriate at this stage in the program. The project would continue collaboration with relevant industry partners which should guide the curriculum to maintain its relevance.

Reviewer 2:

The reviewer commented that future work was focused on growing the program, which was the right focus.

Reviewer 3:

The reviewer noted that future plans seemed to be simply to implement/support year one and year two activities, without much new planned.

Reviewer 4:

According to the reviewer, future work appeared to be business as usual; not necessarily a bad plan, but it did not seem to incorporate fine-tuning for future strategic needs.

Reviewer 5:

The reviewer observed a good understanding of the targets. The reviewer suggested that the project needed to focus more on expanding the target market and maybe involving employees from the participating network (advisory board).

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that the UM-Dearborn GATE Center was focused on educating future automotive engineers on the development of electric drive technologies, which have the potential to achieve significant petroleum reduction.

Reviewer 2:

The reviewer commented that the focus on electric drive vehicles directly supported DOE's petroleum displacement objectives.

Reviewer 3:

The reviewer commented that electric drive education would enable more of the U.S. fleet to move off of petroleum.

Reviewer 4:

The reviewer remarked that the project could produce a new generation of engineers that have the toolset to actively develop advanced powertrains that will reduce fossil fuel consumption as long as we are using automobiles for transportation.

Reviewer 5:

According to the reviewer, the project is focused on ensuring additional trained engineers in advanced electric powertrains.

Reviewer 6:

The reviewer commented that the success of electromobility is dependent on an educated workforce.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the financial resources appeared to be well-spent and that UM has leveraged DOE resources to generate additional funding through industry partnerships.

Reviewer 2:

The reviewer concluded that funding appeared okay, and reported that 70% of funding goes to fellowships, and 25% to professor salaries. There is no budget for equipment, but it appeared to this reviewer that the university felt resources were sufficient.

Reviewer 3:

The reviewer suggested having people with marketing/business development skills assist with deployment.

Reviewer 4:

The reviewer commented that funding seemed sufficient and possibly excessive. The reviewer believed the project should assess the funding level at the project mid-point.

Innovative Drivetrains in Electric Automotive Technology Education (IDEATE): Gregory Plett (University of Colorado) - ti021

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the project's focus was on new certificate programs and the courses supporting certificates. Much of the effort was focused within the Electrical Engineering Department/Degrees.

Reviewer 2:

The reviewer observed that the initiation of the GATE program has been a successful start.

Reviewer 3:

The reviewer observed that the project was geographically well-positioned to train the workforce in electric drive transportation, and observed an excellent strategy varied from short courses to M.S./PhD programs.

Reviewer 4:

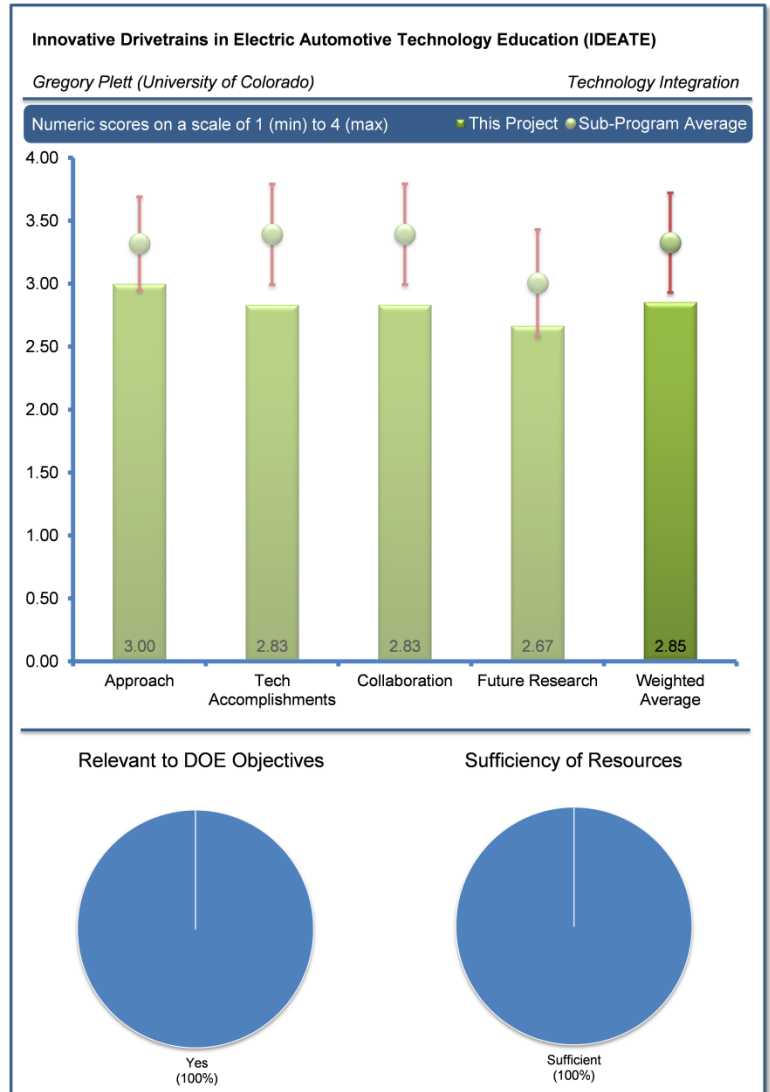
The reviewer acknowledged smart partnering by complementary universities. The reviewer suggested that the project needed to develop a more solid connection to the auto industry. The reviewer asked whether there was something unique about Colorado that was important to the auto industry, such as high altitudes and mountainous terrain/roadways, or cold/hot temperatures. The reviewer would like to know if there was a role in vehicle testing that could be fulfilled by the program.

Reviewer 5:

The reviewer noted that the curriculum was well-designed and met a critical need to educate future automotive engineers in electric drive vehicles. However, a more aggressive promotional strategy may be needed in the future to recruit students and generate interest in the program.

Reviewer 6:

The reviewer commented that the structure of the program was squarely aimed at a perceived deficiency to increase the proficiency level of engineers in the realm of electrified transportation. However, there appeared to be some disconnect if the students were not enrolling at the desired rates.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed good progress for a new program.

Reviewer 2:

The reviewer acknowledged an excellent start for the University of Colorado-Colorado Springs (UCCS) GATE program. The reviewer advised to keep working on attracting students and fostering and sustaining strong relationships with other GATE schools to compare successes.

Reviewer 3:

The reviewer commented that the university appeared to have met most of the planned accomplishments to date, although there have been delays in establishing the IAB. It appeared to the reviewer as though that would happen this Summer, now that the curricula had been developed. The reviewer noted that it now appeared as though minimum student interest levels will be achieved (which was not the case at the time of preparation of the presentation). The focus of activities to date has been primarily to develop courses and establish certificate programs. The application process for fellowships has been developed, though no candidates have yet been selected.

The reviewer explained that the university has a reasonably active advertising approach, developed using the Society of Automotive Engineers (SAE) websites/documents, as well as at SAE events, other conferences, and within the industry.

Reviewer 4:

The reviewer observed that all of the accomplishments to date were related to the development of the curriculum. While significant progress had been made in this area, it appeared as if demand was somewhat low. According to the reviewer, the speaker noted that the goal of recruiting 30 students in the first two years, which was listed in the presentation as at risk, had been successfully met after the presentation was complete.

Reviewer 5:

According to the reviewer, development of new courses and offering of existing courses are on schedule. The reviewer suggested that the project needs to be more aggressive in working with industry partners on offering more on-site training.

Reviewer 6:

The reviewer remarked that the lack of subscription to the program was concerning, and the inference that the IAB could be better utilized suggests the industry partnerships were not as intertwined as the program planned. If that is the case, better collaboration with industry may attract more students if the project sees a better pathway to employment potential at the end of the program.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the progress here has been good, and that the industry is getting involved.

Reviewer 2:

The reviewer noted great collaboration with the University of Colorado-Boulder and advised that the project continue to work with others, especially the industry, to leverage expertise and feedback.

Reviewer 3:

The reviewer observed that the university has developed an IAB, though it has not yet convened a meeting to influence decisions early in the program. Industry partners include the Detroit three, suppliers, and a National Laboratory. The reviewer commented that partners have indicated a willingness to provide internships, permanent jobs, and advice. The university has actively recruited industry members to participate.

Reviewer 4:

According to the reviewer, the level of collaboration with institutions outside of the University of Colorado system was not clear from the presentation. The reviewer suggested that improving collaboration with other institutions as well as with industry partners might help generate student interest in the program.

Reviewer 5:

The reviewer commented that the presentation seemed to imply that the industry collaboration could be better. According to this reviewer, it will be interesting to hear how the industry partnerships are intertwined with the program during the presentation.

Reviewer 6:

The reviewer remarked that the structure for the industry partnership could impede broad participation, especially the IP provisions and membership costs.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked that much of the planned efforts are based upon continued implementation of what has been developed to date. The project is wisely including specific reviews of how things go over the early years of program, in order to refine curricula and advertising approaches.

Reviewer 2:

The reviewer acknowledged a good understanding of the future needs, and commented that the project needs to focus more on recruiting talent.

Reviewer 3:

The reviewer suggested that the project needs to focus on incorporating more objectives for attracting partners. The reviewer acknowledged that it was great to respond to internal feedback, but suggested to be sure to incorporate external feedback as well.

Reviewer 4:

The reviewer pointed out that the primary challenge was to boost enrollment in the program. If the program developed a unique niche it could help get some more attention.

Reviewer 5:

The reviewer commented that if the students were not enrolling at the anticipated rate, it seems that there should be additional efforts describing the relevance of the curriculum to industry or outreach efforts to attract more students, if there is indeed a shortfall of engineers in this arena, and the curriculum is well-matched to the need.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer opined that developing programs to educate the next generation of engineers in electric drivetrain technology is critical to meeting DOE's petroleum displacement objectives.

Reviewer 2:

The reviewer commented that electric drive education is fundamental to reducing petroleum use.

Reviewer 3:

The reviewer concluded that focusing academic content to advanced automotive applications was directly aligned with DOE objectives.

Reviewer 4:

The reviewer observed very good efforts were made towards removing the barriers and enabling electromobility.

Reviewer 5:

The reviewer commented that the project was focused on training the next generation of engineers on advanced electric drive technologies.

Reviewer 6:

The reviewer concluded that conceptually the program met the needs of displacing petroleum. However, according to the reviewer, the curriculum needs to match the needs of industry, and the students need to enroll in the program for the benefits to be realized.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked that funding appeared to be adequate.

Reviewer 2:

The reviewer commented that resources appeared sufficient, and no indication was made that resources were not.

Reviewer 3:

The reviewer remarked that as noted, better cost-share was required.

GATE: Energy Efficient Vehicles for Sustainable Mobility: Giorgio Rizzoni (Ohio State University) - ti022

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said wow.

Reviewer 2:

The reviewer observed a very mature approach that leveraged lessons learned over a long period of time. It was clear that this program was well-administered and is dedicated to continuous improvement.

Reviewer 3:

The reviewer commented that the Ohio State University (OSU) GATE program was well-designed and successfully integrated with other education and research activities at OSU.

Reviewer 4:

The reviewer observed an effective realignment of course offerings to support OSU's format change.

Reviewer 5:

The reviewer commented that there was a broad scope of curricula for this project, but that it was probably not unusual given that this was the third round of GATE awards for the university. The focus of this round was specifically to expand to additional technology areas. The reviewer remarked that this allowed for a high level of integration among vehicle systems, though this also required an effort to ensure that a clear focus for the program was maintained. Specifically, the reviewer concluded, this university relied upon a well-proven approach developed under previous GATE efforts.

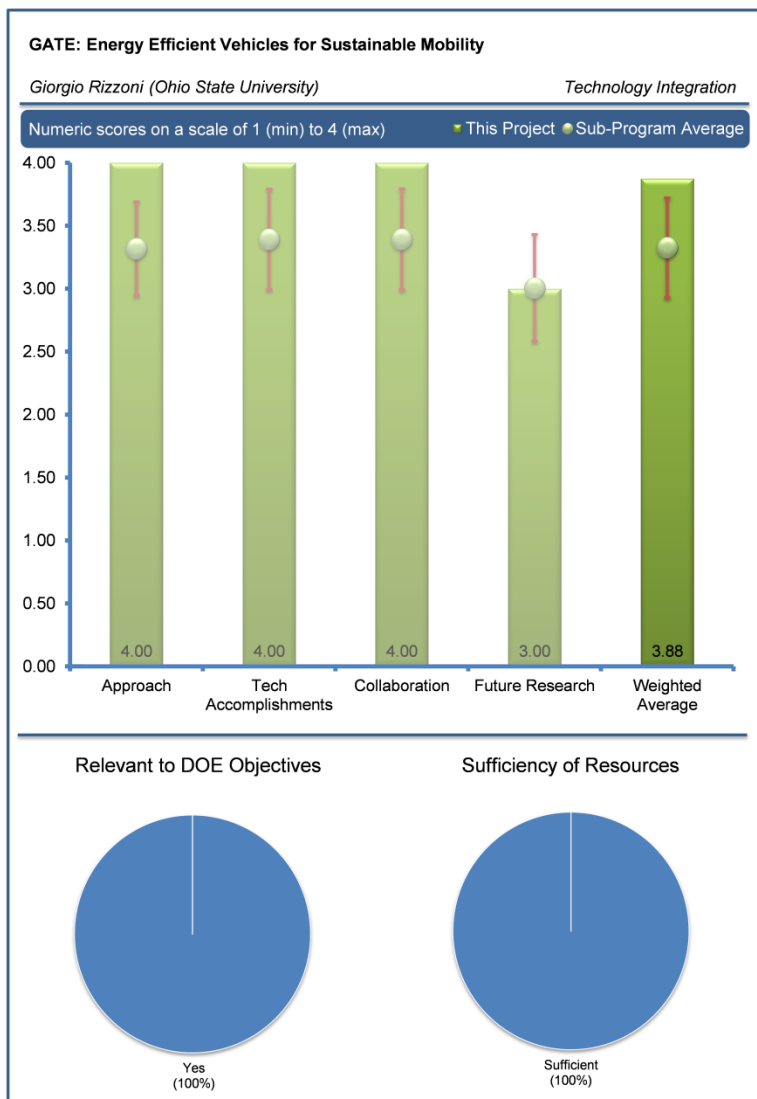
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer said wow.

Reviewer 2:

The reviewer observed that there was a nice replication of industry models and cross-correlation between the research and academic development courses.



Reviewer 3:

The reviewer detailed that the OSU program showed significant progress in three areas: funding for graduate student research and education (excellent record of placing GATE students in industry); many OSU students and industry employees have benefited from the curriculum developed in part using GATE funds; and leveraging of DOE funds to form partnerships with industry provide additional benefits.

Reviewer 4:

The reviewer noted no noticeable barrier to success. The reviewer commented that continued success in education and research was evident.

Reviewer 5:

The reviewer commented that the project team had to adjust course curricula as OSU moved from quarters to semesters. Significant numbers of courses have been developed. Thanks to additional sponsorship funding, the reviewer explained that OSU was able to expand fellowships from 7 to 12. The reviewer also noted that the program has claimed 70 graduates to date, and nearly all are employed in the automotive industry.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer said wow.

Reviewer 2:

The reviewer stated that the project showed excellent leveraging of industry partners.

Reviewer 3:

According to the reviewer, OSU has established several IABs with automakers, suppliers, and electric utility companies. It has also obtained significant funding from other sources. Through Clean Cities, the Program was also working with local fleets to deploy advanced technologies.

Reviewer 4:

The reviewer noted that industry collaborators were both longstanding and dedicated to the program.

Reviewer 5:

The reviewer acknowledged that the OSU GATE Center had established strong partnerships with the industry in terms of funding and research. The distance education program expands the reach and impact of the program to offer courses at the University of Texas (Dallas) and offered a certificate program to the industry.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the future work was focused on the expansion of the automotive systems engineering curriculum and the development of additional graduate level courses. According to this reviewer, the program clearly built on experience gained with the successful implementation of the two prior DOE GATE programs.

Reviewer 2:

The reviewer commented that future activities were built on the successes achieved.

Reviewer 3:

The reviewer commented that the future efforts were mostly focused upon implementing efforts that had already been developed. According to the reviewer, there was no real mention of any significant new activities planned.

Reviewer 4:

The reviewer noted that no future work information was offered in the review charts.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer stated that the primary objective of the OSU GATE project was to educate the next generation of engineers in the development of energy efficient vehicles, which was critical to meeting DOE's petroleum reduction goals.

Reviewer 2:

According to the reviewer, electric drive education was fundamental to petroleum displacement.

Reviewer 3:

The reviewer stated that this project was an education program and achieved its objective of providing new technical talent and research to the industry.

Reviewer 4:

The reviewer commented that this project addressed providing trained engineers in advanced vehicle technologies.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer commented that the administration and collaborator input exemplifies that adequate resources were engaged in the program, and that student recruitment and successful graduation rates were fully in line with program objectives.

Reviewer 2:

The reviewer noted that the DOE funds seemed to have been well-spent and that OSU had done an excellent job leveraging DOE funds to secure funds from external sources and partners. All of the funds go to graduate fellowships.

Reviewer 3:

The reviewer observed that OSU had obtained a substantial cost-share on the order of 75% of total; thus, the funding appeared to be sufficient.

Hoosier Heavy Hybrid Center of Excellence: Gregory Shaver (Purdue University) - ti023

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that good feedback was received from other GATE programs as well as those with industry perspective.

Reviewer 2:

The reviewer commented that the university's focus was on establishing fellowships, developing courses, forming partnerships with industry, and conducting technology transfer. The approach appeared to take a reasoned, rational approach to accomplish the desired goals. The reviewer observed that Purdue was still developing some elements of its approach: a new facility provided opportunities for expanding coursework (still to be determined), and Purdue University (Purdue) did not appear sure yet about how to fully utilize the industry (such as through an IAB).

Reviewer 3:

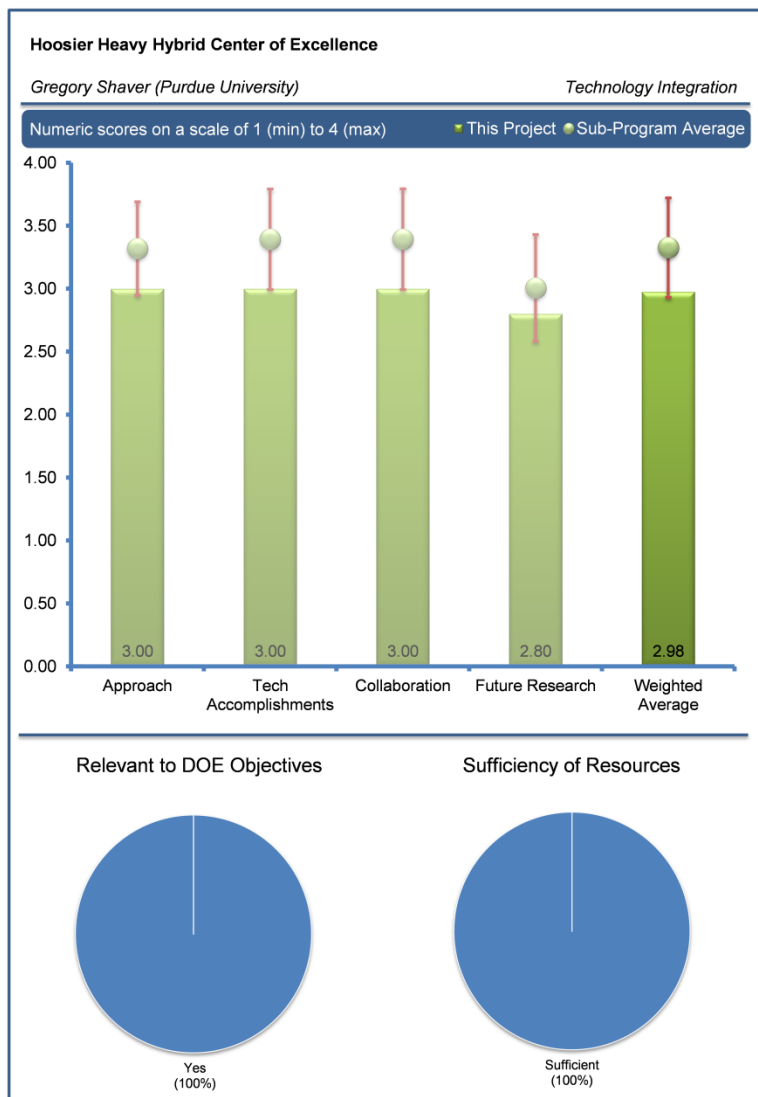
The reviewer noted that the Purdue University GATE Center was building on existing core competencies and supplementing DOE funding with partnerships with industry to provide graduate student research opportunities. In order to reach additional students, the Center launched a Hybrid Vehicle Systems Certificate program. The reviewer felt that the strategy was sound, but suggested that additional industry funding would be required to fund additional research fellowships.

Reviewer 4:

The reviewer remarked that the approach was well thought out, but had not been implemented according to the schedule. The reviewer advised to keep working at it, as the strategy would work over time.

Reviewer 5:

The reviewer concluded that the project appeared to be a solid program, and that the project needed to get the heavy vehicle industry involved. According to the reviewer, this was hard, as investment in hybrid technology is tepid right now. Performance of heavy hybrids in field service has been underwhelming in several applications. The reviewer stated that increased fuel efficiency would help the business case which in turn would increase the interest in the research.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer observed that progress towards building the foundation of the program has been really good. The reviewer also described Purdue's commitment as outstanding.

Reviewer 2:

The reviewer acknowledged that this was a relatively new project, but most of the milestones have been met. According to this reviewer there appeared to be notable accomplishments, including the following: Purdue University GATE Program has recently initiated their first research effort co-funded by the DOE (25%); Cummins and Purdue University (1 student funded); development of a hybrid electric vehicle (HEV) course; and the establishment of a certificate program in hybrid vehicle systems (12 students).

Reviewer 3:

The reviewer commented that there have been delays in getting fellowship candidates, as well as receiving support through industry research projects. This is not unexpected for a new GATE program, but things have moved slower than Purdue anticipated or planned. The reviewer noted that Purdue has also struggled with the economy in Indiana impacting the ability of industry members to participate. Purdue did develop an initial course, and worked to market its certificate program which also includes existing courses. The reviewer commented that Purdue's first project with industry was established, with Cummins providing nearly half the funding (with DOE only supplying around 25%). The reviewer acknowledged that significant efforts were required to establish this GATE program as the first interdisciplinary program at Purdue.

Reviewer 4:

The reviewer advised that the project continue to seek ways to attract leveraging industry funds as well as students into the program.

Reviewer 5:

The reviewer commented that the project needed more successful student participation in the program before a higher rating could be given.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the Purdue University GATE Center has a successful partnership with Cummins diesel and is working to establish additional partnerships in the industry.

Reviewer 2:

The reviewer noted that funding, facility support, and expertise was being provided through a strong partnership with Cummins. Efforts with other industry members have developed slowly, but Purdue was in discussions with several key members.

Reviewer 3:

The reviewer said that this GATE program offered a unique perspective into the medium and heavy vehicle markets. The reviewer suggested that better outreach to stakeholder industry partners might yield greater leverage of DOE funds, and inclusion of military applications/research might be beneficial the GATE program.

Reviewer 4:

The reviewer commented that the collaboration with the initial industrial partners, namely Cummins, needed additional refinement to become as effective to the program as it needed to be. The reviewer noted that expanding to other partners was desirable and was encouraged. The reviewer suggested the project should review the ways that the industrial partners were recruited and to make sure the partners were fully committed to the full goals and responsibilities of the program.

Reviewer 5:

The reviewer noted that Cummins was the main player in heavy vehicles, and that the project needed to secure one or more drive system and energy storage partners. The reviewer assumed that Allison and Parker-Hannifin have been pursued.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked that it was clear that the barriers are understood and that actions were in place to overcome them.

Reviewer 2:

The reviewer acknowledged that the plans were to strengthen and expand participation in the GATE program, particularly through increased industry research projects, though not necessarily through the development of additional courses. The primary near-term focus was on moving into a new jointly-funded laboratory facility, and getting it up and running. The reviewer noted that later efforts appeared focused on how best to make use of the facility for the purposes of this program.

Reviewer 3:

The reviewer commented that having adequate facilities was important and appropriate future work activity. The reviewer suggested that additional future work should include development of a strategic plan for inclusion of industry interests and guidance.

Reviewer 4:

The reviewer suggested that the project needed to get additional power systems or vehicles for the students to work with. The reviewer questioned whether there were other completed government projects from which the GATE project could get these assets.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that heavy vehicle powertrain research was important to petroleum displacement.

Reviewer 2:

The reviewer said that the project was focused on heavy-duty hybrid vehicle systems, which have the potential to significantly reduce petroleum consumption.

Reviewer 3:

The reviewer opined that expanding higher-level science, technology, engineering, and math (STEM) education even for just a few students would help to achieve DOE objectives.

Reviewer 4:

The reviewer commented that this project was providing trained engineers in heavy hybrid technologies.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer concluded that funding seemed sufficient.

Reviewer 2:

The reviewer commented that the approach was that 80-90% of DOE funding goes to fellowships. The University also stepped up and provided additional funding. According to the reviewer, resources seemed sufficient, since DOE funding was only being used for fellowships.

Reviewer 3:

The reviewer suggested that the project keep working to increase participation of new students.

GATE Center of Excellence in Sustainable Vehicle Systems: Imtiaz Haque (Clemson University) - ti024

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the Clemson University (Clemson) GATE Center project was well-designed and had a good strategy for addressing technology barriers in the development of sustainable vehicles through an integrated education and research program for graduate students. Clemson had successfully integrated a number of related activities (e.g., Deep Orange) to provide an impressive array of opportunities for graduate students.

Reviewer 2:

The reviewer stated that Clemson seemed to have a fairly specific coursework plan for candidates. The identified approach was to follow vehicle development processes seen in the industry, developed through Clemson's relationship with industry partners.

Reviewer 3:

The reviewer acknowledged developing the GATE as an integral extension of the Clemson University International Center for Automotive Research (CUICAR) programs. The program is designed to enhance the ongoing development and quality of CUICAR.

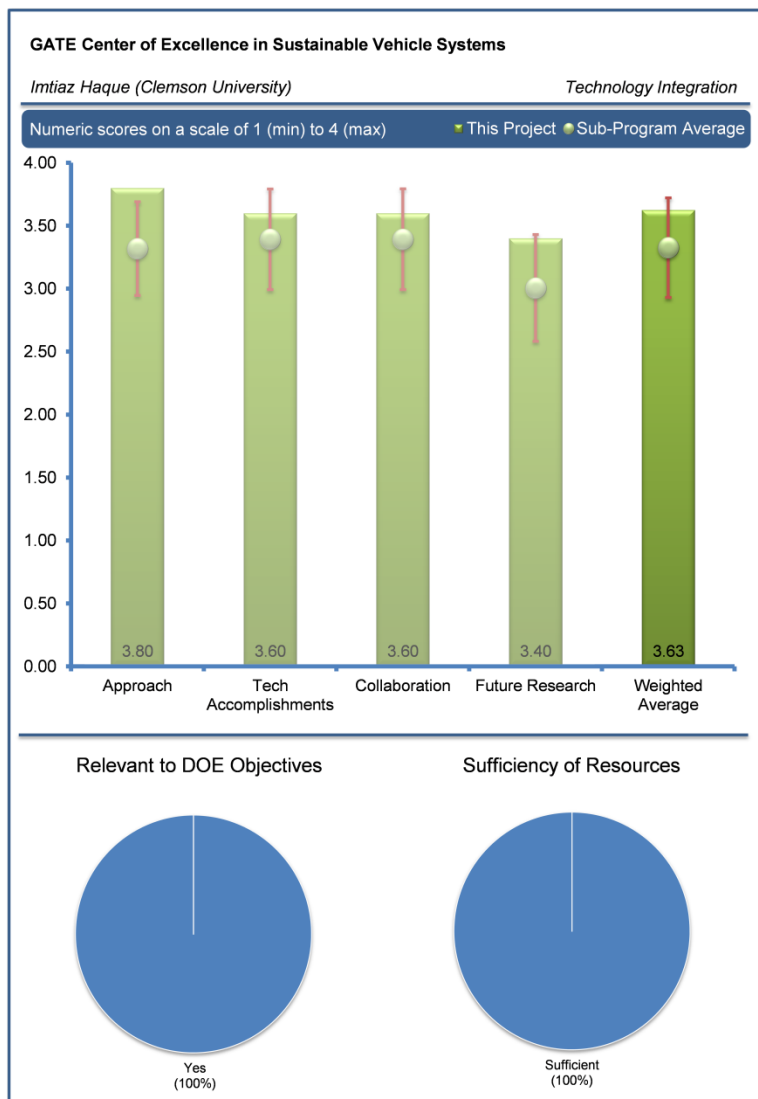
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that all the milestones for 2012 and 2013 had been met. The reviewer noted that the Clemson GATE project had made excellent initial progress in terms of establishment of the GATE Center and curriculum development; recruitment and support of graduate students, and elaborated that the project appeared to be well on the way to meeting enrollment goals, and development of the GATE powertrain laboratory.

Reviewer 2:

The reviewer noted that as measured by participation, this was an outstanding application of GATE funding. The coursework was very applicable to the industry needs of the future. The reviewer acknowledged that these were very well-structured graduate programs.



Reviewer 3:

The reviewer noted that significant capability had been assembled in the lab, and this should be a key enabler for the types of studies performed by the students.

Reviewer 4:

The reviewer commented that over the past year or so, Clemson completed the development of multiple courses and a vehicle integration laboratory. Clemson has 37 students to date in its GATE program, plus many other students taking selected courses within the GATE offerings. The reviewer noted that the original goal was to have 25 students in GATE. The expansion was largely made possible through industry funding, although many students are currently self-funded.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer commented that numerous seminar speakers are obtained from outside the program, particularly from the automotive industry. Clemson obtained additional GATE fellowships from the industry (Mazda and FEV), plus significant funding from the industry. The reviewer noted that the university also obtained related government or industry research project funding of over \$4 million. The reviewer noted that Clemson specifically coordinates with other universities. The reviewer stated that the IAB provides feedback on program, as was specifically utilized to conduct an internal program assessment. Board membership includes automakers, suppliers, and others. In addition, according to the reviewer, Clemson also established employer evaluations (for internships and employment) to guide program improvements.

Reviewer 2:

The reviewer observed excellent interaction with industry partners.

Reviewer 3:

The reviewer observed that a number of partnerships with the industry (OEMs and suppliers) and other universities had been established.

Reviewer 4:

The reviewer noted good collaboration with industry and other universities.

Reviewer 5:

The reviewer stated that the project was integrated to the collaboration partners (over 15) that support the CUICAR graduate programs and its specialized project agendas.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that Clemson provided a relatively specific list of proposed activities, including additional curricula development/upgrades, the utilization of a new laboratory facility, adding faculty members, and increasing students in the program.

Reviewer 2:

The reviewer found that the future work seemed logical and builds on the accomplishments of the first two years.

Reviewer 3:

The reviewer acknowledged that there was a good path forward for future efforts.

Reviewer 4:

The reviewer noted that the project was using funding across a broad area of the program and getting a lot for the resources provided by DOE.

Reviewer 5:

The reviewer commented simply as achieving.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer commented excellent use of funds to increase STEM graduates at the advanced levels.

Reviewer 2:

The reviewer determined that education of future engineers in the design and development of sustainable vehicle systems supported the DOE objective of petroleum displacement.

Reviewer 3:

The reviewer found that Clemson was clearly promoting the development of automotive engineering graduates with a focus on current and future energy efficient vehicle systems.

Reviewer 4:

The reviewer commented that Clemson's GATE Program is aimed at providing engineers who are trained in sustainable vehicle technologies.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer observed excellent leveraging of DOE funds.

Reviewer 2:

The reviewer affirmed that clearly, this was a well-run and well-administered program.

Reviewer 3:

The reviewer commented that the resources appeared to be used effectively in the establishment of this new center. The project team has made good progress in leveraging DOE funds for additional fellowships and internships.

Reviewer 4:

The reviewer commented that resources appeared to be sufficient. Clemson received funding from the industry for the program and additional fellowships. The reviewer noted that Clemson also received significant funding for related research projects. DOE funding goes to equipment, facilities, and curriculum development, rather than the fellowships.

Reviewer 5:

The reviewer commented that funding appeared to be sufficient.

IN-VEHICLE, HIGH-POWER ENERGY STORAGE SYSTEMS: Joel Anstrom (Pennsylvania State University) - ti025

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed an excellent focus on core competencies in energy storage, and fantastic outreach to promote advanced vehicle design at multiple academic levels.

Reviewer 2:

The reviewer commented that the Pennsylvania State University's (Penn State) approach focused on curriculum development and developing relationships between students, faculty, researchers, and employers. The program included three major areas: composites manufacturing; dielectric studies; and batteries, including efforts on flywheels and capacitors. These efforts were integrated with Penn State's EcoCAR2 team. The reviewer noted that often students from the EcoCAR team graduate, and become candidates for GATE. Also, after the student competitions end, EcoCAR vehicles are then used for the GATE program. For this reviewer, a potential concern is that this program does cover so much territory that care must be taken to maintain focus to ensure progress.

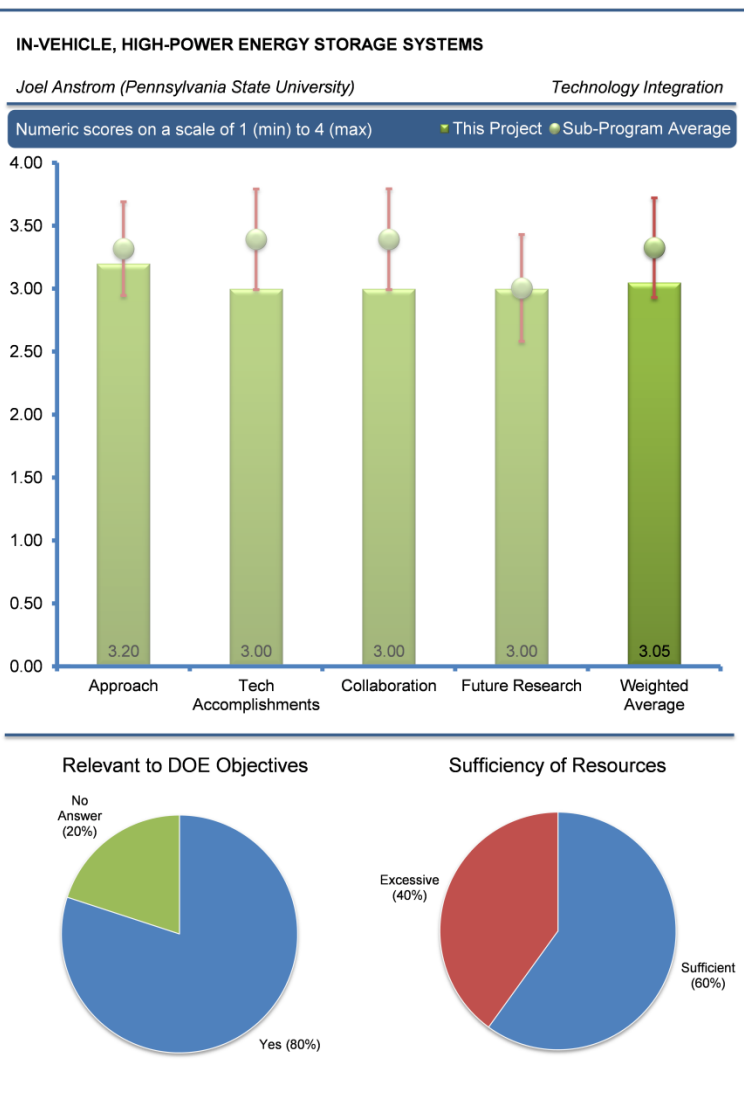
The reviewer noted that this was a third-time GATE program, so the approach is relatively well-established. The list of specific faculty in the program is now up to nine, with four tracks to pursue. This includes team-teaching across disciplines. The reviewer acknowledged that Penn State has included a specific focus on outreach, including adoption of the American Tour de Sol, which has been useful as a recruiting tool.

Reviewer 3:

The reviewer noted that the project's focus was on educational courses and on recruiting students into the long-standing program, and that not much new was presented. According to this reviewer, the project team is just continuing to do what the project was doing with current collaborators.

Reviewer 4:

The reviewer expressed that responding good to this question may be generous. The reviewer did not see evidence of a well-defined academic program above and beyond those of similar institutions that the reviewer has worked with, and that received no federal funding.



Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that over 90 GATE students had been funded to date, though there are only three fellows currently. Over 500 students had been impacted overall by Penn State's GATE program, including students taking individual or multiple courses. The reviewer noted that many have obtained jobs in the industry and National Laboratories, and that there was an extensive list of Penn State GATE-related research projects funded by the government and the industry.

Reviewer 2:

The reviewer noted an interesting approach to redesign the GATE tracks.

Reviewer 3:

The reviewer remarked that all progress was based on individual focus areas as the project team was not a systems curriculum, so the progress was compartmentalized. The reviewer advised that it may be useful to get advisory input from the systems perspective to help guide the individual focus areas.

Reviewer 4:

The reviewer commented that it was hard to identify the progress achieved on this project, and that most of the discussion was on past efforts.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted important collaboration with industry and National Laboratories.

Reviewer 2:

The reviewer acknowledged lots of longstanding collaborators that covered a broad band of the vehicle space.

Reviewer 3:

The reviewer stated to reach outside of Pennsylvania (e.g., University of Michigan, Virginia Tech, Purdue, and others).

Reviewer 4:

The reviewer commented that Penn State was collaborating with GM through EcoCAR2, and also with Clemson, as well as the Pennsylvania College of Technology. The reviewer observed that additional GATE research and projects were being funded by the government and industry, including vehicle and heavy-duty engine original equipment manufacturers. Penn State identifies itself as the preferred academic partner for Volvo (truck, construction, and marine), and also does a lot of work with General Electric. The reviewer noted that Penn State tried to develop an IAB, but indicated that the industry representatives were not necessarily interested in talking with each other. The reviewer advised that it still might be useful to try to resurrect some form of this idea, to assist in monitoring and improving Penn State's program.

Reviewer 5:

The reviewer observed limited industry partnering, and cautioned that the program appeared to be too academic focused.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the future work addressed important next activities and offered a clear timeline.

Reviewer 2:

The reviewer noted that most of Penn State's plan focused on more of the same, although it was looking to expand online courses; the reviewer noted that the first course online was this semester. Several of the courses were considered in flux, meaning Penn State was looking at revising or re-tooling courses.

Reviewer 3:

The reviewer noted that the future work seemed to be maintaining the status quo.

Reviewer 4:

According to the reviewer, the project team reported that future work would be continuing to recruit students, and that the individual areas were evolving their course content as the project team deemed appropriate.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer responded that yes, elaborating energy storage research capability is a prime enabler of petroleum displacement.

Reviewer 2:

The reviewer commented that focus on battery technology offered a key correlation to DOE technology development objectives.

Reviewer 3:

The reviewer stated that energy storage technology and education are important to petroleum displacement.

Reviewer 4:

According to the reviewer, this project is focused on providing trained engineers in the area of advanced vehicle technologies (emphasizing high-power energy storage).

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer indicated that the resources seemed fine and noted that no shortcomings were identified. Most of the DOE funding goes to fellowships. The reviewer noted that the rest of the funding comes from projects and industry.

Reviewer 2:

The reviewer indicated that resources appeared to be more than adequate for the scope of effort that was planned.

GATE Center of Excellence in Lightweight Materials and Manufacturing Technologies: Uday Vaidya (University of Alabama at Birmingham) - ti026

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer applauded the exciting work, and added that lightweighting was greatly needed.

Reviewer 2:

The reviewer commented that the project funded six GATE fellows and an undergraduate group to encourage graduate school progression. According to the reviewer, students seemed to be working in the areas of expertise the students had studied when working in the industry.

Reviewer 3:

The reviewer indicated that the university's program was focused on a technology area not emphasized under other GATE programs, and was designed to take advantage of the growing automotive industry in the Southeast. The reviewer noted that the university appeared to have a strong grasp of materials development efforts needed, and coordinated with the industry on projects. The reviewer also noted that the presentation was somewhat unclear on future plans.

Reviewer 4:

The reviewer believed that the presentation was searching for material by showing student placement by individual. The reviewer pointed out that CAFÉ is a place where you eat, whereas CAFE is corporate average fuel economy.

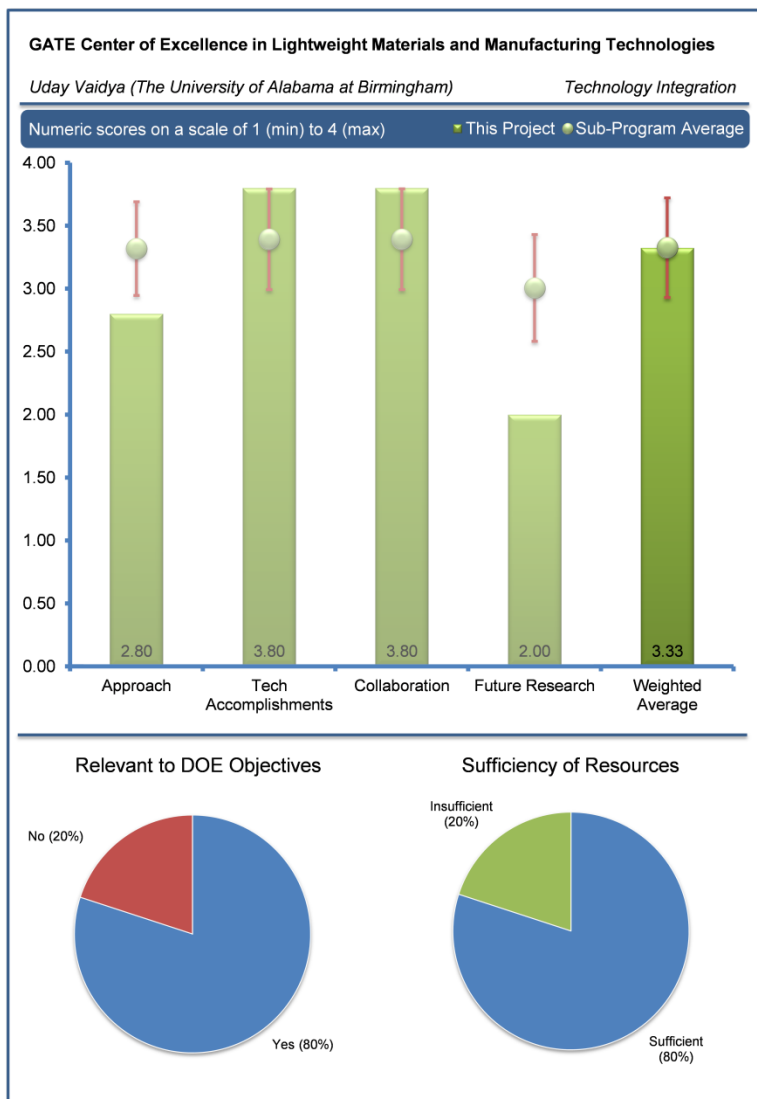
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer acknowledged that the goals for the number of students and the amount of participation had been exceeded.

Reviewer 2:

The reviewer noted that to date, 23 graduate students and 25 undergraduates have been funded. Many had gone on to work for manufacturers, engineering firms, and laboratories. The reviewer noted that a number stayed on to extend their education (higher studies). There are six graduate GATE and four undergraduate students (in the pipeline doing GATE research) at this time, with another 21 undergraduates under consideration for the future. The previously-identified goals were for three graduate and four undergraduate GATE-supported students, so these levels were exceeded. The reviewer observed that seven new courses have been



developed under this phase of GATE, and that the university held the previous round, too. The reviewer concluded that projects have focused on a large number of materials compounds and products. The reviewer highlighted that a significant number of materials investigations have either been completed or were underway, though some may have been under the previous phase of the GATE award – it was unclear from the presentation.

Reviewer 3:

The reviewer commented that the graduate program was performing work in the automotive area while part of the GATE research; however, that the post-graduation employment did not appear to correlate to automotive engineering careers. The undergraduate pipeline appeared to have a stronger connection to the automotive industry.

Reviewer 4:

The reviewer commented that many new courses have been developed and taught over the two GATE grant periods, and that the project team was working well in long fiber thermoplastics toward new manufacturing processes to cost-effectively produce near net shape parts. However, according to this reviewer, the presentation did not include any normal report of progress or adherence to the schedule. The reviewer commented that the presentation did not follow the prescribed format.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the university was working with the industry and government organizations, and has established an advisory board with membership primarily from light/heavy-duty vehicle manufacturers and materials suppliers. A number of projects appeared to be coordinated closely with industry to meet industry needs, which has also resulted in significant leverage for activities. According to the reviewer, an example in addition to coordinated research efforts is a student who is now interning at a materials supplier. The university was also working closely with Oak Ridge National Laboratory (ORNL).

Reviewer 2:

The reviewer noted solid and diverse collaboration with various industries.

Reviewer 3:

The reviewer observed strong and diverse interaction between student research and industry needs.

Reviewer 4:

The reviewer noted a very large list of broad-based collaboration partners across the entire value stream, from raw material to end-use of products.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the presentation focused primarily on the breadth of projects to date or underway, with no specific mention of significant efforts planned, perhaps beyond more of the same, including recruiting the next wave of GATE students.

Reviewer 2:

The reviewer commented just doing projects with the industrial collaborators. The reviewer noted that there was no mention of educational changes or additions for the future.

Reviewer 3:

The reviewer indicated that future work was not presented.

Reviewer 4:

The reviewer commented that new courses had been created for the future, but it was unclear what other activities have been planned.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer determined that materials were clearly an important technical area that directly supported DOE objectives.

Reviewer 2:

The reviewer observed that the project was focused on training engineers in advanced materials and manufacturing, areas critical to the implementation of advanced vehicle technologies.

Reviewer 3:

The reviewer remarked that the project was researching cost-effective lightweight materials that enabled energy use reduction in vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer commented that resources appeared to be sufficient.

Reviewer 2:

The reviewer indicated that there was no indication of a concern.

Reviewer 3:

The reviewer commented that support to promote graduate studies toward automotive needs was necessary, and that this presentation did not offer a clear breakdown of resource usage.

Reviewer 4:

The reviewer was not really sure because no information on the persons involved in the program was given.

EV Community Readiness projects: American Lung Association of the Southwest (CO); Oregon Business Development Department (OR, WA): Kay Kelly (DOE GFO) - ti027

Reviewer Sample Size

A total of eight reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the projects seemed well-conceived, designed, and organized.

Reviewer 2:

According to the reviewer, for Project Fostering Electric Vehicle Expansion to the Rockies (FEVER)/American Lung Association, tasks to address technical barriers were very comprehensive, specific and logically sequenced. For Energizing Oregon/Oregon Business Development, tasks to address technical barriers were more general, but were relevant and adequate. The reviewer added that the strategy to integrate numerous existing elective vehicle (EV) initiatives was sound.

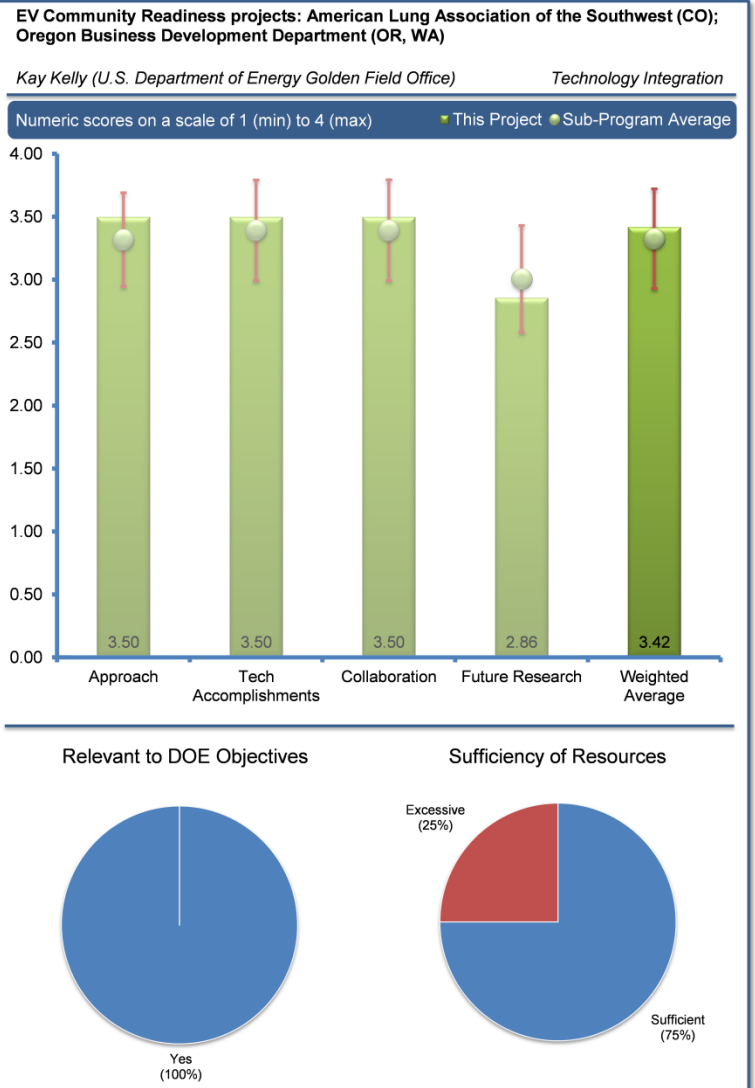
Reviewer 3:

The reviewer commented that the strategy for both initiatives addressed all four barriers cited by the Clean Cities EV Community Readiness projects. Project FEVER's strategy has done a particularly good job of addressing the barrier to EV infrastructure availability. The reviewer noted that the approach has included: developing streamlined permitting and inspection guidelines, developing recommendations on building codes and zoning ordinances, assessing potential grid impacts of EV penetration, and assessing state and local policies relevant to infrastructure. The reviewer also explained that Energizing Oregon established four work groups to address different issues related to EV and electric vehicle supply equipment (EVSE) adoption: deployment, utilities, outreach, and policy. The strategy includes a strong public outreach component, which addresses barriers to consumer acceptance.

Reviewer 4:

The reviewer detailed that Project FEVER's strategy was to reach out to multiple communities, state agencies and EVSE industry/manufacturers and utilities. Many fleets were public or utility-based. The reviewer commented that the plan did focus on many key areas or barriers, grid impacts, streamlining permitting, etc. Partners met twice during the process for each working group. The reviewer commented that air quality and energy benefits and the impacts of plug-in electric vehicles (PEVs) was a unique focus and led to a separate report.

The reviewer commented that the Energizing Oregon deployment strategy was to get a grasp on individual community activities to date and build consensus on best practices. The reviewer concluded that the project strategy led to some unique training, such as with the Oregon Automobile Dealerships Association.



Reviewer 5:

The reviewer commented that, generally, as with the other EV Community Readiness grants, these grants were well-integrated with DOE's other efforts to promote the use of PEVs, including the ARRA grants for EVSE and PEVs, Clean Cities efforts, the Workplace Charging Initiative, etc. The reviewer commented that following the grant completion, the efforts to bring together grant recipients to share ideas in Tennessee, as well as the planned summary report, show the emphasis on integrating all of the individual grants.

The reviewer explained that for Project FEVER, the initial design of the project, specifically the initial subject matter assessment and the barrier mitigation, allowed for a readiness plan that is feasible and relevant.

For Energizing Oregon, the reviewer explained that the initial design of the project, specifically the efforts to develop key elements of the plan and collectively define a roadmap, allowed for a readiness plan that is feasible and relevant.

Reviewer 6:

The reviewer first addressed Colorado Project FEVER. According to the reviewer, this project outlined that the project was going to: develop best practices; assess state policies; evaluate local codes and regulations, zoning allowing EVs; and evaluate the impacts on the grid, and more. The reviewer commented that this plan appeared to be an outstanding use of federal funds. The reviewer believed this because it looked at the building blocks to implementing a new technology and the policies needed to get it off the ground. The reviewer also liked the working groups/survey work to collect feedback early to help guide this group. The surveys could also be helpful to measure the plan's long-term success. The reviewer also noted that this state did not have any prior experience with EVs and was starting from scratch – given that, this appeared to be an effective approach; however, the 105 partners may have been challenging to manage. The reviewer liked that the project team included first responders early on in the development process. According to the reviewer, this had been a proven barrier in the past.

Regarding Oregon's project, the reviewer elaborated that this state appeared to already be EV-ready and already had EVs and stations in the works. The reviewer detailed that this project helped to harmonize the large number of entities in Oregon already working on EVs. Because Oregon was experienced in EV technologies, the reviewer was pleased to see the plan included identifying initiatives that had already been done to date. The reviewer stated that reviewers were to assume that coding and zoning issues had already been addressed. The project looked at the consumer and myth busting. The reviewer was unsure how the funds were used. The reviewer liked that this project used surveys, but noted that it would have been helpful to have more detail on those survey results and how this data was used. This project did have matching resources but the reviewer did not know who it was from and how the resources may have influenced the plan. If the reviewer were rating this strategy alone, it would have received a fair rating.

Reviewer 7:

The reviewer remarked that the American Lung Association of the Southwest and the Oregon Business Development Department EV Readiness grants represented two awardees at the opposite side of the spectrum in EV penetration in the respective states. Project FEVER, the Colorado project, was funding for an early stage initiative, whereas the Energizing Oregon was funding for the State's efforts to streamline and coordinate best practices in a state with significant EV owner penetration.

The reviewer commented that the Colorado plans appeared to be very comprehensive and well-designed. The project team's strategy proved to be an excellent approach for this grant. This reviewer explained that the working groups established early on with 105 partners enabled the project team to work both at the local and state level; and evaluate the EV Grid Impact Assessment, Electric Permit Evaluations, and Methods and Best Practices adopted by participating municipalities including ordinances, zoning, building codes, etc. The reviewer believed these efforts were useful for the project team to create and compile. The reviewer concluded by noting that if scored alone the American Lung Association of Southwest Colorado would have received an outstanding score on Strategy for Deployment.

The reviewer was sure that the Energizing Oregon Readiness Plan was helpful for the project team's impressive stakeholder group, but given the presentation materials supplied, this reviewer was unable to determine if this plan will be pertinent, relevant or useful to other states, industry and academia. The reviewer commented that it was fantastic that the Governor included the Oregon Readiness Plan in his Energy Plan, and the reviewer applauded all the creative efforts made with the State's EcoTourism industry. Because

Oregon is alleged to be one of the more mature states with EV penetration, it would be helpful for this reviewer if the presentations highlighted for other states what data Oregon collected from their surveys to better understand lessons learned. User-friendly EV industry data and information on how many EV owners, vehicles and charging stations are in the state would also have been helpful to the reviewer. The reviewer pointed out that it was not clear why the Portland International Auto Show was highlighted and wished the materials explained more clearly how the grant served to overcome barriers for consumer's availability of vehicles and charging stations. The reviewer acknowledged that Oregon received an almost \$90,000 cost-share, but the reviewer expressed uncertainty where those funds for the total project funding of \$574,000 came from and how the cost-share entity may have benefitted from the Energizing Oregon initiative.

Reviewer 8:

The reviewer explained that both projects (FEVER and Energize Oregon) met the three technical barriers of availability of charging stations, consumer reluctance to buy EVs and the lack of technical experience. The reviewer noted that the remaining technical barrier of vehicle availability was not directly addressed. According to the reviewer, the approach seemed to be that vehicle availability would follow by building market demand.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the technical accomplishments of both projects were outstanding. Projects both delivered on their Readiness Plan, and performed marketing, education and outreach per their Statement of Work.

Reviewer 2:

According to the reviewer, Project FEVER made excellent progress toward the DOE VTO goal of easing market introduction of electric drive vehicle technologies. The presenter noted that several outside groups were using recommendations from Project FEVER for independently-funded Colorado EV and EVSE deployment projects. The reviewer elaborated that the extensive collaboration of the project coordinators with states agencies, local governments, utilities, and other stakeholders suggests that further implementation of the project recommendations is likely. The project also successfully addressed the DOE goal of providing technical and educational assistance to local communities through the aforementioned collaborations, by developing infrastructure permitting and regulatory guidelines, as well as through first responder training. The reviewer said that Energizing Oregon also made excellent progress toward facilitating EVs & EVSE infrastructure deployment. The presenter noted that the Governor's office had already adopted the EV Readiness plan and that the first steps have been taken toward a PEV fleet financing program and a workplace charging initiative. Energizing Oregon also developed an innovative public outreach strategy that included EV tourist routes and itineraries.

Reviewer 3:

For Project FEVER, the reviewer commented that this project was over 98% complete with a month remaining in the grant. Significant technical accomplishments include PEV grid impact minimization efforts; streamlining permitting and inspection; developing best management practices for ordinances, building codes, and other efforts; producing a comprehensive readiness plan; and marketing, educating, and communicating with stakeholders. The reviewer noted that particularly impressive work products included household EVSE volume maps, model permits, and an interactive online resource that will be maintained after the grant is over.

For Energizing Oregon, the reviewer noted that this project was over 95% complete with a month remaining in the grant. Significant technical accomplishments included prioritized action items, reports, an interactive website, presentations, outreach events, and training for electricians and auto dealers. For the reviewer, particularly interesting were the PEV itineraries to be used by the state's tourism agency. The reviewer enthusiastically commented that this was a creative way to address the consumer reluctance barrier. In addition, the workplace charging program is in line with DOE's efforts at the national level in this area.

Reviewer 4:

Regarding Project FEVER/American Lung Association, the reviewer indicated that the project released a well-documented plan, including several nice pieces, e.g., the developed model permit flow chart was particularly good; conducted extensive outreach, and launched a project website.

The reviewer commented that Energizing Oregon/Oregon Business Development released a plan/roadmap; developed and released a separate marketing plan; and launched a project website.

Reviewer 5:

The reviewer commented that readiness plans were completed with good elements. The reviewer enthusiastically explained that the model permit process was great. The reviewer also liked that the Colorado project looked at air quality, which none of the others this reviewer evaluated appeared to address. According to the reviewer, the Colorado website was informative, easy to navigate, and fun. While also informative, the reviewer thought that the Oregon website seemed to lack information that an employer, property owner, or EVSE installer might want.

Reviewer 6:

For Colorado Project FEVER, the reviewer indicated that the goal was to develop a state-wide EV Readiness implementation plan. This project achieved this overarching goal. The plan included the following: best practices and smart grid strategies for residential and buildings, codes; developed a website and newsletter that accomplished significant consumer awareness; and trained 83 first responders, etc. The reviewer noted that this project included the Governor's Energy Office and a number of other state agencies; all of whom adopted the plan. According to the reviewer, although not an indicator of success, the plan had already received awards, both merit and financial. The reviewer concluded that from having limited EV charging to approximately 100 shows the success of this plan. The reviewer also learned during the question and answer session (Q&A) that the state extended a \$6,000 tax credit for EV purchases. The reviewer detailed that \$1 million in Congestion Mitigation and Air Quality Improvement (CMAQ) funding would be used to build infrastructure and vehicles as a result of this plan, which the reviewer remarked was nice. The reviewer identified that one of the outstanding accomplishments to this plan was the installation of a number of EV charging stations.

The reviewer detailed that Oregon's EV readiness project accomplished several dozen surveys and public opinion polling. It released its plan in December 2012; however, this reviewer noted that the final plan and educational materials developed were difficult to find online. The reviewer mentioned that according to the PI, the state is more or less done building out infrastructure, and is now focused on consumer outreach. The project had an exhibit at the Portland International Auto Show to increase consumer awareness. The reviewer commented that the project highlighted that it focused on the EV tourism plan and EV trip guide. The reviewer noted that the working group held a series of webinars in the Summer/Fall of 2012, but was unsure of the audience for those webinars. The reviewer liked that the project included technician training for auto dealers, especially if it was already built out. The reviewers did not know how many workshops were held and how many were educated. The reviewer noted that the project began to develop a fleet financing effort, but did not complete it. It was unclear to the reviewer why the project resulted in educational materials, but the reviewers were not told what they were and the reviewer did not see them on the project's website. The project was not able to complete work-place charging information and a financing charging program. The reviewer will have to rate this project's technical accomplishments at fair.

Reviewer 7:

The reviewer commented that Project FEVER looked at the subject area assessment: grid impact, electrical permitting and inspection, ordinances, building codes and new construction, EV demand and energy benefits, and air quality impacts using demand models across the state. The reviewer detailed that Phase 3 looked at implementing a pilot Smart Grid, enabled strategies for early adopters, streamlined processes for permitting and inspection, best practices for local EVSE ordinances and building codes, reports assessing air quality and energy based on penetration scenarios and state and local policies and best practices, and a dedicated website.

The reviewer commented that Project Oregon coalesced the efforts of multiple players to determine the needs and to share lessons learned. Progress was made in the key area of deployment including working more closely with the tourism industry and dealerships.

Reviewer 8:

The reviewer stated that Colorado developed a robust state-wide EV Readiness Plan with local input. Additionally, many aspects of the Plan and Best Practices ultimately ended up being incorporated at the local level with the participating partners, which were key in a state that had little to no EV owner penetration prior to the EV Readiness Plan. The reviewer remarked that Project FEVER undertook an aggressive scope and appears to have accomplished all the tasks and metrics, which ended up actually being used and implemented; so in other words, stated the reviewer, the work did not just sit on a shelf.

The reviewer detailed that on April 23, 2013 partners in Project FEVER launched Charge Ahead Colorado, a program formed in partnership by the Regional Air Quality Council (RAQC) and the Colorado Energy Office (CEO) to improve air quality and encourage the deployment of EVs. This program has awarded 13 public entities and two not-for-profit organizations with grant funding, to support the purchase of EVs and the expansion of EV infrastructure. The reviewer commented that overall, the program would provide financial support for the purchase of 10 EV fleet vehicles and the construction of 41 new EV charging stations across the state. The reviewer stated that the new charging stations supported by the Charge Ahead Colorado Program would increase the total public charging stations in the state from 79 to 116. The reviewer commented that also worth noting was that in 2013, the Governor signed legislation that extended the \$6,000 state tax credit for EV vehicle purchases through 2021. The reviewer noted that if scored alone, the American Lung Association of Southwest Colorado would have received an outstanding score on Technical Accomplishments and Progress.

The reviewer thought the Oregon presentations of their Energizing Oregon Readiness Plan were not very well done. According to the reviewer, it seemed to take into consideration that the reviewer had a previous working knowledge of what has been accomplished in the state to date. The presentation indicated that two of the four work groups were outreach and deployment, but the presentation materials did not indicate what was accomplished in this regard. The reviewer was surprised to see that only initial steps were taken with these funds to educate employers on fleet financing benefits and/ or workplace charging initiative, as the reviewer would have expected that Oregon's early stage involvement in this sector would have already empowered the state to conduct outreach and education advocacy to at least the largest employers on these very basic deployment matters.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer found that the number of collaborations of both projects were outstanding, and noted that Project FEVER had 105 collaborations.

Reviewer 2:

For Project FEVER/American Lung Association, the reviewer commented that the project included a wide array of relevant project partners, including state and local governments; electricity generators/distributors; utility authorities; departments of public works (DPWs) and Departments of Transportation (DOTs); owners/operators of properties essential to EVSE deployment; plug-in electric drive vehicle manufacturers and retailers; third-party vendors/installers of EVSE; participating fleets; and all three Clean Cities Coalitions from the State of Colorado. The reviewer enthusiastically commented that the project has over 100 collaborative partners in all.

Regarding Energizing Oregon/Oregon Business Development, the reviewer remarked that similar to Project FEVER above, this project also included participation/collaboration from a large number (over 50) of key partners representing virtually every type of stakeholder suited to this kind of project.

Reviewer 3:

For Project FEVER, the reviewer noted that the grant recipients included a collaboration of 3 Clean Cities coalitions, 6 state agencies, 27 local governments, 6 utilities, PEV/EVSE manufacturers, and fleets. These groups appeared to be well-coordinated.

For Energizing Oregon, the reviewer noted that the grant recipients included a collaboration of two Clean Cities coalitions, the Governor's Office, five state agencies, six local governments, the public utilities commission (PUC), five utilities, private partners, and others. According to the reviewer, these groups appeared to be well-coordinated.

Reviewer 4:

The reviewer commented that project FEVER collaborated with over 100 state agencies, local governments, utilities, EVSE providers and other stakeholders. Energizing Oregon also collaborated with a long list of state and local governments and other local stakeholders.

Reviewer 5:

Regarding Colorado Project FEVER, the reviewer reiterated that this project had 105 active partners, many of whom had influence over state/local policies and funding sources. Several academic and industry partners brought a high level of technical expertise to this project and, ultimately, the plan. According to the reviewer, the only lacking major partner were the major OEMs, which would be critical to the long-term success and consumer acceptance of this plan. As this project moves into implementation, the reviewer highly encourages the Project FEVER partners to include the OEM dealers. Also, it was unclear to the reviewer whether or not the partners included fleet managers.

For Oregon, the reviewer commented that this project has a large number of partners, including the Governor's Office, five state offices and the auto dealers/OEMs. The project team has a large number of cities, and one county. The plan was incorporated into the Governor's Energy Plan and the state continued its support after the plan was released. The reviewer was unsure what the plan included or whether any private funding was identified for implementation of the plan. The reviewer remarked that this would have been helpful to spell out. The reviewer liked that the Oregon dealers were involved in the auto EV education.

Reviewer 6:

The reviewer liked the involvement of so many local governments in the Colorado project. The reviewer wished the Colorado DOR were part of this, since the handling of the Colorado tax incentive was making it difficult for consumers to determine their respected tax return; the reviewer commented this was impacting purchase decisions. Perhaps this group could have helped expedite this process. Likewise, according to the reviewer, there was good non-government participation in the Oregon project.

Reviewer 7:

According to the reviewer, collaboration for Project FEVER seemed limited with only two meetings, although the project team did keep these groups informed of the progress and ultimately, received the buy-in that was needed.

The reviewer noted that Energize Oregon had an impressive number of meetings and focus groups and working groups, which led to the plan being adopted by the Governor's Office.

Reviewer 8:

The reviewer praised that the collaboration and coordination for Project FEVER was excellent. The project team's 105 active partners included all relevant entities at that table from universities, state and local government, utility companies, EV charging manufacturers and local refueling stations. While it is understandable that the OEMs have not been active in Colorado given the range limitations of the battery, mountains and weather, going forward it is imperative that the OEMs become more involved if EV adoption is to become a reality. Additionally, the reviewer advised that going forward large employers with fleets should also be engaged.

As stated previously, the reviewer was unsure what was accomplished in the Energizing Oregon Readiness Plan. That being said, for the reviewer it appeared from the materials, that there was coordination with the tourism industry and state and local government. The list of partners was impressive but the reviewer was not really sure what all the results were of a coordinated effort.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that Energize Oregon worked successfully to harmonize the efforts of multiple communities and agencies already working in the PEV space to develop a plan adopted by the Governor's Office and the Transportation Electrification Executive Council. This group held multiple meetings and focus groups to identify current activity and barriers. The reviewer commented that this led to the Governor's Office creating a Memorandum of Understanding (MOU) for continued collaboration with key partners.

The reviewer noted that Project FEVER's report was presented to multiple players that would benefit from clean air, and economic development of a large introduction of PEVs. Subject area assessments were multiple in nature, covering many barriers, and it led to additional state funding for EVSE incentives. The project team developed a model permitting process. The reviewer concluded by stating that education will continue in both projects into 2014.

Reviewer 2:

The reviewer commented that the Project FEVER EV Readiness Plan appeared to be successful in that Colorado had no EV owners and charging stations prior to the Plan and that Colorado is on target to have 116 stations in 2013. Additionally, the Colorado legislature voted to extend the \$6,000 tax credit for EV car purchasers until 2021. The reviewer is hopeful the Working Groups and Best Practices for zoning, permitting, ordinances and charging station installations were helpful for this deployment effort.

Reviewer 3:

The reviewer commented that both projects are scheduled to be completed in June 2013. Follow-up activities are outside the scope of this review.

Reviewer 4:

For Project FEVER, the reviewer indicated that the remaining project activities under the grant were minimal, but the grantees will continue efforts beyond the grant funding for implementation.

Regarding Energizing Oregon, the reviewer commented that remaining project activities under the grant were minimal, and it was unclear how implementation efforts would proceed [DOE Program Clarification: It should be noted that implementation activities were outside the scope of the grant.].

Reviewer 5:

Regarding Project FEVER/American Lung Association, the reviewer commented that the FEVER project has been/will continue to be leveraged by other funded deployment initiatives both in Colorado and in other states/regions.

For Energizing Oregon/Oregon Business Development, the reviewer commented that the future work is rather vague and described in general terms (e.g., continue outreach, etc.).

Reviewer 6:

For the Colorado Project FEVER, the reviewer commented that this plan was completed in December 2012. The project has already led major policy incentives for EVs in Colorado. This is a strong indication this plan was effective and would ultimately lead to the successful implementation of EVs in Colorado. The reviewer concluded that the Project FEVER team and DOE Clean Cities should be pleased with the overall success of its efforts. As a side bar, the reviewer commented that it would be helpful if DOE/Project FEVER followed-up with another survey to assess the impact of this plan down the road. The reviewer also complimented that Denver did an outstanding job laying the groundwork for future success and expansion.

For the Oregon Project, the reviewer indicated that this project was nearly complete. However, the presenters did not indicate how it was going to achieve its long-term success (i.e., where funds could come from to continue the educational ideas presented in the plan). The presenter commented that there were areas that needed additional funding to continue including fleet financing, and work-place

education/outreach, but again, no indication of how the funds would be raised. The reviewer commented that, from what the reviewer could tell, the plan did not outline mechanisms to measure its success. The reviewer would like to know if there would be any additional surveys conducted.

Reviewer 7:

The reviewer generally would have liked to have seen more thought put into communicating results to key stakeholders from all of the EV readiness projects. Plans, websites, and fact sheets were a great start, but the reviewer felt that just as important was getting that information in front of the important stakeholders including from policy officials, to property owners, and to consumers. According to the reviewer, more detail on this, even in the Future Work section, would have been nice.

Reviewer 8:

The reviewer commented that both projects were near completion and had minimal proposed future work. Estimates on how these projects would have a positive impact on EV market acceptance would have been useful to this reviewer.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that the EV Readiness Grants for both Colorado and Oregon were relevant as they introduce, educate, and ultimately encourage consumers to replace combustion engine vehicles with vehicles that use less or no petroleum and reduce carbon emitting pollutants.

Reviewer 2:

The reviewer commented that these grants addressed barriers, including the availability of PEVs and EVSE, consumer reluctance to purchase new technologies, and the lack of technical experience with new technologies. Addressing these barriers will help support VTOs deployment goals, specifically petroleum reduction objectives, partnership efforts to ease market introduction of PEVs, and technical and educational assistance to support local communities and partnerships.

Reviewer 3:

The reviewer remarked that both projects would serve to meet the Clean Cities petroleum reduction goals of 2.5 billion gallons per year by 2020 by building and strengthening community efforts in PEV deployment.

Reviewer 4:

The reviewer stated that the adoption of EVs and plug-in hybrid electric vehicles (PHEVs) has the potential to significantly reduce petroleum use. These community readiness initiatives help facilitate the adoption of EVs and EV infrastructure, as described above.

Reviewer 5:

The reviewer commented that both projects supported grassroots EV market development at the community and state level.

Reviewer 6:

The reviewer remarked that the EV readiness plans for both Colorado and Oregon are relevant to petroleum reduction goals. These plans lay a roadmap for developing EVs in their respective states. As has already been witnessed, these plans were already making an impact through EV charging installations and public incentives.

Reviewer 7:

The reviewer commented that the benefits of EVs were well-known.

Reviewer 8:

The reviewer remarked that EV usage reduced petroleum dependency. The reviewer also commented that neither project estimated how much petroleum would be displaced.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer commented that both projects had already used most of the funding allocated and made significant progress toward project objectives.

Reviewer 2:

For Project FEVER, the reviewer noted that the project funding of \$500,000 was sufficient to complete the work, though these were not cost-share.

For Energizing Oregon, the reviewer commented that the project funding of \$573,923 was sufficient to complete the work, and this included an \$88,923 cost-share.

Reviewer 3:

The reviewer observed that Project FEVER had spent 98% of \$500,000. The project resources seemed adequate for the multiple tasks at hand, bringing together multiple stakeholders to engage in the plan development; development of a website for consumers; training courses for first responders.

The reviewer noted that Energize Oregon was 95% compliant and had numerous tasks, including harmonizing on-going efforts of multiple communities throughout Oregon to develop the plan, educational brochures and events, and training for auto dealers and electricians.

Reviewer 4:

For Energizing Oregon/Oregon Business Development, the reviewer noted that over \$200,000 in project funds remained while the project was 95% complete. The reviewer questioned whether the project appeared to be over-funded [DOE Program Clarification: It is important to note that final invoicing had not taken place at the time this presentation was submitted.].

For Project FEVER/American Lung Association, the reviewer commented that this project appeared to be appropriately-/sufficiently-funded.

Reviewer 5:

First, the reviewer recommended to DOE to have the PIs present their project summaries instead of DOE project managers. It was difficult for DOE project managers to provide the level of detail needed for reviewers to do a thorough evaluation.

Second, according to the reviewer, it was difficult to assess the resources. No budget or spending plan was provided for either project. As to the use of resources, the reviewer's initial reaction was that the reviewer could not believe that DOE spent this much money on an implementation plan. The reviewer thought about how much more could have been done with these resources to actually obtain petroleum displacement. The reviewer stated that it was too early to tell whether or not these funds were used appropriately – time would tell.

Third, according to the reviewer, DOE did not require any cost-share to develop these plans. The reviewer thought DOE should require some level of investment on the industry or state's part in the future to help secure their buy-in and long-term investment, and because the industry or state was going to benefit from the plan. Although Oregon was not required to, this project had almost 20% cost-share. The reviewer remarked, kudos; but the project also had a more established EV infrastructure and industry in place.

Fourth, with such substantial funding going into the development of these implementation plans, the reviewer expects DOE to require the plan include a discussion about the sustainability of the plan's proposed activities (i.e., identify possible funding partners to carry out the plan). If this was a requirement, it was not made clear to this reviewer.

In Project FEVER's case, the project team had already begun to implement the plan. The reviewer questioned how those resources were obtained, and asked whether it was through another DOE or other federal agency grant or industry/state sources. If so, stating this during the presentation would have been helpful to the reviewer.

Reviewer 6:

It was difficult for the reviewer to evaluate how the resources were used in either the Colorado or Oregon project. While the reviewer knew that working groups, website and printed materials were organized and produced, the reviewer was unable to evaluate the expenses for the project from the information and presentations provided. In the past, the DOE has had the PI that received the grants make the presentations for the reviewers, and this year the respective DOE project manager gave the reviewers the presentations. It would be more effective in determining some of the local and regional impacts and long-term benefits of the grants if the person responsible for implementation provided the reviewers the uniqueness and highlights of the project presentation. Also, according to the reviewer, the cookie-cutter hardcopy presentation format used for these reviewer presentations prevented the individuality and exceptionality of each grant to stand on its own.

The reviewer notes that Oregon secured a cost-share while Colorado did not. The reviewer recommended that DOE should require in this tight federal budget funding environment, a cost-share from all recipients of federal government funds.

Reviewer 7:

The reviewer commented that the FEVER project had sufficient funds to complete the work in a timely manner. Energize Oregon has reported \$326,990 funds spent from a budget of \$573,923, yet the project team reported 95% completion. The project may have received excess funding necessary to complete the work [DOE Program Clarification: It is important to note that final invoicing had not taken place at the time this presentation was submitted.].

EV Community Readiness projects: New York City and Lower Hudson Valley Clean Communities, Inc. (NY, MA, PA); NYSERDA (ME, NH, VT, MA, RI, CT, NY, NJ, PA, DE, MD, DC): Mike Scarpino (National Energy Technology Laboratory) - ti028

Reviewer Sample Size

A total of eight reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer first provided general comments. As with the other EV Community Readiness grants, these grants were well-integrated with DOE's other efforts to promote the use of PEVs, including the ARRA grants for EVSE and PEVs, Clean Cities efforts, the Workplace Charging Initiative, etc. The reviewer commented that following the grant completion, the efforts to bring together grant recipients to share ideas in Tennessee, as well as the planned summary report showed the emphasis on integrating all of the individual grants.

Regarding the Northeast Electric Vehicle Network, the reviewer commented that the initial design of the project, specifically the stakeholder advisory group, literature review, and data collection, allowed for a readiness plan that is feasible and relevant.

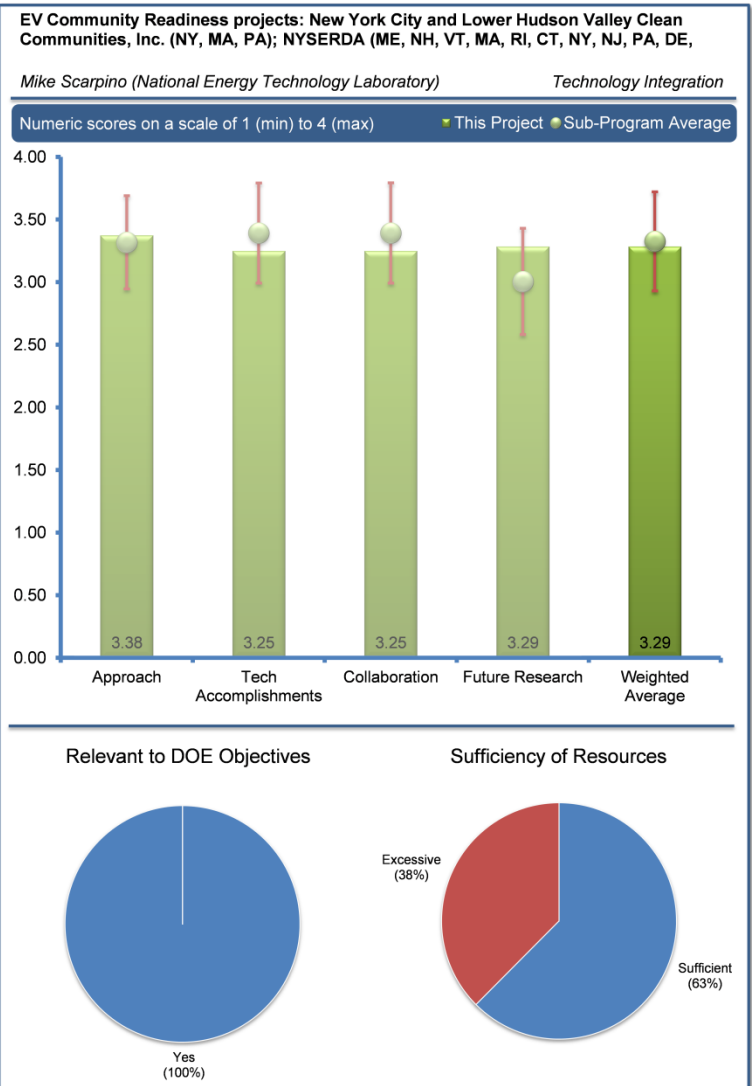
For the New York City and Lower Hudson Valley Clean Communities, Inc. (NYCLHVCC), the reviewer commented that the initial design of the project, specifically the efforts to collect data and analyze information, allowed for a readiness plan that is feasible and relevant.

Reviewer 2:

The projects seemed well-conceived, designed, and organized. For the NYCLHVCC project, the reviewer liked that the team identified the unique characteristics and needs of New York City and proceeded accordingly; specifically car share, garage issues, etc.

Reviewer 3:

The reviewer remarked that the two projects being reviewed were the New York State Energy Research and Development Authority (NYSERDA) Northeast Region and the New York City/Lower Hudson Valley. The reviewer elaborated that both projects got a good rating for addressing the technical barriers. The NYSERDA work identified the four standard barriers and addressed three of these barriers: availability of charging stations, consumer reluctance, and technical experience. The NYCLHVCC project identified three slightly different barriers of public awareness, increased access to charging, and improving vehicle economics.



Reviewer 4:

The reviewer commented that the Northeast Regional Electric Vehicle Network Planning Project was approximately \$1.5 million, funded with \$1 million from DOE and a \$500,000 cost-share from NYSERDA. The partners included 11 states in the northeast from Maine to Washington, DC. The reviewer commented that other partners included Transportation Climate Initiative (TCI), which took the lead, Georgetown Climate Center, 16 Clean Cities coalitions, numerous local governments and the National Association of State Energy Officials (NASEO). The reviewer noted that TCI and Georgetown Climate Center have worked on the Regional Greenhouse Gas Initiative (RGGI) with many of these same partners for years and have a strong track of working on complicated emissions reductions projects. The reviewer noted that this group set out to form a Stakeholder Advisory Group, compile and review literature to better understand regional siting, building and electrical code models, case studies, education and ultimately would present their findings in a plan and best practice documents for EV readiness.

The reviewer noted that it was important to remember that the New York City project already had an EV initiative underway and this \$420,000 from DOE and \$150,000 from New York City is intended to be used to build on those efforts. The reviewer commented that this project was intended to be used to evaluate fast charging station potential, access to EV charging in general, EV taxis, friendlier zoning and building education materials, and overall connectivity issues. This initiative would be using advanced communication outreach including social media to educate businesses and consumers. The reviewer added that data collection and analysis was used to evaluate car sharing and fast charging potential. The reviewer found that extensive parking garage attendant training was another key approach to New York City's implementation strategy.

Reviewer 5:

For NYSERDA, the reviewer commented that the tasks to address technical barriers were suitable and adequate but rather general and not specific. Key stakeholder advisory groups needed to be assembled during the project rather than in advance of the effort. The reviewer found that the cluster approach was a good way to equalize approach to issues across a very wide and diverse geographical project range, including 11 Northeast & Mid-Atlantic States and Washington, DC.

For NYCLHVCC, the reviewer commented that the project addressed several New York City-relevant barriers and opportunities, such as analyzing potential for EVSE for taxi fleets, EVSE installations in parking garages and garage attendant training, EV integration with car-share programs, etc.

Reviewer 6:

Concerning the NYSERDA EV Project, the reviewer remarked that this project received \$1 million in federal funding and \$500,000 in state support. It covered 11 states in the Northeast from Maine to Washington, DC. This project had a tough road to hoe with 11 states. TCI managed the group, which was good because TCI already had a working relationship with these states through the RGGI. The reviewer commented that project tasks were to form an advisory group; conduct literature reviews to better understand current issues and develop its regional siting and design guidelines; building code/permitting/zoning models; education plan; and then writing the actual plan. The presenter shared that one of the primary objectives was to develop a suite of planning documents and best practices guidelines to help implement EV readiness communities throughout the Northeast. In general, according to the reviewer this appeared to be a strong approach.

For NYCLHVCC's EV project, the reviewer commented that this project had \$420,000 from DOE and \$150,000 from New York City. This project targeted fast charging stations, increasing greater access to EV charging, integrating taxis, improving vehicle economics, developing friendly zoning educational materials, addressing connectivity issues, and utilizing social media to promote EVs. The reviewer found that the approach used data collection and analysis to assess car-sharing and fast-EV charging potential. The reviewer commented that the project also developed parking garage attendant training to increase acceptance.

Reviewer 7:

For the NYSERDA project, the reviewer commented that the project worked with a consortium of states, non-governmental organizations (NGOs), NASEO, and Clean Cities coalitions to form a stakeholder advisory group. A literature review helped determine practices already underway. The reviewer commented that local stakeholders were clued into the progress through monthly

webinars as TCI wrote the plan. The strategy was to focus on areas that were common to everyone, whether you lived in Vermont or New York City and developed clusters of focus areas for EVSE deployment.

For NYCLHVCC, the reviewer commented that this project had a few targeted audiences, such as taxis, garage attendants, car sharing public, food truck entrepreneurs and their patrons, and education of the general public and analyzed these markets and developed tools or actual deployment of EVSE. Due to the project being of smaller scope, according to the reviewer, the strategy was focused.

Reviewer 8:

The reviewer commented that the strategy for both initiatives addressed the four barriers cited by the Clean Cities EV Community Readiness projects.

The reviewer noted that NYSERDA's strategy did a particularly good job of addressing the barrier to EV infrastructure availability through the development of region-wide siting guidelines as well as recommendations for building codes, permitting, and zoning ordinances that states and local partners across the region can use. These steps also helped address another barrier, the lack of technical experience with new vehicle technologies.

The reviewer remarked that NYCLHVCC's strategy more directly addressed the barriers to vehicle availability by assessing the possibility of incorporating EVs into the taxi fleet and a city car-sharing program. The reviewer remarked that the strategy also included a public outreach component to address barriers to consumer acceptance; however, nearly all of the project efforts focused on New York City. It was unclear to the reviewer to what extent the project addressed barriers in either Boston or Philadelphia, which were both within the scope of the project's stated goals.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

For the Northeast Electric Vehicle Network, the reviewer noted that this project was over 95% complete with a month remaining in the grant. Significant technical accomplishments included developing planning documents, model building codes, model permitting rules, model zoning ordinances, and education and outreach. The reviewer found that the site design for EVSE, particularly with the Americans with Disabilities Act (ADA)-compliance addressed, would be extremely helpful for the industry. In addition, the analysis related to trends in EV ownership and charging station locations would be useful in that region. The reviewer remarked that in particular, it was interesting to see that the project team identified specific land use clusters that could be considered strong candidates for EVSE deployment regardless of the geography and demographics. This model can be replicated in other areas of the country that are as diverse as the northeast. The reviewer concluded by remarking that the educational materials were creative.

For the New York City Electric Vehicle Readiness project, the reviewer noted that this project was 100% complete with a month remaining in the grant. Significant technical accomplishments included analysis, education and outreach, website and social media engagement, and the completion of the final plan. The reviewer commented in particular, that many of the efforts could be replicated in other cities, including EV CarShare, time-of-use EV metering, building codes, curbside charging, fast charging, and parking attendant training. The reviewer found that the initiative's website was extremely well-executed.

Reviewer 2:

The reviewer noted that NYCLHVCC did an outstanding job of recognizing the unique problems associated with EV charging in the city. The reviewer specified that New York City was not ready for on-street EV charging, so the project spent time and funds on developing public garage charging. The reviewer remarked that NYSERDA also did an outstanding job in meeting their objectives when one looked at the size of the project.

Reviewer 3:

Concerning NYSERDA's EV Readiness Project, the reviewer commented that this project produce and published its plan in October 2012. The project accomplished its objectives: formed a stakeholder advisory group, completed the literature review, collected data for work products, collected feedback on its draft report, finalized guidance documents, and completed outreach events. The reviewer

commented the project also resulted in the development of a college course on EVs. The project generated 14 different products, including the proposed guidance documents, and held more than 100 meetings to educate stakeholders about its plan and the generated documents. The reviewer loved the hang-tag too. The project also identified nine cluster areas that might be good locations for EVs. In the reviewer's opinion, the project team accomplished what was proposed.

For NYCLHVCC, the reviewer remarked that the plan was completed and had been announced by Mayor Bloomberg. The project research concluded that car-sharing could meet 98% of individual trips using the Nissan LEAF based on the 580 trips analyzed. The reviewer remarked that the utilities removed codes, enabling customers to install additional meters and allowed preferred rates. As a result of this plan, the Mayor committed to creating 2,000-10,000 parking spots for EVs throughout the city by 2020. The reviewer also noted that the plan determined that food service trucks should be targeted for conversion to EV or replaced by EVs, improving emissions and consumer awareness while reducing petroleum. The reviewer remarked that the Mayor embraced this concept and was considering how to lend support. The plan identified three direct current (DC) fast-charging sites for a taxis pilot program, and one site had already been installed. The reviewer commented that the plan included a public awareness campaign, allowing voters to determine the location of future EVs, and that Smith was an EV OEM. The reviewer liked this creative outreach effort. The project had already resulted in the training of more than 100 garage attendants. According to the reviewer, it would be interesting to learn if there were questionnaires done along with these trainings. The reviewer questioned if the trainings were effective. Also, the reviewer liked that the presenters listed the publications generated out of this plan in the PowerPoint slides. The reviewer wished that all the presenters did this.

Reviewer 4:

The reviewer remarked that the Northeast Regional Electric Vehicle Network Planning Project accomplished what the project set out to do, including forming a stakeholder advisory group that was engaged, completed literature review, completed guides and disseminated stakeholder outreach to public, fleets, employers, retailers, governments, and utilities. The reviewer remarked that the project team identified nine land use clusters most likely to be early EV adopters that included: medical campus, downtown dwellers and workers, higher education institutions, retail, commercial office, multi-family, leisure destination, regional transportation, fleet, and freight.

The reviewer noted that 14 products were generated including: Site Design for Electric Vehicle Charging Stations; Assessment of Current Electric Vehicle Supply Equipment and EV Deployment; Electric Vehicle Supply Equipment Cluster Analysis; Electric Vehicle Siting and Design Guidelines; EV-Ready Codes for the Built Environment; Creating EV-Ready Towns and Cities: A Guide to Planning and Policy Tools; Plug-In Electric Vehicle Deployment in the Northeast: A Market Overview and Literature Review; and a brochure: Learn About Electric Vehicles and Their Use in the Northeastern United States.

The reviewer noted that in addition to the project team's partners, the project worked with local stakeholders to assess the state of EVs in their jurisdictions and have held over 100 meetings to educate stakeholders about the documents developed. In the New York City EV project, the New York City Mayor's office used New York City Department of Transportation usage data from the first quarter of 2010 for their car share pilot and created a tool to simulate EV usage for the same type of car-share scenario. The reviewer remarked that this per-trip analysis showed that 98% of all individual trips would fit within the electric range of a Nissan LEAF. Since the New York City EV Readiness Plan was finalized, New York City's Mayor Bloomberg announced that the City is committed to ensuring that 2,000 of the 10,000 new parking spots will be EV ready by 2020. The reviewer noted that the New York City Mayor's office worked with the New York City Department of Buildings to amend codes in order to enable customers to install a second meter that would allow Con-Edison customers to take advantage of time of use rates. The analysis also illustrated that the value of the savings for New York City vehicles may not be substantial enough for further demonstration at this time. The reviewer explained that the New York City Mayor's office worked with the local utility, Con Edison, and Nissan to identify three DC fast-charging sites that could be used for the EV taxi pilot program. To date, two of the three sites have been identified, and one DC fast-charger was already installed. The reviewer noted that over 100 parking attendants have been trained. The reviewer concluded that Slide 37 would provide a complete list of all the documents New York City wrote and made available.

Reviewer 5:

Regarding the NYSERDA project, the reviewer commented that there were a number of goals that were met, and the progress included a number of guides on site design, assessment of EVSE placement and cluster analysis, and its impact on the grid; guide on codes; ADA compliance; and a planning guide for communities. The reviewer noted that products were developed to educate the public.

For the NYCLHVCC project, the reviewer remarked that again, the strategy was focused and progress was made in the key areas. Some barriers still remained, but the analysis and outreach to these targeted groups could yield future results. The reviewer commented that vehicle to grid (V2G) was analyzed, but the project team decided to delay work in these areas. The reviewer concluded that it seems a thoughtful process was developed to determine next steps at key decision points.

Reviewer 6:

The reviewer remarked that the readiness plans were completed with good elements. The reviewer added that it was good that the team chose to find common elements to investigate, given the diverse demographics and needs (e.g., Vermont versus New York City). The reviewer liked the examples and graphics for EVSE installations in the document, and observed good content on website as well. Overall, the reviewer observed good communications elements in the NYSERDA project.

The reviewer noted that the NYCLHVCC communications products seemed to be lacking this detail.

Reviewer 7:

The reviewer commented that the NYSERDA project made excellent progress toward the DOE VTO goal to ease the market introduction of electric drive vehicles through voluntary partnerships with local communities as well as the goal of providing technical and educational assistance to local communities. The team created an extensive suite of recommendations for local EV and EVSE deployment, covering siting, codes, and permitting guidelines as well as supporting analyses and market research.

The reviewer suggested that in order for the NYSERDA project to successfully address the DOE goal of reducing petroleum use through EV adoption, these recommendations must be adopted by local and state governments within the Northeast region. While that is outside of the scope of this initiative, it appears that the NYSERDA team successfully engaged the relevant stakeholders and local governments throughout the project. The presenter did note that some partners were installing EVSE based on the guidelines developed under this project.

The reviewer noted that NYCLHVCC also made significant progress toward easing market introduction of EVs and EV infrastructure in New York City through coordinated efforts with the local government and stakeholders. The project provided technical and educational assistance, including training parking garage attendants. The reviewer noted that the project also developed the public outreach platform Mission Electric, which targets both car owners and non-car owners.

Reviewer 8:

For the NYSERDA project, the reviewer noted that a very large suite of guides and documents have been produced and that a project website was launched. This reviewer observed no actual EV/EVSE Community Readiness Plan, though pulling it together has been completed.

For NYCLHVCC, the project resulted in several moderate-modest accomplishments. It is unclear to the reviewer whether a full New York City EV/EVSE Readiness Plan was actually produced through the effort.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that New York City was engaging citizens in EV deployment. The reviewer thought this was great.

Reviewer 2:

For the Northeast Electric Vehicle Network, the reviewer commented that the grant recipients included a collaboration of state agencies, non-profits, local governments, 16 Clean Cities coalitions, and NASEO. These groups appeared to be well-coordinated. The reviewer remarked that EVSE/EV providers and fleets were not included as initial partners, but they were tapped during stakeholder outreach and research.

For NYCLHVCC, the reviewer noted that the grant recipients included a collaboration of a Clean Cities coalition, the Mayor's Office, city agencies, a local utility, PEV/EVSE OEMs, and other cities. These groups appeared to be well-coordinated.

Reviewer 3:

Concerning the NYSERDA project, the reviewer commented that the collaboration and coordination appeared to be most remarkable. The reviewer summarized that collaboration included 16 Clean Cities coalitions, 11 states from Maine to Washington, DC, TCI, Georgetown Climate Center, NYSERDA, NASEO and numerous state and local governments. The reviewer commented that compared to other projects that were mostly a part of or an entire state, the level of local and state government coordination and collaboration was extensive. The reviewer believed that TCI, Georgetown Climate and many of these states have worked on the RGGI with many of these same partners for years and have a strong track of working on complicated emissions reductions projects.

The reviewer commented that the New York City project had few partners because the scope of the project was very limited and defined, and not necessarily a fit for too many. The reviewer identified that partners included New York City government, Empire Clean Cities, New York Power Authority (NYPA), Consolidated Edison, and Beam Charging.

Reviewer 4:

The reviewer commented that the Northeast NYSERDA project consisted of 10 states, numerous Clean Cities members, and seven private sector companies. Because the NYCLHVCC project addressed only New York City and the outlying region, the project had far fewer collaborations, but the project did have the most important collaborators, such as the Mayor's Office, local utilities and the New York City Department of Transportation.

Reviewer 5:

The reviewer noted that the NYSERDA project coordinated with state governments, Clean Cities coalitions, and other stakeholders across the region.

The reviewer commented that the NYCLHVCC project seemed to have strong collaborations with New York City partners, including the local government and industry. According to the reviewer, the level of coordination with Boston and Philadelphia was less clear.

Reviewer 6:

The reviewer commented that TCI managed the activity but kept the stakeholders engaged through monthly webinars. It appeared to the reviewer that this will continue into the future.

For NYCLHVCC, the reviewer observed that collaboration was with city departments and the Empire Clean Cities coalition, but was broadened as the target audiences were engaged in the discussion. The reviewer observed that coordination did occur with Philadelphia.

Reviewer 7:

For the NYSERDA project, the reviewer indicated that this project had 16 Clean Cities coalitions, 11 different states and several state offices, local government organizations, Georgetown's Climate Center, NASEO, and more. The reviewer observed that this project had a large number of organizations; however, the project appeared to be lacking in private partnerships and industry organizations. The reviewer recognized that this may be a limitation of the way the project was presented. The reviewer observed that future solicitations may encourage partnering with a variety of industry members, and this will help ease the plan's transition into action.

The reviewer observed that the NYCLHVCC project had fewer collaborators than other projects. Nevertheless, implementing EVs in New York City has high visibility and sensitive risks and a lot of room for failure. The reviewer was pleased that the Mayor's office,

the New York State DOT, Consolidated Edison, and NYPA took such active leadership roles to ensure this project's success. The reviewer questioned whether Nissan was a partner. If not, the reviewer suggested trying to include an OEM in the next round for future grants.

Reviewer 8:

For the NYSERDA project, the reviewer commented that the project included a large number of Clean Cities coalitions and state partners across a very wide Northeast territory. NYSERDA and Georgetown/TCI appeared to have been effective main coordinating project leads. However, according to the reviewer, there were not many direct private/industry partners involved in the project, such as EVSE/EV OEMs, utilities, EVSE site owners, etc., other than indirectly through Clean Cities coalitions.

For the NYCLHVCC, the reviewer noted that the project had heavy involvement of the New York City Mayor's Office, which was positive. The reviewer thought that the range of other involved stakeholders was rather light. The reviewer found that the Cities of Boston and Philadelphia were purportedly to have a project role; however, no significant role for these other cities materialized.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

For NYSERDA's project, the reviewer commented that according to the information presented, several states have begun to implement the plan and use the guidelines. NYSERDA is committed to continuing to support EV communities and amending zoning, permitting and building codes to advance EV deployment. The reviewer noted that the Clean Cities coalitions will continue to share the materials generated out of this project. The reviewer commented that this plan seemed to already be taking hold, and partnerships would continue to explore barriers beyond this project. The reviewer concluded by stating great job.

The reviewer remarked that as a result of this plan, New York City's Mayor has committed to ensuring 2,000-10,000 new parking spots for EVs by 2020. This showed a high level of commitment from the Mayor's office. The reviewer remarked that it was unclear whether additional resources were committed to carrying out this plan. However, Empire Clean Cities stated that it would continue to work with partners and to push this plan forward. The reviewer expressed confidence about how the EV car-sharing program finds funding, and that it sounded like a great fit.

Reviewer 2:

The reviewer concluded that there appeared to be good momentum on both projects.

Reviewer 3:

The reviewer commented that EV and EVSE deployment is continuing rapidly in the region and the guidance documents will play a major role in shaping future deployment efforts. Partners are doing EVSE installations across the region based on the guidelines developed under this project. The reviewer noted that TCI will work with its Northeast EV Network partners to advance the spread of EVs in the Northeast, and that NYSERDA is continuing to work with communities in New York State to amend zoning, permitting, and building code rules to advance EV deployment. Clean Cities Coalitions are continuing their outreach to stakeholders using the materials developed in this project. The reviewer commented that other states will continue to press for adoption of better local rules and regulations for EV infrastructure. The reviewer noted that the TCI has completed a wide range of guidance documents and stakeholder outreach and education to advance EV deployment across the Northeast and Mid-Atlantic states. Best practices and guidelines documents are relevant to both the public and private sectors in this region and, often, nationwide. The reviewer explained that stakeholder outreach and engagement will continue even past the end of the grant period, and that partnerships formed under this project will continue to push for adoption of these best practices in the region, and will look for new ways to work together on tackling additional challenges to EV deployment.

The reviewer noted that both New York City and Empire Clean Cities remained committed to execute and build on this plan, and all their EV initiatives. Since the New York City EV Readiness Plan was finalized, New York City Mayor Bloomberg announced that the

City was committed to ensuring that 2,000 of the 10,000 new parking spots would be EV ready by 2020. The reviewer commented that by looking at providing electricity to food trucks, the New York City Mayor's office hopes to help reduce overall emissions created by food trucks and to also lay the groundwork for EV-ready curb-side infrastructure. The reviewer suggested keeping an eye on the New York City car share fleet to see if there is a conversion in cars from combustion engines to EVs because the grants analysis illustrated that 98% of current trips could be taken in an EV vehicle.

Reviewer 4:

For the NYSEERDA project, the reviewer remarked that the plan development looked at past progress in various states and communities, and built a set of best practices guides, which will be useful to all communities in the 11 states. Some incentive packages such as in New York developed as a result of the project; some incentives were already in place.

Regarding the NYCLHVCC project, the reviewer commented that this project had key decision points through analysis, which then led to the tools and education of the targeted audiences. The reviewer noted that this project also led to the Mayor providing leadership in setting a goal for new parking spots being EV-ready by 2020 and EV taxi deployment with the placement of DC fast charging.

Reviewer 5:

The reviewer commented that both projects are scheduled to be completed in June 2013. Follow-up activities were outside the scope of this review.

Reviewer 6:

For the NYSEERDA project, the reviewer commented that the future work described was fairly general and non-specific. However, all continued future efforts would be carried out by a large network of capable or relevant project leads and participants.

For NYCLHVCC and Empire Clean Cities, the reviewer noted that the project established a well-branded outreach initiative, with the reviewer citing Mission Electric; and laid the groundwork for significant future initiatives through the Mayor's office.

Reviewer 7:

For the Northeast Electric Vehicle Network, the reviewer commented that the remaining project activities under the grant were minimal, but grantees would continue efforts beyond the grant funding for implementation.

For the NYCLHVCC project, the reviewer remarked that there were no remaining activities under this grant, though there were a number of proposed follow-on opportunities.

Reviewer 8:

The reviewer commented that both projects that were completed were nearly complete so there was limited information on future work. The NYCLHVCC project identified the project team's intention to continue working with the Mayor's Office in reaching the City's 2020 EV goal of one out of three taxis being an EV.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that yes, both projects would help DOE meet its 2020 goal of 2.5 billion gallons of petroleum displaced annually.

Reviewer 2:

The reviewer commented that the adoption of EVs and PHEVs has the potential to significantly reduce petroleum use. These community readiness initiatives help facilitate the adoption of EVs and charging infrastructure, as described previously.

Reviewer 3:

The reviewer found that these grants addressed barriers, including the availability of PEVs and EVSE, consumer reluctance to purchase new technologies, and lack of technical experience with new technologies. Addressing these barriers would help support

VTO's deployment goals, specifically petroleum reduction objectives, partnership efforts to ease market introduction of PEVs, and technical and educational assistance to support local communities and partnerships.

Reviewer 4:

The reviewer commented that both projects supported grassroots EV market development at the community, state and regional levels.

Reviewer 5:

The reviewer remarked that the benefits of EVs were well-known.

Reviewer 6:

The reviewer commented these projects were relevant to reducing petroleum because these EV Readiness Plans served to educate, encourage, and motivate businesses and consumers to transition to vehicles that do not use combustion engines and run on battery powered vehicles.

Reviewer 7:

The reviewer found that these EV readiness projects were relevant to reducing petroleum if they moved beyond the planning stage and into the implementation phase. NYSERDA's project resulted in guidance documents that will accelerate acceptance of EVs throughout the Northeast region.

Reviewer 8:

The reviewer commented that it was difficult to assess how much these two projects directly contributed towards displacing petroleum. However, both projects made positive contributions towards developing the EV market in the Northeast Region and New York City.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that for the NYSERDA project, funding was high, but commensurate with the ambitious geographical scope and level of the total effort.

Reviewer 2:

The reviewer commented that while the NYSERDA project had a higher level of funding, it covered a significantly larger region. Both projects used all or nearly all of the funding allocated and made significant progress toward objectives.

Reviewer 3:

The reviewer noted that it was a large project of \$1.4 million covering 11 states, with cost-share and that there was only 77% completion at the time of submission of presentation.

For the NYCLHVCC project, the reviewer stated that the project had spent all funding at the time of submission.

Reviewer 4:

For the Northeast Electric Vehicle Network, the reviewer noted that the project funding of \$1,494,500 was sufficient to complete the work; this included a \$500,000 cost-share.

The reviewer remarked that for the NYCLHVCC Electric Vehicle Readiness, the project funding of \$567,336 was sufficient to complete the work; this included a \$148,724 cost-share.

Reviewer 5:

The reviewer determined that it was difficult to assess the budget without seeing how the funds were spent. This reviewer also noted to DOE that it would be helpful for future reviewers if the presentations included a slide detailing on how the funds were spent. In general, \$1.5 million seemed excessive for a readiness plan. That said, for the NYSERDA project, the reviewer was encouraged by

New York State providing a \$500,000 initial investment. Likewise, New York City also provided about a 20% match in funding. To this reviewer, this showed a high level of commitment from the state/local government entities driving these plans.

Reviewer 6:

For the reviewer, it was difficult to evaluate how the resources were used in either the Northeast Regional Electric Vehicle Network Planning Project or the New York City project. While the reviewer knew that working groups, websites, printed materials, etc. were organized and produced, the reviewer voiced concerns about being unable to evaluate the expenses for the project from the information and presentations provided. In the past DOE has had the PI that received the grants make the presentations for the reviewers, and this year the respective DOE project manager gave the reviewers the presentations. The reviewer explained that it would be more effective in determining some of the local and regional impacts and long-term benefits of the grants if the person responsible for implementation provided the reviewers the uniqueness and highlights of the project presentation. Also, the cookie cutter hard copy presentation format used for these reviewer presentations prevented the individuality and exceptionality of each grant to stand on its own.

Reviewer 7:

The reviewer stated that both projects reported being near completion, as the NYSERDA project was 95% complete, or completed (in the case of NYCLHVCC, 100% completed), yet both projects reported significant unspent funds. The reviewer did not know whether these unspent funds have been spent but not billed, or if they were in excess.

EV Community Readiness projects: SCAQMD (CA); University of Hawaii: Brett Aristigui (National Energy Technology Laboratory) - ti029

Reviewer Sample Size

A total of eight reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

As a general comment, this reviewer stated that as with the other EV Community Readiness grants, these grants were well-integrated with DOE's other efforts to promote the use of PEVs, including the ARRA grants for EVSE and PEVs, Clean Cities efforts, the Workplace Charging Initiative, etc. Following the grant completion, the efforts to bring to together grant recipients to share ideas in Tennessee, as well as the planned summary report show the emphasis on integrating all of the individual grants.

Regarding the South Coast Air Quality Management District (SCAQMD) project, the reviewer detailed that the initial design of the project, specifically the establishment of coordinating councils, the online survey of community PEV readiness, and compilation of PEV readiness guidelines, allowed for a readiness plan that is feasible and relevant.

For the Hawai'i project, the reviewer detailed that the initial design of the project, specifically the project assessment and information gathering and research, allowed for a readiness plan that is feasible and relevant.

Reviewer 2:

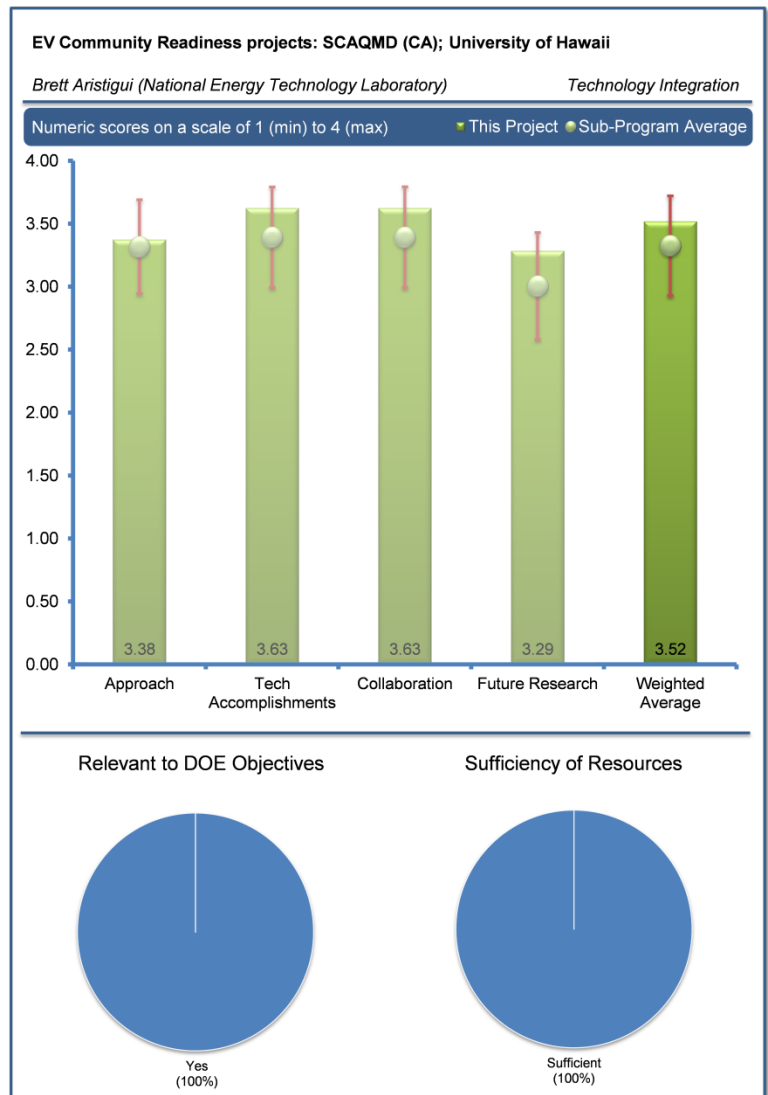
Regarding SCAQMD, the reviewer found that the project's main strategy, which was to develop a central EV/EVSE planning effort that coordinated, harmonized and standardized approaches across all six major regions in California, was excellent.

For the University of Hawai'i project, the reviewer found that the tasks to address technical barriers were quite comprehensive, specific, and relevant.

Reviewer 3:

The reviewer acknowledged that the strategy for both projects addressed the four barriers cited by the Clean Cities EV Community Readiness Projects.

The reviewer described that SCAQMD's approach included developing readiness plans for six areas in California, along with some statewide initiatives. This allowed the project to address barriers to PEV and infrastructure availability by building on existing local efforts and tailoring recommendations to local needs. The reviewer found that the approach also included the development of readiness toolkits for local governments, which helped address another barrier: lack of technical experience with EVs and EVSE.



The reviewer explained that the Maui project's strategy included a strong focus on public outreach to increase consumer acceptance. The project also directly addressed the barrier related to the lack of technical expertise with new technologies through workforce training initiatives. The reviewer found that the project established five working groups to address issues related to EV and EVSE deployment.

Reviewer 4:

The reviewer remarked that the projects seemed well-conceived, designed, and organized.

Reviewer 5:

Regarding SCAQMD, the reviewer detailed that the project team's strategy was to develop six focus areas and six separate plans that would eventually feed into a larger state-wide plan funded by the California Energy Commission (CEC) and to develop a toolkit of best practices around five core issues. The six targeted areas had regional monthly calls and an educational workshop. The reviewer stated that with so much already happening in California, the reviewer was not sure why there were not more stakeholders brought into the process, like the OEMs and larger workplaces and fleets. The reviewer expressed uncertainty about whether much coordination between the six areas occurred since each plan was different. Maybe in the initial meeting all of the stakeholders discussed best practices but this was not clear. The reviewer was unsure how this readiness addressed barrier of reluctance to purchase new technologies.

For the Maui project, the reviewer detailed that the project developed and led a successful strategy focusing on education of ecotourism trade, public, and technical colleges EV, with multiple partners. This led to the first EV101 course and to future International Brotherhood of Electrical Workers (IBEW) collaboration for the technical trades.

Reviewer 6:

The reviewer stated that the SCAQMD received a \$1 million EV Readiness grant from DOE and \$200,000 matching funds identified to be used for six large regions in California including Los Angeles, San Diego, San Joaquin, Central Coast, Bay Area, and Greater Sacramento region to identify the status of current EV inventory, rules, regulations and overall readiness. SCAQMD established councils of representatives from the six regions, forming the Coordinating and Technology Working groups. The reviewer stated that these working groups provided a forum environment for the six regions to share best practices amongst themselves and the state. The project team then surveyed the six areas on their EV readiness and based on the results, identified five core actions to get EV ready: zoning and parking policies, local business codes, streamline permitting and inspection process, participate in training and education for local officials, and outreach to local businesses and residents.

The reviewer described that the EV's in Paradise project received approximately \$300,000 from DOE and raised another approximately \$170,000 in cost-share from fourteen organizations. The lead organizations were University of Hawai'i Maui College, Maui Honolulu Clean Cities Coalition, State of Hawai'i Department of Business, Economic Development and Tourism, and the University of California San Diego. The reviewer commented that Hawai'i as a state has or had legislation and tax credits in place to advance EV purchases and charging station installations. The legislation requires that institutions that have over 100 parking spots install charging stations, which are anticipated to be installed in the next 5 years. The reviewer detailed that the Readiness Grant undertook to identify a plan for educating consumers and businesses about EV and charging stations in a community that did not see its first EV until February 2011. The reviewer expressed that the Readiness Plan was robust and aggressive and outlined how Maui would have mass adoption of EVs. The project team set out to recruit stakeholders and establish working groups, and the stakeholders involved were very extensive; the number of stakeholders appeared to be over 70 entities and even included a broad group from the media. The reviewer noted that the Readiness Plan also included identifying Barriers to EV Readiness, Benefits and Incentives, EV Deployment, Deploying Charging Infrastructure, Analysis of Utility Grid, Local Ordinances and Outreach and Education.

Reviewer 7:

The reviewer described that both projects – SCAQMD and Hawai'i – claimed to address the same four technical barriers. From the presentation these projects addressed the three technical barriers of available charging infrastructure, consumer reluctance and lack of technical experience. The reviewer stated there were no data on directly improving EV purchases even though Hawai'i had several car dealers as partners. Overall the strategy for deployment remained good.

Reviewer 8:

For the California Plug-In Project, the reviewer noted that SCAQMD received \$1 million in federal funding and \$201,209 in collaborative support to implement this project. The reviewer remarked this showed good investment by either the state or the project's industry partners. The project also had unpaid industry partners such as EV suppliers and OEMs.

The reviewer detailed that the project approach was to establish a council that would guide the activities. Council members and technology workgroups had representatives from each city involved in the project. The project partners also conducted an online survey to assess regional EV readiness. The reviewer explained that the council identified five core PEV issues that needed to be addressed in their toolkit: update zoning; update local building codes; streamline permitting and inspection process; participate in training and education; and reach out to local businesses and residents. This approach appeared to be straight-forward. However, the reviewer voiced that it would be helpful to see more assessment of past activities (lessons learned) because this state was quite knowledgeable in EV technologies and their potential problems. This feedback might have proved to be beneficial to other regions of the country. Additionally, the reviewer expressed preference for seeing more promotion of the plan, and acknowledged that this may be a limitation of the slide presentation and not the project.

For the Hawai'i EV Plan, the reviewer noted that the project received \$469,000 from DOE and \$169,000 in cost-share, which was approximately a 20% cost-share. The strong cost-share indicated the partners were committed to the plan's success. The reviewer detailed that this project's approach included a survey to evaluate existing policies, research lessons learned and to assist in the formation of the plan. The reviewer explained that the plan also included developing workforce training, developing key EV policies, identifying barriers, and developing an infrastructure plan. The reviewer noted that the project also incorporated social media as a tool to target the general population.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer noted that the readiness plans for both projects were compiled in an outstanding manner. Outreach and educational tasks were also completed in an outstanding manner.

Reviewer 2:

The reviewer commented that the overall Readiness Grant Plan was robust and appeared to accomplish what SCAQMD set out to do. The end product included a toolkit, 6 regional plans, 6 surveys, 5 PEV readiness documents, 12 councils created (1 on Technology and Coordinating), and findings from all of the analysis conducted. The reviewer noted that San Diego was identified as the leading edge, and that a principal finding out this effort was large difference in readiness between regions and within regions. SCAQMD's plan concluded that there needed to be continued, coordinated regional planning for PEVs and related infrastructure validating that taking the time and effort to create the councils at the outset and conducting workshops in each of the six regions served as a strong foundation going forward. The reviewer commented that each region's plan included workforce charging, multi-unit dwelling issues, utility policy recommendations, and current and potential PEV owners' assessments.

The reviewer commented that the EVs in Paradise Plan accomplished its goals. This report was very user-friendly and set out to be the first island focused EV Readiness Report that other islands could use on an isolated utility grid.

The reviewer remarked that surely there must have been a challenge to include input from the large stakeholder group of over 60 entities, including media partners. This reviewer wagered that this was a really fun project for the stakeholders to work on because there were so many diverse groups involved. The project team created a Maui EV Alliance for all the stakeholders and set up five working groups that had two co-chairs for each group. The reviewer detailed that the five groups were Infrastructure, Policy, Visitor Industry, Residential and Local Business, and Education. The project team took surveys. The reviewer noted that the Alliance met 4 times and the working groups met 17 times.

The reviewer remarked that the Readiness Plan was robust and aggressive, and outlined how Maui would have mass adoption of EVs. The Readiness Plan also identified Barriers to EV Readiness, Benefits and Incentives, EV Deployment, Deploying Charging Infrastructure, Analysis of Utility Grid, Local Ordinances, and Outreach and Education. The reviewer acknowledged that the project team conducted 2 surveys on 8 different occasions and had almost 600 respondents. The reviewer also noted that the project team did mailing campaigns and extensive traditional and new social media communications, and received very good participation and coverage. The project team also surveyed available EV training opportunities in Hawai'i and identified training needs on Maui. The reviewer detailed how the project team developed contact lists and a database containing EV related training information such as facilities, instructors and programs. The reviewer acknowledged that the first EV101 workshop (3 hours) course description was developed and that the course was advertised in the University continuing education catalog in Spring 2013.

The reviewer detailed that the Alliance launched both a website and web portal that contained all of the project team's work product, and in addition to their Readiness Plan the project team evaluated the EV history for the whole state that included the history of early adopters in the state; the evaluation included such critical items as legislation, case studies, best practices and recommendations. The reviewer detailed that the Alliance also does an informative monthly newsletter, weekly columns and 12 episodes of Maui EV. The more than 25 outreach events the project team participated in seemed well-attended and looked like fun. The reviewer remarked that the Alliance also did extensive outreach with the other Hawai'i islands to help promote this ecotourism travel concept. For instance, on the Alliance's website the project team advertised EVs that were available for rental and testimonials for EV owners.

Lastly, the reviewer noted that the first EV was available for purchase in May 2012 and that now over five different EVs were available on Maui for purchase. The reviewer applauded that this too was available on the Alliances informative website.

Reviewer 3:

Regarding SCAQMD, the reviewer explained that this project is over 95% complete with a month remaining in the grant. Significant technical accomplishments include the development of a toolkit, the report publication, and regional workshops. The reviewer stated that the model of PEV coordinating councils, coupled with technology workgroups, seemed to work well. In addition, assessments of municipal readiness and PEV atlas maps provided useful information for moving forward. The reviewer acknowledged that this project also tackled the issue of multi-unit dwellings, which is a key barrier in the industry right now.

Regarding Hawai'i, the reviewer indicated that this project is over 95% complete with a month remaining in the grant. Significant technical accomplishments include website development, stakeholder meetings, and other communications and outreach. The final readiness plan and case study will be valuable documents; in addition, the survey results are useful for the development of a path forward. The reviewer noted that workforce training is valuable, but the value may be in replicating this model elsewhere, since the concentration of PEVs on Maui may not warrant a significant number of trained technicians. The reviewer stated that it was clear that more entities and individuals on Maui were engaged as a result of this project.

Reviewer 4:

The reviewer stated that the SCAQMD project made excellent progress toward its objectives, finalizing all six regional readiness plans and the toolkit for local governments. The plans covered multiple infrastructure types, including workplace charging, multi-dwelling units, and siting for public stations. The fact that the plans were tailored to individual regions with local stakeholders engaged in the process increased the likelihood that the recommendations would be adopted. The reviewer voiced that it also fulfilled the DOE VTO goal of easing market introduction of new electric drive vehicles through voluntary partnerships with local communities as well as the goal of providing technical and educational assistance to local communities. The presenter noted that implementation efforts and follow-up planning initiatives were going forward with funding outside of this project.

The reviewer commented that the Maui project also made significant progress toward its objectives. In particular, the project launched a successful communications campaign that included public events, a TV and radio presence, and social media. The project also made significant progress towards identifying and addressing gaps in EV-related workforce training.

Reviewer 5:

Regarding SCAQMD, the reviewer noted that six very well-documented California regional plans were released; a toolkit was developed; and that workshops were held.

For the University of Hawai'i project, the reviewer commented that a Readiness Plan and two additional plans were released; a website was launched; and significant outreach was conducted.

Reviewer 6:

Regarding the California project, the reviewer expressed a liking for the Readiness Toolkit, and explained that it was simply built around five core actions. The project also addressed multi-unit challenges, while many of the other EV readiness projects did not. The reviewer indicated that aside from the reports and workshops, it was hard to see that much outreach work was done on this project.

For the Hawai'i project, the reviewer expressed a liking for the outreach effort, including social media, TV spots, weekly column, and website, though the latter was merely a front-end to the report.

Reviewer 7:

Regarding the SCAQMD project, the reviewer detailed that the project team performed the tasks as stated by the Statement of Work (SOW) to develop six councils, six readiness plans and six educational workshops and have nearly completed the project.

Regarding the Maui project, the reviewer elaborated that progress was made on all areas except for the consumer behavior survey. Low market penetration will make it difficult to overcome barriers if there is no product to sell and does not overcome the main barrier of sufficient product. The reviewer noted that the project was nearly complete.

The reviewer stated that both projects seemed to accomplish what they set out to do.

Reviewer 8:

For the California PEV Plan, the reviewer stated that this plan seemed to have been developed according to its approach. The coordinating council worked effectively to streamline communications within each region. The reviewer stated that the end result was a list of best practices and lessons learned based on the six regional surveys. The council also learned that the cities varied greatly in their EV readiness, which needed to be accommodated in the plan. The reviewer detailed that the PEV Readiness Toolkit included five core actions to address everything from zoning, parking policies to streamlining permitting and inspection processes. The plan provided a detailed approach for each of the six cities. The reviewer observed that each region's EV readiness report (plan) addressed different levels of readiness, including multi-unit dwelling issues, workplace charging, utility policy recommendation and maps for city planners identifying where growth was expected to occur. The project also resulted in six regional workshops, one in each city/region. The reviewer noted that in addition to this DOE grant, the project resulted in seven additional support documents for the toolkit.

The reviewer expressed concern about not seeing a presented method for measuring the plan's overall success if implemented. Also, the reviewer would like to know if the plan identified potential funding sources, besides DOE, to carry-on the implementation. CEC and DOE were mentioned as potential funders. The reviewer suggested more industry or private funding support, and would have liked to see more discussion about the education and outreach plans laid out in the plan. The reviewer affirmed seeing a discussion only about the six regional workshops, and asked if there were more educational events.

Regarding the Hawai'i Project, the reviewer detailed that this project appeared to be straightforward and accomplished its objectives. The plan was published in December, 2012. The reviewer summarized that the project identified and developed stakeholder working groups. The focus of the effort was on Maui, not the main island. The reviewer identified that outcomes included several educational efforts: a 3-hour training course (EV101) already advertised in the University's continuing education catalog; educating stakeholders about current EV laws; several published reports highlighting results from the plan, such as best practices, case study, performance and cost analysis, and more; numerous outreach events; and media outreach via blogs, YouTube, radio, and TV programs and newsletters. The reviewer acknowledged that the project also used two surveys to gauge public EV awareness, and in all, 71 surveys were completed. The reviewer complimented that the project had a lot of education as part of the project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that both projects seemed to have strong collaborations with state and local governments, industry, and relevant stakeholders.

Reviewer 2:

Regarding SCAQMD, the reviewer indicated that the project included a substantial coalition of project partners, including state and local governments, 3 regional Air Quality Management districts, 13 Clean Cities Coalitions from the state of California, and many other unfunded relevant key private and non-profit stakeholders.

For the University of Hawai'i project, the reviewer noted that the project included participation/collaboration from a substantial number of key partners representing virtually every type of stakeholder suited to this kind of project.

Reviewer 3:

In addressing the California Plug-in Project, the reviewer noted that this project had 13 Clean Cities coalitions, a state air resources board, regional and local governments and non-profit groups. According to the slides, the project also had a number of unfunded partners that included OEMS, EV suppliers and utilities. The reviewer acknowledged that this appeared to be a well-rounded group of participants, and it bode well for this project that the state has agreed to complete 10 more regions/city reports.

For the Hawai'i Project, the reviewer noted that this project had 60 industry partners. Those partners were assigned to one or more of the five working groups.

The reviewer expressed belief that this was the only EV readiness project to incorporate a major oil company, and praised the individual who secured them as a partner. The reviewer hopes they were constructive and not destructive to the overall plan development. The reviewer also noticed the project included several automotive organizations, and liked the diversity of project collaborators: local government, state agencies, coalitions, university of Hawai'i and University of California-San Diego, OEMs, dealers, rental car companies, utilities and EVSE suppliers. The reviewer commented nice group.

The reviewer liked that the project team did surveys to measure project success. The reviewer noted that the project established 5 working groups with more than 60 industry members. The reviewer acknowledged that the level of increased knowledge among stakeholders was significant. The reviewer noted that the project surveyed training stakeholders, and held an EV101 workshop. The reviewer also noted that the project ran an outreach campaign highlighting the state's EV experiences and best practices.

The project performed a survey on public awareness (71) and EV readiness (464). The reviewer noted that the results were that there was a great deal of work that needed to be done to increase consumer awareness, about which the reviewer commented was a big surprise. The reviewer commented that the potential for flooding could be a barrier to EV readiness. Eco-tourism was highlighted as a potential market to embrace EVs. The reviewer noted that the project did a number of outreach events, including 12 episodes, though the reviewer expressed uncertainty pertaining to what kind of episodes. The reviewer stated admiration for the number of collaborators, while also acknowledging the need for continued outreach. The reviewer understood that neighboring islands wanted to have their own plan.

The reviewer noted that the project identified that OEM training was an issue in Hawai'i because drivers might have to take their vehicle to a different island, which according to the reviewer was an interesting challenge.

Reviewer 4:

The reviewer noted that California listed 13 Clean Cities Coalitions, California Air Resources Board (CARB), eight non-profits, and regional/local governments as partners. The reviewer noted that Hawai'i had cost-share partners such as Enterprise Rent-a-Car and the IBEW electrical trade union. The reviewer indicated that both projects showed outstanding collaboration and coordination with others.

Reviewer 5:

Regarding the California project, the reviewer observed good participation in this project.

Regarding the Hawai'i project, the reviewer noted that fewer potential partners were in Hawai'i, but that it was obvious that the team worked through the challenge of coordinating efforts.

Reviewer 6:

The reviewer detailed that the extensive collaboration and coordination in this project was remarkable. The reviewer included a reminder that California is the largest state in the country, so for SCAQMD to embark on such a large project is to be applauded and further for executing at the level SCAQMD were able to achieve in this grant is very impressive. There were many partners in this project that include the six large regions of: Los Angeles, San Diego, San Joaquin, Central Coast, Bay Area, and Greater Sacramento. The reviewer detailed that additional partners include 13 California Clean Cities Coalitions, Bay Area Air Quality Management District (BAAQMD), CEC, Sacramento Area Council of Governments, San Joaquin Valley Air Pollution Control District, CA PEV Collaborative, EV Communities Alliance, California Center for Sustainable Energy, ICF International, Better World, UCLA Luskin, utilities, EVSE suppliers, and OEMs.

The reviewer noted that EV's in Paradise had an extensive list of partners consisting of over 60 entities illustrating to the reviewer how much pent-up enthusiasm in Maui there must have been for this Readiness Plan grant. In addition to the main partners of the University of Hawai'i Maui College, Hawai'i Department of Business, Economic Development and Tourism, Maui Honolulu Clean Cities Coalition, and the University of California San Diego, these partners were active and many contributed to the matching funds. The reviewer noted other partners, including Chevron Energy Solutions, Enterprise Rent A Car, Grand Wailea Resort and Spa, Hawai'i Auto Dealers Association (HADA), Hawaiian Electric Vehicle Network (HEVN), HNU Energy Honua Kai Resort and Spa, Jim Falk Automotive Group, Maui County Office of Economic Development, Maui Economic Opportunity, Inc. (MEO), Rising Sun Solar, AeroVironment, Better Place Hawai'i, General Electric Digital Energy, The Hertz Corporation, Hawai'i Renewable Energy Development Venture (HREDV), High Technology Development Corporation, Manufacturing Extension Partner (now INNOVATE Hawai'i), Maui Hotel and Lodging Association (MHLA), National Renewable Energy Laboratory (NREL), San Diego Regional Clean Fuels Coalition, University of Hawai'i (UH) Mānoa's Hawai'i Natural Energy Institute (HNEI), and UH Mānoa Hawai'i Energy Policy Forum (HEPF). According to the reviewer, the project team created a Maui EV Alliance for all the stakeholders and set-up five working groups that had two co-chairs for each group. The five groups were Infrastructure, Policy, Visitor Industry, Residential and Local Business, and Education. The reviewer noted that if the Alliances website is reviewed, it is possible to see that a whole community has developed around this initiative.

Reviewer 7:

Regarding SCAQMD, the reviewer noted that closer collaboration with private sector stakeholders (OEMs, larger workplaces) seemed like a lost opportunity as well as more coordination amongst the six regions.

Regarding the Hawai'i project, the reviewer acknowledged the project had good collaboration with some key partners that would continue to strive toward PEV deployment. The reviewer also recognized good private sector collaboration and partnership with the Hawai'i Dealership Association.

Reviewer 8:

Regarding SCAQMD, the reviewer noted that the grant recipients included a collaboration of 13 Clean Cities coalitions, state agencies, local governments, non-profits, and consultants. The project capitalized on previous experience in California with collaboration efforts. The reviewer detailed that EV/EVSE OEMs and fleets were not included as partners. The reviewer suggested that more active engagement with these groups may have been beneficial.

Regarding the Hawai'i project, the reviewer detailed that the grant recipients included a collaboration of a Clean Cities coalition, the energy office, and a local university. According to the reviewer, the collaboration for this project was not as strong as the other projects.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that both projects are scheduled to be completed by June 30, 2013. Follow-up activities were outside the scope of this review.

Reviewer 2:

The reviewer noted that going forward, SCAQMD stated that future activities include 10 additional regional PEV readiness projects for other regions in California to be funded by the CEC; and statewide PEV readiness plan to be funded by CEC. California PEV Collaborative and regions to work on PEV challenge areas identified in the plans including multi-unit dwellings, workplace charging, consider funding pilot demonstration projects, develop additional planning strategies, distribution of charging with inter-regional corridor plans or sub-regional planning studies, and follow up with actions identified in Governor's Zero Emissions Vehicle (ZEV) Action Plan.

The reviewer noted that the Maui project planned on continuing neighbor island outreach and stakeholder follow-up activities that include facilitating discussion and information sharing. The reviewer remarked that Maui would continue monthly EV newsletters and build a distribution list; present on EV deployment progress at local community and sustainability associations, i.e., Rotary and Kiwanis; and encourage local auto dealers and rental car agencies to publicize EV arrivals and lease options via social media. The reviewer summarized that Maui planned to develop a directory of vacation accommodations with charging station access and would encourage stakeholders to support the introduction of local policies such as EV parking ordinances, enforcement of State EV laws, and education and outreach regarding State EV laws. Maui wants to research financing mechanisms and strategies to lower costs of EV and EVSEs, partner with Visitor Industry to promote EVs, increase user familiarity, and introduce EV car sharing and EV carpooling.

Reviewer 3:

Regarding the SCAQMD project, the reviewer recognized that California has had a substantial amount of slated future EV/EVSE readiness work to follow this project. Several efforts carried out under this project will continue through leveraged state funding.

Regarding the University of Hawai'i project, the reviewer noted that the project intends to continue a number of relevant although general EV/EVSE readiness activities.

Reviewer 4:

Regarding SCAQMD, the reviewer noted that the work would feed into the CEC overall state plan for EV readiness; next steps included matching initiatives with the ZEV program. The reviewer expressed uncertainty as to why this did not happen as part of the program to begin with. The work will lead to an additional 10 areas of the state and targeted work in multi-unit dwelling (MUD) and the workplace. The reviewer noted that there is also state incentive funding for infrastructure.

Regarding the Maui project, the reviewer commented that the project would lead to work on the other islands and sharing lessons learned which may help with the automakers making the state a higher priority. Additional outreach is part of the continuation of the project and working with more dealerships. The reviewer noted that the project has decided that car sharing may be a better approach. The project team will continue working on vacation destinations for EVSE placements to correspond with the project's car sharing and rental agency programs.

Reviewer 5:

Regarding the SCAQMD project, the reviewer noted that this project's plan was complete. DOE's funds helped to not only develop this plan, but also spurred 10 additional regional PEV readiness reports/subprojects. The reviewer acknowledged that CEC, as a result of this project, was developing a statewide PEV readiness plan.

Regarding the Hawai'i Project, the reviewer noted that the project completed its plan last year. Now, all that was left is implementation, which technically was not part of this project. The reviewer commented that the plan has already attracted attention.

Several neighboring islands want to develop their own plans. The project planners want to develop vacation accommodations with charging stations, and are working on encouraging stakeholders to support local policy changes, such as EV parking ordinances, etc. The reviewer would have liked to see what entities were ponying up additional resources to carry out this plan.

Reviewer 6:

The reviewer indicated that both projects seemed to have adequate plans for continued work. As a general note, the reviewer indicated that in all of the EV readiness projects, the reviewer would have liked to see more thought put into communicating results to key stakeholders. Plans, websites, and fact sheets were a great start, but just as important is getting that information in front of the important stakeholders, from policy officials, to property owners, to consumers. According to the reviewer, more detail on this, possibly in the Future Work section, would have been nice.

Reviewer 7:

Regarding SCAQMD, the reviewer noted that the project team's remaining project activities under the grant were minimal, but grantees would continue efforts beyond the grant funding for implementation.

Regarding the Hawai'i project, the reviewer noted that the remaining project activities under the grant were minimal, but grantees would continue efforts beyond the grant funding for implementation.

Reviewer 8:

Regarding SCAQMD, the reviewer noted that the project identified a good future research plan. The reviewer commented that Hawai'i had a more limited future plan. This had to do more with California's long standing interest in EVs, and Hawai'i's first endeavor into EV charging.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer affirmed yes, these projects were relevant in so much as they prepare a pathway to achieving increased EV infrastructure and, ultimately, their use. This use is expected to lead to greater petroleum reduction.

Reviewer 2:

The reviewer indicated that the adoption of EVs and PHEVs has the potential to significantly reduce petroleum use. These community readiness initiatives help facilitate the adoption of EVs and charging infrastructure, as described above.

Reviewer 3:

The reviewer stated that these projects were relevant to reducing petroleum because EV readiness plans served to educate, encourage, and motivate businesses, government and consumers to transition to vehicles that do not use combustion engines, emit less pollutants and use battery powered vehicles.

Reviewer 4:

The reviewer commented that both projects support grassroots EV market development at the community and state-level.

Reviewer 5:

The reviewer remarked that both projects would help DOE with its 2020 goal of 2.5 billion gallons of petroleum reduced annually as the projects prepare their communities for greater market penetration, with California being the largest contributor to this effort. The reviewer commented that it was explained during the Hawai'i presentation that the large Island of Hawai'i is the biggest auto market and it is difficult to get EVs on the island of Maui.

Reviewer 6:

The reviewer commented that these grants addressed barriers, including the availability of PEVs and EVSE, consumer reluctance to purchase new technologies, and the lack of technical experience with new technologies. Addressing these barriers would help support

VTOs deployment goals, specifically petroleum reduction objectives, partnership efforts to ease market introduction of PEVs, and technical and educational assistance to support local communities and partnerships.

Reviewer 7:

The reviewer commented that the benefits of EVs were well-known.

Reviewer 8:

The reviewer commented that it was not possible to calculate actual petroleum displacement, but that these projects reduced the timeline for accepting EVs both in Hawai'i and California.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that while the SCAQMD project had a significantly higher level of funding, it covered six regions and developed six regional readiness reports. The reviewer concluded that both projects made significant progress toward objectives.

Reviewer 2:

Regarding SCAQMD, the reviewer noted that the project funding consisting of \$1,201,209 was sufficient to complete the work; this included a \$201,209 cost-share.

Regarding Hawai'i, the reviewer noted that the project funding, consisting of \$469,063, was sufficient to complete the work; this included a \$169,370 cost-share.

Reviewer 3:

The reviewer noted that both projects stated being at 95% completion and the total project budget, specifically \$1,201,209 for SCAQMD, and \$469,063 for Hawai'i, but did not list the funds that had been spent. Therefore the reviewer assumed the funding was sufficient.

Reviewer 4:

Regarding SCAQMD, the reviewer noted that resources had been nearly drawn down.

Regarding Hawai'i, the reviewer noted that resources were sufficient although the reviewer was not sure what would be done with the funding that was redirected from the study of consumer behavior; but, the project team was able to complete tasks as laid out in the SOW with the amount of funding allocated.

Reviewer 5:

The reviewer stated that both projects accomplished a lot of work for the funding. So from that standpoint, the allocated funding was commensurate with project accomplishments.

The reviewer noted that in both cases, California and Hawai'i were states where an immense amount of EV/EVSE promotion, development, and deployment work had already occurred and was continuing to occur with the support of various public and private funding sources.

The reviewer noted that from a knowledge-sharing and program policy standpoint, it made sense for DOE to partner with these states; however, according to the reviewer it was not entirely clear that either state absolutely needed this funding to continue to make progress on EV readiness.

Reviewer 6:

The reviewer commented that as stated in other evaluations, this reviewer did not have sufficient information to assess the resources and budget for these projects. The reviewer suggested to DOE to include a slide on how the project funds were spent in future presentations. Generally, the reviewer found it excessive to spend between \$500,000 and \$1.2 million to develop these plans. If DOE

continues to fund readiness plans, the reviewer suggested that the agency include a designated percentage of funds to provide education for the plan, beyond one or two workshops.

The reviewer reiterated to please use the PIs instead of the DOE project managers. On several occasions, the manager was not able to answer the level of detail requested. Nevertheless, the reviewer thought it was probably a good exercise for the project managers.

Reviewer 7:

The reviewer noted that both the SCAQMD and Maui projects secured cost-shares for their projects, and not many of these readiness grants chose to leverage the federal dollars in this manner, so these two groups should be recognized for their leadership in this regard. The reviewer detailed that Maui listed over 14 high-profile groups that donated to the matching funds, and in general the reviewer believed that the Maui enthusiasm for participating in the cost-share was symbolic of the overall enthusiasm for use of the Readiness grant.

The reviewer expressed difficulty in evaluating how the resources were used in either the SCAQMD project or the University of Hawai'i Maui College project. While the reviewer acknowledged that that working groups, websites, printed materials, surveys, etc. were organized and produced, the reviewer voiced the inability to evaluate the expenses for the project from the information and presentations provided. In the past, DOE has had the PI that received the grants make the presentations for the reviewers, and this year the respective DOE project manager gave the reviewers the presentations. This reviewer expressed that it would be more effective in determining some of the local and regional impacts and long-term benefits of the grants if the local person responsible for implementation of the grant provided the reviewers the uniqueness and highlights of the project presentation. Also, the reviewer expressed belief that the cookie cutter hard copy presentation format used for these reviewer presentations prevented the individuality and exceptionality of each grant to stand out on its own.

EV Community Readiness projects: Delaware Valley Regional Planning Commission (PA); Metropolitan Energy Information Center, Inc. (KS, MO): David Kirschner (National Energy Technology Laboratory) - ti030

Reviewer Sample Size

A total of eight reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the projects seemed well-conceived, designed, and organized.

Reviewer 2:

The reviewer detailed that the strategy for deployment for the two projects (Kansas/Missouri and Delaware Valley) listed the four standard barriers of vehicle/fuel availability, charging station availability, consumer reluctance and lack of technical experience. The Kansas/Missouri project addressed a fifth technical barrier of uncertainty of electricity distribution.

Reviewer 3:

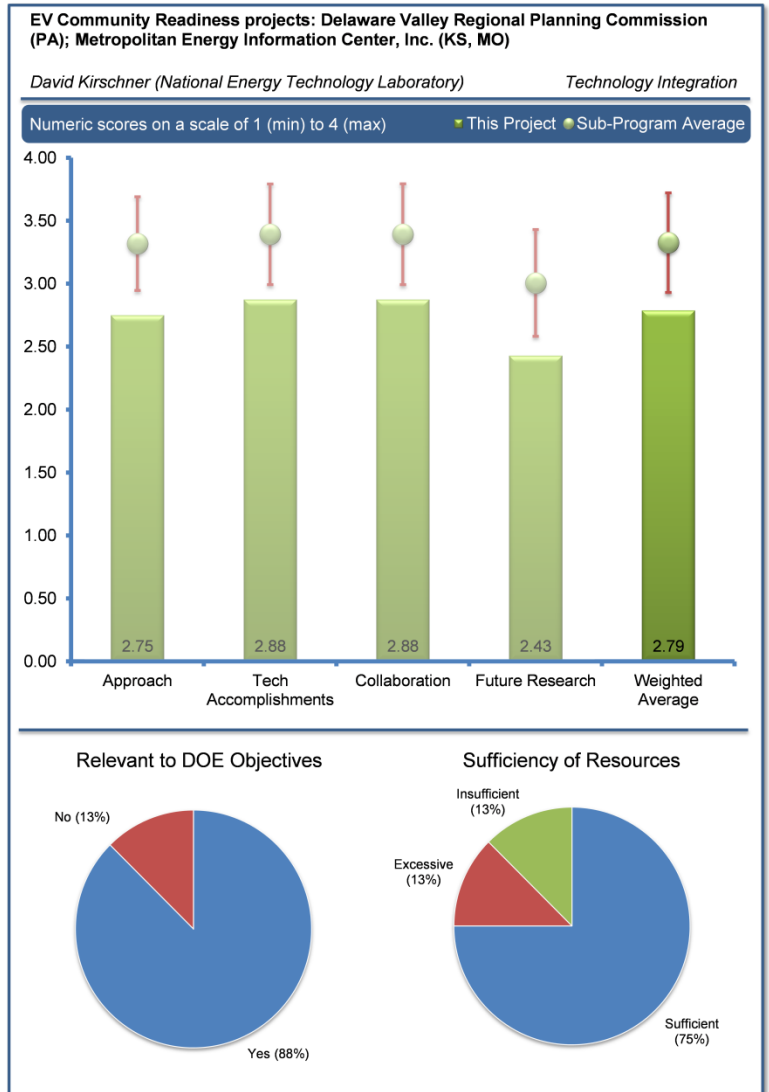
As a general comment, the reviewer noted that as with the other EV Community Readiness grants, these grants were well-integrated with DOE's other efforts to promote the use of PEVs, including the ARRA grants for EVSE and PEVs, Clean Cities efforts, the Workplace Charging Initiative, etc. Following the grant completion, the efforts to bring to together grant recipients to share ideas in Tennessee, as well as the planned summary report showed the emphasis on integrating all of the individual grants.

Regarding the Kansas – Missouri project, the reviewer detailed that the initial design of the project, specifically the stakeholder steering committee and task teams, allowed for a readiness plan that was feasible and relevant.

Regarding the Delaware Valley Regional Planning Commission (DVRPC) project, the reviewer detailed that the initial design of the project, specifically the white paper outlining opportunities and barriers and the Garage-Free Summit, allowed for a readiness plan that was feasible and relevant.

Reviewer 4:

Regarding the EV Community Readiness project in Metropolitan Energy Information Center, Inc. Kansas, the reviewer detailed that the project received almost \$442,000 of funding from DOE. The project team's strategy stated that its objectives included developing a plan with accompanying guidance documents, and wherever possible, executing planning elements to accelerate the adoption of PEVs and charging infrastructure in the metropolitan areas of Kansas City, Missouri-Kansas; Wichita; Topeka and Lawrence/Douglas County, Kansas. The Plan called for working with regional stakeholders to inform the planning process and adapt planning documents



to local audiences. The reviewer detailed that the plan also intended to coordinate region-wide stakeholder outreach, conduct necessary research, and recommend model policy and planning approaches. The reviewer described that another objective was to develop infrastructure deployment plans for light- and heavy-duty PEVs for both fleet and public use. The Plan stated it would establish a stakeholder steering committee and task teams to evaluate Greater Kansas City Plug-in Readiness strategy for completeness and establish planning goals and a schedule to achieve success. The reviewer detailed that the Plan also stated that it would analyze data, assemble information from the task teams and submit documents for peer review. The reviewer commented that the training and outreach objectives seemed limited in scope to training for electricians, and to create a project website for consumer and municipal information, to create a consumer/operator EV and EVSE educational program, establish fleet outreach tactics and perform on-going identification of additional outreach and training needs.

The reviewer described that the DVRPC project received almost \$390,000 from DOE for the Southeastern Pennsylvania Regional Electric Vehicle Infrastructure Planning. The grantee said that the objective of this project was to create a community based electric vehicle infrastructure readiness plan and to implement activities in anticipation of larger electric vehicle deployment efforts in the future. The reviewer detailed that the strategy included gathering, evaluating and compiling data on EV charging infrastructure, EV demand, early adopters, fleets, vehicle and charging station financings, zoning, permitting, and all other relevant info needed to launch an EV community. Once the project team gathered the data, the team will use it to write a Plan for the region. The reviewer also indicated that the strategy also included forming a Stakeholder Advisory Group.

Reviewer 5:

The reviewer stated that the strategy for both projects addressed the four barriers cited by the Clean Cities EV Community Readiness projects.

The reviewer described that the Metropolitan Energy Center (MEC) strategy focused on addressing barriers to EV infrastructure deployment by assessing the potential for a regional corridor of public charging stations and assessing potential grid impacts. It also included a well-developed workforce training component and outreach to local communities and the public.

The reviewer detailed that the DVRPC strategy addressed barriers to EV and EVSE availability through research and analysis on potential EV demand, EV infrastructure demand, and potential grid impacts. The reviewer commented that there did not seem to be a significant component on public outreach that would address the barrier related to consumer acceptance.

Reviewer 6:

Regarding the MEC project, the reviewer noted that the project tasks to address technical barriers were suitable and relevant. Incorporation of analysis tasks, such as the EV corridor analysis and utility grid assessment, was particularly good.

Regarding the DVRPC project, the reviewer commented that the tasks to address technical barriers were mainly analysis-based; however, the tasks were relevant, fairly comprehensive and specific.

Reviewer 7:

Regarding the MEC project, the reviewer noted that the Kansas City Regional Clean Cities received \$441,478 from DOE with no cost-share. This project was expected to develop a plan with accompanying guidance documents and execute planning elements to accelerate the adoption of PEVs/charging infrastructure near Kansas City, Wichita, Topeka and Lawrence/Douglas County, Kansas. The reviewer detailed that the project was expected to work with regional stakeholders to inform the planning process and adapt planning documents to local audiences, and was expected to coordinate region-wide stakeholder outreach, conduct necessary research, and recommend model policy and planning approaches. The plans were supposed to include infrastructure deployment plans for light- and heavy-duty PEVs for both fleet and public use.

Regarding Delaware's plan, the reviewer detailed that this project received \$390,000 in federal funding with no recognized matching support to develop an EV readiness plan for the state. As with other plans, this team proposed to collect data on barriers prior to developing its strategy. The reviewer described that the project included an evaluation of household EV demand and potential early adopters in residential markets. The plan analyzed charging infrastructure requirements and potential approaches for providing EVSE. The reviewer stated that the project also evaluated grid impacts and regulatory issues such as zoning, permitting, connectivity, etc.

Reviewer 8:

Regarding the Kansas City project, the reviewer noted that standard barriers and one additional barrier of the impact on regional transformers were addressed with products developed, such as the grid assessment work, education of technicians, and promotion to dealers through the use of hang tags.

Regarding the Delaware project, the reviewer commented that some of the barriers would be overcome with the EV assessment of likely EV owners, and that key areas for EVSE deployment would be helpful to bring about availability of vehicles and EVSEs, but that the consumer reluctance to purchase vehicles or technical expertise developed were not addressed. The reviewer noted that no tools/materials were mentioned other than that an outreach plan was developed. The Garage Free Summit would potentially be helpful to those who do not have access to off-street parking. The reviewer concluded that the assessment looked thorough.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that both projects prepared very thorough readiness plans targeted towards accelerating EV adoption in their area.

Reviewer 2:

Regarding the Kansas City project, the reviewer noted that the project was 92% completed at the time of presentation submissions. The project completed a number of tasks, such as working with stakeholders in four communities, a corridor analysis of flat versus hilly terrain, grid impacts, creation of training curriculum, and marketing materials for consumers.

Regarding the Delaware project, the reviewer commented that 83% spent in February 2013 was less complete than other projects reviewed by this reviewer. The reviewer noted that a literature review, Garage Free Summit, and preliminary assessment of EV home and work locations penetration was completed for the EV Project, and that a guidance plan for municipalities was conducted and finalized.

Reviewer 3:

Regarding MEC, the reviewer liked the corridor analysis and EV/EVSE concentration maps. The reviewer thought that the grid assessment was also good. The reviewer noted that the website was informational, and that the Plan contents were easily accessible.

For the DVRPC project, the reviewer noted that a good analysis and information was gathered. The reviewer commented that education/outreach to stakeholders was not as far along as other projects.

Reviewer 4:

Regarding the MEC Kansas City Project, according to the reviewer, the project accomplished what was planned. The partners have already begun to implement their plan. The reviewer complimented great job. Similar to other plans, this project collected stakeholder feedback/input as part of a data collection phase, including a grid assessment. The reviewer explained that the project resulted in presentations to seven municipalities and three Clean Cities coalitions, including a discussion of benefits and recommended steps. The project generated a website and several publications available through the website. This project embraced a number of outreach and educational activities, including distributing hang tags. The reviewer noted that the project also developed two videos and numerous documents (approximately eight), which could be found on the website. The project developed certificates for businesses and communities that reach certain accomplishments with a score on how EV ready they were. The reviewer applauded this concept, which helps cities brag about their EV ready status. This model is available to share, which the reviewer commented was nice. In addition, the project management posts updates and events on its social media outlets and website. The project also developed an automotive and electrical technicians training with the help of Kansas City Community College.

Regarding the DVRPC project, the reviewer noted that the project team completed surveys and a literature review as part of data collection prior to drafting its plan. This team also explored NYSERDA and New York City as they developed their plans. The project team generated several documents and placed them online along with the plan. The reviewer noted that DVRPC completed its plan in

November 2012 and addressed the proposed concerns with recommendations for zoning, planning and potential incentives. The project also included educational outreach activities, including hosting a Garage-Free Summit to train parking garage attendants. The reviewer detailed that the plan also identified a need to educate home owners associations (HOAs) and targeted home owners. The project developed guidance specific to municipalities to help them prepare for EVs. The reviewer opined that the slides provided too much detail on the data analysis and not enough with how the team used that information.

Reviewer 5:

The reviewer concluded that the MEC project made significant progress toward the DOE VTO goal of providing technical and educational assistance to local communities. The project conducted outreach to local municipalities on the benefits of EVs, developed implementation recommendations and guidance documents for different audiences, and developed electric vehicle-related curricula and workforce training. The reviewer noted that the project also took some practical steps to educate consumers, including developing vehicle hangtags describing the benefits of EVs.

The reviewer found that the DVRPC made good progress on assessing the potential deployment of EVs in the region, which could inform strategies to ease market introduction. DVRPC also conducted stakeholder outreach, including hosting the Garage-Free Summit with cities and regional stakeholders to discuss charging infrastructure for consumers without dedicated off-street parking. The reviewer noted that the presenter stated that further outreach and coordination with other regional EV projects was planned, but it was unclear to what extent the readiness plan recommendations would be implemented. The reviewer thought it was unfortunate that the readiness plan were not available to review.

Reviewer 6:

Regarding the MEC project, the reviewer detailed that the EV/EVSE readiness plan touching on several key/relevant areas was released (some plan sections were more detailed than others); outreach initiatives were conducted and a project website was launched.

Regarding the DVRPC project, the reviewer indicated that the project produced a range of valuable analysis products and an outreach plan. However, according to the reviewer, it was not clear if a comprehensive EV/EVSE readiness plan had been completed, if the website had been launched, etc. The reviewer forgot to ask for this during the review session and did not see document links in the presentation slides.

Reviewer 7:

Regarding the Kansas – Missouri project, the reviewer noted that this project was over 92% complete with a month remaining in the grant. Significant technical accomplishments include outreach, development of the readiness plan, an EV corridor analysis, EV technician training curriculum, which can be replicated in other areas of the country, EV/EVSE concentration maps, utility grid assessment, and a website. In addition, the reviewer remarked that the grantees launched the Electrify Heartland EV Coalition and EV Business Coalition, which provides unique opportunities for stakeholder and community engagement. Moving forward, the grantees will capitalize on these coalitions and the partnerships formed during the project.

Regarding the DVRPC project, the reviewer noted that the project was over 90% complete with a month remaining in the grant; the reviewer commented that it seemed that this project was a bit behind the other grantees, but that plans were in place to complete the project on time. The reviewer detailed that significant technical accomplishments included an analysis of EV demand, EVSE requirements, and issues with grid integration, as well as the development of the readiness plan. In addition, the development of a regional regulatory scheme and incentive structure would allow for consistent actions throughout the region. The reviewer detailed that the group also conducted an analysis on PEVs ability to meet mobility needs, which will assist in the consumer reluctance issues.

Reviewer 8:

The reviewer described that the EV Community Readiness project in Metropolitan Energy Information Center, Inc. Kansas, Missouri seemed to achieve very few of its objectives outlined in the Strategy question. The one objective the project team did seem to execute on was auto and electrical technicians from four regional colleges; attended SAE training on Hybrid Electric and Battery Technology. However, there was no indication as to how many actual people attended the course and were able to utilize the training they received. Furthermore, the reviewer stated that there were so much U.S. Department of Labor (DOL) funds available for this type of curriculum

that it seemed like U.S. DOL funds would be a better fit for this activity than U.S. DOE funds. While the reviewer agreed that the technicians needed to understand a new technology as an essential component when launching new and innovative technologies, the reviewer expressed that there was a failure to see other more pressing and critical components that were first needed to implement a successful and comprehensive EV Readiness Plan. Therefore the reviewer did not understand the value of the training provided.

The reviewer pointed out that the stakeholder group seemed small and insufficient to support a grant of this size. So when the Plan talked about doing activities with the stakeholder group to seek input, perform outreach, etc., it really was just a handful of entities ultimately included. The reviewer listed these entities as the MEC, IBEW, University of Missouri Kansas City, Kansas City Community College, Black & Veatch, LilyPad EV, and Polsinelli Shughart, which is a law firm. The reviewer noted that this was an unusual stakeholder group to assemble to accomplish the aggressive goals established in the project team's Strategy [DOE Program Clarification: It is important to note that the entities mentioned comprise a smaller "Steering Committee," which is part of a much larger Kansas City stakeholder group that interacts through meetings and outreach, and to the general public via media and other communications.].

The reviewer provided an example of what appeared to be a misrepresentation, noting that the website was just created in March 2013 – the grant was awarded in October 2011 and is over in June 2013. The reviewer described that if an entity was serious about involving and recruiting stakeholders, community outreach, EV and charging station awareness and availability, garnering media, etc., a website would be created at the front end of this type of effort, not three months before the project ends. The reviewer believed that another item DOE should review further is which entities did what under this grant as it appeared that other similar efforts by the MEC may have been a duplication of work product and partners. Even the Readiness report that the MEC stated was available on the website was really not available in its entirety, as the reviewer asserted not having the ability to even find a cover page to the report. The reviewer considered that maybe the MEC was trying to make the report user-friendly but there was no place to go to access the full report. The reviewer commented that there were a bunch of sections available but the reviewer did not have the time to evaluate each section available to see if in fact there was a complete report available. When the reviewer tried to look for one section, it was not in the link indicated where it would be available, so the reviewer encourages DOE to review the report in its entirety to make sure it includes what is represented in the Table of Contents. The reviewer noted that another item DOE may want to look at was whether or not any outreach was done in any meaningful way to educate businesses, consumers and the government about EVs, fleets, and light- and heavy-duty PEVs for both fleet and public use, as that was a main objective identified in the project team's strategy. Regarding the website, the reviewer detailed that many of the items represented that would be included in the website were not really there, so DOE may want to evaluate the effectiveness and completeness of one of the very few items the MEC did accomplish very late in the process.

The reviewer did not believe the DVRPC readiness plan was executed or accomplished very much of what the plan stated it would do. The reviewer indicated an inability to find any report or white paper that indicated that the Stakeholder Advisory Group the project team said it would create or any documentation to illustrate that the project team compiled, analyzed EV and charging station and early adopter data, planning and zoning codes, fleets, or anything the project team said it would research to form a regional plan.

The reviewer explained that maybe the project team wrote a plan or white paper but the reviewer could not locate it. The reviewer elaborated that there were some random slides and statistics in the presentation provided, but the reviewer really did not know what all the data meant. The reviewer referenced Slide 26, which said, April 2012: Receive address and vehicle type information for 2,225,595 passenger vehicles registered in 5 counties of southeastern Pennsylvania. The reviewer would like to know what this meant and how it was pertinent. The reviewer asked what this number represented; perhaps how many cars there were in five counties in southeastern Pennsylvania. The reviewer would like to know what Slide 30 was. The reviewer explained that it would be helpful if somehow this data was explained as to what purpose it served, especially as the reviewer was not a self-proclaimed statistics whiz. The reviewer believed that DOE should evaluate what was really accomplished in this grant as the reviewer could not tell from the information provided or what was available on the Internet.

The reviewer expressed an understanding that the project team participated in a few TCI EV events, and hosted a TCI event about garage charging, but other than that, the reviewer was hard-pressed to elaborate from the materials supplied and available on the web what all was accomplished with these grant funds.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed good collaboration apparent on both projects.

Reviewer 2:

The reviewer stated that both projects seemed to have collaborated with the appropriate stakeholders, local governments, and the industry.

Reviewer 3:

Regarding the MEC project, the reviewer stated that the project includes a good cross-section of relevant participants and stakeholders.

For the DVRPC project, the reviewer stated that the project has a similarly good mix of key/relevant stakeholders; however, participation from OEMs and EVSE providers is fairly light.

Reviewer 4:

Regarding the MEC project, the reviewer stated that this team was comprised of a number of state and local governments, educational institutions and one Clean Cities Coalition. A few industry partners were involved. The reviewer suggested more OEM participation, and the reviewer reported not seeing a utility listed as a partner either. The reviewer questioned if this was just missed or were these stakeholders not involved. The reviewer indicated that future DOE projects should require a utility partnership at some level.

Regarding the Delaware project, the reviewer indicated that this project had relatively few partners comparably. Nevertheless, the reviewer identified as two major partners NYCLHVCC and NYSERDA/TCI. The reviewer expressed curiosity if NYSERDA and TCI received additional funds to develop the same resources for Delaware as for the other 11 states under the NYSERDA project. The reviewer suggested that this might be something DOE should investigate. According to the reviewer, understanding how the funds were used would have been helpful to the reviewers. The reviewer noted that the Delaware partners also included state agencies, several counties and local metropolitan planning organizations (MPOs). The reviewer was pleased to see PECO as a partner. The reviewer would have liked to see more involvement with the OEMs and other EV industry members.

Reviewer 5:

The reviewer noted that the collaborations of both projects were good, but not outstanding, as some of the other Technology Integration Projects reviewed.

Reviewer 6:

Regarding the Kansas –Missouri project, the reviewer indicated that the grant recipients included a collaboration of a Clean Cities coalition, community colleges, a law practice, utilities, state agencies, an MPO, municipalities, PEV/EVSE manufacturers, and the Electric Power Research Institute (EPRI). This project also collaborated with the electrician training center of the IBEW Local Union, which was unique and proved to be beneficial to the success of the project. The reviewer noted that these groups appeared to be well-coordinated.

Regarding the DVRPC project, the reviewer stated that the grant recipients included a collaboration of a Clean Cities coalition, utility, city government, county governments, state agencies, and others. The reviewer noted that these groups appeared to be well-coordinated.

Reviewer 7:

Regarding the Kansas City project, the reviewer indicated that there appears to have been close collaboration with communities and the project plans to launch a business coalition. The reviewer stated uncertainty about why some of the larger businesses were not part of the initial briefings. The reviewer pointed out that only two dealerships (and only one mainstream dealership) were part of the collaboration. Community colleges seemed to be an active participant and four communities, but one slide indicated seven communities were given the plan. The reviewer stated that due to the nature of the presentations given by the contract manager versus

the PI of the project, it was difficult to get the level of detail of the breadth of the partnerships and number of people reached during meetings.

Regarding the Delaware project, the reviewer observed good collaboration with neighboring states and cities on the Garage Free Summit. The reviewer noted that the project interviewed fleets but it was hard to understand the extent of the partnership. The reviewer expressed uncertainty about the ongoing work to facilitate the current partnerships or future partnerships.

Reviewer 8:

The reviewer remarked that the MEC, IBEW, University of Missouri-Kansas City, Kansas City Community College, Black & Veatch, LilyPad EV, and Polsinelli Shughart, which is a law firm, were the Steering Committee Partners listed on the ElectrifyHeartland.org website. The reviewer notes that Clean Cities was not listed as a partner on the Steering Committee. While the reviewer understands that the MEC is associated with Clean Cities, for the reviewer, this seemed strange. While other stakeholders/partners were referenced in the presentation materials it did not really seem like they had any involvement. That being said, the reviewer hardly thought the Steering Committee members represented a very broad and or diverse group of stakeholders, so the reviewer did not believe there was much collaboration and coordination with other institutions. The reviewer suggested that DOE compare the documents submitted to secure this grant and which groups were represented as stakeholders/partners/steering committee because it did not look right to this reviewer that DOE would choose this group and plan on its collaboration, coordination and contributions made to date on this grant. The reviewer acknowledged that mention of the Greater Kansas City Plug-in Readiness Strategy, and while the reviewer understands it was separate from this effort it was referenced in the Electrify Heartland Plan and was confusing. The reviewer wondered if work was done once, and paid for by the federal government more than one time. As a last example, the reviewer noted that the EV Business Coalition was misleading as there was no mention of any companies as a part of a Business Coalition; and when the reviewer tried to review that part of the Readiness Plan report, the reviewer was unable to locate it. While listed in the Table of Contents, the reviewer could not find the section on the website. Even if the reviewer was missing it, and it was present, it was not in a user-friendly fashion and the reviewer spent a lot of time trying to find it. The reviewer said that something appeared wrong with the project team not making their entire report available [DOE Program Clarification: It should be noted that the Kansas City Plug-in Readiness Strategy was completed in April 2011 by in-kind volunteer efforts (not a deliverable under this project).].

As the reviewer previously stated, the DVRPC Readiness hosted a TCI conference and participated in a few other TCI/NYSERDA events. Other than that, the reviewer expressed an inability to tell from the materials supplied, who besides TCI/NYSERDA the project team partnered with, as the reviewer was unsure who the project collaborated with on anything because no documentation was supplied to the reviewer nor were available on the website illustrating any findings [DOE Program Clarification: The plan can be found on the following website: http://www.dvrpc.org/asp/pubs/publicationabstract.asp?pub_id=12055A.].

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

Regarding the MEC project, the reviewer indicated that the project description of future work was fairly general; however, the project had laid a sizable amount of groundwork for further efforts to build on.

Regarding the DVRPC project, the reviewer indicated that the project's envisioned future work tasks were pretty specific, analysis products would be expanded on, leveraging other DOE-funded EV initiatives. Completed analysis products would also be drawn on in future outreach efforts.

Reviewer 2:

The reviewer indicated that the Kansas/Missouri project planned to continue launching and engaging the community with the readiness plan. The reviewer said that the Delaware Valley planned to continue building the momentum for EVs and their outreach activities.

Reviewer 3:

The reviewer indicated that both projects were scheduled to be completed in June 2013. Follow-up activities were outside the scope of this review.

Reviewer 4:

Regarding the MEC project, the reviewer said that this project was completed and published. The slides indicated that the outreach and education would continue; according to the reviewer this was a good sign that the plan had support. The partnerships indicated a continued push for greater adoption and deployment, but no specific continued funding support was mentioned. The reviewer said the project laid the groundwork and would be presented to State officials.

Regarding Delaware's project, the reviewer stated that the project plan was now complete and that the partners were looking for ways to use the materials generated, and to encourage EV readiness adoption throughout the region. The reviewer commented that no discussion was provided as to where additional funds might be derived to implement this plan. The reviewer suggested that DOE should request that this be a part of future plans.

The reviewer also strongly recommended to DOE to please not have two projects in one form next year. The reviewer stated it was unnecessary; reviewers could have filled out two evaluation forms instead of one. The reviewer thought it was fine having two projects in one PowerPoint presentation, just not the forms.

Reviewer 5:

Regarding the MEC project, the reviewer stated that the remaining project activities under the grant were minimal, but grantees would continue efforts beyond the grant funding for implementation.

Regarding the DVRPC project, the reviewer stated that remaining project activities under the grant were minimal, but grantees would continue efforts beyond the grant funding for implementation.

Reviewer 6:

Regarding the DVRPC project, the reviewer stated that it was hard to tell how well thought-out the plans going forward were for this project. To date, the plan had not been posted on the Clean Cities website.

As a general note, the reviewer stated that in all of the EV readiness projects, the reviewer would have liked to see more thought put into communicating results to key stakeholders. Plans, websites, and fact sheets are a great start, but just as important was getting that information in front of important stakeholders, from policy officials, to property owners, to consumers. The reviewer indicated that more detail on this, even in the Future Work section, would have been nice.

Reviewer 7:

Regarding the Kansas City project, the reviewer stated that future work would include the launch of the communities and business coalition and Heartland Electrify EV coalition. The reviewer expressed uncertainty on what the differences were between the coalitions but continued emphasis in the area of EV deployment to a broader audience is planned. The project team will continue to work with state officials in EVSE placement. The reviewer said that nothing was mentioned about broadening the education or outreach with dealerships, unless this was part of the business coalition work.

Regarding the Delaware project, the reviewer stated that the project plan builds on the work of surrounding states/cities, which was important, and the reviewer thinks the contractor will continue to press for PEV-friendly regulations in southeastern Pennsylvania. The reviewer expressed uncertainty if the contractor will use additional data to improve workplace charging and who the lead would be for continuing the build-up of the effort.

Reviewer 8:

The reviewer stated that the MEC represented that next steps would be for them to launch EV Ready Communities and an EV Business Coalition, engage community to implement recommendations through regional energy events, MPOs and small group meetings, engage state officials with EVSE corridor recommendations, and continue outreach to stakeholders via exhibits, media

releases and a website. As the reviewer stated, either these activities to date had not really occurred, or if so, no information was provided to illustrate that it had occurred, so the reviewer expressed skepticism, that if the MEC has not executed in the past with the EV Readiness program, then DOE should not count on the project executing on future planned activities.

The reviewer noted that DVRPC Readiness said the project team would use other Clean Cities data, research and materials and TCI/NYSERDA data, research and materials to build EV momentum in the relevant area. The reviewer said that because it did not appear that the project team accomplished what their Strategy set out to do, or if the project did, it was too hard to find, the reviewer encouraged DOE to really evaluate whether the DVRPC had the capacity to execute and advance EV Readiness work in their region.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that as with all of these EV readiness projects, these projects support the implementation and deployment of EVs. If the plans are implemented, the projects will lead to petroleum reductions.

Reviewer 2:

The reviewer indicated that both projects would serve to meet the Clean Cities petroleum reduction goals of 2.5 billion gallons per year by 2020, by building and strengthening community efforts in PEV deployment.

Reviewer 3:

The reviewer indicated that the adoption of EVs and PHEVs vehicles has the potential to significantly reduce petroleum use. These community readiness initiatives help facilitate the adoption of EVs and charging infrastructure, as described previously.

Reviewer 4:

The reviewer indicated that these grants addressed barriers, including the availability of PEVs and EVSE, consumer reluctance to purchase new technologies, and lack of technical experience with new technologies. Addressing these barriers will help support VTO's deployment goals, specifically petroleum reduction objectives, partnership efforts to ease market introduction of PEVs, and technical and educational assistance to support local communities and partnerships.

Reviewer 5:

The reviewer stated that both projects supported grassroots EV market development at the community and state-level.

Reviewer 6:

The reviewer indicated that the benefits of EVs were well-known.

Reviewer 7:

The reviewer stated that the Kansas/Missouri project estimates that 0.4% of future vehicle purchase will be an EV in part due to adopting the readiness plan.

Reviewer 8:

The reviewer stated that it was hard to see how these two projects ultimately supported the DOE objectives of petroleum displacement. The reviewer understood that both of these projects tried to achieve this goal; however, the reviewer expressed an inability to tell from the documents submitted and/or available online illustrate how either the MEC and/or DVRPC Readiness grants achieved anything towards petroleum reduction.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that both projects used all or nearly all of the funding allocated and made significant progress toward objectives.

Reviewer 2:

Regarding the Kansas City project, the reviewer stated that 92% of funding had been spent. The reviewer indicated that some good relevant studies were deliverables, as well as a number of outreach products to suggest that sufficient funding was allocated.

Regarding the Delaware project, the reviewer noted that 82% of funding was spent as of February 2013. The reviewer stated that an extensive study of PEV potential households and concentration matched with employment density, high volume interchange, and key public venues with longer than average visits seemed quite comprehensive and a good use of funding.

Reviewer 3:

Regarding the Kansas – Missouri project, the reviewer indicated that the project funding of \$441,478 was sufficient to complete the work, though there was no cost-share.

For DVRPC, the reviewer stated that the project funding of \$387,698 was sufficient to complete the work, though there was no cost-share.

Reviewer 4:

The reviewer indicated that resources were sufficient for both projects. Delaware Valley was 90% complete with funds spent of \$321,944 from a total budget of \$387,698. Kansas/Missouri was 92% complete, spending \$406,132 from a total budget of \$441,478.

Reviewer 5:

The reviewer would have liked to see more documentation, information/outreach on the Pennsylvania project.

Reviewer 6:

The reviewer noted that the MEC was granted \$441,478, and Delaware was given \$387,698, and neither had nor were required to have a cost-share. Both plans were accomplished within the granted budgets. The reviewer expressed that it was difficult to assess if the funds were sufficient because reviewers were not provided a budget to evaluate. In the future, the reviewer recommended to please dedicate at least one slide to how the funds were spent. In other words, the reviewer asked how much each deliverable cost. The reviewer stated that if these readiness plans were going to continue, the reviewer would expect DOE to require some level of industry or government support, even if it was in-kind. The reviewer indicated that the local stakeholders need to show they are invested in the long-term success of these plans.

The reviewer stated that with Delaware specifically, it appeared NYSERDA and TCI were involved in this project separately from its own project. The reviewer encouraged DOE to investigate how the funds were used and if the funds were spent appropriately. The reviewer felt that it would not be good use of federal funds to have two grants pay for the creation of the same materials unless they were substantially different. The reviewer referenced Slide 34 (i.e., Make use of TCI/NYSERDA research and materials) and commented that DOE should be clear on how these funds were put to use if these two partners were not given additional funding.

Reviewer 7:

The reviewer expressed skepticism that the resources for either the MEC or DVRPC Readiness grants were utilized efficiently because the reviewer could not tell what if anything these two grants accomplished. In general, it was difficult for this reviewer to evaluate how the resources were used in either the MEC or DVRPC Readiness grants because the presentations provided did not indicate what really was done. The reviewer stated that the information and presentations provided and available on the web did not provide any transparency on the expenses or final product deliverables. In the past, DOE has had the PI that received the grants make the presentations for the reviewers and this year the respective DOE project manager gave the reviewers the presentations. The reviewer recommended that it would be more effective in determining some of the local and regional impacts and long-term benefits of the grants if the person responsible for implementation provided the reviewers the uniqueness and highlights of the project presentation. Also, the cookie cutter hard copy presentation format used for these reviewer Readiness Grant presentations this time prevented the individuality and exceptionality of each grant to stand on its own merits, and the reviewer believed these two grants presented at first blush like the projects had accomplished more than what is available.

EV Community Readiness projects: Center for the Commercialization of Electric Technologies (TX); City of Austin, Austin Energy (TX): Neil Kirschner (National Energy Technology Laboratory) - ti031

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the Texas Triangle project had a comprehensive list of 10 tasks in their approach to help provide input needed to develop the reports required by this effort. The milestones completed in this project in year one included the data gathering, feedback and outreach of the project helped them to be successful in completing the required reports.

The reviewer commented that the City of Austin also had a very comprehensive list of tasks to accomplish, to provide input for the development of the readiness report. The stakeholder engagement, including stakeholder meetings and surveys, were essential to the success of the project.

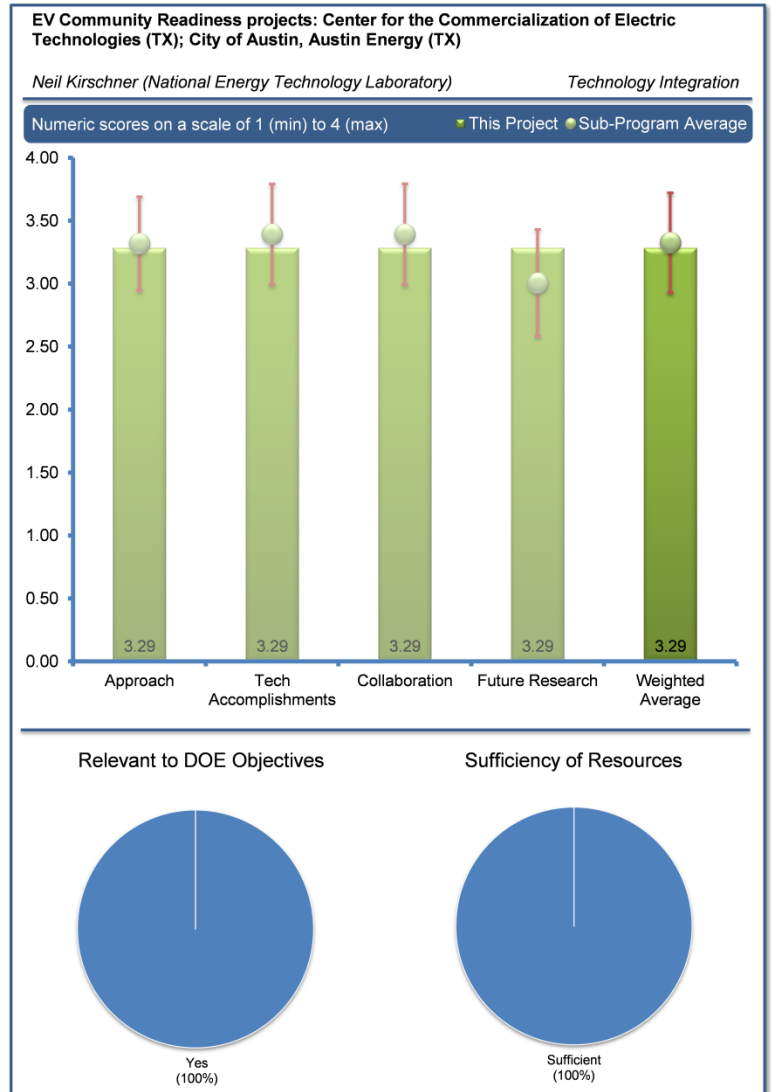
Reviewer 2:

Regarding the Center for Commercialization of Electric Technologies (CCET) Texas Triangle EV Ready Project, the reviewer was impressed with the overall proposed plan to form an EV corridor than ran between Dallas, Houston and San Antonio. The reviewer did not notice a multi-city installation and implementation plan, such as permitting, codes, etc. The only city that was identified as a participant was the City of San Antonio. Second, the reviewer said that CCET identified the high cost of PEVs but did not offer a discussion on the impact to the plan or the EV market in those regions.

Regarding the City of Austin project, the reviewer stated an excellent project because the project team took a few extra steps by proving a roadmap, discussed a business model, building codes, marketing, and conducted a survey.

Reviewer 3:

Regarding the CCET Project, the reviewer stated that the team made a good move to expand their work to a statewide program, as this would extend results beyond the Texas Triangle area. The reviewer commented that another positive aspect of the strategy is the work on PEVs, grid connection, and ancillary services with the Electric Reliability Council of Texas (ERCOT), which was quite forward looking given the state of V2G at this time. This will be implemented in an electric truck fleet, and the team is working on identifying the fleet now. The reviewer remarked that it would have been useful to discuss how the project team was handling (or will handle) billing issues with corridor charging (i.e., multiple suppliers of EVSE services do not yet have compatible billing and payment



systems). The reviewer elaborated that the appropriate next step in the strategy was being pursued; CCET is working to put their information in front of those who can implement the recommendations.

Regarding the Austin project, the reviewer commented that the project covered the cities of Austin and San Antonio. The reviewer noted some overlap of regional coverage with the other Texas project, and asked whether this project team collaborated with the other Texas project, or if the activities were separate. The reviewer found that the strategy was reasonable to accomplish the development of the plan. Good approach to use sub-teams to work on various aspects of the plan (likely allowed for more focused efforts). Surveys of EV owners, multi-family owners and residents, employers, and employees were valuable. The reviewer remarked that it should be useful to the region to have captured this information to assist with planning now and in the future.

Reviewer 4:

Regarding Texas Triangle, the reviewer indicated that the project was focused on doing the necessary planning, development of model ordinances/permitting, and conducting the needed outreach. Near the end of the project, there was a look toward initial implementation of recommendations, some of which would occur after the project ends.

Regarding the City of Austin, the reviewer commented that the project was focused on conducting necessary analyses and planning, developing model codes/ordinances, and preparing a marketing plan.

Reviewer 5:

The reviewer commented that the overall rating was between good and outstanding. The reviewer found that the Austin/Austin Energy project included utilities from the project's beginning, and had OEM involvement (i.e., GM, Ford, and Nissan). The reviewer also noted that a local Toyota dealer was also involved.

This reviewer observed that engagement with a utility never occurred in the CCET project. The reviewer noted that ERCOT, engaged at the end, is a regional systems operator, not a utility. CCET planning proved to be top-down. The reviewer remarked that the engagement of GM at the beginning by CCET was a plus.

Reviewer 6:

The reviewer commented that their plan was ambitious considering the budget and well-thought out. The project leveraged the Plug-in Conference to promote the project's work. The reviewer added that involving a technical advisory group was a good way to make sure the developed plan was feasible.

Reviewer 7:

The reviewer commented that both EV readiness plans addressed barriers to EV deployment, such as vehicle and charging infrastructure, and appeared to be feasible for implementation. The reviewer found that it appeared there could have been more coordination between the projects. For example, the reviewer would like to know how the corridor approach highlighted in the Triangle plan will be integrated with the vehicle/charging infrastructure deployed in Austin.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

Regarding CCET, the reviewer thought that the three-volume plan to develop an interlink travel corridor plan along the Texas triangle with the intent to create a state-wide program PEV Community was an excellent deliverable. It opens the possibility for other cities in the State to join and expand the corridor beyond Houston, Dallas and San Antonio. The reviewer suggested it would be a good idea to engage a representative from the State.

Regarding the Austin project, the reviewer commented that the three documents (i.e., a communication plan, an ordinance toolkit, and a workplace and multi-family housing issue identification) showed that the project team has a strong understanding of its audience and is clearly addressing its needs by dividing the reports by subject.

Reviewer 2:

Regarding the Texas Triangle project, the reviewer commented that the team completed extensive documentation for regional planning activities, and prepared both private and utility business case models. The team also conducted several outreach events and convened a technical advisory committee. The reviewer concluded that the project team appeared to have pretty much accomplished what was planned on time.

Regarding the City of Austin, the reviewer remarked that the team conducted extensive surveys to inform planning and analysis needs. The team also completed planning and conducted four stakeholder meetings, plus conducted additional outreach efforts including surveys. In particular, the team also worked to identify workplace and multi-unit issues. The reviewer found that the project appeared to have completed planned activities in a timely manner.

Reviewer 3:

Regarding the CCET Project, the reviewer found that the project had completed an extensive three-volume plan that was now available on a dedicated webpage. The project had completed the plan for a V2G demonstration for ancillary services with the Texas ISO, which was a unique aspect of this work. The reviewer remarked that the project had also performed several outreach activities that were useful, and that public feedback on Plan recommended actions should be useful.

Regarding the Austin project, the reviewer commented that the survey work was a major highlight of the project: much information was collected on EV and EVSE attitudes among key near-term users (current EV owners, employers, etc.). Survey results should be valuable qualitatively beyond the Austin/San Antonio region for EVSE planning. The reviewer found that the recommendation roadmap was also a valuable output – it was quite detailed and thorough. The flow chart graphic provided in the PI's presentation was very useful in outlining the key recommendations in a single page. The reviewer commented that other valuable accomplishments include the set of customizable ordinances in a toolkit, and the initial issue identification for workplace and multifamily housing cases. The reviewer remarked that the report included a unique interoperability roadmap showing how devices, systems, and applications interconnect in a widespread EV/EVSE deployment scenario. The reviewer noted that this could be applicable outside of this project.

Reviewer 4:

The reviewer commented that both the City of Austin and the Texas triangle projects completed reports as required by this effort.

The reviewer remarked that the Texas Triangle plan provided both a PEV infrastructure readiness plan as well as a detailed plan for multi-phase demonstration of PEV fleets.

The reviewer noted that the City of Austin also completed a very thorough PEV initiative regional plan, which included a best practices guide and a communications plan, in addition to a private and utility business case model.

The reviewer found that these plans would help both communities in their follow-on efforts.

Reviewer 5:

Both plans demonstrated progress toward DOE goals with the Austin plan being quantitative in nature, which may help demonstrate petroleum replacement and other goals.

Reviewer 6:

The reviewer remarked that the fact that the project had led to a follow-on project related to ancillary services and PEVs was a testament to the project's technical accomplishments. V2G and similar technologies are an important enabler for PEVs.

Reviewer 7:

The reviewer commented that taken together, the results for CCET and Austin/Austin Energy were good in the sense that it helps illustrate what works and what does not. The CCET project focused on infrastructure installation along highways, but had fairly limited success in getting actual infrastructure installed. The reviewer remarked that the problems with demand charged limiting DC fast charger installations were discovered and noted by CCET. Though it was unfortunate that CCET had such limited success, it was also informative.

The reviewer commented that Austin/Austin Energy focused on residential and commercial locations within the metro areas of Austin and San Antonio and implemented an intra-urban charging network. Austin/Austin Energy gained many partners and had sold a significant numbers of vehicles. The reviewer commented that Austin/Austin Energy started with a small number of partners, but very effectively executed a plan. From the reviewer's perspective, the sum was greater than the parts. A focused study in a limited region with a pair of relatively close metro areas did far better than a more diffused study of a large region attempting to focus on linking large cities considerably further apart, than for Austin and San Antonio [DOE Program Clarification: Please note that the purchase of vehicles and the installation of charging equipment were outside the scope of these Clean Cities community readiness projects. Although some communities may have chosen to implement those steps in parallel with these projects, no DOE funding was used to support the purchase or installation of vehicles or hardware.].

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that both the Texas Triangle project and the City of Austin effort have a very strong list of collaborators.

The reviewer found that it was very good to hear that these two projects each built on the other and avoided duplication of efforts.

Reviewer 2:

Regarding the Texas Triangle project, the reviewer commented that the team coordinated with local planning organizations, particularly through outreach efforts. Partners included laboratories, EVSE providers, a vehicle manufacturer, and others.

Regarding the City of Austin project, the team worked with EVSE organizations, universities, utilities, and local governments primarily, but also worked with an extensive list of organizations overall, adding manufacturers, dealers, Councils of Governments (COGs), chambers of commerce, and associations. So, while operating in a smaller geographic area than the Texas Triangle project, this team appears to have at least exposed a far larger number of organizations to EV issues.

Reviewer 3:

Regarding the CCET Project, the reviewer commented that there was a reasonably balanced list of partners (Clean Cities Coalitions, one vehicle OEM, two EVSE suppliers, and other supporting organizations). The reviewer said that there was not much direct engagement from local municipalities based on the collaborations list (their contribution may have been through the public feedback sessions or through the local Clean Cities coalitions).

Regarding the Austin project, the reviewer commented that this project included a great list of collaborators, including major vehicle OEMs, EVSE providers, the Texas electricity ISO, several local planning organizations, and the leader of the other Texas EV planning project. According to the reviewer, the inclusion of a local apartment association was a good idea and thought that this might be a good partner for other Clean Cities areas to consider.

Reviewer 4:

The reviewer commented that the project team worked with a large number of relevant groups.

Reviewer 5:

The reviewer commented that both had good collaborators. The reviewer recommended that both consider working with the U.S. Green Building Council (USGBC) and the EPA-ENERGY STAR® to ensure that these efforts were not only supported but encouraged through incentives in the Leadership in Energy and Environmental Design (LEED) rating system and Energy Use Guide. The EERE Building Technologies Office may be able to offer additional guidance.

Reviewer 6:

The reviewer commented that Austin/Austin Energy was outstanding in the end, with multiple OEMs, utilities, EVSE suppliers, NGOs and EVSE suppliers.

The reviewer remarked that CCET was only fair. The project did not indicate any growth in partners from beginning to end. A poor rating would be attached to a project admitting a loss of original partners.

Reviewer 7:

The reviewer commented that the Texas Triangle EV Readiness Plan could have benefited from including various metropolitan planning organizations and a representative from the Texas Department of Transportation as partners in the project.

The reviewer commented that the Austin Plan had an extensive number of partners, including the State DOTs and MPOs.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that both projects planned on continuing the work in this area. One project would perform follow-on work on their own, which showed great initiative, while the other project has received a follow-on award from the DOE.

Reviewer 2:

Regarding the CCET Project, the reviewer indicated that given that the project would be completed this year, the wrap-up activities appeared reasonable: final refinement of the plan with Clean Cities, and implementation of activities through the distribution of the plan to appropriate authorities.

Regarding the Austin project, the reviewer commented that efforts outlined were appropriate to wrap up the current project. The City of Austin and Austin Energy received an award to perform some follow-on work as part of the 2012 Clean Cities alternative fuel market project awards.

Reviewer 3:

Regarding the Texas Triangle project, the reviewer noted that efforts were virtually complete. The plan was to move forward with full implementation of recommendations, and to look at establishing a deployment fleet.

The reviewer indicated that for the City of Austin, efforts were nearly complete. This team received a follow-on grant from DOE to conduct implementation.

Reviewer 4:

The reviewer clarified that the outstanding rating applied only to Austin/Austin Energy. A follow-on proposal was submitted into a competitive solicitation by DOE and Austin/Austin Energy won the support for follow-on work. The reviewer commented that the high cost-share at the outset of the initial project demonstrated local commitment to the introduction of PEVs.

Reviewer 5:

The reviewer recommended that the two Texas projects work together to avoid duplicative efforts and to talk about opportunities where both projects can effectively collaborate. Both projects should continue to refine plans as necessary and distribute the plan to a government implementation authority. As mentioned previously, the reviewer suggested also working with ENERGY STAR and LEED for effective incentives.

Reviewer 6:

The reviewer suggested that the Triangle plan needed to focus on how to further develop the corridor approach undertaken in the readiness plan, and that both plans needed to coordinate and collaborate on how the two plans would intersect. The reviewer explained that this would help to ensure that EV owners could operate their vehicles within and around Austin as well as intra-regional travel along Texas interstates without range anxiety.

Reviewer 7:

The reviewer commented that the project did not just propose future work; it has undertaken a follow-on project related to V2G.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer asserted that the project was elaborating that displacement of petroleum fuel by installing EV plugs strategically and easing the path to EVs.

Reviewer 2:

The reviewer pointed out that electrical energy (i.e., kilowatt-hours [kWh]) from utilities use almost no oil, so the implementation of PEVs serves DOE goals of petroleum displacement.

Reviewer 3:

The reviewer commented that the development of an EV Community Readiness Plan definitely supports the overall objective of DOE to promote petroleum displacement. By having a plan ready, the community will be poised to implement the use of EVs when future projects and funding are available for the deployment of EVs.

Reviewer 4:

For the CCET Project, the reviewer commented that the project addressed DOE petroleum reduction goals, as it connects to three major Texas cities with coordinated electric vehicle plans. The reviewer also commented that the project addresses identified barriers to more widespread EV/EVSE deployment in this region.

Regarding the Austin project, the reviewer commented that this project was relevant to the goals and objectives of Clean Cities, and addressed the barriers outlined in the presentation. The project covered a large geographic area within Texas.

Reviewer 5:

Regarding the Texas Triangle project, the reviewer commented that the project was designed to address multiple needs for PEVs, including data and information for consumers, costs, multi-unit dwellings, charging along corridors, and streamlining EVSE permitting.

Regarding the City of Austin project, the reviewer commented that the project was designed to prepare an EV readiness plan and address information for consumers, availability of vehicles, and technical information for technicians.

Reviewer 6:

The reviewer responded yes. The reviewer elaborated that although planning activities were not typically funded by DOE, that planning activities were incredibly important to the success of PEVs and the vehicle's ability to displace petroleum. PEVs require the coordination of a number of stakeholders in an area, and this project helped address some of the most important barriers to consumer adoption.

Reviewer 7:

The reviewer responded yes, and clarified that both plans supported the goal of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

Regarding the CCET Project, the reviewer commented that the project was funded adequately, and included a cost-share. Not all projects in this series included a cost-share, (and it was not a requirement), so the CCET inclusion of cost-share was a plus.

Regarding the Austin project, the reviewer commented that this project was funded adequately, and included a cost-share.

Reviewer 2:

The reviewer commented that resources were sufficient and appeared to be on track to use all of the funds to complete the project.

Reviewer 3:

Regarding the Texas Triangle project, the reviewer commented that resources appeared sufficient, particularly since efforts were nearly complete and the budget nearly spent.

Regarding the City of Austin project, the reviewer indicated that the project was nearly complete, but may have funds left.

Reviewer 4:

The reviewer stated that it seemed that Austin was able to do much more; however, the City of Austin did have a larger budget. The reviewer suggested considering collaborative projects in areas that are close to leverage the resources.

Reviewer 5:

The reviewer commented that it appeared that the funds were used efficiently and effectively.

Reviewer 6:

The reviewer commented that Austin Energy still listed hundreds of thousands of dollars of project funds available to be spent, so it may have had more funds than needed, though the reviewer pointed out that the remaining funds may largely be cost-share funds.

The reviewer stated that there was insufficient money for CCET to succeed because installing infrastructure to support intercity travel of PEVs was not a cost-effective starting point, particularly since two of the three cities at the corners of the Texas Triangle were not committed to helping CCET [DOE Program Clarification: Please note that the purchase of vehicles and the installation of charging equipment were outside the scope of these Clean Cities community readiness projects. Although some communities may have chosen to implement those steps in parallel with these projects, no DOE funding was used to support the purchase or installation of vehicles or hardware.].

EV Community Readiness projects: Clean Energy Coalition (MI); Clean Fuels Ohio: Erin Russell-Story (National Energy Technology Laboratory) - ti032

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

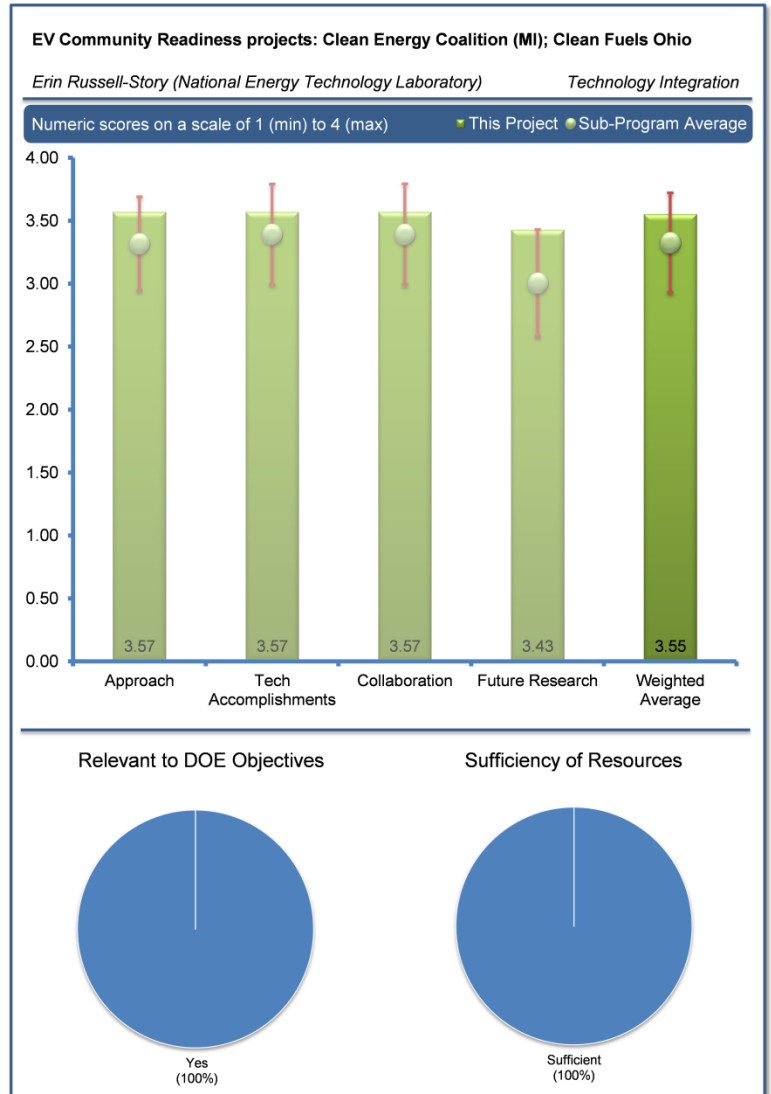
Regarding the Michigan project, the reviewers said that the strategy for achieving the goals of the project was appropriate. The team established project management practices in developing a stakeholder register early on in the process, and ensuring stakeholder involvement in the work. The reviewer indicated that it was good to see the project team's flexibility in adjusting to changing conditions (shift to direct stakeholder engagement from wiki push communications based on feedback). The team conducted a number of data collection activities to support their planning efforts; this was very important to ensure that plans would be based on the best information available. The reviewer believed that the model regulations and incentives were also valuable as it helped municipalities address this issue quickly, and made it more likely that PEV issues would be addressed. The team performed outreach to many of the right people, including the key municipalities in Michigan. The Team put their tools in the hands of those who were renovating existing buildings or constructing new buildings, to expand the PEV readiness to as many buildings as possible.

Regarding the Ohio project, the reviewer said that the project focused on three cities (Columbus, Cleveland, and Akron) along the state's Northeast/Southwest corridor. This included two of the largest cities in Ohio (Columbus and Cleveland) along a key travel corridor. The reviewer noted that planning efforts included a marketing strategy for collecting information for the plan, developing a brand identity for the planning efforts, and distributing the materials upon project completion; this sort of planned outreach would help ensure success for this effort.

Reviewer 2:

The reviewer stated that the approach used by the Clean Energy Coalition in Michigan to create a stakeholder database, perform research and data collection was instrumental in being able to successfully publish their readiness plan and to develop and implement model regulations and incentives.

The reviewer stated that the Clean Fuels Ohio project identified tasks of data collection, market analysis and modeling as well as the development of a strategy for updating building codes, permits and zoning information, and the development of a marketing strategy, which provided the required input for finalizing the project's Readiness Plan.



Both projects successfully completed the tasks to allow for a successful Plan to be finalized.

Reviewer 3:

Regarding Michigan, the reviewer remarked that the project framed a plan with research and stakeholder input, conducted one-on-one meetings, and shifted from Wiki to direct stakeholder meetings because it proved more effective. The project team was shopping the plan to key players in Michigan.

The reviewer stated that the Ohio project identified key areas of focus that addressed consumer concerns and technical engineering experience. Both projects are looking at state-wide implementation with roughly equal funding and excellent collaborations.

Reviewer 4:

The reviewer stated that the Michigan project was focused on developing a community plan, based upon research and stakeholder input. The project also focused on related outreach and development of implementation planning elements. The project included on-going activities to get the word out on the plan and to move stakeholders along on implementation, even after completion of the project. The reviewer indicated that the team was also trying to get the plan in the hands of builders/developers to incorporate necessary changes into new construction early.

Regarding the Ohio project, the reviewer stated that the project had a similar focus (to Michigan) on developing a community plan to assist implementation, including grid modeling, locating stations, local government input, consumer research and fleet studies, and ADA compliance/model design for siting. The project includes a specific emphasis on using the Drive Electric Ohio website as a key element of on-going outreach.

Reviewer 5:

The reviewer noted that this review covered two projects: Clean Energy Coalition (CEC): Plug-In Ready Michigan; and Clean Fuels Ohio: Charging Forward with Electric Vehicles in Ohio.

The reviewer commented that both of these projects were well-designed and executed, though it would have been good to have information on how stakeholders were identified. Specific comments on each project are below.

Regarding the Michigan project, the reviewer commented that the main objective of this work was to develop an electric vehicle preparedness plan for the State of Michigan. The plan was developed through a combination of research, data collection and stakeholder input. The approach included stakeholder workshops, outreach to municipalities, and collaborations with the industry. The reviewer noted that in addition to the community readiness plan, signage recommendations were made for the state of Michigan. The project was well-designed and executed and noted that a wide variety of stakeholders were engaged in the creation of the plan.

Regarding the Ohio project, the reviewer commented that the main objective of this work was to develop an electric vehicle preparedness plan for the state of Ohio. The work included detailed infrastructure studies, development of a marketing strategy, stakeholder outreach and other collaborations. The project targeted a specific corridor within the state of Ohio. The reviewer noted that while the rationale for limiting the readiness plan to a single corridor (rather than the entire state) was not articulated in the presentation, the approach to the project was in line with this objective. The reviewer summarized that throughout the course of the project, six large stakeholder meetings were held in the target cities (Cleveland and Columbus); the final plan and other information are posted on the Drive Electric Ohio website.

Reviewer 6:

The reviewer stated that technical barriers were addressed in both readiness plans. Michigan did a very good job at addressing EV signage and zoning issues.

Reviewer 7:

The reviewer stated that CECs Michigan plan benefitted from prior organization and development before obtaining project funding (Michigan Plug-in Electric Vehicle Task Force). The project had an excellent organizational structure, with well-selected topics and appropriate participants in each topic. The reviewer noted that in this case, though cost-share was not officially listed, the reality is that

DOE funds were able to extend and expand an on-going effort. The reviewer found that the presentation on Slide 7 was a very nice illustration of work flow and organization. CEC developed a very good strategy for serving the needs of the whole state, taking into account important differences in level of commitment and interest by different communities. The reviewer concluded that being able to have a project plan that scheduled early production of a PEV plan for dissemination during the project time frame was an excellent feature.

The reviewer found that the Ohio project plan was good, though not outstanding, indicating that Ohio was not as far along as Michigan. The reviewer concluded that the plan was sound, but compared to Michigan, some key steps (like plan completion) had to be scheduled for later.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer found that the Clean Fuel Ohio Project completed several milestones including EV research and studies, obtained stakeholder feedback and project outreach, which ultimately allowed the project to develop their final output of the Ohio EV Readiness Plan as well as the model permitting and code templates, and a consumer marketing strategy.

The reviewer commented that the Clean Energy Coalition in Michigan completed milestones of data gathering and obtained direct stakeholder feedback through project outreach efforts to help develop the final plan, Plug-in Ready Michigan: An Electric Vehicle Readiness Plan.

The reviewer concluded that both projects were very successful in preparing and publishing the required EV Readiness Plans.

Reviewer 2:

Regarding the Michigan project, the reviewer found that the team has developed a thorough and extensive plan with a toolkit that contains important resources that municipalities will be able to reuse. One useful addition this project has made to the EV planning community is characterizing levels of community enthusiasm/interest for being EV ready (particularly for planning and zoning), with specific tailored strategies to address these three types of interest levels in the toolkit plan. The reviewer noted that considerable data collection contributed to the plan development (including Pike Research forecast for PEV sales in Michigan). The reviewer found that signage recommendations would be useful. This reviewer further commented that it was good to see a sign reserving charging spots for EV use only, with potential for citation for violators. The reviewer also noted a well-done and easy to locate web page for the plan resources, media releases, and videos.

Regarding the Ohio project, the reviewer complimented several accomplishments were notable in this project. Ohio State completed grid modeling for PEVs (optimizing the location of EVSE in the Columbus metro area). The reviewer noted that the University of Akron completed a study of PEV demand in the Cleveland/Akron area relative to consumer behavior and purchasing habits: this included estimating PEV demand in the region, and developing a methodology for locating DC fast chargers based on travel time, grid readiness, and vehicle distributions. The reviewer noted that a document on ADA compliance was also developed (this can be a useful resource beyond this project area). Model zoning and building codes were also developed and templates included in the final plan. The reviewer also noted that an extensive planning document with appendices was the final result of this work. Information will go on a dedicated website, which will serve as the key distribution point for information.

Reviewer 3:

The reviewer commented that Michigan produced case studies as part of its plan and provided tool kits. Notably, Michigan also created recommended signage and a three-tiered approach to planning and zoning language. The reviewer strongly emphasized that the ideas were excellent. The reviewer observed that Ohio looked at a corridor approach for its plan, which addressed marketing strategies, policy, and education. The reviewer found that both have very good plans but Michigan showed more innovation to their approach. However, Ohio presented well on addressing permitting and code issues.

Reviewer 4:

Regarding the Michigan project, the reviewer commented that the project completed all planned activities, even including quarterly working group meetings. The team also held numerous meetings with local governments to assist with continuing implementation. The reviewer found that the readiness plan was the primary accomplishment, an item that would be used extensively moving forward. The plan as completed provided a clear focus on addressing the existing process and solutions for planning and zoning issues.

Regarding the Ohio project, the reviewer found that the project completed all activities to date, including the readiness plan to form the basis for future implementation. Ohio completed a significant amount of research and studies, held six large stakeholder meetings, and conducted a number of other outreach efforts.

Reviewer 5:

The reviewer detailed that Michigan regards their toolkit as the heart of the project. The project's desire was to get the toolkit in the hands of those institutions and organizations that can make good use of it. Michigan's plan was completed earlier than other projects, put on the web, and had a record of 173 downloads in 2 months. The reviewer complimented that given that it was not intended as consumer information, but for institutions doing all of the necessary work to enable PEVs, that the result was impressive. The reviewer also complimented the fact that Michigan could get the plan done early enough to provide a report on its downloads was a notable accomplishment.

The reviewer stated that although Ohio's project is nominally a corridor plan for Columbus, Cleveland and Akron, multiple products were of statewide interest and value (EPRI's fast charge siting study, the consumer survey). In contrast to Michigan, where a plan was complete in November, Ohio stated that the plan was done in March and that there were plans for a website, but that none had been implemented yet.

The reviewer concluded that based on the presentation, both studies were productive in generating publications and presentations and both were very effective in linking to the broad range of stakeholder groups necessary to support PEV market introduction. OEMs, EVSE suppliers, utilities, governments, NGOs, Clean Cities programs, and planning organizations were study collaborators.

Reviewer 6:

The reviewer commented that both plans indicate that the technical accomplishments outlined in the plans demonstrated progress towards DOE goals and provided a solid foundation for implementation activities to begin.

Reviewer 7:

The reviewer detailed that both of the projects have been completed, and that the completed EV readiness plans have been released to the public.

Regarding the Michigan project, the reviewer noted that this project had a clear deliverable and implementation plan. The final plan has been completed and submitted to DOE and posted on the CEC website. The plan has been downloaded 173 times since March 2013.

Regarding the Ohio project, the reviewer noted that the final plan for this project had been completed, but there was less clarity on other activities.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer commented that the Michigan project team worked with 40 partners in this activity (i.e., all of the Clean Cities Coalitions in Michigan, key local governments (Detroit, Ann Arbor, Dearborn, Warren, and others), many institutions (University of Michigan Transportation Research Institute [UMTRI], Michigan Public Service Commission [(PSC], and all three Detroit OEMs). The reviewer concluded that this represented a good list of collaborators who have a stake in implementing EVSE projects in Michigan.

The reviewer commented that the Ohio project's collaborators included several Ohio universities, all major Ohio utilities, and the industry (OEMs, EVSE providers). Collaboration with important state agencies was a positive aspect of this project, as was the collaboration with local governments. The project team gathered stakeholder feedback through six meetings. The reviewer noted a good use of partner expertise to complete focused tasking (e.g., universities for modeling and analysis, communication firm for market strategy).

Reviewer 2:

The reviewer commented that the collaboration and coordination of both projects had a very complete list of Clean Cities coalitions, other agencies and institutions, utilities, local governments and industry partners that were involved in the effort.

Reviewer 3:

The reviewer noted that the Michigan project worked with as many as 40 organizational partners. The project had clear efforts to focus on local government decision-makers in particular. Participants included a number of industry members (vehicle manufacturers, EVSE, utilities), governments, Clean Cities coalitions, and others.

Regarding the Ohio project, the reviewer noted that the project worked with a large list of organizations, including utilities, local governments, industry partners, and others. Stakeholder input was critical to development of the plan, and was obtained through numerous meetings.

Reviewer 4:

The reviewer commented that both the Michigan and Ohio projects have collaborated with a broad range of other institutions including Clean Cities coalitions, municipalities, utilities, and industry (including OEMs).

Reviewer 5:

The reviewer stated that both studies were very effective in linking to the broad range of stakeholder groups necessary to support PEV market introduction. OEMs, EVSE suppliers, utilities, governments, NGOs, Clean Cities programs, and planning organizations were study collaborators.

Reviewer 6:

The reviewer commented that both project had invited many key partners but it would be useful to talk to the USGBC (LEED rating system) and ENERGY STAR representatives.

Reviewer 7:

The reviewer found that collaboration was good on both projects. However, according to the reviewer it would have been beneficial to include representatives from the respective State DOTs to participate in the working groups.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that both the Michigan and Ohio projects received follow on funding from DOE to implement EV initiatives in the community. The projects will be able to utilize the plans developed in this current project.

Reviewer 2:

Regarding the Michigan project, the reviewer noted that the project was complete, though the team was continuing some implementation steps. Michigan received a follow-on award from Clean Cities, though those efforts were not under this project.

Regarding the Ohio project, the reviewer noted that the project was complete. The team will continue efforts to conduct outreach, including workshops, and received a follow-on award from Clean Cities for implementation.

Reviewer 3:

Regarding the Michigan project, the reviewer commented that current work was completed, so no future work was planned under this funding. The team received a follow-on project in the 2012 Clean Cities alternative fuel market project awards.

Regarding the Ohio project, the reviewer commented that the outlined future work was reasonable given the budget remaining as of the publication date of the presentation. Statewide local government workshops should be useful in reaching key implementers for this initiative. The team received a follow-on project from the 2012 Clean Cities market project awards.

Reviewer 4:

The reviewer commented that both the Michigan and Ohio plans were completed and portions of their plans are being implemented under a new award.

The reviewer remarked that the Michigan project is complete as of November 2012. The proposed future work included building on completed effort through the Michigan Fuel Forward Program.

The reviewer noted that the Ohio project was complete as of March 2013. The proposed future work included maintaining the Drive Ohio website and conducting local government workshops. The planned workshops would clearly build on completed work.

Reviewer 5:

The reviewer commented that both projects developed good plans that could be used to solicit additional funding partners to execute implementation steps. Both have new funding to continue work on alternative fuels readiness.

Reviewer 6:

The reviewer remarked that most of the planning had been completed; therefore the only task left was to be able to present it to decision-makers at the local level for implementation.

Reviewer 7:

The reviewer encouraged Ohio in its next steps or implementation to pursue the corridor perspective of this project by gathering information/data on EV usage and travel patterns for the corridor between Columbus and Cleveland.

The reviewer commented that the readiness plan for Michigan provided a foundation for the statewide deployment of EVs and associated infrastructure. The reviewer encouraged the project to continue outreach and education activities as actual deployment takes place throughout the state.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer remarked that the projects fully supported petroleum displacement, and what was really nice about electric vehicle projects were that the projects supported more than one area of sustainability. It addressed vehicles and buildings.

Reviewer 2:

The reviewer commented that the development of an EV Community Readiness Plan definitely supported the overall objective of DOE to promote petroleum displacement. By having a plan ready, the community would be poised to implement the use of EVs when future projects and funding were available for the deployment of EVs.

Reviewer 3:

The reviewer commented that the Michigan project was relevant to VTO deployment goals and would reduce barriers to electric drive deployment.

The reviewer found that the Ohio project is relevant to achieving VTO deployment goals and removing barriers identified in the presentation.

Reviewer 4:

The reviewer commented that the Michigan project was designed to address the availability of information on plug-in vehicles, as well as to develop technical experience with new vehicle technologies.

The reviewer found that the Ohio project had the same objectives as the Michigan project.

Reviewer 5:

The reviewer commented that both of these projects indirectly supported the DOE objectives of petroleum displacement through creating community readiness plans for EVs. The adoption of EVs in these states would lead to displacement of internal combustion engine vehicles that run on petroleum.

The reviewer also noted that for the Michigan project, the EV readiness plan has already been downloaded 173 times as of March 2013.

Reviewer 6:

The reviewer noted that electricity uses essentially no oil, so selling kWh to provide transportation services meets DOE objectives.

Reviewer 7:

The reviewer agreed that both projects supported DOE's petroleum displacement goal.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

Regarding the Michigan project, resources provided for the project were adequate to meet project needs.

Regarding the Ohio project, resources provided were adequate to meet project needs: commitment of cost-share (not required) was a positive contribution to the project.

Reviewer 2:

The reviewer commented that both budgets were about the same and the plans appeared to be well-thought out.

Reviewer 3:

The reviewer found that funding levels on both projects were sufficient and will be all costed by the completion of the efforts.

Reviewer 4:

The reviewer found that it appeared that funds were used in an efficient and effective manner.

Reviewer 5:

The reviewer commented that the projects were complete.

Reviewer 6:

The reviewer commented that Michigan's accomplishments were timely.

Reviewer 7:

The reviewer remarked that the Michigan project was complete, with about 5% of funds left, so resources seemed sufficient.

The reviewer concluded that the Ohio project was complete, with as much as 25% of funds left (as of March), so resources seemed sufficient. The reviewer expressed concern as to whether all the funding would be spent, though due to the cost-share, it is possible that the funds remaining will be the non-DOE funds [DOE Program Clarification: It is important to note that final invoicing had not taken place at the time this presentation was submitted.].

EV Community Readiness projects: South Florida Regional Planning Council; Virginia Department of Mines, Minerals and Energy: Darren Stevenson (National Energy Technology Laboratory) - ti033

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found that both projects provided a solid foundation for EV deployment activities in Southeast Florida and Richmond. The reviewer found that technical barriers were addressed in both plans. The reviewer really liked the Southeast Florida plan because it combined a plan for the Southeastern part of the state and a specific corridor.

Reviewer 2:

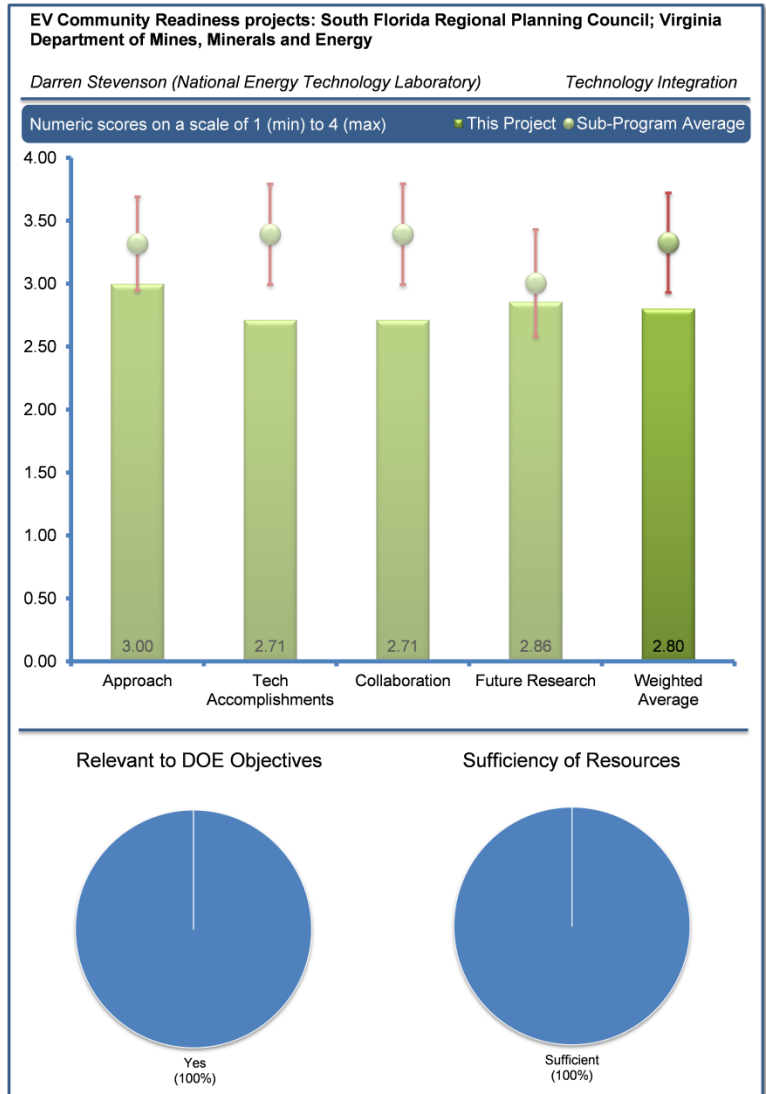
The reviewer commented that the Richmond Electric Vehicle Initiative (REVi) developed a successful four-phase program to gather information in support of the development of their Electric Vehicle Readiness Plan. A major component of the work that was done in this effort was related to public outreach, including creating an electric vehicle information hotline, developing marketing material, and educating the stakeholders and public. The reviewer found that these activities were important to the success of an EV program.

The reviewer detailed that a comprehensive approach was developed by the Drive Electric Florida project. The seven tasks outlined in the effort provided an excellent basis to develop the final output of the REVi Readiness Plan and the development of a U.S. Route 1 Clean Transportation Corridor Project.

The reviewer concluded that both plans identified and addressed the barriers to the EVs in their communities.

Reviewer 3:

Regarding the Florida project, the reviewer commented that the emphasis of the project was to develop a community readiness plan, as well as to develop a specific mass transit corridor plan. A key focus was to work with fleets on EV adoption and infrastructure siting. The reviewer commented that the project also addressed codes/permitting/policies. In particular, the team attempted to take advantage of their natural advantages for the project, such as large numbers of tourists, in order to expose a greater population to EV technologies (such as through rental car companies and mass transit). The reviewer noted that the Florida climate was considered by many to be favorable for EVs, so projections under the project were for significant potential for market penetrations.



The reviewer commented that the Virginia project was focused on planning and implementation, with a significant emphasis on outreach. The team worked to develop siting and ADA guides.

Reviewer 4:

Regarding the Florida project, the reviewer commented that the overall strategy in the statement of project objectives was reasonable. The project team was addressing fleet users (PI noted that the team conducted a survey of about 200 fleets and 20 responded, with 11 being interested in exploring EVs for their fleets). Codes and permitting are addressed as well; these were particularly important. The reviewer noted that as with other projects in this series, the team performed an analysis of the local EV landscape, but this strategy included a scorecard of the number of EVs in each area for now and the future (seemed to be a unique aspect of this project). The reviewer found that the project was also setting the groundwork for a future U.S. Route 1 EV demonstration project, which is useful.

Regarding Virginia, the reviewer commented that this project focused only on the Richmond area of Virginia. The strategy outlined in the presentation appeared logical, and addressed the basic needs of an EV/EVSE plan, including materials for charging station site design (a useful addition). The reviewer noted that the formal conference to share the plan results is a good idea for disseminating project information.

Reviewer 5:

The reviewer noted that this review covered two projects: Florida Gold Coast Sustainable Community planning for EV and Charging Infrastructure; and REVi.

Regarding the Florida project, the reviewer commented that the project's objective was to create a community-based electric vehicle infrastructure readiness plan. The two-part plan included a plan for Southeastern Florida and a future demonstration project along U.S. Route 1 mass transit corridor in Miami-Dade County. The reviewer noted that the approach included outreach to fleet managers, a review of local government codes and permitting, and an infrastructure selection and siting analysis. Recommendations were made for updates to local government regulations. The project drew upon an existing network of stakeholders and included plans for outreach and education.

Regarding REVi, the reviewer noted that the project's objective was to develop an EV readiness plan for the city of Richmond, Virginia. The reviewer noted that this project targeted a much smaller geographic area than some of the other projects funded under the same solicitation.

Reviewer 6:

Regarding the Florida Gold Coast Community Planning, the reviewer remarked that the project was 100% complete, with \$18,000 left to be spent on outreach. The main partners included Florida Power and Light (FPL), Hertz, and CALSTART.

Regarding the REVi, the reviewer commented that the project was 90% complete. The reviewer noted a total plan and recommendation that was available on both the Richmond and Clean Cities websites. The reviewer also noted \$70,000 was left for the project to draw down. The project team could continue work until June 30 and have 90 days from then to draw funds.

The reviewer commented that both projects would pursue additional funding for implementation. Richmond was selected as a roll-out for the Ford Focus.

The reviewer concluded that both have generated interest from wide variety of partners but may also benefit from reaching out to the USGBC for LEED rating and ENERGY STAR for inclusion and incentives in the energy use guide.

Reviewer 7:

The reviewer noted that the two projects were disparate in location, separated by several states. The Florida project was very unique with respect to its focus on a high density of multi-family high rise buildings on a corridor close to an ocean bay. The reviewer commented that the project did not integrate well with other efforts. The only comparable location might be Honolulu. The reviewer commented that the Virginia project focused on only one metro area. There was limited evidence of a desire to make the work applicable to other areas in the state. The reviewer remarked that both were good in the sense that utilities were partners from the start.

The reviewer noted that one OEM and one major rental fleet was a partner at the start in the Florida project, while Richmond did not have either. The reviewer concluded that neither project had EVSE or EVSE installers involved as initial partners.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer found that the Drive Electric Florida project successfully completed a variety of milestones over the duration of the project. The data gathering and project outreach in year one provided necessary information to help with the development of their plan. The reviewer determined that the eight fact sheets and the Fleet Manual Toolkit in addition to two published volumes of the Getting Southeast Florida Plug-in Ready were very good accomplishments.

The reviewer remarked that in addition to the REVi Readiness Plan that was completed in this project, the effort specifically included planning zoning and development guidelines, information regarding siting electric vehicle charging stations, signage guidelines and policy recommendations.

The reviewer concluded that both projects included new construction, workplace and housing requirements for electric charging through building codes, which was a very important issue.

Reviewer 2:

Regarding the Florida project, the reviewer noted that this project employed a five-phase approach to the completion of an EV readiness plan. The final deliverable was a two-volume plan covering: the summary of recommendations and strategies for southeast Florida; and the U.S. Route 1 corridor project. Numerous fact sheets were developed in addition to the plan, which will help magnify the impact of the project. Other deliverables included a template for model zoning code and a fleet manual toolkit. The project was more than 90% complete as of the date of the review.

Regarding REVi, the reviewer commented that this project was more than 90% complete as of the date of the review. The project included planning, zoning and development guidelines. The reviewer noted that the PI worked with partners to develop signage guidelines. In addition to the plan, the project employed a variety of other outreach tools (e.g., website video, outreach at vehicle shows, and news articles). The reviewer complimented that the effort to get information into the public domain was a strength of the project.

Reviewer 3:

For the Florida project, the reviewer described that the project's plan is for future demonstration along the U.S. Route 1 mass transit corridor in Miami-Dade County.

The reviewer detailed that the approach is to promote fleets' EV adoption. The project surveyed 200 fleets with only 20 respondents. The project team needs to continue to reach out to fleets. The project reviewed local government codes and made recommendations. The reviewer detailed that the project identified opportunities for smart grids, and the total plan is in two volumes. First is the recommendations and strategies for the area. The reviewer noted that Volume Two looks closer at the U.S. Route 1 corridor project, which has a high tourist traffic and local population. The reviewer detailed that by the year 2022, can have 200,000 EVs on the road. The project prepared fact sheets to hand out (myths and facts, siting PEV charging, etc.) and prepared a template for model zoning code and a fleet manual toolkit. The reviewer noted that the project is also working with a rental car company.

Regarding the Richmond project, the reviewer detailed that the project convened an advisory board and workgroup to integrate EV policy and incentives, and to advise state and local governments.

The reviewer found that both projects have done an outstanding job in identifying approaches that would yield the highest success for each given region. The reviewer noted that Virginia has also addressed charging for people with disabilities. This could be useful to other planners in other regions as well.

Reviewer 4:

Regarding the Florida project, the reviewer noted that the team appears to have completed all planned activities, including the report (plan) at the end of March 2013. The report included recommendations (Volume One) and corridor planning (Volume Two). The reviewer noted that recommendations specifically included policy changes, including zoning/permitting, government procurement, and others. The reviewer noted that the project also developed key outreach materials to influence consumers and decision-makers, including assembling a fleet manual toolkit (including standard Clean Cities materials plus fact sheets developed for this project).

Regarding the Virginia project, the reviewer commented that the team appears to have completed all planned activities. In particular, the team developed key technical documents to assist in installing/siting EVSE. The project also conducted numerous outreach activities, as well as development of policy recommendations.

Reviewer 5:

The reviewer found that the development of fact sheets for the Southeast Florida project was very effective and helped communicate the information to stakeholders and the public.

The reviewer found that the Business Case Forum related to the Richmond project was a very innovative way to convince potential EV buyers that it made economic sense to own/lease an EV.

Reviewer 6:

Regarding the Florida project, the reviewer noted that a two-volume plan was developed: Volume One included both statewide recommendations and regional discussion for Southeast Florida. The Southeast Florida discussion included good infographics and maps, along with forecasts of PEV implementation. The reviewer noted that these infographic resources were repeated for each county in the region as well. The reviewer commented that among the useful information collected as part of the planning efforts is that Florida residents typically travel less than 40 miles/day, which is good for PEVs. A series of fact sheets (two to four pages) are also available to the public: these address important issues related to PEV deployment (such as EV myths, EV readiness for multi-unit dwellings, workplace charging). The reviewer found that the project team also described a specific fleet toolkit and further opined that this is good for addressing fleet concerns about EVs. The reviewer commented that the U.S. Route 1 corridor plan is a positive aspect of this proposal and that it outlines specific activities to develop an electric vehicle car-sharing system near mass transit.

Regarding the Virginia project, the reviewer cautioned that based on funding used as of March 1, the project appeared to be somewhat behind in the completion of tasks. The project team's meeting about business case for EVSE included the Mayor of Richmond, who participated in the ceremony for the first official plug-in of a downtown station. The reviewer commented that the outreach appeared to be a major part of this project. The reviewer detailed that the project also addressed electric vehicle charging station siting and EV charging for persons with disabilities (both in collaboration with Clean Fuels Ohio's EV project), and that these would be useful shared documents.

Reviewer 7:

The reviewer commented that a major goal of the Florida project was to engage up to seven fleets. One fleet was listed as a partner at the beginning, but in the collaborations slide, that no fleets were mentioned. The reviewer pointed out that no fleet installations were highlighted in the presentation. The reviewer commented that for a project that intended to focus on fleets, the consumer survey information in the presentation was misplaced because it characterized individuals and households rather than fleets owned by businesses. In the presentation it was stated that fleets had been surveyed and some had responded. The reviewer commented that unfortunately, none were described as collaborators. Similarly, there was no mention of collaboration with either developers or operators of any multi-family apartment or condo complexes.

The reviewer commented that according to the presentation, Richmond similarly did not appear to have engaged enough stakeholders. However, the plan did provide a long list of partners that was suitably diverse. The reviewer stated that the plan was relatively short with considerably less detail per dollar of expenditure than many other projects. The reviewer noted that it appeared that the project

manager was not familiar with PEVs at the outset and had to attend functions at locations outside Richmond in order to learn and obtain information.

The reviewer noted that the plan was brief, and it covered desirable topics. The reviewer found that it might merit a good rating if it had listed many web links to sources that would assist communities, EVSE installers, code designers, architects PEV purchase intenders and so forth. However, it did not do so. The reviewer observed that Ford did choose to release its first Focus electric in Richmond, according to the presentation. The reviewer complimented that the subcontract on ADA compliance and needs of disabled persons is to be commended, and is a good contribution to the state of knowledge. The reviewer noted that it was unfortunate that the presentation did not list Richmond's collaboration with Clean Fuels Ohio and NYSERDA on the two charge point facility design documents. The Richmond plan did dig further into spatial detail than other projects concerning the probable evolution of the Richmond metro area, including an examination of the most probable locations for charge point installations in new growth areas, where it is much less expensive to install charge points (compared to retrofits).

The reviewer observed that the Florida plan was considerably more lengthy and detailed than the Richmond plan. It does include a much more extensive use of web links, so it has greater potential to lead readers in the right direction regarding specifics. The reviewer explained that whereas other projects include survey results, the absence of a discussion or presentation of the fleet survey results and implications was unfortunate. While seven counties are listed as collaborators, it seemed inappropriate that a corridor plan for a short segment of highway in only one of the seven counties was a highlight of the plan. The reviewer cautioned that if this corridor plan does end up as a failure (too early to draw that conclusion), the finding may be a significant contribution in a negative sense, by illustrating that this was not a good strategy for introducing PEVs.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the Drive Electric Florida project has a very comprehensive list of collaborators, including Clean Cities Coalitions and other state and local government agencies.

The reviewer commented that the Richmond Electric Vehicle Initiative is collaborating with a variety of state and local governments as well the local Clean Cities coalition and over 50 additional institutions.

Reviewer 2:

Regarding the Florida project, the reviewer noted that partners primarily included utilities, a rental car company, an automaker, and local governments.

Regarding the Virginia project, the reviewer noted that primary partners included a utility, a university, and local planning organizations. Overall, the project included over 50 collaborators.

Reviewer 3:

The reviewer noted that the Florida project is working with rental car companies, utilities, and fleets.

Regarding the Richmond project, the reviewer noted that the project partnered with the Richmond Mayor, and local Michael Phillips (Virginia Clean Cities) to promote EVs. Outreach is a big part of the work in addition to developing zoning guidelines. The reviewer also noted EV charging for people with disabilities handbook.

The reviewer found that both projects had very good partners, but the reviewer recommended that the projects work with buildings to ensure the correct education, rating system, and incentives were in place. This could be part of the education and outreach but has to start through collaboration.

Reviewer 4:

The reviewer commented that the Florida plan had district DOTs and MPO involved in the project, but would have benefited from having a state DOT representative as well.

The reviewer noted that the Richmond plan had the MPO involved, but could have also benefited from having a representative from the state DOT.

The reviewer complimented that the Richmond project did an excellent job of attracting interest from local politicians and the media.

Reviewer 5:

Regarding the Florida project, the reviewer found that partners and collaborators were adequate, and included a rental car company (very pertinent given the large tourism industry in South Florida). The local utility worked closely with the coalition to administer the project. The reviewer noted that the collaborators included many local municipalities in South Florida, but not many private organizations or state agencies (with the exception of DOT). Project collaborators also included the Central Florida Clean Cities Coalition.

The reviewer found that the Virginia project partners included the Department of Mines, Minerals and Energy (DMME), the local electric utility, several local governments (covering the major cities and counties in the region), and a local community college – reasonable partners for this effort. The reviewer noted that the collaboration list was a bit sparse on private companies (at least as listed in the presentation).

Reviewer 6:

Regarding the Florida project, the reviewer noted that the project included collaboration with Clean Cities coalitions, Florida DOT, and local governments and agencies. The reviewer voiced uncertainty about the degree of collaboration with listed partners, including OEMs.

Regarding REVi, the reviewer commented that the project includes collaborations with a broad range of other institutions including Clean Cities coalitions, municipalities, utilities, and other institutions. The reviewer noted that the project did not seem to have included OEMs in the project, but did include a major utility (Dominion Virginia Power).

Reviewer 7:

The reviewer commented that these two projects show little productive collaboration with industry partners, universities, or laboratories.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that although these projects did not receive any follow-on funding from DOE to implement EVs, both projects still had plans to do future work. It is a very positive sign from both communities that these projects will still have activities in this area even without additional funding.

Reviewer 2:

Regarding the Florida project, the reviewer noted that the project is nearly complete. The team will continue activities through its Clean Cities efforts, and look for additional funding.

Regarding the Virginia project, the reviewer noted that the project is nearly complete. The team is planning to continue implementation, even though it received no follow-on award from Clean Cities. The project is planning to continue through its normal Clean Cities activities.

Reviewer 3:

The reviewer found that both of these projects are near completion. Proposed future work is an appropriate build on to existing activities.

Regarding the Florida project, the reviewer commented that the future work proposed includes continued collaboration with Clean Cities coalitions and implementation of the U.S. Route 1 corridor master plan.

Reviewer 4:

The reviewer commented that both projects were the right to get things rolling toward implementation. The reviewer suggested boosting incentive programs a little more (see previous comment).

Reviewer 5:

The reviewer encouraged Southeast Florida to pursue the U.S. Route 1 Clean Transportation Corridor deployment approach if future funding is secured. Also, the reviewer encouraged research on smart grid and solar deployment opportunities.

The reviewer encouraged Richmond to collaborate with the I-95 Corridor coalition to expand EV charging infrastructure to the Interstate.

Reviewer 6:

The reviewer commented that the Florida project's proposed future research is appropriate, but did not seem to match the considerable funding remaining (25% remaining as of March). The reviewer pointed out that the U.S. Route 1 corridor project implementation will depend on additional funding, which is being sought but has not been secured as yet.

Regarding the Virginia project, the reviewer noted that future work to complete the project is appropriate and noted a focus on outreach and implementation. The reviewer commented that the Team is seeking other sources of funding, but nothing has been located yet.

Reviewer 7:

The reviewer commented that in the case of Richmond, the pathway problem is that production was too slow and too much remained to be done on codes and standards, working with the state and localities. This is recognized, but the reviewer cautioned that the project may not have the time to do it effectively. Working on signage also seemed reasonable.

The reviewer commented that in the case of South Florida, the same needs as in Richmond appeared to exist. However, there may not be an alternate pathway to promotion of PEV ownership in the region, given the strong need to find fleet and multi-family stakeholders and partners willing to commit to PEVs. The reviewer stated that this seemed to be a dead end, perhaps because this was not a financially viable location to promote PEVs. The project leader had pointed out that the share of PEV sales in Florida as a whole was relatively high on a percentage basis, but was is no comparison in the presentation of PEV success rates in this region relative to the rest of Florida, and no discussion of why. The reviewer commented that the image chosen for the plan cover was ironic – a speeding car on a limited access highway with trees beside the highway. The reviewer indicated that the plan was full of will do statements rather than have done examples and lessons.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer found that both projects supported the DOE goal of petroleum displacement.

Reviewer 2:

The reviewer commented that these projects lead to petroleum displacement and can be coupled with energy use for buildings. Because electricity can come from renewable sources such as wind and solar these projects have long-term potential and were highly sustainable.

Reviewer 3:

The reviewer commented that the development of an EV Readiness Plan definitely supported the overall objective of DOE to promote petroleum displacement. By having a plan ready, the community would be ready to implement the use of EVs when future projects and funding are available for deployments of EVs.

Reviewer 4:

The reviewer stated that the Florida project is relevant to the Clean Cities petroleum displacement goals and barriers identified within the presentation.

The reviewer stated that the Virginia project addresses Clean Cities goals and barriers related to petroleum displacement and electric vehicle technologies.

Reviewer 5:

The reviewer commented that the Florida project is addressing plug-in vehicle availability, information, and technical experience.

Regarding the Virginia project, the reviewer stated the project addressed the same goals as Florida.

Reviewer 6:

The reviewer remarked that electricity does not use oil.

Reviewer 7:

The reviewer commented that both of these projects indirectly supported the DOE objectives of petroleum displacement through creating community readiness plans for EVs. The adoption of EVs in these states would lead to displacement of internal combustion engine vehicles that run on petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that resources were enough to produce quality work that would yield results.

Reviewer 2:

Regarding the Florida project, the reviewer commented that resources appeared adequate to complete the work outlined for the project.

Regarding the Virginia project, the reviewer remarked that resources appeared adequate to complete the statement of work; the cost-share contribution was a positive for this project.

Reviewer 3:

The reviewer remarked that both projects seemed to have sufficient funding and although the projects had not spent all of their funding to date, by the end of the project the projects anticipated all funds would be spent.

Reviewer 4:

The reviewer commented that the Florida project was nearly complete, with nearly all funding spent, so resources appeared sufficient.

The reviewer remarked that the Virginia project was nearly complete with 80% spent, so resources appeared sufficient (but there were concerns on all DOE funds getting spent by the end).

Reviewer 5:

The reviewer commented that it appeared that funding was sufficient and was used efficiently and effectively.

Reviewer 6:

Regarding REVi, the reviewer remarked that this project was 90% complete as of the review date, but had only drawn down 50-60% of available funds. The reviewer noted that this may have been indicative of delayed invoicing or that resources were excessive for the work completed [DOE Program Clarification: It is important to note that final invoicing had not taken place at the time this presentation was submitted.].

EV Community Readiness projects: Center for Transportation and the Environment (GA, AL, SC); Centralina Council of Governments (NC): Trev Hall (National Energy Technology Laboratory) - ti034

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

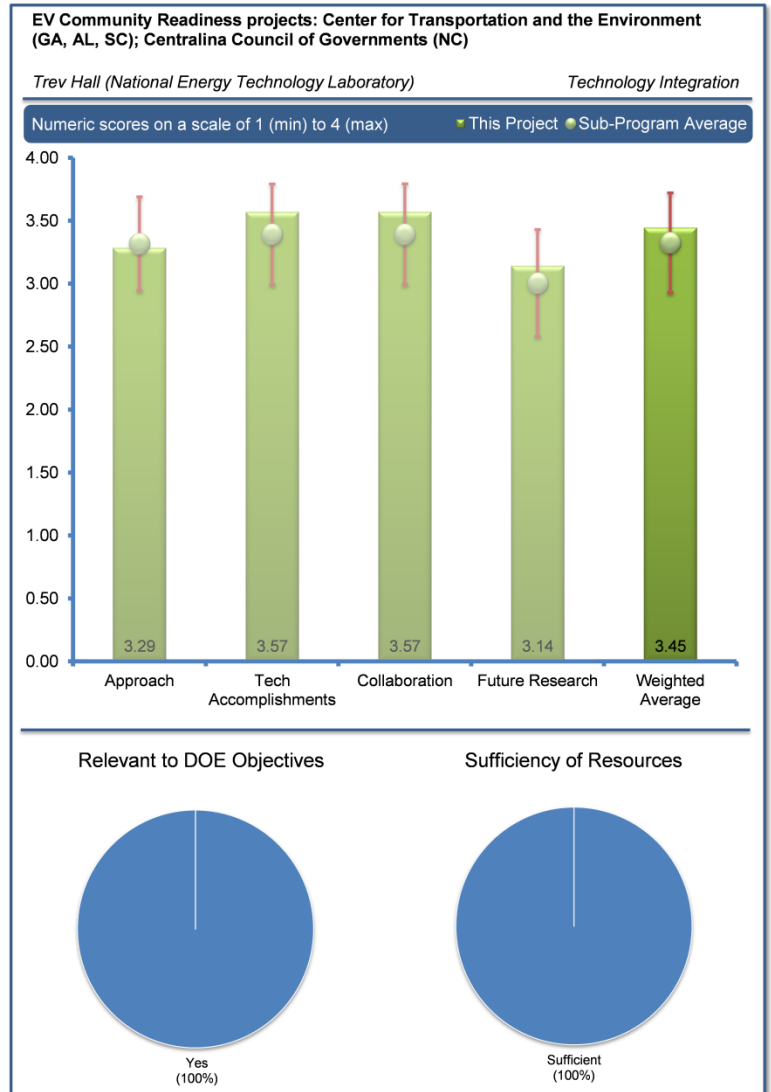
Reviewer 1:

Regarding the Center for Transportation and the Environment (CTE) project, the reviewer noted that the project covered three states (i.e., South Carolina, Georgia, and Alabama). There was appropriate focus on stakeholder awareness through workshops and outreach efforts. The reviewer commented that conferences, legislative updates, and pilot program outreach were key stakeholder interactions. EV demographic analysis with demand forecast, demand analysis, and EVSE/geographic information system (GIS) analysis assisted with planning efforts. The reviewer found that it was valuable to include grid impacts and smart grid in the analysis efforts. Pilot implementation of plans was good (i.e., test plans, see how well they work, and gather feedback to improve final products). The reviewer commented that the communications plan and templates were included in planning efforts, which is important in a multi-state project. The reviewer noted that the team conducted a prioritization of outreach activities because of a large number of participants.

For the North Carolina statewide project, the reviewer observed a good use of DOE funds to cover a broad area, and a very detailed and organized list of barriers to PEV readiness, identified through a symposium with stakeholders (good way to collect a comprehensive list of barriers to address at start of project). The reviewer noted the project recruited community stakeholders – get local perspective and participation in implementation efforts. The community planning matrix that was customized to specific community needs was good, and also focused the task force on topics of most relevance. The reviewer commented that an EV driver cannot do the mountains to sea trip right now, but the state was working on it. This reviewer pointed out that there are 540 miles between mountains and sea across the state.

Reviewer 2:

The reviewer indicated that the Southeast Regional program developed a five-phase approach with a variety of tasks to obtain information to allow the project to develop their readiness plan. EV demand and impact analysis and analysis of deployment barriers were an essential part of the approach in this project. The reviewer identified that stakeholder workshops were another very important part of the approach to developing the readiness plan.



The reviewer remarked that the North Carolina PEV readiness initiative's approach was a very well-planned effort. The effort included recruiting and coordinating stakeholder meeting and developing a North Carolina taskforce. The reviewer added that the information gathered from the outreach activities helped in the finalizing of the required output.

Reviewer 3:

The reviewer found that both study plans were appropriate for their respective region when considering the level of enthusiasm for and knowledge about PEV implementation in the Southeast. The reviewer noted that CTE's focus was more on the early development of knowledge and enthusiasm for state level planning, while Centralina was able to focus on three regions and the government and business organizations serving those regions, which represented 60% of the North Carolina population. The reviewer remarked that CTE was more top-down covering a wider region, while Centralina was middle-up (to the state level) and down (to the consumer).

Reviewer 4:

The reviewer commented that both plans addressed technical barriers and appeared to provide the necessary information/foundation for actual deployment activities in North Carolina and the Southeast. Both projects seemed to be well-defined and feasible for implementation.

Reviewer 5:

The reviewer noted that this review covered two projects: the Southeast EV readiness planning program; and the North Carolina PEV Readiness Initiative: Plugging in from Mountains to Sea.

Regarding the Southeast project, the reviewer commented that the project implemented a five-phase approach that included project initiation, analysis (EV demand and impact), analysis (deployment barriers and solutions), completion of the EV Readiness Plan, and communications and outreach. The reviewer noted that there was a focus on stakeholder awareness including consumers, fleet managers, facility managers, local governments, and utilities. Stakeholder engagement activities included workshops, conferences, etc.

The reviewer commented that the North Carolina project included the development of five separate plans for EV readiness – one statewide and four regional – and had a large focus on community stakeholder involvement. The reviewer detailed that there were three levels of stakeholder involvement: statewide, locally through community planning efforts, and topically through working groups. The project collaborated with a utility company to gather data on grid impact/considerations and developed a complete list of barriers to EV penetration.

Reviewer 6:

Regarding the Southeast project, the reviewer noted that the primary focus was on stakeholder awareness, including consumers, fleets, local governments, property/facility managers. Additional key elements emphasized were EVSE availability/accessibility/awareness, market potential, grid impacts, and permitting/zoning/signage. The reviewer noted that the plan was designed to address readiness, but also incorporated best practices for use by implementers. The reviewer noted that after the development of the plan, the project focused on outreach and communications, to continue engaging stakeholders.

The reviewer commented that the North Carolina project was focused on developing a state-wide plan as well as four regional plans. The team explicitly focused on recruiting stakeholders, with a key element of the project focused on outreach.

Reviewer 7:

Regarding the Southeast Regional EV Readiness planning program, the reviewer noted that the project is 90% complete and spent \$629,000 out of \$740,000 (as of 12/31/12). Further, this reviewer reported that mostly administrative costs remain.

The reviewer commented that the North Carolina project is 97% complete, and noted similar partners as the Southeastern project.

The reviewer indicated that both projects had a good approach for their locations. It would have been stronger if the projects had included USGBC and ENERGY STAR as well as more education on safety with first responders. Southeast included electrical contractors, which is very useful. The reviewer added that other regions may want to consider this as a good approach as they move forward.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer detailed that milestones met in the North Carolina PEV readiness initiative included stakeholder meetings in 15 communities and multiple statewide meetings provided the necessary input for the development of their readiness plan. The reviewer complimented that the project successfully created five PEV readiness planning documents.

The reviewer noted that the Southeast regional PEV readiness plan project successfully created and published the EV Deployment Readiness Plan and workbook.

Reviewer 2:

Regarding the CTE project, the reviewer noted that the EV Adoption in the Southeast study included grid impact analysis, EV sales forecasts, and EVSE placement, and described it as a significant accomplishment to feed EV planning work. The reviewer noted that the team also developed a three-volume EV Readiness Workbook, which includes a thorough examination of EV readiness, checklists for stakeholder groups, and other resources. The reviewer observed that a conference series was held with 200 attendees to present the Workbook in each of the three participating states (helpful to get the word out about resources available). The reviewer noted that project materials do not seem to be available on a central website: rather, each state provided the materials separately.

Regarding the North Carolina project, the reviewer commented a great value in having statewide plans as well as regional plans covering major metro areas. The reviewer noted that events and workshops reached more than 2,000 people (35 events), which was a good outreach effort.

Reviewer 3:

The reviewer commented that the Southeast project team completed all planned activities, including the plan in late March (in the form of a workbook). The team included several key findings while conducting research to support the plan. The reviewer commented that these findings influenced the development of plans for implementation, particularly as they impacted awareness issues. The team also developed detailed best practices. The reviewer identified that the team also conducted 10 outreach workshops, an EV Readiness Conference Series, and multiple Ride-and-Drives.

The reviewer commented that the North Carolina team appeared to have completed all planned efforts, although there were some efforts to continue revising the plan. Under this project, the team set up a multi-piece task force to address individual issue areas. The reviewer commented that the project activities completed included an extensive list of outreach events (35 in total).

Reviewer 4:

The reviewer commented that the Southeast plan included a task for smart grid analysis, which is very important when considering future electricity needs.

The reviewer liked the idea of the state-wide and regional components to the North Carolina plan. This provides a more comprehensive approach towards EV deployment within the state and from a regional perspective.

Reviewer 5:

Regarding the Southeast project, the reviewer noted that barriers addressed included awareness and education, EVSE availability, keys to reducing range anxiety, market potential, grid impact potential, and permitting and zoning. The reviewer noted that there was a good list of partners.

For the North Carolina project, the reviewer noted that safety, range, etc., were addressed.

The reviewer commented that the project supported local initiatives, that the community readiness plan was the biggest deliverable, and that the project developed a roadmap. The project took a multilateral approach – a regional as well as state-wide approach.

Reviewer 6:

The reviewer found that CTE's products included some excellent research on target markets. The reviewer noted that interesting real world examples of EVSE installation experience were included. Predictions of the most probable markets for the largest cities in Georgia and South Carolina were developed analytically. The reviewer observed that a plan evaluation was conducted with two smaller pilot cities in each state implemented. Conferences, workshops and ride and drives took place in each of the participating states. The reviewer noted that publications were readily accessed from the Atlanta Clean Cities website. The reviewer commented that CTE made good use of academic researchers for the assessment of barriers and markets, helping lay a foundation assuring that PEVs can be workable in the Southeast.

The reviewer commented that Centralina's project was very strong in engaging businesses to participate in workplace charging. Separate plans for four different regions were completed, as well as a state plan. The reviewer observed that while the logo emphasized intercity driving of PEVs across the state, this was not an emphasis of the project. The reviewer acknowledged that installation of EVSE at residences and businesses were emphasized. From a list of 10 initial partners, Centralina expanded involvement to 250 stakeholders, 25 of which received awards for their participation. The reviewer noted that technical community colleges were involved to implement training, and numerous stakeholder meetings were held (many dozens). The reviewer concluded that this was a grassroots effort.

Reviewer 7:

The reviewer noted that the Southeast project is 90% complete. Deliverables included a demand impact study and an EV readiness workbook. According to the reviewer, the PI noted that the demand impact study was a challenging task as demand was difficult to forecast. The reviewer commented that the project team looked at hybrid adoption rates and other innovative technology to help forecast EV demand. The study included a baseline and accelerated demand scenario and the associated impact on the grid, which included input from a utility (i.e., power company). The reviewer remarked that the EV Readiness Workbook was completed in 2012.

The reviewer noted that the North Carolina project is 97% complete. Five individual readiness plans were completed. The reviewer noted several outreach events, including trainings and workshops that were held over the course of the project. The reviewer noted that it was unclear from the presentation whether or how the other technical accomplishments highlighted were directly linked to the present study.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer remarked that the CTE presentation (Georgia, South Carolina, and Alabama) initial slide indicated 67 partners and ended with a list of 67 collaborators. The reviewer commented that this was an impressive number and its composition was excellent. The reviewer elaborated that Clean Cities coalitions, local and state agencies, NGOs, utilities, universities, EVSE suppliers and installers, automotive OEMs, and fleets were involved.

The reviewer noted that Centralina (North Carolina) started with only 10 partners, but ended working with 250 stakeholders. The reviewer observed that the extent and composition of the stakeholders, as listed in the plan, was even more impressive than for the CTE project.

Reviewer 2:

The reviewer commented that the CTE project's list of collaborators was quite extensive, and included all Clean Cities coalitions in the region, plus local utilities and regional planning boards, local municipalities, and several universities. The reviewer noted that the list of businesses included relevant vehicle OEMs and EVSE suppliers, along with several fleets. The reviewer concluded that this was a good list of organizations to support this project.

Regarding the North Carolina project, the reviewer noted a large list of more than 250 partners included in development of plan documents, including vehicle OEMs, universities, local planning organizations, municipalities, and others. The reviewer commented that it appeared the right people were involved in the work.

Reviewer 3:

The reviewer noted that both the Southeast Regional EV Readiness Planning Program and the Centralina Council of governments North Carolina PEV Readiness Initiative had an extensive list of partners and collaborators, which have helped to make their projects successful.

Reviewer 4:

The reviewer commented that for the Southeast project the collaboration list included a large list of coalitions, local/state governments, institutions, utilities, and businesses (approximately 65 in total).

The reviewer commented that for the North Carolina project, partners focused primarily upon local governments/planning organizations, as well as utilities and industry members. In particular, the task force included over 250 members.

Reviewer 5:

The reviewer commented that the Southeast project had collaboration/partnerships with Clean Cities coalitions. The reviewer found that the project included an impressive list of collaborators including a major utility company (Dominion).

The reviewer commented that the North Carolina project included a great list of collaborators, but that it was unclear whether there was any partnership with OEMs.

Reviewer 6:

The reviewer noted that the Southeast project's goal is to achieve a 2.5 billion gallon reduction of petroleum by 2020. The reviewer noted that the project conducted workshops and pilot programs to see if the proposed plan was viable and worth expanding on through a larger platform.

The reviewer commented that sharing the draft plan with experts early in the development phase was a really good approach to ensuring success later.

Reviewer 7:

The reviewer commented that the Southeast Regional Plan could have benefited from having expanded participation from the three state DOTs and multiple MPOs.

The reviewer commented that the North Carolina plan could have benefited from participation from the state DOT.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the CTE project's closeout work to finish the project is reasonable (i.e., update workbook and complete outreach). The reviewer noted that the slides indicate that the project efforts will continue through May 2014 as part of regular Clean Cities activities under that funding source.

Regarding the North Carolina project, the reviewer commented that the future work continued with the activities already started under the project appeared appropriate. The reviewer stated good plans for statewide webinars and PEV scorecard implementation, as well as workplace challenge activity.

Reviewer 2:

The reviewer commented that the activities for both projects will continue until May 2014, including updating the EV readiness workbook and to continue the on-going outreach and marketing programs for the Southeast Region EV readiness program.

The reviewer commented that the North Carolina PEV Readiness initiative will continue to work with over 250 stakeholders and host a series of webinars focused on implementation strategies recommended in the PEV roadmap.

The reviewer affirmed that it is very good that these communities will continue to work on their initiative without additional funding.

Reviewer 3:

The reviewer noted that the Southeast project is nearly complete. Some outreach is ongoing, and that the team is revising the Readiness Workbook. The team will continue efforts as part of coalition activities.

The reviewer noted that for the North Carolina project, activities were nearly complete. The team will continue outreach activities on their own (as part of Clean Cities). The task force will also continue to operate.

Reviewer 4:

The reviewer noted that the presentation indicated that both projects would continue to May 14, 2014, focusing on implementation and outreach, and taking advantage of the technical and organizational knowledge developed during the respective projects. The reviewer observed that continued involvement of most, if not all, stakeholders/collaborators is anticipated.

Reviewer 5:

The reviewer encouraged North Carolina to pursue the Mountains to Sea corridor approach for EV charging infrastructure deployment in any future research/implementation effort, and to coordinate with current and future EV deployment efforts in the Raleigh area.

Reviewer 6:

The reviewer remarked that both projects had identified that they would like to continue work after the project completion, and that plans build on the past progress.

For the Southeast project, the reviewer commented that future plans included continued work on the EV readiness workbook, continued ongoing outreach and marketing activities.

Reviewer 7:

The reviewer commented that the Southeast project's deliverables included a forecast of EV sales demand, placement analysis, and impact analysis. The reviewer noted a readiness workbook, which includes a checklist and a description of actions that each stakeholder should take in preparation for EVs. Lastly, the reviewer noted case studies, installation guides, model ordinances, and external resources availability to support EV readiness. The reviewer also noted that studies showed that charging during off-peak hours had no impact on the grid.

Regarding the North Carolina project, the reviewer noted that the project would like to continue the North Carolina PEV taskforce. The reviewer also commented recruit businesses through a charging outreach effort.

The reviewer remarked that both as part of their Clean Cities effort (no additional funding/grants awarded) that it may be useful to talk with city officials and construction companies to encourage and incentivize this project as part of the LEED rating system and energy use guides to generate more interest.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer remarked that the development of an EV Community Readiness Plan definitely supported the overall objective of DOE to promote petroleum displacement. By developing a plan, the community would be ready to implement the use of EVs when future projects and funding became available for the deployment of EVs.

Reviewer 2:

The reviewer commented that both of these projects indirectly supported the DOE objectives of petroleum displacement through creating community readiness plans for EVs. The adoption of EVs in these states would lead to displacement of internal combustion engine vehicles that run on petroleum.

Reviewer 3:

The reviewer noted that the CTE project is addressing the petroleum displacement goals of Clean Cities, and barriers outlined by the project team.

The reviewer commented that the North Carolina project addressed the barriers and petroleum displacement goals of Clean Cities.

Reviewer 4:

The reviewer noted that electricity generation used almost no oil, so substitution of electricity for gasoline met DOE objectives.

Reviewer 5:

The reviewer remarked that Southeast focused on availability/information on EVSE, stakeholder education, market penetration, grid impacts, and permitting/zoning.

The reviewer noted that the North Carolina project focused on incentives, education/outreach, infrastructure, and policies/codes/standards.

Reviewer 6:

The reviewer commented that both projects supported DOE's petroleum displacement goal.

Reviewer 7:

The reviewer commented that the projects reduced GHG, petroleum, noise pollution, and could also lead to further innovation and self-reliance through on site electricity generation or rebates for clean energy.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer commented that both projects brought co-funding and made use of it. The reviewer observed that the Southeast Region project had spent 85% of total available funds, but more than DOE provided. The reviewer found that the North Carolina project also had spent more than the funds that DOE provided and had spent 97% of the available funds. The reviewer pointed out that both projects were to be commended for obtaining and making use of funds beyond those provided by DOE.

Reviewer 2:

The reviewer indicated that the funding was at the right level to create plans that have very good potential in accelerating EV adoption.

Reviewer 3:

The reviewer commented that resources appeared sufficient to address the tasks outlined for the CTE project and that inclusion of cost-share was a positive aspect for the project.

The reviewer noted that for the North Carolina project, resources were sufficient to complete project tasks, and it was good to have cost-share included (not required by funding opportunity).

Reviewer 4:

The reviewer commented that the funds are sufficient for this project and should all be spent by the conclusion of the project.

Reviewer 5:

The reviewer commented that for the Southeast project, resources appeared sufficient.

The reviewer commented that for the North Carolina project, the activities were largely complete, with funding largely spent out, so resources were probably fine.

Reviewer 6:

The reviewer commented that it appeared that funding was sufficient and used effectively and efficiently.

Acronyms and Abbreviations

Acronym	Definition
ADA	Americans with Disabilities Act
AFV	Alternative Fuel Vehicle
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ARRA	American Recovery and Reinvestment Act
AXP	Automotive X-Prize
BAAQMD	Bay Area Air Quality Management District
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board
CCET	Center for Commercialization of Electric Technologies
CEC	California Energy Commission
CEC	Clean Energy Coalition
CEO	Colorado Energy Office
CMAQ	Congestion Mitigation and Air Quality Program
COG	Councils of Government
CTE	Center for Transportation and the Environment
CUICAR	Clemson University International Center for Automotive Research
DC	Direct Current
DMME	Department of Mines, Minerals and Energy (Virginia)
DOE	U.S. Department of Energy
DOL	U.S. Department of Labor
DOT	Department of Transportation
DPWs	Department of Public Works
DVRPC	Delaware Valley Regional Planning Commission
EPA	Environmental Protection Agency
EPAct	Energy Policy Act
EPRI	Electric Power Research Institute
ERCOT	Electric Reliability Council of Texas
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FEVER	Fostering Electric Vehicle Expansion to the Rockies
FPL	Florida Power and Light
GATE	Graduate Automotive Technology Education
GHG	Greenhouse Gases
GIS	Geographic Information Systems
GM	General Motors Corporation
HADA	Hawai'i Auto Dealers Association

Acronym	Definition
HEPF	Hawai'i Energy Policy Forum
HERDV	Hawai'i Renewable Energy Development Venture
HEV	Hybrid Electric Vehicle
HEVN	Hawaiian Electric Vehicle Network
HNEI	Hawai'i Natural Energy Institute
HOA	Home Owners Associations
IAB	Industry Advisory Board
IBEW	International Brotherhood of Electrical Workers
kWh	Kilowatt-hours
LEED	Leadership in Energy and Environmental Design
MEC	Metropolitan Energy Center
MEO	Maui Economic Opportunity, Inc.
MHLA	Maui Hotel and Lodging Association
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
MUD	Multi-Unit Dwelling
NASEO	National Association of State Energy Officials
NGOs	Non-Government Organizations
NREL	National Renewable Energy Laboratory
NYCLHVCC	New York City and Lower Hudson Valley Clean Communities, Inc.
NYPA	New York Power Authority
NYSERDA	New York State Energy Research and Development Authority
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
OSU	Ohio State University
PEV	Plug-in electric vehicle
PI	Principal Investigator
PSC	Public Service Commission
PUC	Public Utilities Commission
Q&A	Question and Answer
R&D	Research and Development
RAQC	Regional Air Quality Council
REVi	Richmond Electric Vehicle Initiative
RGGI	Regional Greenhouse Gas Initiative
SCAQMD	South Coast Air Quality Management District
SAE	Society of Automotive Engineers
SOW	Statement of Work
STEM	Science, Technology, Engineering, and Math
TCI	Transportation Climate Initiative
UH	University of Hawai'i

Acronym	Definition
UM	University of Michigan
UMTRI	University of Michigan Transportation Research Institute
USGBC	U.S. Green Building Council
UCCS	University of Colorado-Colorado Springs
V2G	Vehicle-to-grid
VTO	Vehicle Technologies Office
ZEV	Zero-Emissions Vehicle

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9. Vehicle Analysis

The Vehicle Analysis (VAN) subprogram provides testing and analysis relevant to the Vehicle Technologies Office (VTO). The subprogram mission is to plan, execute, and communicate technology, societal, economic, and interdisciplinary analyses for the U.S. Department of Energy (DOE), the Office of Energy Efficiency and Renewable Energy (EERE), VTO, and external stakeholders. Overarching activities within this subprogram serve to develop and deploy vehicle technologies that reduce the use of petroleum while maintaining performance, power, and comfort, and help people access and use efficient, clean vehicles that meet their transportation needs. VAN subprogram activities include the following.

- Model, test, and validate vehicle components within virtual systems before they are used in actual vehicles.
- Conduct statistical research on energy use and transportation with National Laboratories and other federal agencies.
- Provide software tools to industry for vehicle simulation, technology evaluation, economic modeling, and transportation emissions measurement.

The VAN subprogram envisions providing a robust transportation energy analysis by focusing on five research areas:

- **Macroeconomic Accounting:** Using models and tools such as VISION +, the VAN subprogram is currently updating baseline scenarios to match historical and AEO-projected future data; expanding the tool set to novel analysis modes (e.g., off-highway); and designing and executing integrated, coherent, macroeconomic analysis scenarios that examine and estimate VTO technology research and development (R&D) benefits.
- **Market Penetration and Consumer Behavior:** Using models and tools such as Market Assessment of Advanced Automotive Technologies (MA3T), Automotive Deployment Options Projection Tool (ADOPT), VCM, SEDS, and TRUCK, the VAN subprogram is coordinating four vehicle choice models (VCMs) for suite operation using common input; refining range-anxiety research for incorporation into models; and estimating market penetration scenarios for input to various analyses.
- **Emissions and Environmental Modeling:** Using models and tools such as the Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation (GREET) model, the VAN subprogram is currently providing input to and publishing a DOE well-to-wheel (WTW) official Program Record; researching and incorporating facility/infrastructure cycle data; and developing “GREET.net” further—a user-friendly software platform.
- **Vehicle Modeling:** Using models and tools such as Autonomie, FASTSim, and HTEB, the VAN subprogram is currently calculating vehicle cost-performance pair meta-data, establishing VTO inputs for official EERE Low-Carbon Scenarios, and facilitating a DOE Levelized Cost of Driving (LCD) Official Program Record.
- **Technology and Market Data:** Using models and tools such as TEDB, xEVdata, and the SRA database, the VAN subprogram published the Transportation Energy Data Book (31st Edition), tracks and publishes xEV sales domestically and abroad, and is developing a database to test the economic effects on vehicle sales.

The long-term VAN subprogram R&D strategy in each of the five various areas of research is:

- **Macroeconomic Accounting:** author and publish benefit metrics and methodology, and to prepare and execute iterative analytical updates as VTO goals, targets, and milestones are updated.
- **Market Penetration and Consumer Behavior:** cross-validate VCMs via suite operation; incorporate two additional vehicle choice models for a more robust market penetration “triangulation”; expand VCM dialogue by engaging with experts beyond the DOE community; and to compare and refine the models accordingly.
- **Emissions and Environmental Modeling:** continue the expansion of GREET.net user-friendly graphical user interface (GUI); research and refine “back-end” infrastructure and facility data; and to formally begin a vehicle-fuel pathway water footprint modeling.
- **Vehicle Modeling:** continue development of user-friendly vehicle characteristics GUI and diagnostic metrics; author and publish results and methodology documentation; and to leverage vehicle characteristic meta-data into a family of spin-off publications.

- Simulation and Technology Market Data: continue updating and disseminating data sources regularly; expand market knowledge with third-party data; and to distill and publish robust economic effects affecting and related to vehicle sales.

Subprogram Feedback

DOE welcomed optional feedback on the overall technical subprogram areas presented during the 2013 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area who volunteered to provide subprogram overview comments responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1: Was the subprogram area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Question 3: Does the subprogram area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Office's needs?

Question 4: Other Comments.

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc., as reviewer responses were optional.

Subprogram Overview Comments: Jacob Ward (U.S. Department of Energy) – van000

Question 1: Was the sub-program area adequately covered? Were important issues and challenges identified? Was progress clearly presented in comparison to the previous year?

Reviewer 1:

The reviewer indicated yes, and added that the analysis projects were critical to determining where to allocate R&D funding.

Reviewer 2:

The reviewer reported that the area was well covered, and added that progress was clearly presented in comparison to the previous year.

Question 2: Are plans identified for addressing issues and challenges? Are there gaps in the project portfolio?

Reviewer 1:

The reviewer confirmed that the plans were identified well. This reviewer added that there was no real discussion of gaps in the project portfolio, but that it was hard to cover all of the areas in 15 minutes. This reviewer added that perhaps there were not any gaps as this was a relatively mature program area.

Reviewer 2:

The reviewer noted that there was a heavy emphasis on vehicle choice modeling. This reviewer suggested that it might be useful to add some emphasis on collaborations that would evaluate data from the current alternative-vehicle demonstration projects (and American Recovery and Reinvestment Act [ARRA] projects) as well as CA projects.

Question 3: Does the sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program's needs?

Reviewer 1:

The reviewer felt that yes, this was a mature, clearly focused area and appeared to be well managed.

Reviewer 2:

The reviewer asserted that this was an important component of the VTO.

Question 4: Other Comments

No comments were received in response to this question.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, as well as numeric scoring responses (*on a scale of 1 to 4*). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A summary table presenting the average numeric score for each question for each project is presented below.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Analysis of Vehicle Technologies and Reduction of Oil Use and GHG Emissions	Tom Stephens (Argonne National Laboratory)	9-5	3.40	3.20	3.20	3.60	3.30
WTW Analysis of Vehicle/Fuel Systems and GREET Development	Michael Wang (Argonne National Laboratory)	9-8	4.00	3.50	3.50	3.50	3.63
Consumer Vehicle Technology Data	Mark Singer (National Renewable Energy Laboratory)	9-11	3.00	2.50	2.50	2.83	2.67
Analytical Modeling Linking the FASTSim and ADOPT Software Tools	Aaron Brooker (National Renewable Energy Laboratory)	9-15	3.33	3.33	3.33	3.33	3.33
Updating and Enhancing the MA3T Vehicle Choice Model	Zhenhong Lin (Oak Ridge National Laboratory)	9-18	3.25	3.25	3.25	3.25	3.25
Overall Average			3.40	3.16	3.16	3.30	3.24

Analysis of Vehicle Technologies and Reduction of Oil Use and GHG Emissions: Tom Stephens (Argonne National Laboratory) – van001

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the focus was excellent because it provides analysis needed by other efforts. The reviewer felt that one of the primary focuses was the identification of technical barriers; these barriers were identified well. The reviewer indicated that important new potential barriers that need to be addressed have been identified, and that new work was being done on the reaction of manufacturers and what it took to get them to build new vehicles. The reviewer also described the focus on the transition from early adopters to mainstream customers as excellent.

Reviewer 2:

The reviewer felt that one other potential aspect to investigate is how the deployment of individual technologies impacts and interacts with the deployment of other technologies. The reviewer noted that understanding how the capital and resource constraints of original equipment manufacturers (OEMs) impact the simultaneous deployment of technologies within a timeframe could provide understanding of the penetration of advanced vehicle technologies, especially as a response to Corporate Average Fuel Economy (CAFE) and greenhouse gas (GHG) standards.

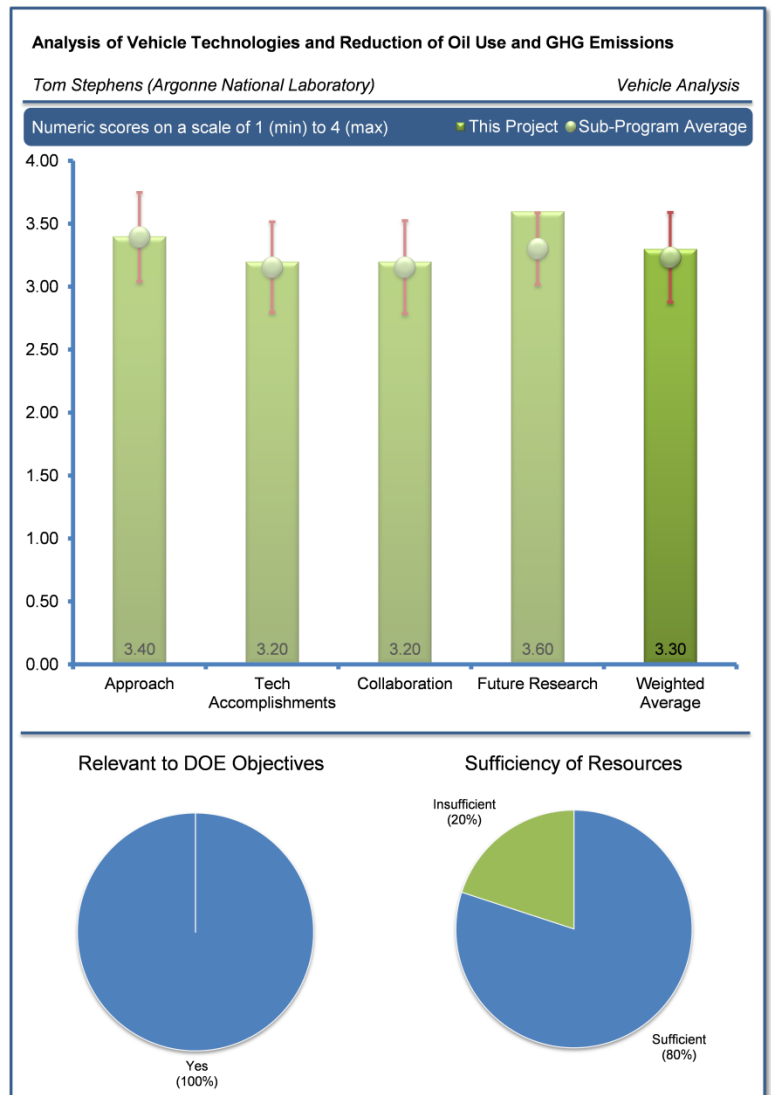
Reviewer 3:

The reviewer commented that the use of data sources and methods based on multiple strategies regarding technology penetration, investment strategies, and industry resources provided multiple avenues to evaluate investor decision behavior.

Reviewer 4:

The reviewer felt that this project is an important component of the analysis needed to understand the issues facing technologies that could play a role in reducing both the nation's dependence on oil and its GHG emissions from transportation sources. The reviewer noted that incorporating more analysis on assessing the transition costs, barriers, and potential policy solutions would make the analysis more useful in informing policy makers.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.



Reviewer 1:

The reviewer observed a template for vehicle technology deployment timing that incorporates the following: potential for delays for the transition to mass markets; and remaining uncertainty identified as recent developments in computer simulation and design, rapid prototyping, modular platforms, and other ways of fast-tracking deployment. The project also examined alternative ways of replicating due diligence on deployment investments through cash flow and decision tree analysis.

Reviewer 2:

The reviewer felt that it was difficult to evaluate the progress towards objectives because future scenarios are, by definition, uncertain. The reviewer noted that the work is important because it identifies potential barriers that are often overlooked in analyses. The reviewer also described the use of historical technology penetration data to help understand the barriers and timelines to new technology penetration as good, and that the use of cash flow analysis and decision tree analysis are good tools to identify investor decision points. The reviewer felt that there should be more work done quantifying and monetizing non-cost barriers of advanced technology vehicles by customer segments instead of merely identifying them and ranking them overall.

Reviewer 3:

The reviewer felt that the technology deployment template was a useful tool and a good accomplishment; however, the reviewer noted that adding to the tool's value going forward will rely on the ability to evaluate the impact of the remaining uncertainties identified, including modular platforms and rapid prototyping.

Reviewer 4:

The reviewer felt that more analysis on the transition cost and barrier would make the project more useful.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer noted that, though the direction of the project supports other projects, the work was done relatively independently.

Reviewer 2:

The reviewer reported the following collaboration and coordination: W. McManus (Oakland University); A. Brown and L. Vimmerstedt (National Renewable Energy Laboratory [NREL]); John German (International Council on Clean Transportation [ICCT]); Z. Lin (Oak Ridge National Laboratory [ORNL]); A. Birky (TA Engineering, Inc.); A. Brooker (NREL); and A. Vyas (Argonne National Laboratory [ANL]).

Reviewer 3:

The reviewer indicated that collaborating with automakers and suppliers could be helpful.

Reviewer 4:

The reviewer stated that future project work could incorporate previous work on transitions costs performed by ORNL during the development of the Hydrogen Transition (HyTrans) model.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the project correctly identified some key remaining uncertainties including the impacts of computer simulations, rapid prototyping, and modular platforms. The reviewer felt that the focus on development pathways was excellent.

Reviewer 2:

The reviewer indicated that the focus of the proposed future work hits the points with the biggest impact.

Reviewer 3:

The reviewer listed the following items when responding to this question: deployment pathways; global sales trends; improve and integrate models; and improve interagency collaboration.

Reviewer 4:

The reviewer felt that it would be valuable if similar methodologies could be employed to capture risks associated with fuel infrastructure development and how the presence or lack of fueling infrastructure could impact the risk assessment for auto producers.

Reviewer 5:

The reviewer thought that future work should incorporate more analysis on assessing the transition costs and barriers and potential policies solutions because that type of analysis would be useful for policy makers.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer noted that the project is an important component of the analysis needed to understand the issues facing technologies that could play a role in reducing both the Nation's dependence on oil and its GHG emissions from transportation.

Reviewer 2:

The reviewer felt that understanding what drives or inhibits the deployment of advanced technologies will help DOE better evaluate what technologies deserve funding and additional research. The reviewer also felt that the research will also help DOE determine how funding can break down some of the barriers to widespread deployment of advanced technologies.

Reviewer 3:

The reviewer indicated that the barriers addressed by this project were routinely ignored by many analyses, which makes the results useless. The reviewer also stated that, despite the inherent uncertainties in assessing future scenarios, it is essential to identify potential barriers and inject as much realism as possible in order for technology analyses to have any validity.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer felt that the resource levels seemed to be appropriate.

Reviewer 2:

The reviewer described the work as important, but difficult to quantify. Further, this reviewer felt that the current resources were appropriate.

Reviewer 3:

The reviewer felt that more resources could be devoted to analysis of the transition costs and barriers of advanced vehicle and fuel technologies.

Reviewer 4:

The reviewer noted that no information was given.

WTW Analysis of Vehicle/Fuel Systems and GREET Development: Michael Wang (Argonne National Laboratory) – van002

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the approach for the project was excellent. The reviewer felt that this was an outstanding tool, and indicated that it was used in several regulatory environments including California's Air Resources Board (ARB) for low-carbon fuel standard (LFCS) and at the U.S. Environmental Protection Agency (EPA).

Reviewer 2:

The reviewer felt that the work seems to be taking the right approach by considering the evolution of technologies over time, considering the effects of regulation, and building a consistent platform to compare life-cycle analyses (LCAs) for different technologies.

Reviewer 3:

The reviewer indicated that the success of the GREET project is a model that should be used to demonstrate the value and importance of government funded analysis of technology research and development. The reviewer noted that continued development and enhancement of the GREET model is very important to maintaining its relevance in the state of the art of LCAs.

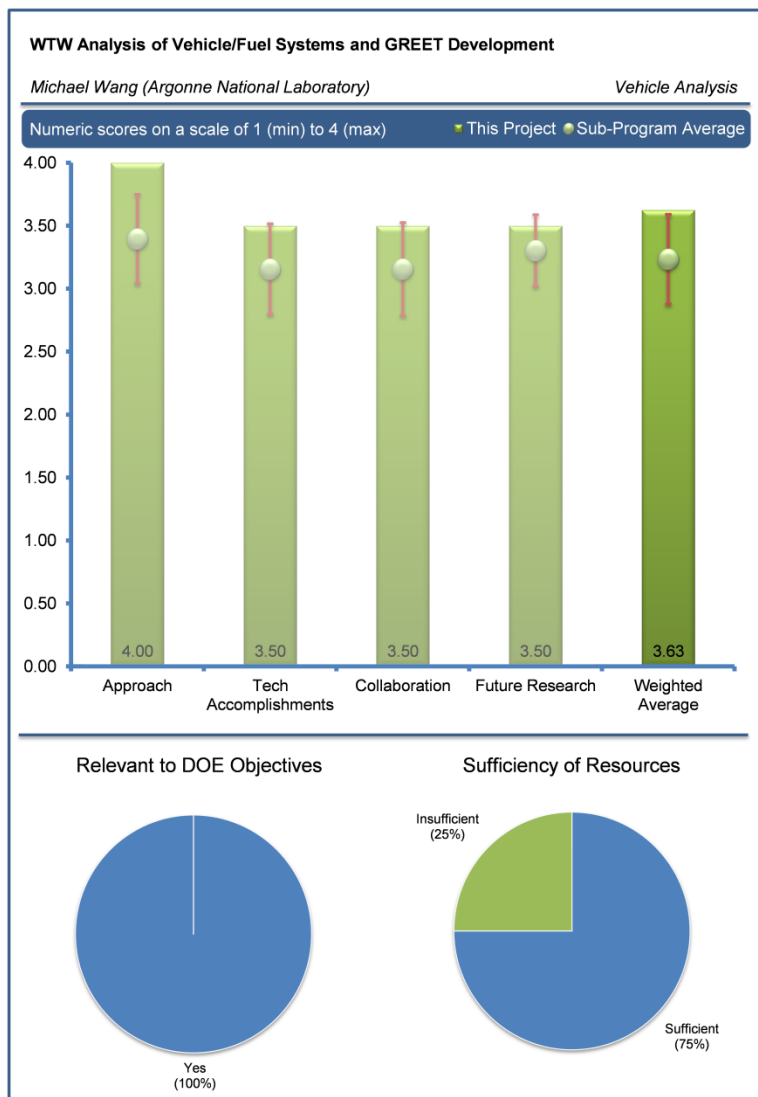
Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer commented that the presentation indicated that the project had made very good progress towards its goal of building an adaptable, expandable and transparent platform. The reviewer additionally felt that, given the current and anticipated proliferation of plug-in hybrid electric vehicles (PHEVs), the progress on PHEV performance and fuel-cycle simulation is very timely and important. The reviewer noted that the expansion of electricity generation modeling by region in order to allow for a more accurate evaluation of PHEV vehicles is of particular importance.

Reviewer 2:

The reviewer indicated that the GREET model accomplishments were excellent; however, the reviewer mused that more resources could be devoted to the incorporation or enhancement of indirect factors such as land use and economic factors. The reviewer noted that the inclusion of indirect factors could potentially change lifecycle GHG of technologies significantly.



Reviewer 3:

The reviewer felt that the list of research proposals was relevant and that the work evaluating oil sands and other upstream crude oil sources was timely. The reviewer noted that more differentiation between upstream petroleum types in the research would have improved the results.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The project leaders reached out to the fuel producers, automakers, and suppliers, which the reviewer felt were the right sources to contact. In addition, the reviewer noted that the literature reviews and incorporation of Autonomie simulation results were very appropriate.

Reviewer 2:

The reviewer stated that additional stakeholder input and collaboration would be useful.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the proposed future work seemed very appropriate and that the focus on lightweighting materials for CAFE purposes will be very important.

Reviewer 2:

The reviewer indicated that the GREET model's accomplishments were excellent; however, more resources could be devoted to the incorporation or enhancement of indirect factors (e.g., land use and economic factors) that could potentially change lifecycle GHG of technologies significantly.

Reviewer 3:

The reviewer stated that the incorporation of short-lived GHG and water was timely. The reviewer felt that more work on oil sands, other conventional petroleum sources, and incorporating methane leakage in the distribution system would be useful.

The reviewer also noted that very little mention was made of how the stochastic elements of GREET were constructed, how they interacted, or how they could be improved; this related directly to the consequential versus attributional methodology of LCA. Further, this reviewer affirmed that any change in one component of the LCA chain should impact the others. The reviewer did indicate that the study of this feedback was complicated and may be beyond the scope of this model.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer felt that the project was very relevant. Having a common platform to evaluate and compare LCAs will be a critical tool in developing strategies to reduce petroleum use given the transition to so many new vehicle technologies and the proliferation of alternative fuels and sources.

Reviewer 2:

The reviewer reiterated that the success of the GREET project is a model that should be used to demonstrate the value and importance of government funded analysis of technology research and development. Continued development and enhancement of the GREET model is very important to maintaining its relevance in the state of the art of LCAs.

Reviewer 3:

The reviewer stated that GREET calculates both GHG emissions and energy consumption. The reviewer felt that both GREET and GHG are valuable in the evaluation of the merits of DOE programs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer felt that the project was appropriately funded and staffed.

Reviewer 2:

The reviewer indicated that the funding level looked reasonable for this type of project.

Reviewer 3:

The reviewer felt that the success of the model's use by government, academia, and industry justified increasing the resources put toward analysis, updating, and enhancing the GREET model.

Consumer Vehicle Technology Data: Mark Singer (National Renewable Energy Laboratory) – van003

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that gathering data on consumer purchases was highly valuable, especially if trends can be tracked over time. The reviewer felt that the survey could be more useful if it also asked customers about recent purchase decisions; however, given the \$25,000 budget, the approach was great.

Reviewer 2:

The reviewer felt that understanding consumer preference and willingness to pay for vehicle attributes is critical to understanding the potential impact advanced technologies and regulation will have on new vehicle purchase decisions. Measuring shifts in the value or perceived importance of vehicle descriptors like safety, quality, dependability, and efficiency as vehicle attributes change over time will be critical to successful deployments.

Reviewer 3:

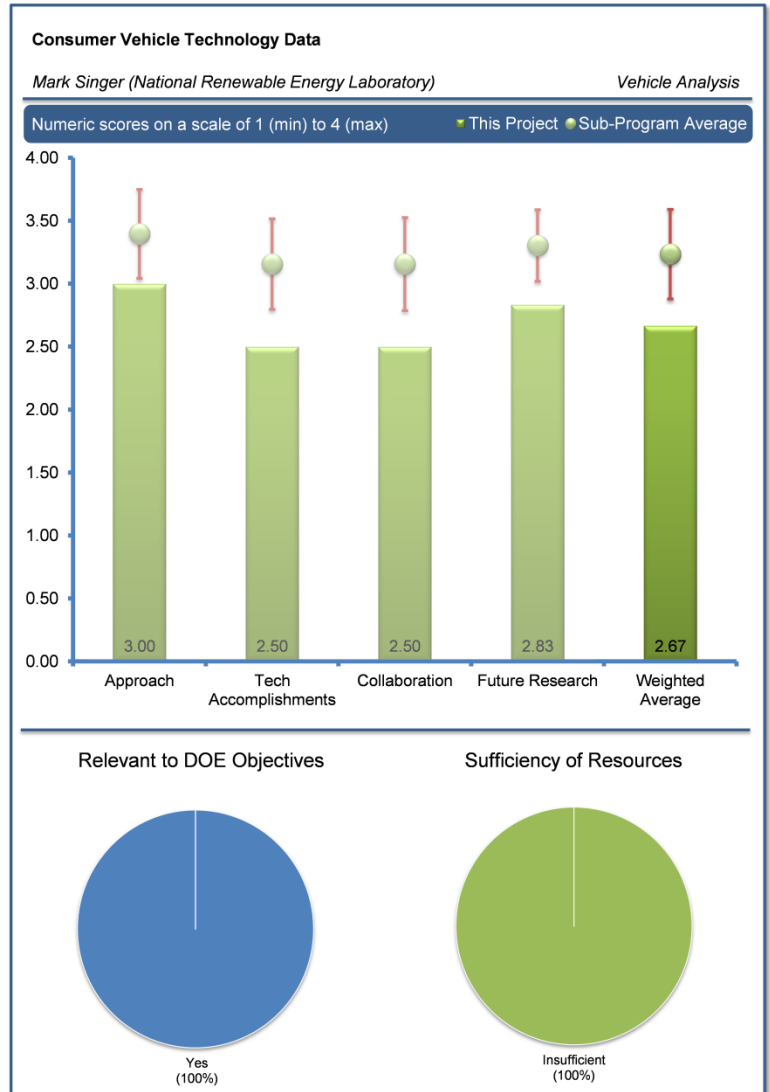
The reviewer noted that, from the project description, it appeared that the VTO has not recently funded collection of data on consumer preferences for vehicle models and technology choice. The reviewer felt that, while it appeared that this type of information collection could be useful in the development of vehicle choice models and other VTO analytical exercises, additional resources should be devoted ensuring that the relevant information is collected. The reviewer indicated that the project may benefit by incorporating information collected by University of California, Davis researchers on consumer preferences and what data and questions are important for future surveys.

Reviewer 4:

The reviewer stated that the approach seemed to be generally effective, but obtaining more recent survey results needed to be a focus because obtaining a better understanding of survey responses to observed consumer behaviors is critical for decision/policy makers.

Reviewer 5:

The reviewer noted that the approach was to develop VTO expertise in historical survey trends, develop VTO expertise in the relationship of survey responses, and to respond to VTO researcher requests to administer survey efforts. The reviewer indicated that no response was given to questions regarding why survey results from December 2005 through January 2013 have yet to be published.



Reviewer 6:

The reviewer observed no consistent set of questions or trend analysis, and that the presentation showed survey responses from as long ago as 2006.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that the project seemed to be making good progress. The observation that consumers required a large difference in fuel economy to affect behavior was a key finding. Additionally, the reviewer felt that another key finding was that consumers desired a payback period of 1-1.5 years.

Reviewer 2:

The reviewer noted that this type of information collection could be useful, but accomplishments have been hindered due to lack of funding. The reviewer recommended that VTO should increase funding of its surveying efforts if resources are available.

Reviewer 3:

The reviewer observed the following survey results: consumer settings define the potential market; market perceptions of how consumer views relate to observed behavior; consumer sentiments towards specific technologies; change in consumer views over time; and consumers' willingness to pay for improved fuel economy.

Reviewer 4:

The reviewer noted that the trends over time were useful; however, the fact that the results had not been published in eight years was disturbing. The reviewer felt that asking about what customers were intending to do yielded highly biased results, indicating that this was well known phenomenon. The reviewer suggested that asking customers about factors that influenced their purchase of a new vehicle in the past six months would be more accurate and provide more useful information.

Reviewer 5:

The reviewer felt that some of the survey data was too out of date to be useful; also the reviewer indicated that a trend analysis would be necessary to make the data very useful.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that there was extensive evidence of collaboration and coordination with other research entities. This reviewer noted VTO research efforts conducted by ORNL, ANL, and NREL scientists, coordination with DOE vehicle deployment efforts, and the Opinion Research Corporation.

Reviewer 2:

The reviewer remarked that the responsiveness to individual requests for information was good; however, the reviewer felt that coordination with other research institutions could be improved. It was noted that numerous academic and private organizations perform this type of research.

Reviewer 3:

The reviewer indicated that increased funding could help improve collaboration and coordination.

Reviewer 4:

The reviewer stated that, given the lack of available data, collaboration and potential cost sharing opportunities should be explored to further develop data collection and analysis in this area.

Reviewer 5:

The reviewer felt that collaborating with other polling entities and research organization outside of DOE could help.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the project contained a well thought out plan to maintain and develop new data while expanding expertise to develop new and enhanced future studies. The activities specifically referenced by the reviewer included developing a coordinated consumer views effort drawing from the experience of historical efforts to enhance future studies and continued administration of new survey efforts and the maintenance of data from prior efforts.

Reviewer 2:

The reviewer commented that, considering the significant changes in fuel prices and consumer attitudes towards new vehicle powertrains and technologies from the timeframe when many of the surveys were completed (i.e., 2006 through 2008), the focus on new survey efforts is vital. The reviewer indicated that partnering with new institutions is a good focus, and stated that new survey efforts and partnering with new institutions really seemed to be the right focus areas.

Reviewer 3:

The reviewer stated that it appears that this program has not been a priority for DOE and interest waned in the past. The reviewer suggested that DOE either make the program a priority or discontinue it. The reviewer expressed hope that future plans will be followed through.

Reviewer 4:

The reviewer suggested that participants on this project should reach out to other organizations to elicit suggestions for survey frames and consumer opinion, and other areas that need further examination.

Reviewer 5:

The reviewer ranked this area as fair not poor, suggesting that additional funding would help future research.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the ability of new technologies to reduce petroleum use is dependent on consumer acceptance so understanding consumer demands and behaviors is very important.

Reviewer 2:

The reviewer commented that the study appears completely relevant to DOE objectives of petroleum displacement through analysis of historical trends and projections to the future.

Reviewer 3:

The reviewer indicated that information on changes in consumer sentiment can be useful to help inform DOE on future work, especially if trends can be established over a long period of time. Given the historical data gathered in this area, it would be useful to continue this work. The reviewer stated that asking consumers about factors influencing recent purchase decisions would be even more valuable. This question is far more accurate than asking consumers about future considerations. In addition, this data is not available from any public source, so it would be very valuable.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the program should be maintained and the results published and communicated, which likely takes more than \$25,000 per year. The reviewer also suggested that another survey should be implemented that targets recent vehicle purchasers and asks them about the factors influencing their recent purchase decision.

Reviewer 2:

The reviewer indicated that it appears that this effort does not possess sufficient resources and support to promote the results of their research efforts, otherwise material developed as far back as 2006 would have been published by now.

Reviewer 3:

The reviewer commented that, given the outdated nature of many of the survey results, it seemed that additional funding would be required.

Reviewer 4:

The reviewer stated that, at current funding levels, only minimal effort can be employed to address project goals.

Reviewer 5:

The reviewer indicated that this work is underfunded to successfully meet its goals. It needs either more funding to create a robust consumer survey component or the funding should be shifted to other projects.

Analytical Modeling Linking the FASTSim and ADOPT Software Tools: Aaron Brooker (National Renewable Energy Laboratory) – van004

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the project appears to be on schedule and has successfully integrated the two models into one usable simulation.

Reviewer 2:

The reviewer commented about the well thought-out approach and scope of research effort, specifically noting vehicle powertrain and consumer choice modeling. This reviewer noted the following unique aspects: consumer preference changes based on income; income level changes over time and number of sales; extensive validation; and competition of advanced vehicles with entire existing fleet. The reviewer also referenced the comparison of consumer preferences to cost-effectiveness.

Reviewer 3:

The reviewer indicated that the approach seems to have a logical progression and that the consideration of mass compounding is important and that it seems the consumer preference is solely based on income levels and does not consider other factors.

Reviewer 4:

The reviewer stated that modeling impacts of technology improvements on consumer choice and sales is a great goal, but that it is not entirely clear if all the required inputs to properly model effects have been considered.

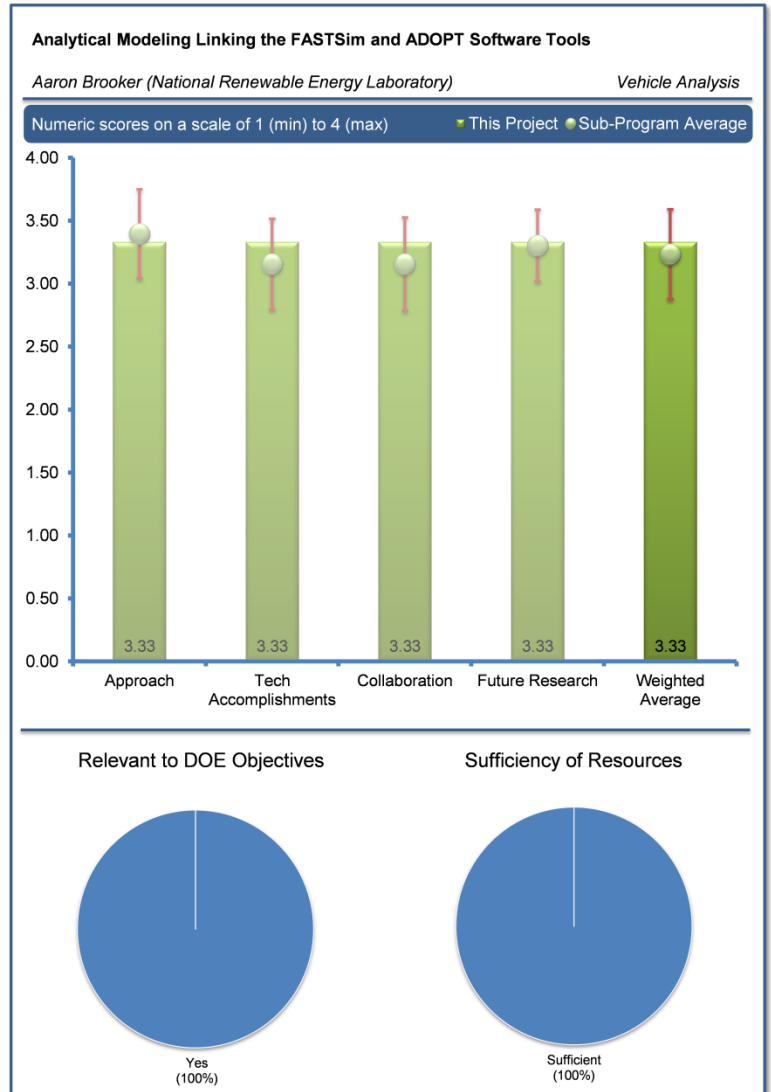
Reviewer 5:

The reviewer noted that, while the presentation provided a good overview of the project's work, there needed to be more information about ADOPT, vehicle choice model, and the parameters and assumptions underlying it.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer stated that there was lots of progress, but that the project seems to be assuming that existing data and validations can be extended to new technology types. Also, consumer preferences may not be properly incorporated into the model.



Reviewer 2:

The reviewer stated that while it looks like significant progress has been made in linking the Future Automotive Systems Technology Simulator (FASTSim) and ADOPT models it is not clear that these are the appropriate models for analyzing vehicle lightweighting. Lightweighting is a function of manufacturer's preference relative to other technologies in achieving fleet fuel economy or GHG reductions targets as opposed to a consumer preference.

Reviewer 3:

The reviewer commented that the run time reduction was impressive and provides significant advantages for future investigations. Additionally, expanding the number of represented vehicles and having the capability to evolve vehicles is beneficial to adding realism.

The reviewer felt that it seemed superfluous to add all of the current models to a simulation that extends to 2050, since all of the current types will be replaced in the future. Additionally, it was not explained how new models are introduced and impact of fuel prices and other exogenous factors.

Question 3: Collaboration and coordination with other institutions.**Reviewer 1:**

The reviewer commented that the collaboration with industry, government, academia and data providers seemed to be a good mix.

Reviewer 2:

The reviewer noted that feedback was received from industry and government. Industry partners included Chrysler, Ford, and General Motors (GM). Government partners included ANL, the Energy Information Agency (EIA), and ORNL. Data was provided by PA Consulting Group, Polk and SRA International (Sentech). The reviewer also noted extensive documentation for collaboration and coordination with other institutions.

Reviewer 3:

The reviewer noted coordination with industry and other groups.

Reviewer 4:

The reviewer felt that the project had excellent data sources, but that the reviewer did not see much collaboration with other modelers or organizations.

Reviewer 5:

The reviewer felt that, while currently the level of collaboration was good, this was a very interesting approach to examining the impact of income on consumer behavior and how shifts in income could impact vehicle purchase/production in the future. The reviewer felt that additional effort should be made or funded to solicit comment and feedback on this modeling effort.

Reviewer 6:

The reviewer commented that while it looked like the FASTSim and ADOPT models have coordinated with industry and government, it was unclear how the FASTSim, ADOPT and the MA3T models relate to one another.

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the proposed improvements were appropriate and included some of the major areas of concern.

Reviewer 2:

The reviewer commented that the proposed future work seemed to be appropriate. Incorporating other factors to consumer choice would be helpful and looking at a saturation point for consumers' desire on acceleration performance could be useful. The reviewer felt that the effect of CAFE will be important.

Reviewer 3:

The reviewer noted several fiscal year (FY) 2013 goals, including: improve confidence in projections by running ADOPT through historical periods and comparing the model to actual sales and vehicle changes, evolve capabilities into compressed natural gas (CNG) vehicles by adding a CNG engine map. Another goal was to add the ability to optimize powertrains for consumer choices into FASTSim from ADOPT, enhance flexibility to consider more technology improvement options, and to improve user friendliness and post online. The noted potential FY 2014 work included: linking vehicle miles traveled to fuel cost and efficiency, expanding vehicle evolution to allow vehicles to change in class size, adding CAFE effects, adding penalties that captures battery electric vehicles' slow recharge time and low range, completing a framework to run in parallel with other models for comparison, applying to key technology target areas such as batteries, fuel cells, and CNG, and estimating sensitivity to external factors such as fuel prices, income projections, and refueling station availability.

Reviewer 4:

The reviewer felt that, given the variation in consumer preference by income level, it would be interesting to explore this further by including or examining the preference terms for a greater number of vehicle attributes. The reviewer also recommended funding or examining price sensitivities on unit sales (elasticity) by income group.

Reviewer 5:

The reviewer indicated that there was a need to compare projections with other models; not just validation with historical data.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?**Reviewer 1:**

The reviewer commented that it was important to be able to estimate the impacts of technology progress on future product sales and fuel, and GHG reductions. However, the reviewer felt that this was definitely a garbage in, garbage out scenario; the inputs are key to the accuracy of the output. It is important for ADOPT to carefully coordinate with efforts elsewhere in DOE to evaluate potential barriers to advanced technologies.

Reviewer 2:

The reviewer indicated that incorporating consumer choices is required when evaluating the impact of new technologies on petroleum reduction.

Reviewer 3:

The reviewer stated that DOE needs a suite of tools for evaluating vehicle technologies from the producers and consumers perspective; development of the FASTSim and ADOPT models along with other models such as the MA3T are resources that DOE should further develop.

Reviewer 4:

The reviewer commented that analysis of penetration is important in guiding technology decisions in the VTO.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?**Reviewer 1:**

The reviewer stated that this project was sufficiently funded given the current objectives, but thought that this project could benefit from additional funding.

Reviewer 2:

The reviewer indicated that, given the quality of the results of this research, resources should be adequate.

Reviewer 3:

The reviewer felt that the resources seemed appropriate for the work.

Reviewer 4:

The reviewer noted that the resources seemed to properly reflect the priority and amount of work needed.

Updating and Enhancing the MA3T Vehicle Choice Model: Zhenhong Lin (Oak Ridge National Laboratory) – van005

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work – the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that it was a complicated but important model. The concept showed dedication to making the model accurate and overcoming barriers.

Reviewer 2:

The reviewer stated that, from the information in the presentation, the approach seems appropriate.

Reviewer 3:

The reviewer noted that the presentation slides were cluttered and difficult to understand. The reviewer felt that the material is obviously cogent to the research effort but it was not presented in an understandable fashion.

Question 2: Technical accomplishments and progress toward overall project and DOE goals – the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals.

Reviewer 1:

The reviewer indicated that the automation calibration and runtime reduction seemed to be important accomplishments. Additionally, the validation results seemed to be promising.

Reviewer 2:

The reviewer felt that there were lots of functional improvements the last year, but not a lot of improvements to the inputs for the high cost of the project (\$770,000).

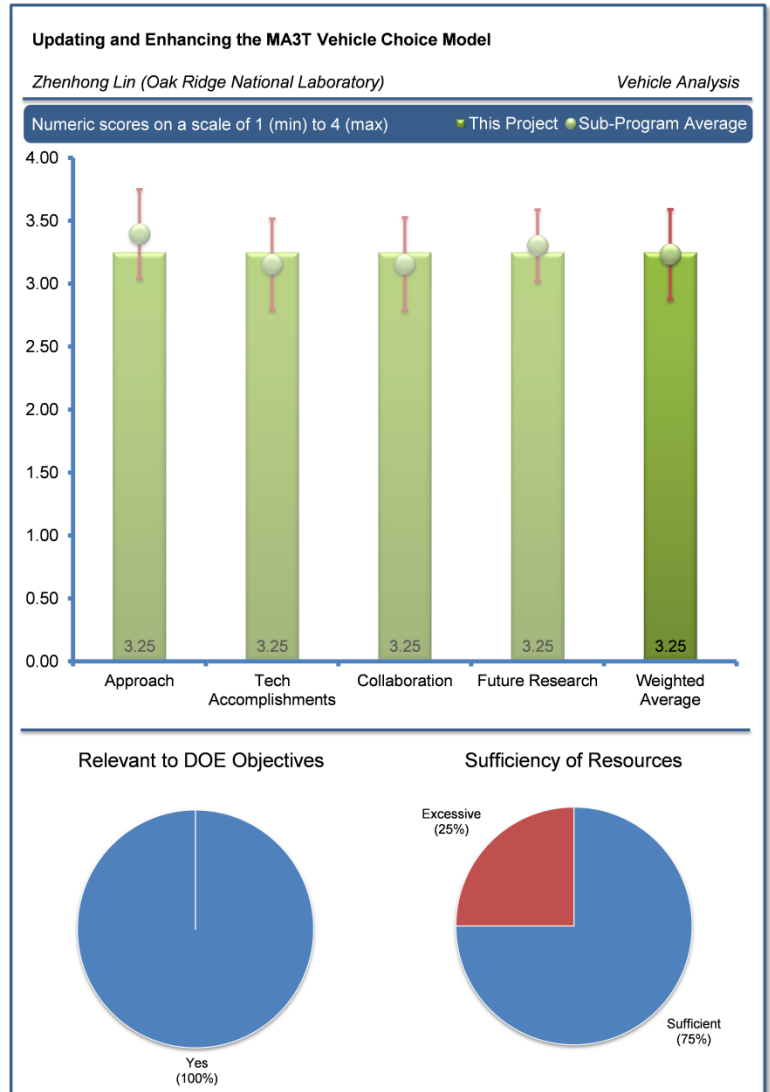
Reviewer 3:

The reviewer commented that the accomplishments were presented in a disjointed, haphazard manner and was difficult to understand. Also, the material presented as accomplishments seemed repetitive of earlier studies.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that there was a high level of coordination, both within and outside DOE.



Reviewer 2:

The reviewer commented that the collaboration efforts seemed to be appropriate.

Reviewer 3:

The reviewer commented that the list of research partners and coordination efforts for present and future research was impressive, noting preparing input data and processing model results with Jonathan Ford and Karen Sikes (SRA International, Inc.), vehicle attribute data and application of MA3T in analyses with Tom Stephens and Aymeric Rousseau (ANL), scenario setup and infrastructure analysis with Jing Dong (Iowa State University), and electricity carbon intensity with Laura Martin (DOE/EIA).

Question 4: Proposed future research – the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the proposed future work on consumer behavior, industry behavior, technology innovation and uncertainties seemed to cover all the bases.

Reviewer 2:

The reviewer indicated that the future work is properly focused, but not very ambitious when compared to cost of the project. In addition, the reviewer added that it should have more focus on consumer barriers to advanced technology vehicles.

Reviewer 3:

The reviewer commented that it needs to better understand consumer behavior, industry behavior, technology innovation, and associated uncertainties. The reviewer was unsure whether this has already been addressed in previous studies in a more understandable fashion. The reviewer did note that an impressive list of future initiatives are presented for the remainder of 2013 and 2014 but that it appeared to be a duplication of efforts related to previous presentations.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer felt that it addresses numerous aspects of alternative fuel usage and alternative fuel vehicle choice.

Reviewer 2:

The reviewer noted that, as stated in some of the other reviews, consumer choices are vital to understanding the impact of new technologies on petroleum reductions.

Reviewer 3:

The reviewer indicated that it was important to have models to turn technology improvements into market share increases, and fuel reductions, and carbon dioxide (CO₂) reductions. The reviewer was not clear on how this project differed from the project VAN004. The reviewer felt that there was a lot of redundancy between these two projects, especially in the consumer choice module.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the resources seemed to be sufficient.

Reviewer 2:

The reviewer indicated that information regarding resources available to the project were not sufficient enough to offer a comment on the sufficiency of resources.

Reviewer 3:

The reviewer indicated that \$770,000 for some operational improvements and relatively minor improvements to the inputs seemed to be excessive.

Acronyms and Abbreviations

Acronym	Definition
ADOPT	Automotive Deployment Options Projection Tool
ANL	Argonne National Laboratory
ARB	Air Resources Board
AMR	Annual Merit Review
ARRA	American Recovery and Reinvestment Act
CAFE	Corporate Average Fuel Economy
CNG	Compressed Natural Gas
CO₂	Carbon Dioxide
DOE	U.S. Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
EPA	U.S. Environmental Protection Agency
FASTSim	Future Automotive Systems Technology Simulator
FY	Fiscal Year
GHG	Greenhouse Gas
GM	General Motors
REET	Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation
GUI	Graphical User Interface
HyTrans	Hydrogen Transition
ICCT	International Council on Clean Transportation
LCA	Life-Cycle Analysis
LCFS	Low Carbon Fuel Standard
LCD	Levelized Cost of Driving
MA3T	Market Assessment of Advanced Automotive Technologies
NREL	National Renewable Energy Laboratory
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PHEV	Plug-In Hybrid Electric Vehicles
R&D	Research and Development
VAN	Vehicle Analysis
VCM	Vehicle Choice Model
VTO	Vehicle Technologies Office
WTW	Well-to-Wheels

10. Acronyms

Acronym	Definition
°C	Degrees Celsius
°K	Temperature in degrees Kelvin
1-D	One-Dimensional
3D	Three Dimensional
3-DEP	Three Dimensional Engineered Preform
A	Ampere
A/C	Air Conditioning
ABR	Advanced Battery Research
AC	Alternating Current
ACEC	Advanced Combustion and Emissions Control
ADA	Americans with Disabilities Act
ADOPT	Automotive Deployment Options Projection Tool
ADVISOR	Advanced Vehicle Simulator
AEC	Advanced Engine Combustion
AEV	All Electric Vehicle
AFR	Air to Fuel Ratio
AFV	Alternative Fuel Vehicle
AGMA	American Gear Manufacturers Association
Ah	Ampere-hour
AHD	Advanced Hybrid Drives
AHSS	Advanced High Strength Steel
Al	Aluminum
ALD	Atomic Layer Deposition
AMI	Advanced Metering Infrastructure
AMOX	Ammonia Oxidation
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
AP	Atmospheric Processing
APBF	Advanced Petroleum-Based Fuels
APE	Advanced Power Electronics
APEEM	Advanced Power Electronics and Electric Machines Program
APRF	Advanced Powertrain Research Facility (Argonne National Laboratory)
APS	Advanced photon source
APU	Auxiliary Power Unit
ARB	Air Resources Board
ARPA-E	Advanced Research Projects Agency - Energy
ARRA	American Recovery and Reinvestment Act

Acronym	Definition
ASI	Area-specific Impedance
ASTM	American Society for Testing and Materials
AT-PZEV	Advanced Technology Partial Zero Emissions Vehicle
ATR	Attenuated Total Reflectance
Au	Gold
AVFL	Advanced Vehicle/Fuel/Lubricant Committee
AVFL-18	Project 18 under Advanced Vehicle/Fuel/Lubricants of the Coordinating Research Council
AVTA	Advanced Vehicle Testing Activity
AVTE	Advanced Vehicle Testing and Evaluation
AXP	Automotive X-Prize
B	Boron
B100	Biodiesel blend of 100% neat biodiesel
B20	Biodiesel blend of 20% neat biodiesel
BAAQMD	Bay Area Air Quality Management District
BatPac	Battery Pack
BATT	Batteries for Advanced Transportation Technologies
BES	DOE Basic Energy Sciences
BEV	Battery Electric Vehicle
Bi₂Te₃	Bismuth Telluride
BIM	Bonded Interface Material
BMEP	Brake Mean Effective Pressure
BMS	Battery Management System
BNL	Brookhaven National Laboratory
BOL	Beginning of Life
BOM	Bill of Material
BSFC	Brake-specific fuel consumption
BSNO_x	Brake-specific NO _x
BSPM	Brake-specific Particulate Matter
BTE	Brake Thermal Efficiency
C	Carbon
C/S	Codes and Standards
Ca	Calcium
CAEBAT	Computer-Aided Engineering of Batteries
CAFE	Corporate Average Fuel Economy
CALPHAD	Computer Coupling of Phase Diagrams and Thermochemistry
CAN	Controller Area Network
CARB	California Air Resources Board
CB	Carbon Black
CCET	Center for Commercialization of Electric Technologies
CD	Charge Depleting
CE	Coulombic Efficiency

Acronym	Definition
CEC	California Energy Commission
CEC	Clean Energy Coalition
CEO	Colorado Energy Office
CF	Carbon Fiber
CFD	Computational Fluid Dynamics
CFTF	Carbon Fiber Technology Facility
CI	Compression Ignition
CLEERS	Cross-Cut Lean Exhaust Emissions Reduction Simulation
CMAQ	Congestion Mitigation and Air Quality Program
CMC	Carboxymethyl Cellulose
CNG	Compressed Natural Gas
CNT	Carbon Nanotubes
Co	Cobalt
CO	Carbon Monoxide
CO₂	Carbon Dioxide
COG	Councils of Government
COP	Coefficient of performance
COTS	Commercial-Off-the-Shelf
CPES	Virginia Polytechnic Institute Center for Power Electronics Systems
CPUC	California Public Utilities Commission
Cr	Chromium
CR	Compression Ratio
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council
CS	Charge Sustaining
CSS	Cascade Sierra Solutions
CTE	Coefficient of Thermal Expansion
CTE	Center for Transportation and the Environment
CTQ	Critical to Quality
Cu	Copper
CUICAR	Clemson University International Center for Automotive Research
CY	Calendar Year
D3	Downloadable Dynamometer Database
DASI	Diesel-Assisted Spark Ignition
dB	Decibel
DBA	Direct Bonded Aluminum
DBC	Direct Bonded Copper
DC	Direct Current
DCFC	Direct Current Fast Chargers
DDC	Detroit Diesel Corporation
D-EGR	Dedicated-Exhaust Gas Recirculation

Acronym	Definition
DEIS	Directed Energy Ignition System
DERC	Diesel Engine Research Consortium
DEWGS	Domain Expert Working Groups
DF	Dissipation Factor
DFT	United Kingdom Department for Transport
DFT	Density Functional Theory
DI	Direct Injection
DIC	Digital Image Correlation
DISI	Direct Injection Spark Ignited
DME	Dimethyl Ether
DMME	Department of Mines, Minerals and Energy (Virginia)
DMP	Diesel-Micro-Pilot Ignition
DOC	Diesel Oxidation Catalyst
DOE	U.S. Department of Energy
DoE	Design of Experiment
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
DPC	Diphosphinato Catecholate
DPF	Diesel particulate filter
DR	Demand Response
DRGS	Distributed Renewables, Generation, & Storage
DSC	Differential Scanning Calorimetry
DSNY	City of New York Department of Sanitation
DSRC	Dedicated Short-Range Communications
DV	Design Validation
DVRPC	Delaware Valley Regional Planning Commission
E0	0% Ethanol blend with gasoline
E10	10% Ethanol blend with gasoline
E20	20% Ethanol blend with gasoline
E30	30% Ethanol blend with gasoline
E70	70% Ethanol blend with gasoline
E85	85% Ethanol blend with gasoline
E100	100% Ethanol
EC	Ethylene Carbonate
ECI	Electronic Concepts, Inc.
ECN	Engine Collaboration Network
ED/AX	Energy Dispersive Analysis of X-Rays
EDS	Energy Dispersive X-ray Spectroscopy
EDV	Electric Drive Vehicle
EELS	Electron Energy Loss Spectroscopy
EGR	Exhaust Gas Recirculation

Acronym	Definition
EH&S	Environmental Health and Safety
EHN	2-Ethylhexyl Nitrate
EIA	Energy Information Administration
EIL	Engines in the Loop
EIS	Electrochemical Impedance Spectroscopy
EISA	Energy Independence and Security Act of 2007
EMA	Engine Manufacturers Association
EMC	Ethyl Methyl Carbonate
EOL	End of Life
EPA	U.S. Environmental Protection Agency
EPAct	Energy Policy Act
EPC	Efficient Power Conversion
EPR	Electron Paramagnetic Resonance
EPRI	Electric Power Research Institute
EQR	Equivalence Ratio
ERC	Engine Research Center
ERCOT	Electric Reliability Council of Texas
EREV	Extended Range Electric Vehicle
ES	Energy Storage
ESEM	Environmental Scanning Electron Microscopy
ESI	Electronically Stored Information
ESR	Equivalent Series Resistance
ESS	Energy Storage System
EtOH	Ethanol
EV	Electric Vehicle
EVSE	Electric Vehicle Supplemental (Supply) Equipment
EVSP	Electric Vehicles Standards Panel
EVWPT	Electric Vehicle Wireless Power Transfer
EXAFS	Extended X-ray Absorption Fine Structure
F	Fluorine
FACE	Fuels for Advanced Combustion Engines
FAME	Fatty Acid Methyl Ester
FASTSim	Future Automotive Systems Technology Simulator
FAT	Fleet Analysis Tool
FCTO	Fuel Cell Technologies Office
FE	Finite Element
FE	Fuel Economy
Fe	Iron
FEA	Finite Element Analysis
FEM	Finite Element Method
FEMA	Failure Mode and Effects Analysis

Acronym	Definition
FEVER	Fostering Electric Vehicle Expansion to the Rockies
FF	Flex Fuel
FFRDC	Federally Funded Research and Development Center
FFV	Flex-Fuel Vehicles
FHWA	Federal Highway Administration
FIB	Focused Ion Beam
FMCSA	Federal Motor Carrier Safety Administration
FMEP	Friction mean effective pressure
FMVSS	Federal Motor Vehicle Safety Standards
FOA	Funding Opportunity Announcement
FPE	Free-piston engine
FPL	Florida Power and Light
FRION	Flame Retardant Electrolyte Ions
FSP	Friction Stir Processing
FSW	Friction Stir Welding
FTIR	Fourier Transform Infrared Spectroscopy
FTP	Federal Test Procedure
FY	Fiscal Year
GA	Genetic Algorithm
GaN	Gallium Nitride
GATE	Graduate Automotive Technology Education
GDCI	Gasoline Direct Compression Engine
GDI	Gasoline Direct Injection
GE	General Electric
GEM	Greenhouse Gas Emissions Model
GEN 2	Generation 2
GHG	Greenhouse Gas
GIS	Geographic Information System
GM	General Motors Corporation
GMZ	GMZ Energy Inc.
GPF	Gasoline Particulate Filter
GPRA	Government Performance and Results Act
GPS	Global Positioning System
GPU	Graphics Processing Unit
GREET	Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation
GS	Grain Size
GSA	General Services Administration
GTDI	Gasoline Turbocharged Direct Injection
GTI	Gas Technology Institute
GTRI	Georgia Tech Research Institute
GUI	Graphical User Interface

Acronym	Definition
GVL	Ester Solvent
GVPD	Global Vehicle Development Process
GWh	Gigawatt hours
GWP	Global Warming Potential
H₂	Hydrogen
H₂O	Water
HAADF	High-Angle Annular Dark-Field
HADA	Hawai'i Auto Dealers Association
HALT	Highly Accelerated Life Test
HAN	Home Area Network
HATCI	Hyundai America Technical Center Inc.
HC	Hydrocarbon
HCA	High-capacity Anode
HCC	High-capacity Cathode
HCCI	Homogeneous Charge Compression Ignition
HCFS	High-Pressure Common-Rail Fuel-Supply System
HD	Heavy-Duty
HE	High Energy
HECC	High Efficiency Clean Combustion
HEDGE	High-Efficiency Dilute Gasoline Engine
HEPF	Hawai'i Energy Policy Forum
HERDV	Hawai'i Renewable Energy Development Venture
HEV	Hybrid Electric Vehicle
HEVN	Hawaiian Electric Vehicle Network
Hf	Hafnium
HH	Half-Heusler
HIL	Hardware-in-the-loop
HMI	Human-to-Machine Interface
HNEI	Hawai'i Natural Energy Institute
HOA	Home Owners Associations
HPC	High Performance Computing
HPDC	High Pressure Die Cast
HPLB	High-pressure, lean burn
HRSXRD	High-resolution Synchrotron X-ray Diffraction
HS	High Strength
HTML	High Temperature Materials Laboratory
HV	High Voltage
HVAC	Heating, Ventilation and Air Conditioning
HVC	High Voltage Cathode
HVM	High-Volume Manufacturing
HWFET	Highway Fuel Economy Test

Acronym	Definition
HyTrans	Hydrogen Transition
IAB	Industry Advisory Board
IAC	International Automotive Components
IBEW	International Brotherhood of Electrical Workers
IC	Internal Combustion
ICCT	International Council on Clean Transportation
ICE	Internal Combustion Engine
ICME	Integrated Computational Materials Engineering
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated Gate Bipolar Transistor
IL	Ionic Liquids
IMEP	Indicated Mean Effective Pressure
INL	Idaho National Laboratory
IP	Induction Period
IP	Intellectual Property
IPM	Interior Permanent Magnet
IPO	Initial Public Offering
IQT	Ignition Quality Tester
iR	Insulation Resistance
IR	Infrared
IREQ	Institut de Recherche d'Hydro-Québec
ISFC	Indicated Specific Fuel Consumption
ISO	International Organization for Standardization
ITE	Indicated Thermal Efficiency
ITS	Intelligent Transportation Systems
ITS JPO	Intelligent Transportation Systems Joint Program Office
JCI	Johnson Controls, Inc.
JPL	Jet Propulsion Laboratory
K	Potassium
KASIT	Korea Advanced Institute of Science and Technology
KIVA	Computational Fluid Dynamics Modeling Software
Kn	Knudsen Number
KSI	Kips per Square Foot
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt Hour
L/P	Lignin/PAN Polymer Blend Precursor
LANL	Los Alamos National Laboratory
LBMP	Lithium-Bearing Mixed Polyanion
LBNL	Lawrence Berkeley National Laboratory

Acronym	Definition
LCA	Life-Cycle Analyses Analysis
LCCF	Low-Cost Carbon Fibers
LCD	Levelized Cost of Driving
LCFS	Low Carbon Fuel Standard
LD	Light-Duty
LDB	Lean Downsized Boosted
LED	Light-Emitting Diode
LEED	Leadership in Energy and Environmental Design
LEESS	Lower-Energy Energy Storage System
LES	Large Eddy Simulation
LEV	Low Emission Vehicle
LFO	Lithium Iron Oxide
LFP	Lithium Iron Phosphate
Li	Lithium
Li₂MnO₃	Lithiated transition metal oxides
LiBF₄	Lithium tetrafluoroborate
LiBOB	Lithium bis(oxalato)borate
LII	Laser Induced Incandescence
Li-Ion	Lithium Ion
LiPF₆	Effective electrolyte salt for lithium-ion battery
LiPON	Lithium Phosphorous Oxynitride
LiTFSI	Lithium Bis(Trifluoromethanesulfonyl)Imide
LLFC	Lean Lifted Flame Combustion
LLNL	Lawrence Livermore National Laboratory
LMNO	Ni-substituted manganese spinel oxides
LMR	Lithium Manganese Rich
LNG	Liquid Natural Gas
LNT	Lean NO _x Trap
LRIP	Low Rate Initial Production
LRRI	Lovelace Respiratory Research Institute
LT	Low Temperature
LTC	Low Temperature Combustion
LTT	Low Transformation Temperature
MA	Maleic Anhydride
MA3T	Market Assessment of Advanced Automotive Technologies
MAP	Microwave Assisted Plasma
MATLAB	Numerical Analysis Software
MB	Methyl Butyrate
MB	Mercedes Benz
MCH	Methylcyclohexane
MD	Medium-Duty

Acronym	Definition
MDU	Multiple-Dwelling Unit
MEC	Metropolitan Energy Center
MEDC	Michigan Economic Development Corporation
MEMS	Micro-Electro-Mechanical Systems
MENA	Magnesium Electron North America
MEO	Maui Economic Opportunity, Inc.
MERF	Materials Engineering Research Facility (Argonne National Laboratory)
Mg	Magnesium
MgO	Magnesium oxide or Magnesia
MgOH2	Magnesium Hydroxide
MHLA	Maui Hotel and Lodging Association
MIT	Massachusetts Institute of Technology
mJ	Millijoule
MLD	Molecular Layer Deposition
Mn	Manganese
Mo	Molybdenum
MOS	Metal-Oxide-Semiconductor
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
MOU	Memorandum of Understanding
MOxST	Metal Oxygen Separation Technologies, Inc.
MPa	Megapascal
MPC	Model Predictive Controller
MPG	Miles Per Gallon
MPO	Metropolitan Planning Organization
MSU	Michigan State University
MTBE	Methyl Tertiary Butyl Ether
MTU	Michigan Technological University
MUD	Multi-Unit Dwelling
MW	Molecular Weight
MWh	Megawatt-hour
MXene	Exfoliated MAX phases (2D structures)
N₂O	Nitrous Oxide
NASA	National Aeronautics and Space Administration
NASEO	National Association of State Energy Officials
NBB	National Biodiesel Board
NC	North Carolina
NCA	Battery cathode material (nickel cobalt aluminum oxide)
NCM	Nickel Cobalt Manganese Oxide
NCSU	North Carolina State University
Nd	Neodymium
NDE	Non-Destructive Evaluation

Acronym	Definition
NDT	Non-Destructive Testing
NETL	National Energy Technology Laboratory
NF	Nanofiber
NGOs	Non-Government Organizations
NH₃	Ammonia
NHTS	National Household Travel Survey
NHTSA	National Highway Traffic Safety Administration
Ni	Nickel
NIST	National Institute of Standards and Technology
Nm	Newton-meters
NMC	Nickel Manganese Cobalt Oxide
NMP	N-Methylpyrrolidone
NMR	Nuclear Magnetic Resonance
NO	Nitric Oxide
NO₂	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
NPBFL	Non-Petroleum-Based Fuels and Lubricants
NREL	National Renewable Energy Laboratory
NSC	NO _x Storage Catalyst
NSF	National Science Foundation
NSR	NO _x Storage Reduction
NTRC	National Transportation Research Center
NVO	Negative Valve Overlap
NYCLHVCC	New York City and Lower Hudson Valley Clean Communities, Inc.
NYPA	New York Power Authority
NYSERDA	New York State Energy Research and Development Authority
O	Oxygen
O&M	Operations and Maintenance
O₂	Oxygen
OBD	On-Board Diagnostics
OCV	Open Current Voltage
OEM	Original Equipment Manufacturer
OH	Hydroxide
ONR	Office of Naval Research
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
OSC	Oxygen storage capacity
OSU	Ohio State University
OTR	On the Road
P	Phosphorous
PACCAR	Commercial Vehicle Manufacturer (Kenworth, Peterbilt, DAF)

Acronym	Definition
PAN	Polyacrylonitrile
PCCI	Premixed Charge Compression Ignition
Pd	Palladium
PDF	Pair Distribution Function
PE	Power Enrichment
PEEM	Power Electronics and Electric Machines
PEN	Polyethylene Naphthalate
PET	Polyethylene Terephthalate
PEV	Plug-in Electric Vehicle
PFI	Port Fuel Injection
PGM	Platinum group metal
PHEV	Plug-In Hybrid Electric Vehicle
PHEV10	Plug-In Hybrid Electric Vehicle with a 10-mile range on a single charge
PHEV40	Plug-In Hybrid Electric Vehicle with a 40-mile range on a single charge
PI	Principal Investigator
PIV	Particle Image Velocimetry
PLC	Programmable Logic Controller
PLZT	Lead Zirconium Titanate
PM	Permanent Magnet
PM	Particulate Matter
PN	Particulate Number
PNNL	Pacific Northwest National Laboratory
PP	Polypropylene
PPC	Partially Premixed Combustion
PPG	Pittsburgh Plate Glass Company
PRC	People's Republic of China
PRF	Primary Reference Fuels
PSC	Public Service Commission
PSU	Penn State University
Pt	Platinum
PTO	Power Take Off
PUC	Public Utilities Commission
PWM	Pulse Width Modulation
PZEV	Partial Zero Emissions Vehicle
PZT	Lead Zirconate Titanate
Q&A	Question and Answer
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
RANS	Reynolds-Averaged Navier Strokes
RAQC	Regional Air Quality Council

Acronym	Definition
RCCI	Reactivity Controlled Compression Ignition
RCM	Rapid compression machines
RE	Rare Earth
RF	Radio Frequency
RESS	Regenerative Energy Storage System
REVi	Richmond Electric Vehicle Initiative
RFA	Renewable Fuels Association
RGGI	Regional Greenhouse Gas Initiative
RI	Ringing Intensity
ROI	Return on Investment
RON	Research Octane Number
RPM	Rotations per Minute
RT	Room Temperature
Ru	Ruthenium
RVP	Reid Vapor Pressure
S	Sulfur
SA	Standards Association
SACI	Spark assisted compression ignition
SAE	Society of Automotive Engineers
SBR	Styrene Butadiene Rubber (Copolymer)
SCAQMD	South Coast Air Quality Management District
SCE	Single Cylinder Engine
SCR	Selective Catalytic Reduction
SCTE	Single Cylinder Test Engine
SDG&E	San Diego Gas and Electric
SEI	Solid Electrolyte Interface
SEM	Scanning Electron Microscope
SEP	Smart Energy Profile
SFTP	Supplemental Federal Test Procedure
SGIP	Smart Grid Interoperability Panel
Si	Silicon
SI	Spark Ignition
Si₃N₄	Silicon nitride
SIC	Single Ion Conducting
SiC	Silicon Carbon
SIDI	Spark Ignition Direct Injection
SIF	Spray-Interactive Flamelet
SIMS	Secondary Ion Mass Spectrometry
SKU	Skutterudite
SMC	Sheet Molding Compound
SMOG	Si/MgO/Graphite

Acronym	Definition
Sn	Tin
SNL	Sandia National Laboratories
SOA	State of the Art
SOC	State of Charge
SOFC	Solid Oxide Fuel Cell
SOI	Scenario of Interest
SOP	Start of Production
SOW	Statement of Work
SpaciMs	Spatially Resolved Capillary Inlet Mass Spectrometer System
SPEEK	Sulfonated Poly Ether Ether Ketone
SPR	Surface Plasmon Resonance
SSHD	Single-Stage Hot Deformation
STEM	Science, Technology, Engineering, and Math
SULEV	Super Low-Emission Vehicle
SUNY	State University of New York
SWRI	Southwest Research Institute
TARDEC	U.S. Army Tank Automotive Research, Development and Engineering Center
TCI	Transportation Climate Initiative
TDC	Top Dead Center
TE	Thermoelectric
TED	Thermoelectric Devices
TEG	Thermoelectric Generator
TEM	Transmission Electron Microscopy
TEMats	Thermoelectric Materials
TFSI	Bis(trifluoromethane)sulfonimide [(CF ₃ SO ₂) ₂ N]
TGA	ThermoGravimetric Analyzer
Ti	Titanium
TIM	Thermal Interface Material
TIM	Time Integrity Modules
TIVCT	Twin Independent Variable Camshaft Timing
TM	Transition Metal
TMA	Tri Methyl Aluminum
TMS	Thermal Management System
TPMS	Tire-Pressure Monitoring System
TRB	Transportation Research Board
TRU	Trailer Refrigeration Unit
TSB	Technology Standard Board
TSE	Truck Stop Electrification
TWB	Tailor Welded Blanks
TWC	Three-Way Catalyst
U.S.	United States of America

Acronym	Definition
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability
UC	University of California
UCCS	University of Colorado-Colorado Springs
UDDS	Urban Dynamometer Driving Schedule
UH	University of Hawai'i
UHC	Unburned hydrocarbons
UK	United Kingdom
UL	Underwriters Laboratories
UM	University of Michigan
UMTRI	University of Michigan Transportation Research Institute
UNLV	University of Nevada-Las Vegas
USABC	U.S. Advanced Battery Consortium
USAMP	U.S. Automotive Materials Partnership
USCAR	U.S. Council for Automotive Research
USGBC	U.S. Green Building Council
UV	Ultra Violet
UW	University of Wisconsin
UWM	University of Wisconsin-Milwaukee
V	Vanadium
V	Volt
V2G	Vehicle-to-Grid
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VAN	Vehicle Analysis
VC	Vinylene Carbonate
VCM	Vehicle Choice Model
VCT	Variable Camshaft Timing
VEHMA	Vehma International
VF	Voltage Fade
VMT	Vehicle Miles Traveled
VPSC	Viscoplastic Self-Consistent
VSS	Vehicle and Systems Simulation
VSST	Vehicle and Systems Simulation and Testing
VT	Vehicle Technologies
VTO	Vehicle Technologies Office
VVA	Variable Valve Actuation
W	Watt
W/mK	Watts per Millikelvin
WBG	Wide Bandgap
WERC	Wisconsin Engine Research Consultants
WFO	Work for Others

Acronym	Definition
WH	Waste Heat
WHR	Waste Heat Recovery
WOT	Wide Open Throttle
WPT	Wireless Power Transfer
WSU	Wayne State University
WTW	Well-to-Wheels
XANES	X-ray Absorption Near Edge Spectroscopy
XAS	X-ray Absorption Spectroscopy
XML	Extensible Markup Language
XPS	X-ray Photoelectron Spectroscopy
XRD	X-ray Diffraction (Crystallography)
XRF	X-ray Fluorescence
ZDDP	Zinc Dialkyl-Dithio-Phosphate
ZEV	Zero-Emissions Vehicle
Zn	Zinc
Zr	Zirconium
ZrO₂	Zirconium dioxide
ZT	Thermoelectric Figure of Merit

11. Cross-Reference of Project Investigators, Projects, and Organizations

Cross Reference, Sorted by Project Investigator

<i>Page Number</i>	<i>Principal Investigator, Organization. Project Title (Session)</i>
9-15	Aaron Brooker; National Renewable Energy Laboratory. Analytical Modeling Linking the FASTSim and ADOPT Software Tools (Vehicle Analysis)
1-13	Abdullah Bazzi; Chrysler LLC. Advancing Transportation Through Vehicle Electrification - PHEV (Vehicle & System Simulation)
2-80	Ahmad Pesaran; National Renewable Energy Laboratory. Progress of Computer-Aided Engineering of Batteries (CAEBAT) (Energy Storage)
6-58	Alan Luo; USAMP. Mg Intensive Vehicle Front End Sub-structure (Light-Weight Materials)
4-212	Alexander Sappok; Filter Sensing Technologies, Inc.. Radio Frequency Diesel Particulate Filter Sensor and Controls for Advanced Low-Pressure Drop Systems to Reduce Engine Fuel Consumption (Advanced Combustion)
2-201	Ali Abouimrane; Argonne National Laboratory. Impact of Surface Coatings on LMR-NMC Materials: Evaluation and Downselect (Energy Storage)
1-128	Allan Lewis; Hyundai. Wireless Charging (Vehicle & System Simulation)
3-32	Allen Hefner; National Institute of Standards and Technology. Characterization, Modeling, and Reliability of Power Modules (Advanced Power Electronics)
1-141	Andreas Malikopoulos; Oak Ridge National Laboratory. Autonomous Intelligent Plug-in Electric Vehicles (PEVs) (Vehicle & System Simulation)
2-20	Andrew Jansen; Argonne National Laboratory. Fabricate PHEV Cells for Testing & Diagnostics (Energy Storage)
2-180	Andrew Kercher; Lawrence Berkley National Laboratory. Lithium-Bearing Mixed Polyanion (LBMP) Glasses as Cathode Materials (Energy Storage)
7-17	Andrew Wereszczak; Oak Ridge National Laboratory. Thermoelectric Mechanical Reliability (Propulsion Materials)
7-29	Andy Wereszczak; Oak Ridge National Laboratory. Improved Organic Dielectrics for Power Electronics and Electric Motors (Agreement ID:23279) (Propulsion Materials)
2-148	Anthony Burrell; Argonne National Laboratory. Addressing the Voltage Fade Issue with Lithium-Manganese-Rich Oxide Cathode Materials (Energy Storage)
1-162	Anthony Markel; National Renewable Energy Laboratory. Fast Charge Technology Adoption Challenges (Vehicle & System Simulation)
2-30	Arumugam Manthiram; University of Texas at Austin. High Capacity, High-voltage Cathode Materials for Lithium-ion Batteries (Energy Storage)

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2-72	Austen Angell; Arizona State University. Sulfone Liquids and Sulfate/Triflate Solids for High Voltage Electrolytes (Energy Storage)
2-15	Avie Judes; Johnson Controls-Saft. JCS PHEV System Development-USABC (Energy Storage)
3-61	Ayman El-Refaie; General Electric Global. Alternative High-Performance Motors with Non-Rare Earth Materials (Advanced Power Electronics)
1-70	Barney Carlson; Idaho National Laboratory. Electric Drive and Advanced Battery and Components Testbed (EDAB) (Vehicle & System Simulation)
6-37	Barney Carlson; Idaho National Laboratory. Vehicle Mass Impact on Vehicle Losses and Fuel Economy (Light-Weight Materials)
4-171	Bill Partridge; Oak Ridge National Laboratory. CRADA with Cummins on Characterization and Reduction of Combustion Variations (Advanced Combustion)
4-89	Bill Partridge; Oak Ridge National Laboratory. Cummins/ORNL-FEERC CRADA: NOx Control & Measurement Technology for Heavy-Duty Diesel Engines (Advanced Combustion)
4-47	Bill Pitz; Lawrence Livermore National Laboratory. Chemical Kinetic Models for Advanced Engine Combustion (Advanced Combustion)
5-8	Bob McCormick; National Renewable Energy Laboratory. Performance of Biofuels and Biofuel Blends (Fuels Technologies)
2-117	Brad Brodie; DENSO International America. Stand-Alone Battery Thermal Management System (Energy Storage)
5-5	Brad Zigler; National Renewable Energy Laboratory. Fuels for Advanced Combustion Engines (Fuels Technologies)
8-54	Brett Aristigui; National Energy Technology Laboratory. EV Community Readiness projects: SCAQMD (CA); University of Hawaii (Technology Integration)
2-53	Brett Lucht; University of Rhode Island. Development of Electrolytes for Lithium-ion Batteries (Energy Storage)
2-9	Brian Barnett; TIAX LLC. PEV and HEV Battery Cost Assessment (Energy Storage)
1-164	Brian Choe; SCAQMD. Zero Emission Heavy Duty Drayage Truck Demonstration (Vehicle & System Simulation)
3-114	Brian Peaslee; Magna E-Car Systems of America, Inc.. Electric Drive Component Manufacturing: Magna E-Car Systems of America, Inc. (Advanced Power Electronics)
2-183	Bryant Polzin; Argonne National Laboratory. Cell Fabrication Facility: Current Research Activities in Electrode and Cell Prototyping (Energy Storage)
3-69	Burak Ozpineci; Oak Ridge National Laboratory. Traction Drive System Modeling (Advanced Power Electronics)
7-55	C.K. Narula; Oak Ridge National Laboratory. Catalysts via First Principles (Agreement ID:10635) (Propulsion Materials)

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2-74	Chengdu Liang; Oak Ridge National Laboratory. Carbon/Sulfur Nanocomposites and Additives for High-Energy Lithium Sulfur Batteries (Energy Storage)
4-188	Chris Caylor; GMZ Energy Inc.. Nanostructured High-Temperature Bulk Thermoelectric Energy Conversion for Efficient Automotive Waste Heat Recovery (Advanced Combustion)
8-10	Chris Mi; Regents University of Michigan. Center for Electric Drive Transportation at the University of Michigan - Dearborn (Technology Integration)
1-167	Christine Smith; Houston-Galveston Area Council. Zero Emission Cargo Transport - Houston #1 (Vehicle & System Simulation)
1-169	Christine Smith; Houston-Galveston Area Council. Zero Emission Cargo Transport - Houston #2 (Vehicle & System Simulation)
2-198	Christopher Johnson; Argonne National Laboratory. Arresting VF: Theory-Guided Synthetic Approaches to Cathodes (Energy Storage)
4-38	Christopher Powell; Argonne National Laboratory. Fuel Injection and Spray Research Using X-Ray Diagnostics (Advanced Combustion)
3-44	Christopher Whaling; Synthesis Partners. Interim Update: Global Automotive Power Electronics R&D Relevant To DOE 2015 and 2020 Cost Targets (Advanced Power Electronics)
5-12	Chuck Mueller; Sandia National Laboratories. Fuels and Combustion Strategies for High-Efficiency Clean-Combustion Engines (Fuels Technologies)
4-114	Chuck Peden; Pacific Northwest National Laboratory. Deactivation Mechanisms of Base Metal/Zeolite Urea Selective Catalytic Reduction Materials, and Development of Zeolite-Based Hydrocarbon Adsorber Materials (Advanced Combustion)
4-83	Chuck Peden; Pacific Northwest National Laboratory. Enhanced High Temperature Performance of NOx Storage/Reduction (NSR) Materials (Advanced Combustion)
2-134	Chunmei Ban; National Renewable Energy Laboratory. Atomic Layer Deposition for Stabilization of Amorphous Silicon Anodes (Energy Storage)
4-99	Clay Maranville; Ford Motor Company. Thermoelectric HVAC and Thermal Comfort Enablers for Light-Duty Vehicle Applications (Advanced Combustion)
4-150	Corey Weaver; Ford Motor Company. Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development (Advanced Combustion)
3-97	Curt Ayers; Oak Ridge National Laboratory. Electric Motor Architecture R&D (Advanced Power Electronics)
6-22	Curt Lavender; Pacific Northwest National Laboratory. Non-Rare Earth High-Performance Wrought Magnesium Alloys (Light-Weight Materials)
3-15	Cy Fujimoto; Sandia National Laboratories. Improved High Temperature Polymer Film Capacitors (Advanced Power Electronics)

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1-77	Dale Oehlerking; Navistar. SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer (Vehicle & System Simulation)
4-44	Dan Flowers; Lawrence Livermore National Laboratory. Computationally Efficient Modeling of High-Efficiency Clean Combustion Engines (Advanced Combustion)
4-96	Dan Greenbaum; Health Effects Institute. Advanced Collaborative Emissions Study (ACES) (Advanced Combustion)
2-192	Daniel Abraham; Argonne National Laboratory. Electrochemical Characterization of Voltage Fade in LMR-NMC cells (Energy Storage)
2-24	Daniel Abraham; Argonne National Laboratory. Mitigating Performance Degradation of High-Energy Lithium-Ion Cells (Energy Storage)
2-56	Daniel Scherson; Case Western Reserve University. Bifunctional Electrolytes for Lithium-ion Batteries (Energy Storage)
8-89	Darren Stevenson; National Energy Technology Laboratory. EV Community Readiness projects: South Florida Regional Planning Council; Virginia Department of Mines, Minerals and Energy (Technology Integration)
6-9	Dave Warren; Oak Ridge National Laboratory. Advanced Oxidation & Stabilization of PAN-Based Carbon Precursor Fibers (Light-Weight Materials)
6-32	Dave Warren; Oak Ridge National Laboratory. Improving Fatigue Performance of AHSS Welds (Light-Weight Materials)
6-19	Dave Warren; Oak Ridge National Laboratory. On-Line Weld NDE with IR Thermography (Light-Weight Materials)
4-50	David Carrington; Los Alamos National Laboratory. 2012 KIVA-Development (Advanced Combustion)
7-21	David J. Singh; Oak Ridge National Laboratory. Thermoelectrics Theory and Structure (Propulsion Materials)
8-65	David Kirschner; National Energy Technology Laboratory. EV Community Readiness projects: Delaware Valley Regional Planning Commission (PA); Metropolitan Energy Information Center, Inc. (KS, MO) (Technology Integration)
4-120	David Koeberlein; Cummins. Cummins SuperTruck Program - Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks (Advanced Combustion)
1-87	David Koeberlein; Cummins. Development and Demonstration of a Fuel-Efficient Class 8 Highway Vehicle (Vehicle & System Simulation)
2-155	David Wood; Oak Ridge National Laboratory. Overcoming Processing Cost Barriers of High-Performance Lithium-Ion Battery Electrodes (Energy Storage)
2-158	David Wood; Oak Ridge National Laboratory. Roll-to-Roll Electrode Processing and Materials NDE for Advanced Lithium Secondary Batteries (Energy Storage)
4-59	Dean Edwards; Oak Ridge National Laboratory. Accelerating Predictive Simulation of IC Engines with High Performance Computing (Advanced Combustion)

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2-186	Dean Miller; Argonne National Laboratory. Linking Electrochemical Performance with Microstructural Evolution in Lithium Battery (Energy Storage)
1-33	Derek Rotz; Daimler Trucks North America LLC. Class 8 Truck Freight Efficiency Improvement Project (Vehicle & System Simulation)
1-156	Dileep Singh; Argonne National Laboratory. Nanofluids for Cooling Power Electronics for HEV (Vehicle & System Simulation)
2-84	Donghai Wang; Pennsylvania State University. Development of High Energy Density Lithium-Sulfur Cells (Energy Storage)
2-140	Donghai Wang; Pennsylvania State University. Synthesis and Characterization of Structured Si-Carbon Nanocomposite Anodes and Functional Polymer Binders (Energy Storage)
4-180	Doug Crane; Gentherm. Thermoelectric Waste Heat Recovery Program for Passenger Vehicles (Advanced Combustion)
3-37	Doug DeVoto; National Renewable Energy Laboratory. Reliability of Bonded Interfaces (Advanced Power Electronics)
3-47	Doug DeVoto; National Renewable Energy Laboratory. Reliability of Electrical Interconnects (Advanced Power Electronics)
4-199	Edward Keating; General Motors. High Energy Ignition and Boosting/Mixing Technology (Advanced Combustion)
6-48	Elizabeth Stephens; Pacific Northwest National Laboratory. SPR Process Simulation, Analyses, & Development for Mg Joints (Light-Weight Materials)
1-66	Eric Rask; Argonne National Laboratory. Advanced Technology Vehicle Lab Benchmarking - Level 2 (in-depth) (Vehicle & System Simulation)
1-150	Eric Rask; Argonne National Laboratory. Battery Energy Availability and Consumption during Vehicle Charging across Ambient Temperatures and Battery Temperature (conditioning) (Vehicle & System Simulation)
2-92	Erin O'Driscoll; Dow Kokam. Development of Large Format Lithium Ion Cells with Higher Energy Density (Energy Storage)
8-82	Erin Russell-Story; National Energy Technology Laboratory. EV Community Readiness projects: Clean Energy Coalition (MI); Clean Fuels Ohio (Technology Integration)
6-35	Felix Paulauskas; Oak Ridge National Laboratory. Microwave Assisted Plasma Processing of Carbon Fiber (Light-Weight Materials)
1-171	Fred Wagner; Energetics, Inc.. EV Roadmap V2.0 (Vehicle & System Simulation)
2-111	Gary Voelker; Miltec UV International. Utilization of UV or EB Curing Technology to Significantly Reduce Costs and VOCs in the Manufacture of Lithium-Ion Battery Electrodes (Energy Storage)
6-17	George Husman; Zoltek. Development and Commercialization of a Novel Low-Cost Carbon Fiber (Light-Weight Materials)

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8-18	Gerogio Rizzoni; Ohio State University. GATE: Energy Efficient Vehicles for Sustainable Mobility (Technology Integration)
3-49	Gilbert Moreno; National Renewable Energy Laboratory. Two-Phase Cooling R&D (Advanced Power Electronics)
7-5	Glenn Grant; Pacific Northwest National Laboratory. Novel Manufacturing Technologies for High Power Induction and Permanent Magnet Electric Motors (Agreement ID:23726) (Propulsion Materials)
7-48	Glenn Grant; Pacific Northwest National Laboratory. Tailored Materials for Improved Internal Combustion Engine Efficiency (Agreement ID:23725) (Propulsion Materials)
4-66	Gouming Zhu; Michigan State University. Flex Fuel Optimized SI and HCCI Engine (Advanced Combustion)
1-21	Greg Cesieli; General Motors. Advanced Vehicle Electrification and Transportation Sector Electrification (Vehicle & System Simulation)
1-49	Greg Cesieli; General Motors. Plug-in Hybrid (PHEV) Vehicle Technology Advancement and Demonstration Activity (Vehicle & System Simulation)
3-102	Greg Grant; Delphi Corporation. Low-Cost U.S. Manufacturing of Power Electronics for Electric Drive Vehicles (Advanced Power Electronics)
2-162	Greg Krumdick; Argonne National Laboratory. Process Development and Scale-up of Advanced Cathode Materials (Energy Storage)
2-165	Greg Krumdick; Argonne National Laboratory. Process Development and Scale up of Advanced Electrolyte Materials (Energy Storage)
4-183	Greg Meisner; General Motors. Development of Cost-Competitive Advanced Thermoelectric Generators for Direct Conversion of Vehicle Waste Heat into Useful Electrical Power (Advanced Combustion)
3-54	Greg Smith; General Motors, Advanced Technology Center. Next Generation Inverter (Advanced Power Electronics)
8-14	Gregory Plett; University of Colorado. Innovative Drivetrains in Electric Automotive Technology Education (IDEATE) (Technology Integration)
8-21	Gregory Shaver; Purdue University. Hoosier Heavy Hybrid Center of Excellence (Technology Integration)
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5-17	Sandia National Laboratories; Magnus Sjoberg. Advanced Lean-Burn DI Spark Ignition Fuels Research (Fuels Technologies)
4-11	Sandia National Laboratories; Mark Musculus. Heavy-Duty Low-Temperature and Diesel Combustion & Heavy-Duty Combustion Modeling (Advanced Combustion)
4-15	Sandia National Laboratories; Paul Miles. Low-Temperature Automotive Diesel Combustion (Advanced Combustion)
4-26	Sandia National Laboratories; Richard Steeper. Automotive HCCI Engine Research (Advanced Combustion)
4-33	Sandia National Laboratories; Terry Johnson. Free-Piston Engine (Advanced Combustion)
1-164	SCAQMD; Brian Choe. Zero Emission Heavy Duty Drayage Truck Demonstration (Vehicle & System Simulation)
1-39	SCAQMD; Matt Myasato. SCAQMD:Plug-In Hybrid Electric Medium-Duty Commercial Fleet Demonstration and Evaluation (Vehicle & System Simulation)
2-100	Seeo; Hany Eitouni. High-Voltage Solid Polymer Batteries for Electric Drive Vehicles (Energy Storage)
1-25	Smith Electric Vehicles; Robin Mackie. Smith Electric Vehicles: Advanced Vehicle Electrification + Transportation Sector Electrification (Vehicle & System Simulation)
4-157	Stanford University; Kenneth Goodson. Thermoelectrics Partnership: Automotive Thermoelectric Modules with Scalable Thermo- and Electro-Mechanical Interfaces (Advanced Combustion)
2-142	Stanford University; Yi Cui. Wiring up Silicon Nanoparticles for High Performance Lithium-ion Battery Anodes (Energy Storage)
2-145	SwRI; Kwai Chan. Synthesis and Characterization of Silicon Clathrates for Anode Applications in Lithium-Ion Batteries (Energy Storage)
3-44	Synthesis Partners; Christopher Whaling. Interim Update: Global Automotive Power Electronics R&D Relevant To DOE 2015 and 2020 Cost Targets (Advanced Power Electronics)
8-31	The University of Alabama at Birmingham; Uday Vaidya. GATE Center of Excellence in Lightweight Materials and Manufacturing Technologies (Technology Integration)
6-70	The University of Alabama at Birmingham; Uday Vaidya. GATE Lightweight Materials Center (Light-Weight Materials)
2-9	TIAX LLC; Brian Barnett. PEV and HEV Battery Cost Assessment (Energy Storage)
2-125	TIAX; Suresh Sriramulu. Implantation, Activation, Characterization and Prevention/Mitigation of Internal Short Circuits in Lithium-Ion Cells (Energy Storage)
8-34	U.S. Department of Energy Golden Field Office; Kay Kelly. EV Community Readiness projects: American Lung Association of the Southwest (CO); Oregon Business Development Department (OR, WA) (Technology Integration)
1-99	University of California at Riverside; Matthew Barth. Next Generation Environmentally Friendly Driving Feedback Systems Research and Development (Vehicle & System Simulation)

<i>Page Number</i>	<i>Organization, Principal Investigator. Project Title (Session)</i>
8-14	University of Colorado; Gregory Plett. Innovative Drivetrains in Electric Automotive Technology Education (IDEATE) (Technology Integration)
4-86	University of Houston; Michael Harold. Development of Optimal Catalyst Designs and Operating Strategies for Lean NOx Reduction in Coupled LNT-SCR Systems (Advanced Combustion)
4-63	University of Michigan; Margaret Wooldridge. A University Consortium on Efficient and Clean High-Pressure, Lean Burn (HPLB) Engines (Advanced Combustion)
2-44	University of Pittsburgh; Prashant Kumta. Nanoscale Heterostructures and Thermoplastic Resin Binders: Novel Lithium-Ion Anodes (Energy Storage)
2-53	University of Rhode Island; Brett Lucht. Development of Electrolytes for Lithium-ion Batteries (Energy Storage)
2-30	University of Texas at Austin; Arumugam Manthiram. High Capacity, High-voltage Cathode Materials for Lithium-ion Batteries (Energy Storage)
3-57	UQM Technologies; Jon Lutz. Unique Lanthide-Free Motor Construction (Advanced Power Electronics)
3-112	UQM Technologies; Luke Bokas. Electric Drive Component Manufacturing Facilities (Advanced Power Electronics)
6-58	USAMP; Alan Luo. Mg Intensive Vehicle Front End Sub-structure (Light-Weight Materials)
6-67	USAMP; Lou Hector. ICME Development of 3rd Gen Advanced High Strength Steels (Light-Weight Materials)
4-132	Volvo Trucks; Pascal Amar. Volvo SuperTruck - Powertrain Technologies for Efficiency Improvement (Advanced Combustion)
6-17	Zoltek; George Husman. Development and Commercialization of a Novel Low-Cost Carbon Fiber (Light-Weight Materials)

12. Project and Program Statistics Calculations Overview

A numerical evaluation of each project within each subprogram area and a comparison to the other projects within the subprogram area necessitates a statistical comparison of the projects utilizing specific criteria. For each project, a representative set of experts in the project's field were selected to evaluate the project based upon the criteria indicated in the Introduction. Each evaluation criterion's sample mean and variance were calculated utilizing the following formulas respectively:

$$\bar{x}_{j,k} = \frac{1}{n} \sum_{i=1}^n x_{i,j,k}$$

$$s_{\bar{x}_{j,k}}^2 = \frac{1}{(n-1)} \sum_{i=1}^n (x_{i,j,k} - \bar{x}_{j,k})^2$$

where $x_{i,j,k}$ is an individual reviewer's score for that criterion and n is the number of reviewers for the given project who answered the question¹. The index i represents an index over the reviewers assigned for the project; the index j represents an index over the projects in that specific subprogram area; the index k represents an index over the questions asked. The sample mean for each project criterion is represented in the graph by their respective bar graph value. These calculations were performed for the numeric values supplied by the reviewers for questions one through four (those questions indicated with weight values in the Introduction).

The above values $\bar{x}_{j,k}$ and $s_{\bar{x}_{j,k}}^2$ can be used to extend the evaluation to the entire subprogram. In order to calculate the variance of each subprogram criterion, the sample variances must be propagated to the calculated variance of each subprogram criterion score. The subprogram area mean and variance for each evaluation criterion are then calculated as follows:

$$\bar{X}_k = \frac{1}{m} \sum_{j=1}^m \bar{x}_{j,k}$$

$$Var(\bar{X}_k) = \sigma_{\bar{X}_k}^2 = \frac{1}{m^2} \sum_{j=1}^m s_{\bar{x}_{j,k}}^2 = \frac{1}{m} \sum_{j=1}^m \bar{x}_{j,k}^2 - (\bar{X}_k)^2 + \frac{1}{m^2} \sum_{j=1}^m s_{\bar{x}_{j,k}}^2$$

where m is the number of projects in a subprogram area. This method of calculation allows each project to weigh evenly on each evaluation criterion of the subprogram area. The criteria means and average of the project variances values for each subprogram area (e.g., Hybrid and Vehicle Systems Technologies, Advanced Combustion Engine Technologies, Technology Integration, etc.) are represented on each project graph as the Program Area Average bullets and the red error bar ranges, respectively, for each question. In some sense, the red error bars provide a range by which projects can be evaluated by their criteria with respect to an entire subprogram area's performance. The error bar calculation was changed from the 2011 Annual Merit Review report where the expectation of the sample error was the value calculated for the error bars. This change was made so that the error bar provides a more relevant comparison for the criteria measurements of the projects to the subprogram averages.

Each question's score is assumed to be independent of the others for a given project (that is, for example, the question of the quality of the future research should have no bearing on the current accomplishments). Each project's weighted average score can then be calculated as follows²:

¹ If all of the reviewers do not answer all of the questions, the value of n will be different for some questions for a project.

² There is no need to calculate a variance for this value since it is not displayed, and it has no bearing on any future calculated value in the analysis.

$$\bar{x}_j = \frac{\sum_{k=2}^5 w_k * \bar{x}_{j,k}}{\sum_{k=2}^5 w_k}$$

where w_k is the weight that question k has on the overall score of the j^{th} project average \bar{x}_j . The value above, \bar{x}_j , is indicated in the graphics by the Weighted Average bar. As was done for each individual project, each question's score is assumed to be independent of the others for a given subprogram. Each subprogram's weighted average score and weighted variance can then be calculated as follows:

$$\bar{X} = \frac{\sum_{k=2}^5 w_k * \bar{X}_k}{\sum_{k=2}^5 w_k}$$

$$Var(\bar{X}) = \frac{\sum_{k=2}^5 w_k^2 * Var(\bar{X}_k)}{\sum_{k=2}^5 w_k^2}$$

These values represent the Program Area Average bullet and its red error bar in the Weighted Average column.

The answers to questions five and six are represented by pie charts below the combination bar/bullet graph.

Appendix A: Merit Review Attendees

Name	Affiliation
Rene Abarcar	Energetics Incorporated
Tarek Abdel-Baset	Chrysler Group, LLC
Kristin Abkemeier	New West Technologies, LLC
Ali Abouimrane	Argonne National Laboratory
Daniel Abraham	Argonne National Laboratory
Judi Abraham	Conference Management Associates, Inc.
Salvador Aceves	Lawrence Livermore National Laboratory
Sumanta Acharya	National Science Foundation
Jesse Adams	U.S. Department of Energy
Radoslav Adzic	Brookhaven National Laboratory
Kareem Afzal	PDC Machines
Ertan Agar	Drexel University
Anant Agarwal	U.S. Department of Energy, EERE,
Nisha Agrawal	Defense Production Act Committee
Rajesh Ahluwalia	Argonne National Laboratory
Aysha Ahmed	NHTSA
Shabbir Ahmed	Argonne National Laboratory
Channing Ahn	U.S. Department of Energy (IPA)/Caltech
Sang Hyun Ahn	National Institute of Standard and Technology
Christopher Ainscough	National Renewable Energy Laboratory
Oyelayo Ajayi	Argonne National Laboratory
V'yacheslav Akkerman	Department of Mechanical and Aerospace Engineering, West Virginia University
Mohamed Alamgir	LG CHEM POWER
Tracy Albers	GrafTech International Holdings Inc.
Paul Albertus	Robert Bosch, LLC
Jim Alkire	U.S. Department of Energy
Jan Allen	Army Research Laboratory
Jeffrey Allen	Michigan Technological University
Gokhan Alptekin	TDA Research
Charles Alsup	U.S. Department of Energy /NETL
Jesus Alvarez	A123 Systems, Inc.
Allison Aman	U.S. Department of Energy - Golden Field Office
Pascal Amar	Volvo Technology of America
Khalil Amine	Argonne National Laboratory
Ramin Amin-Sanayei	Arkema
David Anderson	U.S. Department of Energy
Everett Anderson	Proton OnSite
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Michele Anderson	Office of Naval Research
Karl Andersson	Volvo Global Truck Technology

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Anthony Androsky	BRTRC
Charles Austen Angell	Arizona State Chemistry
Michael Angelo	University of Hawaii at Manoa
Joel Anstrom	The Larson Transportation Institute
Donald Anton	Savannah River NL
Laurent Antoni	CEA Liten
George Antos	National Science Foundation
Bachir Aoun	Argonne National Laboratory
Koorosh Araghi	NASA Johnson Space Center
Shane Ardo	California Institute of Technology
Muhammad Arif	National Institute of Standards and Technology
Brett Aristegui	U.S. Department of Energy
Cheryl Arnold	LNE Group
John Arnold	Miltec Corporation
Kodie Arnold	Electricore, Inc.
Samuel Arthur	DuPont
Timothy Arthur	--
Koichiro Asazawa	Daihatsu Motor Co.,LTD
Radoslav Atanasoski	3M
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Dianne Atienza	Georgetown University
Pradeep Attibele	Chrysler Group LLC
Tom Autrey	Pacific Northwest National Laboratory
Tom Avedisian	Cornell University
Michelle Avillanoza	New West Technologies, LLC
Curt Ayers	Oak Ridge National Laboratory
Katherine Ayers	Proton Onsite
Kristine Babick	Energetics, Inc.
Byungchan Bae	Korea Institute of Energy Research
Chulsung Bae	Rensselaer Polytechnic Institute
Je-Hyeong Bahk	Birck Nanotechnology Center, Purdue University
Jianming Bai	National Synchrotron Light Sources
Brent Bailey	Coordinating Research Council, Inc.
U. (Balu) Balachandran	Argonne National Laboratory
Perla Balbuena	Texas A&M University
Viktor Balema	Sigma-Aldrich Corporation
Nitash Balsara	Lawrence Berkeley National Laboratory
James Banas	JSR Micro Inc./JM Energy

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Dmitry Bedrov	University of Utah
Noriko Behling	Analyst and Author
Marcel Belanger	Federal Transit Administration
Mark Belchuk	Freudenberg Fuel Cell Component Technologies SE & Co. KG
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Roy Benedek	Argonne National Laboratory
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Thomas Benjamin	Argonne National Laboratory
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Richard Blint	N2Kinetics Research, LLC
Rolf Blissenbach	General Motors
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Cary Bloyd	Pacific Northwest National Laboratory
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Brad Boyer	Ford Motor Company
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Can Erdonmez	Brookhaven National Laboratory
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Rob Farrington	National Renewable Energy Laboratory
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Seth Federspiel	U.S. Department of Energy, EERE
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George Fenske	Argonne National Laboratory
Scott Ferguson	Teledyne
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Stuart Funk	LMI
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Thomas Garetson	ECotality
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