Mission Goal Accomplishments

There were many noteworthy Alliance mission accomplishments in FY15. EERE management commends the Alliance for overall excellence in leadership and technical accomplishments in FY15. Some highlights include:

- GOAL 1.0: EFFICIENT AND EFFECTIVE MISSION ACCOMPLISHMENT
    - **Research Productivity**. In FY15, researchers submitted 168 records of invention (ROIs), an all-time high that was 32% above FY 2014. Additionally, NREL has been notified that it is in the running for three R&D 100 awards: SunStop – a dynamic window technology, a new process for bioethylene production, and a solar cell optimizer (in partnership with Maxim Integrated); DOE looks forward to the results of the selection process.
    - **Impact of NREL Analysis.** NREL made a significant contribution with its analysis support to the Quadrennial Energy Review (QER) and the Quadrennial Technology Review (QTR) and its coordinating role across national laboratories.
- GOAL 2.0: EFFICIENT AND EFFECTIVE STEWARDSHIP AND OPERATION OF RESEARCH FACILITIES
    - **Stewardship of NREL Facilities**. Alliance accomplishments exceeded expectations in terms of the targets addressing Relevance, Value, and Impact at most major user facilities across the laboratory (Biomass and Biosciences Research, Materials and Chemical Science and Technology, and the National Wind Technology Center).
- GOAL 3.0: PROVIDE EFFECTIVE AND EFFICIENT PROGRAM MANAGEMENT
    - **National Laboratory Coordination.** The Vehicle Technologies Office at NREL established a Transportation Working Group (TWG) with representatives from 10 national laboratories. The TWG serves as a mechanism for discussing new opportunities that have the potential for accelerating vehicle technology development.
    - **New Program Leaders Strengthen Program Management and Communications.** Alliance hired several new program managers during FY15 to fill key program leadership positions. DOE expects that the selections will strengthen communications with the programs and provide stronger leadership regarding delivery on commitments in FY16.
    - **Alliance Managed Change.** Changes to the direction of research are expected and occur each year. Alliance managed program priorities and timeline changes to minimize the impacts to research goals and objectives in most areas.
- GOAL 4.0: PROVIDE SOUND AND COMPETENT LEADERSHIP AND STEWARDSHIP OF THE LABORATORY
    - **Key Strategic Investments.** Alliance made several key hires during FY 2015 to strengthen its core competencies and technical management team. These hires positioned Alliance to better support the investments required to advance the development of the Grid Modernization Plan and the addition of key expertise in automotive and battery engineering, cyber-physical systems security and grid resilience, and joint appointments in the fuels arena.

- **Alliance Partnerships Impact Markets.** Alliance expanded its collaboration with key customers that has added greatly to its market penetration for several of the programs managed at NREL. Some of the collaborations with the Laboratory included:
  • SolarCity and HECO – integration of solar power on the grid, reduce soft cost barriers to PV penetration
  • Wells Fargo – innovation incubator that is advancing innovative building efficiency technologies
  • Abengoa Solar – development of high-concentration photovoltaics
  • Bonneville Power Administration – multiple projects on improving energy efficiency of residential and commercial buildings
  • San Diego Gas & Electric – multiple projects to improve PV and battery storage integration on distribution feeders

Operations Goal Accomplishments

In the operations area, EERE leadership and GFO commend the Alliance for exceeding expectations for many operational goals. Performance highlights include (see the Golden Field Office Appendix for the complete set of comments):

- GOAL 5.0: ENVIRONMENT, SAFETY, AND HEALTH MANAGEMENT
  - **Implemented the Facility Quality Manager Model.** As a result of the Research and Operations Safety Enhancement (ROSE) Project, Alliance assigned quality managers to each of NREL's major facilities to integrate quality management into facility operations. This team is organized in a matrix management environment that reports to Quality Management Systems and Assurance (QMS&A) and the facility manager. The collaborative setting helps meet the needs of the individual facilities while aligning with NREL's purpose, mission, and core values. This initiative experienced immediate results by serving as a valuable communications conduit between Alliance's research partners and the QMS&A organization on topics such as upcoming assessments, corrective actions, lessons learned, and policy and procedure updates.
  - **Established Corrective Action Board.** Alliance recognized an opportunity to evaluate and strengthen the cause analyses and corrective actions resulting from events and assessments and, in January 2015, established the Corrective Action Board (CAB) to provide a systematic approach to ensuring the integrity and effectiveness of the Corrective Action and Preventive Action (CAPA) process and to address issues impacting the CAPA process.
  - **Established EHS Data Analysis Report**. Alliance formalized a tracking and trending process to collect lab-wide EHS data and developed a quarterly EHS Data Analysis Report to document the results. The process for analyzing EHS data is documented in a desk procedure, with the goal of identifying actionable trends. The scope of the tracking and trending process includes quarterly analysis of occurrences and events, EHS inspection findings, and worker safety and health non-compliances.
  - **Released Updated Lessons Learned System.** Alliance strengthened its knowledge-sharing ability with other laboratories when NREL joined forces with Pacific Northwest National Laboratory (PNNL) to adopt a new Lessons Learned tool this past fiscal year. The innovative, research-based search engine allowed staff to explore a large collection of lessons learned from laboratories across the U.S. Department of Energy system.

- GOAL 6.0: BUSINESS OPERATIONS

  - **Improved the Efficiency of the Contracts Process and Aligned with M&O Procurement Offices.** As an FY 2015 business system process improvement project, Alliance transitioned from acquiring subcontractor-submitted, hard-copy technical deliverables to electronic deliverables. This upgrade resulted in gained efficiency through a streamlined statement of work format and elimination of printed reports for hundreds of subcontracts. This cost-savings change also aligns NREL with the other M&O procurement offices and is a necessary step toward acquiring a fully automated procurement system.
  - **Launched Human Capital Management System.** Alliance successfully deployed its Workday Human Capital Management (HCM) system in June 2015. The fully integrated payroll, timekeeping, and HCM tool provided real-time data for staff and managers.
  - **Exceeded All Socioeconomic Small Business Goals.** In FY 2015, the laboratory's outstanding commitment to supporting small businesses was recognized by the National Veteran Small Business Coalition (NVSBC) with a "Champion of Veteran Enterprise Award." The award recognizes NREL for exceeding the FY 2014 congressional mandated goal and DOE PEMP target for allocating 3% of total subcontract dollars spent to veteran-owned small businesses and service-disabled, veteran-owned small businesses. Alliance far exceeded the established goal by awarding 9.1% to service-disabled, veteran-owned small businesses and 12.5% to veteran-owned small businesses.

- GOAL 7.0: INFRASTRUCTURE STEWARDSHIP AND SITE OPERATIONS

  - **Resolved S&TF Structural Deficiencies**. After identifying structural steel deficiencies in the Science and Technology Facility (S&TF) during the design phase for building a new clean room, Alliance took quick and assertive action to both ensure the facility was safe to occupy while mitigation plans were being developed and to ultimately resolve the issue with the architectural/engineering firm involved in the building's original construction. Design solutions are well underway to modify the structural steel components and allow Alliance to successfully complete the clean room construction project, enhancing the utility and capability of this facility.

- GOAL 8.0: SECURITY AND EMERGENCY MANAGEMENT

  - **Upgraded Security on Critical Operations.** Alliance updated the NREL Continuity of Operations Plan (COOP) in FY 2015, which focused on improvements that were determined as "critical to being sustained to minimize impact." Based on assessments and validation of key processes, Alliance focused its primary security efforts on information and business systems in FY 2015. Response plans were designed to ensure continuity and reliable services under probable disruption scenarios and ensure that essential services could be restored quickly and effectively.
  - **Secured the Work Environment Against Identified and Assessed Security Vulnerabilities and Threats.** Alliance's risk-based approach in this area supported NREL's overall mission objectives by providing a safe, secure, and supportive work environment. An enhanced focus on detection, deterrence, and denial of threats – while enhancing capabilities to respond quickly and professionally when detected – allowed

NREL security professionals to move expeditiously on a threat by an employee with a firearm in April 2015.

Areas for Improvement

Although overall performance has exceeded expectations, EERE leadership would like to highlight some areas for improvement from FY15, particularly in the solar technologies area. Performance issues between NREL and the Solar Energy Technologies Office were identified in the prior two annual evaluations, and certain issues continue to persist today. The following areas for improvement were noted by the rating entities (see the Appendices for all comments):

Advanced Manufacturing (AMO)

- NREL staff are usually responsive with appropriately quick turnaround of information requests. However, there are examples where NREL can improve in terms of effective communication, response, and ultimately performance; for example, progress on Tasks, Subtasks and Milestones is not proactively provided as part of a regular reporting format. NREL needs to implement this as a fundamental project management responsibility.
- As a consequence, there have been examples of NREL's progress not aligning with DOE's expectations.

Bioenergy Technologies (BETO)

- NREL should be more proactive in seeking out collaborations without being prompted by BETO technology managers.

Building Technologies (BTO)

- NREL has not adequately responded to user needs in order to successfully deploy the Technology Performance Exchange (TPEx). The structure and process that NREL developed around TPEx have made it difficult and costly for equipment manufacturers to upload required data to TPEx and for 3rd party evaluators to incorporate technology demonstration data.
- NREL failed to effectively deploy the BuildingSync data format in the market in FY15. NREL did not dedicate enough staff to the project and, as a result, did not make the expected progress. NREL has lagged in working with FEMP to get FEMP's compliance Tracking System ready to import BuildingSync files and failed to make adequate progress in working with the market to encourage early adopters to use this data format. This caused the project to fall behind and make less impact than planned.
- NREL did not provide significant new information or exhibit strategic thinking when asked to examine use cases for Advanced Energy Design Guides that DOE needed to inform its strategy. Despite clear feedback from DOE on a draft, the problem was not rectified. As a result of NREL's ineffective management of this project and poor communication with DOE, the outcome/deliverable was unusable.

Fuel Cell Technologies (FCTO)

- NREL is encouraged to minimize the practice of modifying milestones in response to unexpected delays or problems. Milestone modification should be coordinated with DOE managers to develop a plan that effectively addresses the root cause of the delay or problem, and to adjust subsequent milestones as approved.
- NREL should continue to focus on improving their long-term planning of high risk R&D to accommodate alternative and risk mitigation strategies, and communication of key personnel changes relevant to DOE projects.
- NREL failed to meet the scheduled milestones for the GM-CRADA and exceeded the planned budget. As a result, additional funds will be required to achieve the deliverables in FY16.
- NREL should improve their quality control and review process to ensure their reports, accomplishments, and other documents are accurate, precise, and convey the actual status to outside audiences not familiar with the project.
- NREL performed techno-economic analysis of multiple renewable hydrogen production pathways for Oahu, Hawaii, as a first step in understanding the most cost effective way of providing hydrogen infrastructure. NREL should have coordinated the analytical work with DOE to ensure the most relevant assumptions were used for analysis.

Geothermal Technologies (GTO)

- Multiple milestones were delayed - GRR sustainability plan, some Strategic Analysis relating to the Vision Study, Geothermal Desalination, etc. As in past years, GTO is mindful of the imposition new priorities may create, causing delays to existing milestones; however, there were AOP milestone delays that were not the result of any external factors.
- While communication between NREL staff and GTO occurs regularly and appears open and responsive, it is often difficult to ascertain the impacts of these communications on the direction of projects. Additionally, the allocation of funding for individual projects is not as transparent as would be desired, as the scope between multiple ongoing projects occasionally becomes blurred.
- During discussions relating to project scope and budget for both new projects and modifications to existing projects, talks occasionally take on the air of a negotiation between adversaries rather than a collaboration among partners.

Solar Energy Technologies (SETO)

- NREL had a set of mixed results across SETO topics. Overall, the PV subprogram missed 70% of their milestones, but the research time was well-spent in answering some fundamental questions that have had decisive impact on the field, and on NREL's choice of research topics. Some areas still continue to perform poorly, especially CSP, where most of the topics had to be down-scoped due to under-performance. BOS had a mixed year and SI, despite major pivots and down-scoping in the prior years, has maintained enough relevant research to pivot to new interesting areas for FY16-18.
- NREL's response to Sunlamp resulted in a higher level of industry engagement in the Systems Integration area. In the PV area, none of the research performed moved into the

industry nor did the funds-in through CRADAs and partnerships increase, a key indicator for the past three years and last year. The SABC project had some impact in the community, but fell short of the expectations for publications, impact, and output.

- The stewardship of non-ESIF user facilities continues to be a weak point. The optical characterization facility, solar resource calibration, and numerous PV research facilities (PDIL, etc.) are under-used, less than impactful, or need to have a revamped business model. The delays in building out the PV clean room, caused by the structural issues in the S&TF building, are serious and will adversely impact the PV research.
- There was an unnecessarily high level of cost, both financial and human, involved in the preparation of Sunlamp proposals. Most BOS projects were not managed in a timely manner, whether with staggered requests for extensions, or with delayed project pivots. Customer-facing programs, such as cell measurement and verification and solar resource calibration, are still lagging in developing sustainable business models, despite years of requests from the program.
- NREL filled the position of solar program manager, but continues to lack flexibility in identifying, hiring, and sometimes retaining top technical talent. The program has attempted to offer tools to help with this activity in the past, but they went unused (new hire fund, etc.). Not enough strategic relationships are formed with industry, and not enough diversity exists among the academic partners.
- NREL needs to be better at being able to pivot from one area of relevance to the next, following, but preferably leading, the field. The feedback from the stakeholders continues to be mixed.

Wind and Water Power Technologies (WWPTO)

- NREL continues to struggle with technical/R&D leadership in the area of Distributed Wind. Steps have been made to improve overall project management capabilities and communications, but work remains in effective technical leadership and in meeting project deliverables on-time.
- NREL needs to involve WWPTO leadership in the decision making process and critical funding decisions when engaging EERE Leadership. Third-party communication over critical issues in FY15 led to frustration, confusion and inefficiency in meeting critical funding needs at the end of the fiscal year. Line Program Managers should be empowered to engage (and be the main point of contact) with the Program on all issues impacting funding.

Golden Field Office (GFO)

- The NREL I.T. program has experienced problems meeting deadlines in their Plan of Actions and Milestones (POA&M), which raises their risk level and has caused two short-term continuous authorizations to be issued this year. Inadequate communications internally at NREL and with GFO have hampered their ability to meet federal compliance (Risk Management Approach/Contractor Assurance System).

CONCLUSION

In conclusion, EERE leadership looks forward to a continuing partnership with the Alliance to bring clean energy solutions to the Nation. FY16 will bring new challenges and opportunities, and EERE looks to the Alliance to continue to position NREL as a key leader to address challenging energy issues. The following tables summarize the scores provided by the DASs and contributing evaluators for the four FY15 Mission Goals and from GFO for the four Operations Goals. These scores formed the basis for the PEB's final evaluation and scoring.

Summary of Mission Scoring

Program	1.0: EFFICIENT AND EFFECTIVE MISSION ACCOMPLISHMENT		2.0: EFFICIENT AND EFFECTIVE STEWARDSHIP AND OPERATION OF RESEARCH FACILITIES		3.0: PROVIDE EFFECTIVE AND EFFICIENT PROGRAM MANAGEMENT		4.0: PROVIDE SOUND AND COMPETENT LEADERSHIP AND STEWARDSHIP OF THE LABORATORY	
EERE DASs							3.4	B+
Adv. Manufacturing	3.6	A-			3.4	B+		
Bioenergy	3.6	A-	3.3	B+	3.9	A	3.8	A
Buildings	3.5	A-	3.5	A-	3.4	B+	3.4	B+
FEMP	3.8	A			3.5	A-	3.8	A
Fuel Cells	3.8	A	3.3	B+	2.8	B	3.6	A-
Geothermal	3.4	B+			2.9	B	3.2	B+
Solar	2.9	B	2.2	C+	3.2	B+	2.8	B
Strategic Programs	3.5	A-			2.9	B	3.2	B+
Vehicles	4.0	A	4.0	A	4.0	A	4.0	A
Wind/Water	3.6	A-	4.0	A	3.3	B+	2.9	B
Science - BER	3.5	A-			3.3	B+	3.4	B+
Science - BES	3.4	B+			3.4	B+		
Weight per Goal	55%		10%		15%		20%	
Weighted Score	1.9		0.3		0.5		0.7	
OVERALL MISSION PERFORMANCE SCORE	3.5							
	A-							

Summary of Operations Scoring

Golden Field Office Scoring	5.0 Environment, Safety, and Health Management	6.0 Business Operations	7.0 Infrastructure Development and Site Operations	8.0 Security and Emergency Management
Goal Score	3.9 A	3.9 A	3.6 A-	3.5 A-
Weight per Goal	30%	25%	20%	25%
Weighted Score	1.2	1.0	0.7	0.9
OVERALL OPERATIONS PERFORMANCE SCORE	3.7			
	A-			

Scoring Ranges (for reference)

Numerical Score	4.1-4.3	3.8-4.0	3.5-3.7	3.1-3.4	2.8-3.0	2.5-2.7	2.1-2.4	1.8-2.0	1.1-1.7	0.8-1.0	0.0-0.7
Letter Grade	A+	A	A-	B+	B	B-	C+	C	C-	D	F

MISSION GOALS – DETAILED SCORING

The following pages include a scoring table for each of the four Mission Goals, with scores broken down by individual Performance Objective for each rating entity that provided a score. For each rating entity, all of the raw comments provided for each Performance Objective are included in the Appendices.

Goal 1.0 Efficient and Effective Mission Accomplishment

The Alliance exceeded these performance objectives. The performance scores, by Program, are shown in the following table, with all raw comments shown in the Appendices.

Program	1.0: EFFICIENT AND EFFECTIVE MISSION ACCOMPLISHMENT (55%)					
	1.1: Advance Science and Technology: Alliance manages promising areas of research and development that yield innovations that can improve energy efficiency, renewable energy, sustainable transportation, and clean energy systems in the near term and transform them in the long term.		1.2: Deliver Credible and Objective Analyses. Alliance conducts analyses involving multiple disciplines (e.g., technical, economic, market, sustainability, manufacturing, policy) to provide useful insights that inform DOE and other stakeholders.		1.3: Demonstrate Relevance and Market Impact. Alliance moves NREL-originated knowledge and knowhow into commercial product lines, provides valuable assistance to clean energy businesses, and removes barriers to adoption of clean energy technologies.	
EERE DASs						
Adv. Manufacturing			3.6	A-		
Bioenergy	3.7	A-	3.3	B+	3.7	A-
Buildings	3.5	A-	3.4	B+	3.5	A-
FEMP					3.8	A
Fuel Cells	3.5	A-	4.0	A	4.0	A
Geothermal	3.5	A-	3.5	A-	3.3	B+
Solar	3.0	B	3.3	B+	2.5	B-
Strategic Programs			3.5	A-		
Vehicles	4.0	A	3.8	A	4.0	A
Wind/Water	3.7	A-	3.7	A-	3.5	A-
Science - BER	3.5	A-				
Science - BES	3.4	B+	3.3	B+		
Average Objective Score (average of program scores)	3.5	A-	3.5	A-	3.5	A-
Weight per Objective	50%		20%		30%	
Weighted Average of Objective Scores	3.5					
	A-					
WEIGHTED PERFORMANCE GOAL SCORE	1.9					

Goal 2.0 Efficient and Effective Stewardship and Operation of Research Facilities

The Alliance met these performance objectives. The performance scores are shown in the following table, with all raw comments included in the Appendices.

Program	GOAL 2.0: EFFICIENT AND EFFECTIVE STEWARDSHIP AND OPERATION OF RESEARCH FACILITIES (10%)			
	2.1 Effectively Steward the ESIF User Facility. Alliance research operations are effective in ensuring that the ESIF is available to and used by the community.		2.2: Effectively Steward Major Research Facilities. Alliance research operations are effective in ensuring that major research facilities are available to and are used by the RD&D community.	
EERE DASs				
Adv. Manufacturing				
Bioenergy	3.4	B+	3.1	B+
Buildings	3.5	A-	3.5	A-
FEMP				
Fuel Cells	3.3	B+		
Geothermal				
Solar	2.8	B	1.5	C-
Strategic Programs				
Vehicles	3.9	A	4.0	A
Wind/Water			4.0	A
Science - BER				
Science - BES				
Average Objective Score (average of program scores)	3.4	B+	3.2	B+
Weight per Objective	50%		50%	
Weighted Average of Objective Scores	3.3			
	B+			
WEIGHTED PERFORMANCE GOAL SCORE	0.3			

Goal 3.0 Provide Effective and Efficient Program Management

The Alliance met these performance objectives. The performance scores, by Program, are shown in the following table, with raw comments included in the Appendices.

Program	3.0: PROVIDE EFFECTIVE AND EFFICIENT PROGRAM MANAGEMENT (15%)			
	3.1: Effective Program Planning and Execution. Alliance program management leadership and practices provide effective plans that demonstrate understanding of requirements for impact and align with program goals.		3.2: Effective Communications and Response. Alliance program leadership and practices result in effective, ongoing communication and response.	
EERE DASs				
Adv. Manufacturing	3.6	A-	3.0	B
Bioenergy	3.8	A	4.1	A+
Buildings	3.3	B+	3.6	A-
FEMP	3.5	A-	3.5	A-
Fuel Cells	2.6	B-	3.2	B+
Geothermal	2.9	B	2.8	B
Solar	3.0	B	3.6	A-
Strategic Programs			2.9	B
Vehicles	4.0	A	3.9	A
Wind/Water	3.3	B+	3.2	B+
Science - BER	3.4	B+	3.2	B+
Science - BES	3.4	B+		
Average Objective Score (average of program scores)	3.3	B+	3.4	B+
Weight per Objective	70%		30%	
Weighted Average of Objective Scores	3.4			
	B+			
WEIGHTED PERFORMANCE GOAL SCORE	0.5			

Goal 4.0 Provide Sound and Competent Leadership and Stewardship of the Laboratory

The Alliance met all performance objectives, as determined by the EERE DASs. The performance scores, by Program, are shown in the following table, with raw comments included in the Appendices.

Program	4.0: PROVIDE SOUND AND COMPETENT LEADERSHIP AND STEWARDSHIP OF THE LABORATORY (20%)					
	4.1: Laboratory Strategy. Alliance strategy for NREL ensures delivery on core programs while positioning the laboratory to create and execute new opportunities for impact.		4.2: Steward Core Competencies. Alliance effectively attracts leading talent and forms strategic research collaborations that extend the capabilities of the laboratory.		4.3: Leadership and Lasting Value. Alliance leadership and engagement delivers strategic mission value.	
EERE DASs	3.4	B+	3.4	B+	3.4	B+
Adv. Manufacturing						
Bioenergy	3.7	A-	3.8	A	3.8	A
Buildings	3.4	B+	3.5	A-	3.3	B+
FEMP			3.8	A		
Fuel Cells	3.6	A-	3.6	A-	3.7	A-
Geothermal	3.0	B	3.5	A-	3.0	B
Solar	3.1	B+	2.5	B-	2.8	B
Strategic Programs					3.2	B+
Vehicles	3.9	A	4.1	A+	3.9	A
Wind/Water	3.0	B	3.0	B	2.8	B
Science - BER	3.4	B+				
Science - BES						
DAS Scores (Staff Scores)	3.4 (3.4)	B+	3.4 (3.5)	B+	3.4 (3.3)	B+
Weight per Objective	25%		40%		35%	
Weighted Average of Objective Scores	3.4					
	B+					
WEIGHTED PERFORMANCE GOAL SCORE	0.7					

In accordance with the FY15 PEMP requirements, the EERE Deputy Assistant Secretaries (DASs) evaluated the leadership and stewardship of NREL in Goal 4 based on input from relevant EERE Technology Offices and other sources. The Alliance is commended for its leadership and for developing a stewardship strategy and vision that enhances NREL's value and mission capabilities. Most input received was positive, with certain areas for improvement noted by some Offices. The DASs concluded that the Alliance met expectations for Goal 4, as indicated by their overall Goal 4 performance score shown above.

OPERATION GOALS – DETAILED SCORING

The following section summarizes the scoring for each of the four Operation Goals, with scores also shown for individual sub-objectives. For each Operation Goal, the performance comments provided by GFO staff are included in the GFO Appendix.

Overall Operations Score – 3.7, A-

Goal 5.0: Environment, Safety and Health Management

The contractor's performance relative to this Goal should demonstrate that environment, health, and safety (EHS) are a priority; that processes and practices are in place to effectively identify and manage risks to protect NREL workers, the local community, and the environment; and that the laboratory complies with all applicable DOE requirements, regulations, laws, and laboratory policies and procedures.

Overall Score – 3.9, A

PERFORMANCE OBJECTIVE 5.1 (50%): Alliance maintains a safe and healthful workplace through continuous improvement of its integrated safety management systems. **Score = 4.0, A**

PERFORMANCE OBJECTIVE 5.2 (50%): Alliance systems are effective in providing environmental protection and environmental compliance. **Score = 3.7, A-**

Goal 6.0: Business Operations

The Contractor's performance in this area should demonstrate efficient, effective business operations that are operating at minimum cost within a continual improvement environment and in compliance with DOE requirements, laws, regulations, laboratory policies, and procedures.

Overall Score – 3.9, A

PERFORMANCE OBJECTIVE 6.1 (25%): Alliance develops, enhances, operates, and maintains risk-based business systems and processes to support RDD&D. **Score = 3.9, A**

PERFORMANCE OBJECTIVE 6.2 (25%): Alliance operates and maintains effective financial systems that support RDD&D management and enable fiscal responsibility. **Score = 3.9, A**

PERFORMANCE OBJECTIVE 6.3 (25%): Alliance procurement processes support mission goals and DOE socioeconomic efforts. **Score = 3.9, A**

PERFORMANCE OBJECTIVE 6.4 (25%): Alliance human resource management systems are effective in providing the talent needed to implement the NREL mission. **Score = 3.9, A**

Goal 7.0: Infrastructure Stewardship and Site Operations

The evaluation of Alliance's performance with respect to this goal focuses on the effective provision of a capable, efficient, and mission-focused environment that enables the laboratory to pursue its technology targets and national goals, while providing a leadership example for sustainable energy that sets the bar for others.

Overall Score – 3.6, A-

PERFORMANCE OBJECTIVE 7.1 (70%): Alliance effectively maintains research and support infrastructure. **Score = 3.6, A-**

PERFORMANCE OBJECTIVE 7.2 (30%): Alliance demonstrates NREL leadership in sustainable laboratory operations. **Score = 3.5, A-**

Goal 8.0: Security and Emergency Management

The Contractor's performance against this goal must demonstrate that security and emergency management programs and practices enable the mission, while ensuring that threats and vulnerabilities are assessed and managed, computer networks and information are properly protected, and response to emergencies is immediate and appropriate.

Overall Score – 3.5, A-

PERFORMANCE OBJECTIVE 8.1 (50%): Alliance creates a secure work environment based on identified and assessed security vulnerabilities and threats, and manages programs to avoid or mitigate these risks. **Score = 4.0, A**

PERFORMANCE OBJECTIVE 8.2 (25%): Alliance protects computer information networks and proprietary business-sensitive information. **Score = 1.9, C**

PERFORMANCE OBJECTIVE 8.3 (25%): Alliance mitigates potential site emergencies and effectively responds to actual emergencies. **Score = 4.0, A**

APPENDICES – COMPLETE SETS OF COMMENTS AND SCORES

Advanced Manufacturing (AMO)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 3.6	Grade: A-

Goal Evaluation:

- NREL provides strong technical support for AMO through their analysis, model & tool development, and publications.
- The Lab provide credible, professional, and independent technical input that informs AMO's efforts.
- NREL staff have been thought leaders helping to develop methods to better understand the broader life cycle impacts materials and manufacturing technologies, and have been innovating and developing methodologies and tools that are extending the state-of-the-art

Objective 1.1: Advance Science and Technology

Weight: N/A **Score:** N/A **Grade:** N/A

Objective Evaluation:
N/A

Objective 1.2: Deliver Credible and Objective Analyses

Weight: 20.00% **Score:** 3.6 **Grade:** A-

Objective Evaluation:
NREL provides technical support for AMO through their analysis, model & tool development, and publications. NREL demonstrates professional, credible and objective analysis and critical thinking with in the areas of clean energy and technology analysis. The efforts have advanced the DOE/EERE/AMO mission by informing programmatic initiatives; by contributing insights and knowledge through in conference proceedings; and by supporting a multi-lab strategic analysis team that is developing useful and new approaches to help AMO better understand the potential energy and emissions impacts of next generation materials and manufacturing. NREL has made important contributions to a number of areas including: Strategic Analysis - NREL is

leading the development of important methodologies and associated tools that enable the program to estimate more robustly the embodied energy of materials, including key industrial commodities, as well as important classes of materials such as critical materials and advanced composites. This has included the development and peer review of the Materials Flow through Industry (MFI) tool, which will be able to estimate the impacts of materials substitutions, as well as the effects of efficiency improvements resulting from improved methods of manufacture. The Lab provides credible, professional, and independent technical input that informs AMO's efforts. In addition, NREL staff have been thought leaders helping to develop methods to better understand the broader life cycle impacts materials and manufacturing technologies, especially in the area of manufacturing competitiveness analysis. **Multi-Lab Collaborative Analysis** – NREL has coordinated and collaborated with other Labs to develop more informed analyses that benefit from the broader perspective of a range of interdisciplinary analysts and researchers. For example, NREL has collaborated with LBNL on the development of important methodologies to estimate more robustly the net energy impacts of manufacturing technologies. This has includes collaboration on the development LBNL's LIGHTEn-UP methodology and tool, which has been used to develop initial estimates of the life cycle energy impacts of the AMO R&D projects, as well as scenario developments that help inform strategic direction. **Quadrennial Technology Review** –This past year NREL has also been a key contributor to the Quadrennial Technology Review (QTR) Chapter 6 – Innovating Advanced Manufacturing, as well as supporting Technology Assessments. **Bandwidth Analyses** – NREL provided technical oversight and contributed to the publication of four deep-dive analyses (Bandwidth Studies) that are bottoms-up assessments of the technical potential to reduce energy and associated emissions from the four most energy-consuming industries in the US: Chemicals; Petroleum Refining; Pulp & Paper; and Iron & Steel. NREL staff that support AMO have strong analytical capabilities, and in many cases have unique technical capabilities and experience that ensures their work is not only first-rate but uniquely insightful. NREL staff are well-regarded and recognized in their respective research communities, and regularly assume leadership roles in their fields of expertise – especially in the areas of life cycle analysis, energy modeling, manufacturing competitiveness analysis and integrating analysis.

Objective 1.3: Demonstrate Relevance and Market Impact

Weight: N/A **Score:** N/A **Grade:** N/A

Objective Evaluation:
N/A

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score:	Grade:

Goal Evaluation:

This Goal and associated Objectives are not applicable.
Objective 2.1: Effectively Steward the ESIF User Facility
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A
Objective 2.2: Effectively Steward Major Research Facilities
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A

Goal 3.0: Provide Effective and Efficient Program Management

Score: 3.4 **Grade:** B+
Goal Evaluation: • NREL has coordinated and collaborated with other Labs to develop more informed analyses that benefit from the broader perspective of a range of interdisciplinary analysts and researchers. • NREL staff are knowledgeable of AMO's strategic direction, and are consequently strong contributors to conceptual project and analysis development. • In FY15, NREL played a strong role in contributing to the QTR chapter on manufacturing and the associated 14 Technology Assessments.
Objective 3.1: Effective Program Planning and Execution
Weight: 70.00% **Score:** 3.6 **Grade:** A-
Objective Evaluation: As indicated in Objective 1.2, NREL has coordinated and collaborated with other Labs to develop more informed analyses that benefit from the broader perspective of a range of interdisciplinary analysts and researchers. The planning required to do this is difficult and time-consuming as it requires integrated planning with other performers (in this case, three other labs), but has the potential to lead to better analysis outcomes. NREL has done a reasonable job in developing AOP work scopes and work plans in coordination with other member of the multi-lab team, and has taken initiative in developing integrated work plans within a DOE planning framework (the AOP SharePoint site) that is not conducive to this type of (multi-lab integrated) planning. A notable improvement in the FY16 AOP SOW development is that NREL prepared a

very responsive and highly detailed SOW that includes a sufficient level of detail including well-developed Tasks and associated Milestones. NREL staff are knowledgeable of AMO's strategic direction, and are consequently strong contributors to conceptual project and analysis development. That has enabled NREL to respond well when faced with changes/adaptations in planned work. In F15, this was a particular issue as the DOE Quadrennial Technology Review (QTR) became a high priority for not only DOE but also for AMO, as the Office used the QTR process to concurrently extend, refine and align AMO strategic planning and communication, and NREL adapted in order to contribute to this effort. The QTR process included the development of 14 Technology Assessments, which required a significant level of effort that was unanticipated when the FY15 AOP was developed. NREL – and the entire multi-lab team - played a strong role in contributing to the QTR chapter on manufacturing and the associated 14 Technology Assessments. In particular, NREL led authorship on the "Sustainable Manufacturing – Flow of Materials" Technology Assessment, which is a critical, foundational TA in that it lays out concepts of life cycle energy, materials flow analysis, and sustainable manufacturing approaches that cut-across all manufacturing. NREL has shown in practical terms that it can be responsive to Office needs, and has provided input with impact that align with program goals.

Objective 3.2: Effective Communications and Response

Weight: 30.00% **Score:** 3.0 **Grade:** B

Objective Evaluation:

NREL staff operate with a high degree of professionalism and high standards in engagement with DOE. Researchers provide thorough and well-considered insights, information and research output of the high quality. In general, the information is provided in a timely manner, but in some cases Tasks and milestones take longer than originally anticipated. This is likely attributable to the high demands placed on staff, and likely reflect the Lab's management weaknesses in effectively moderating workload for individual staff members. As some examples of where NREL exemplifies effective practices:

- NREL staff as a matter of business are highly engaged in communications with AMO technology managers through regular conference calls and other means of regular information sharing that facilitate effective project management.
- NREL staff have been proactive in ensuring there are no real or perceived conflicts of interest.
- NREL staff are usually responsive with appropriately quick turnaround on information requests. However, there are several examples of where NREL can do better in terms of effective communication, response, and ultimately performance; for example:
- Progress on Tasks, Subtasks and milestones is not proactively provided as part of a regular reporting format. This is a fundamental project management responsibility that NREL needs to implement.

As a consequence of the previous bullet point, there have been examples of where NREL's progress has not aligned with DOE's expectations.

· Coordination between analysis activities, especially across technology offices. NREL has unique insights into cross-cutting technology issues which gives the Lab the opportunity to leverage analyses synergistically. For example, a manufacturing competitiveness analysis of carbon fiber (CF) composites done for AMO should be communicated with and if possible coordinated with a manufacturing competitiveness analysis of CF for wind turbines. The Lab should proactively seek to inform both offices of their work in order to achieve the best coordinated and combined outcomes. This could be accomplished, for example, by holding cross-office briefings at the planning, work, and results stages. While some amount of information transfer occurs, there is significant opportunity to improve; this will become critical if new initiatives such as CEMAC are to be successful.

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00%	**Score:**	**Grade:**
Goal Evaluation: Not Applicable		
Objective 4.1: Laboratory Strategy		
Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		
Objective 4.2: Steward Core Competencies		
Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		
Objective 4.3: Leadership and Lasting Value		
Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		

Bioenergy Technologies (BETO)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 3.6	Grade: A-

Goal Evaluation:

Objective 1.1: Advance Science and Technology

Weight: 50.00% **Score:** 3.7 **Grade:** A-

Objective Evaluation:

NREL proved numerous innovations that are impactful to the overall mission of BETO. Generally strong LDRD projects. NREL produces significant R&D in the sustainable transportation sector that are meaningful for BETO. From the biochemical conversion perspective, areas of particularly standout accomplishment have been in the following: a) Lignin upgrading. Muconic acid has been produced at high titers (near industrial relevance) from APL feedstock. This muconic acid intermediate has then been efficiently chemically transformed into adipic acid, an impactful commodity chemical. Separately, published the first demonstration of lignin consolidated bioprocessing in Green Chemistry, wherein microbes secrete ligninolytic enzymes, depolymerize lignin, and uptake the resulting aromatic compounds for conversion to value-added products. b) Pretreatment. Demonstrated a reduced severity pretreatment concept designed to minimize downstream inhibitory compounds at an industrially relevant solids loading that significantly exceeded (~230 g/L) the monomeric sugar yields from corn stover when compared to Alliance's state-of-the-art dilute acid pretreatment (~160 g/L) while using commercially relevant enzyme packages and loadings. c) Organism identification and optimization. Very high titers/rates/yields of succinic acid from a C5 sugar stream were achieved and a new reactor design was employed for biofilm forming organisms. Multiple genetically tractable oleaginous organisms have been identified which can convert mixed sugars into TAGs. In the area of thermochemical conversion research, the NREL team is preparing their pilot plant for the FY17 experimental verification of BETO's $3/gge cost target. They have two configurations available, thus allowing for the potential verification of two different pathways. They have also made considerable progress in identifying next generation advanced catalysts for ex situ catalytic fast pyrolysis, one of the most promising pathways for the next experimental verification. NREL also demonstrated that ex situ upgrading resulted in lower hydrogen

consumption and a higher quality product (lower oxygen content) from downstream hydrotreating. Additional areas of accomplishment have been in the following: Integrated Bench-Scale Tests Produce Hydrocarbon Fuels from Key U.S. Biomass Feedstocks to understand the field- to-fuel impact of low-cost feedstocks on conversion performance. In a joint project between NREL, Idaho National Laboratory, and Pacific Northwest National Laboratory, several industrially relevant biomass feedstocks were evaluated at the bench scale for production of hydrocarbon fuel blendstocks via fast pyrolysis and hydrotreating. Feedstock choice was found to have significant effects on product yield (0.17–0.27 gfuel/gfeed), product composition, hydrogen consumption, and carbon efficiency to fuel. Techno-economic analysis was used to estimate conversion costs in a commercial process, which varied from $2.50 to $4.10/gallon of gasoline equivalent. This approach will be extended to other thermochemical biofuels processes, enabling the coordinated development of biomass resources and conversion technologies. Reforming aqueous waste from pyrolysis processes- Because the cost of wastewater management from a pyrolysis plant is $0.40/gal, NREL researchers have explored the catalytic reforming of the aqueous waste streams to produce hydrogen and fungible hydrocarbons. NREL successfully used zeolite catalysts to produce hydrocarbon intermediates that can be processed in a refinery to produce transportation fuels (i.e., recovered at least 25% carbon). The excess water in the waste stream reacts with coke precursors to reduce the rate of catalyst coking and form phenolics. Phenolics are important intermediates for making renewable polymers. NREL researchers have also synthesized bimetallic catalysts for reforming the aqueous waste stream to form at least 70% hydrogen.
Published 120 publications: 52 journal articles, 8 technical reports, 17 presentations, 29 posters, and 14 additional publications, such as outreach materials, book chapters, etc. Produced 259 on-time milestones.

Objective 1.2: Deliver Credible and Objective Analyses

Weight: 20.00% **Score:** 3.3 **Grade:** B+

Objective Evaluation:

The vast majority of the analysis for Conversion has been very good. NREL provides many of our Design Cases and State of Technology assessments. These documents guide much of the R&D that BETO funds and provide a baseline to evaluate new ideas against. NREL has the relevant expertise to provide these cross-discipline analyses. Significant design reports/analyses were published (see below). Completed reports in 2015:

- Completed pyrolysis techno-economic analysis with PNNL. In collaboration with PNNL, completed techno-economic analyses for pyrolysis (with ex-situ and in-situ upgrading) and indirect liquefaction, and published each as a process design report • Completed fast pyrolysis techno-economic analysis. Completed a

detailed process and techno-economic analysis of alternative processing strategies for fast pyrolysis using fixed-bed technology and multiple pathways from biomass to oxygenated intermediates capable of being upgraded to distillate range blendstocks.

- Released the Jobs and Economic Development Impact (JEDI) model for hydrocarbon production via fast pyrolysis. This is the first publicly available model that can be used to estimate jobs and other economic impacts resulting from the deployment of hydrocarbon biofuel facilities. (Highlighted by EERE's Bioenergy Technologies Office, or BETO, on Twitter and Facebook)
- Completed and published the process design report projecting the economic potential for the catalysis of cellulosic sugars to hydrocarbons pathway. This report provides the first public assessment of the economic potential for direct catalysis of hydrolysate sugars, and highlights important considerations and cost/sustainability tradeoffs regarding choices for hydrogen sourcing to satisfy the large hydrogen demands required by the process.
- Developed comparative economic and sustainability analyses of seven jet fuel production pathways from both lignocellulosic and starch-based sugars. These efforts have considered both first-of-kind economics as well as target designs with key technical barriers. NREL has played an important role in contributing to international dialogues on bioenergy sustainability. In FY15, scientists at NREL contributed to the completion of the SCOPE (Scientific Committee for Problems on the Environment) report on Bioenergy and Sustainability. Areas for improvement: Often the data that supports the Design Cases and SOT's is generated at NREL. This situation leads to potential conflict of interest: researchers worry that these analysis tasks will dictate their performance requirements and might be informing the analysis tasks accordingly. The analysis tasks, such as Design Cases and SOT's, need to be divorced from the performance metrics for the experimental researchers. Also, NREL needs to actively explore ways of incorporating experimental results from other sources beyond NREL researchers as noted above. A lack of NREL experimental data should not prevent pursuit of design cases or state of technology analyses; there are several external sources, including PNNL that could provide the necessary data.

Strategic analysis project PIs are proactive in communicating with BETO and responsive to BETO requests.

Sustainability and Strategic Analysis PIs have collaborated effectively with other labs and outside organizations on projects addressing refinery integration, high octane fuels, and co-optimization of fuels and engines.

1. State of technology analyses (SOTs) for conversion pathways for which the primary advances are not occurring at NREL - for things like the catalytic upgrading of sugars cases and in-situ catalytic fast pyrolysis case, a strategy

should be put in place to help gather a limited amount of new information from partners to offer updated numbers based on similar parameters as the initial design case. If the situation has changed too dramatically since the base case was published continued SOTs should be re-evaluated with input from BETO but until then design cases should be done for each pathway for each year.

2. The BSM has been used to analyze questions which may be out of scope for the model. For example, it is used to implicitly compare conversion technologies with only a very limited mechanistic understanding for what reasonable assumptions in these areas are. In addition, there are plans in FY16 to explicitly compare conversion technologies, which, if they go forward should do so with very large levels of input from BETO and Conversion PIs at the labs.
3. NREL could be more proactive in seeking out collaborations without being prompted by BETO technology managers.

Objective 1.3: Demonstrate Relevance and Market Impact

Weight: 30.00% **Score:** 3.7 **Grade:** A-

Objective Evaluation:
Innovations resulted in 2 patent awards, 13 patent filings, 32 records of invention, and 14 active licenses.
Particularly notable CRADAs and contracts have been with Johnson Matthey on fast pyrolysis; Ecopetrol on new international feedstocks; Shell on new energy collaborations; and Petrobras and Ensyn through the Brazil Bilateral partnership.
Leveraged DOE funds through the establishment of industry and research partnerships, with nearly 30 organizations (CRADAs, Work for Others, and Licensing Agreements) Cooperative Research and Development Agreements (CRADAs) • Ecopetrol America Inc. • Enerkem • General Mills • Georgia Institute of Technology • Johnson Matthey • Petrobras – Cenpes • R.J. Reynolds Tobacco Company • Shell Global Solutions • Virent, Inc. Work for Others Partnerships • Abengoa Research, S.L. • BASF Corporation • California Safe Soil • Cargill Inc. • Cobalt Technologies • DSM Biotechnology Centre • DuPont • Ethanol Technologies Ltd. • Grain Millers, Inc. • Green Earth Institute Co., Ltd. • JGC Corporation • Leaf Resources Limited • NexSteppe • Novozymes, Inc. • POET Research Center • SABIC Americas, Inc. • Shell International Exploration & Production B.V. • TechnoSolutions Corporation • Toyota Central R&D Labs • University of British Columbia.
In support of accelerating commercialization and increasing deployment, NREL maintains the Alternative Fuels Data Center biofuels pages, which receive more than 500,000 website page views per year and the BioEnergy Atlas tools, which receive close to 100,000 page views per year. These tools are a useful resource to a broad set of bioenergy stakeholders. Improvements in FY15 focused on enhancing the user experience and updating datasets.

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score: 3.3	Grade: B+

Goal Evaluation:

Objective 2.1: Effectively Steward the ESIF User Facility

Weight: 50.00% **Score:** 3.4 **Grade:** B+

Objective Evaluation:

During FY 2015, Peregrine supported 51 research and development projects involving modeling and simulation across nine EERE Offices and Programs (BETO, BTO, ESI, Geothermal, H2, Solar, Vehicles, Water, and Wind). Peregrine sustained an average utilization of 83% year to date. In response to continued high demand for computational resources, DOE approved the expansion plan for Peregrine to add an additional petaflop of computational capability to the existing system for a total of approximately 2.2 petaflops peak. Alliance and Hewlett-Packard have worked closely together. NREL researchers are very involved with the HPC part of ESIF and it is of great benefit to the BETO program.

Objective 2.2: Effectively Steward Major Research Facilities

Weight: 50.00% **Score:** 3.1 **Grade:** B+

Objective Evaluation:
For Bioenergy, ESIF facilities were relatively effectively utilized by the RD&D community.
WFO, FOAs, CRADAs, Industrial Use, CRADA Partner Cost Share, FOA cost share, and $ Value of Partnerships were all exceeded.
CRADA Costs, WFO Costs, and % new partnerships were not met. This could be improved for FY16.

- Alliance developed a new enzyme that works on both major components of biomass (cellulose and hemicellulose) simultaneously through a novel two-pronged mechanism that allows for significantly (14x) faster digestion than any known commercial enzyme packages. This was Office of Science funded work in the basic-applied space.
- Alliance did preliminary techno-economic analysis along with small-scale blended pyrolysis oil and vacuum gas oil

- Ensyn Corp. produced larger volumes of pine pyrolysis oil, which made it possible to refine the techno-economics at NREL
- Petrobras processed 2,000 gallons of raw pyrolysis oil in a continuous 70-hour run at its FCC (fluid catalytic cracking) unit. The resulting streams were distilled into gasoline and diesel precursor fractions and hydrotreated to "partially renewable" gasoline and diesel fuels.
- The "renewable" diesel fuel underwent independent Part 79 testing by Southwest Research Institute and the results merited a renewable diesel category approval by the U.S. EPA to Ensyn.
- A new pathway of biomass pyrolysis oils to diesel, produced in a conventional refinery, is approved as an advanced biofuel by the EPA. The Brazil Bilateral – Petrobras– Alliance CRADA sponsored by BETO and EERE International Program worked with Ensyn Corp. as a commercial supplier for pyrolysis oils to evaluate the economic and technical viability of blending pyrolysis oils into refinery unit operations.

Goal 3.0: Provide Effective and Efficient Program Management

Score: 3.9	Grade: A	
Goal Evaluation:		
Objective 3.1: Effective Program Planning and Execution		
Weight: 70.00%	**Score:** 3.8	**Grade:** A

Objective Evaluation:

NREL documented a series of recommendations and strategies to ensure that two of BETO's promising process designs for hydrocarbon fuel production (fermentation of sugars and fast pyrolysis).

BETO and NREL engage in a multiple month, iterative process for AOP development that entails the proposal and review of both new ideas and workscope for continuing projects. An indirect indication of success in this regard is the fact that 9 out of BETO's ~40 FY15 Dashboard milestones were Alliance's, which was significantly more than any other lab. SMART milestones were used frequently and the quality of milestones improved significantly from past years.

NREL and BETO adhered to a change control process that is consistent with the guidelines developed and implemented by EERE as a whole. For any significant change in scope, budget or timing (examples could be timing delay of a deliverable, a change in work scope, adding or dropping of planned workscope, etc.), a change control form is filled out documenting the change, who requested the change (NREL or BETO) and what the impacts of the change will be. These change control forms were reviewed and approved by the Laboratory Program Manager (LPM) at NREL and the appropriate Technology Manager/Leadership team member at BETO. In FY15, Alliance managed 21 change requests via this system, and the agreed upon changes are reflected in the new AOP plans.

NREL has introduced several new projects that are leading the way in biofuel development. Their catalyst cost model project was one of the few new proposed projects that reviewed well and was viewed as a useful tool for the industry. As a result, this project has grown to incorporate PNNL. NREL was the most responsive to our directive to merge catalysis projects across labs and to help identify areas for collaboration. NREL took the lead on organizing new projects and coming up with new research directions. All NREL staff- from the staff scientists and post docs to PIs and LRM- have been extremely responsive and proactive in working with BETO. NREL has also provided valuable input to BETO strategic planning efforts.

Objective 3.2: Effective Communications and Response

Weight: 30.00% **Score:** 4.1 **Grade:** A+

Objective Evaluation:

NREL Biomass management has been very effective and responsive in communications with BETO. In particular, Adam Bratis has also provided excellent feedback for BETO decision makers through our strategic planning process. Individual PIs have also been very responsive to requests from BETO staff. NREL did an excellent job of responding to our concerns about the efficacy of a large project that did not review well by external reviewers. NREL helped us identify options for resolving this issue, ultimately by discontinuing the project while keeping valuable elements of the project alive as tasks in other, better managed projects. As evidenced by public presentation forums where multiple national labs are involved (e.g., Peer Review, the Catalysis Working Group, etc.), NREL consistently does the best job of tailoring their research goals to make the biggest impact on the biofuels industry.

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00% **Score:** 3.8 **Grade:** A

Goal Evaluation:

Objective 4.1: Laboratory Strategy
Weight: 25.00% **Score:** 3.7 **Grade:** A-
Objective Evaluation: NREL proposed and worked on several ideas for the big ideas summit including the Chemical Conversion big idea with direct impact to BETO
Objective 4.2: Steward Core Competencies
Weight: 40.00% **Score:** 3.8 **Grade:** A
Objective Evaluation: There have been several technical hires in the conversion area in FY15 of excellent scientists. NREL is encouraged to maintain many of its current biomass PIs who have excellent technical capabilities. NREL regularly collaborates with other leading researchers in the field at academic institutions and private companies providing additional value to BETO.
Objective 4.3: Leadership and Lasting Value
Weight: 35.00% **Score:** 3.8 **Grade:** A
Objective Evaluation: NREL has worked with BETO to build strategic cases for existing and proposed program activities and initiatives.

Building Technologies (BTO)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 3.5	Grade: A-

Goal Evaluation:

NREL supports several key BTO program areas: developing emerging, high-impact building technologies that are generally five years or less to market-ready; accelerating energy performance improvements in existing and new residential and commercial buildings by demonstrating and deploying a suite of cost-effective technologies, tools and solutions.

Objective 1.1: Advance Science and Technology

Weight: 50.00% **Score:** 3.5 **Grade:** A-

Objective Evaluation:
1.1.B.1 Technology innovations and improvements demonstrate progress toward program goals.

- NREL provides key support in buildings energy modeling and simulation that leverages EnergyPlus. Future updates need to be better documented to ensure successful future outcomes.
- NREL helped re-strategize the windows testing facility to leverage WFO investments and are beginning to support BTO in the Grid/Transactive control cross-cutting strategy. NREL continues to work effectively to reach their mission of playing a strong contributing role in creating a fully sustainable built environment. NREL played a key in developing and rolling out a common definition for zero energy buildings.
- In addition, NREL developed a Final report and new testing agreements with Sage Electrochromics and Heliotrope Technologies; demonstrated 4"x4" transparent VI with less than 0.01 W/m-K and more than 50% transparency with low-e coatings.

Objective 1.2: Deliver Credible and Objective Analyses

Weight: 20.00% **Score:** 3.4 **Grade:** B+

Objective Evaluation:
1.2. B.1 Key analyses are delivered that are objective, relevant and timely, and provide new insights

- NREL provided vital and high quality support of BTO goals framework and analysis, and was a key participant in the development of the framework and methodology. This included use of OpenStudio to help validate initial goals through the development of small office test cases and, exploring over 12 measures in multiple climate zones. NREL also supported BTO's input into the EERE QTR.
- Strong linkage of technology demonstration outcomes with better buildings stakeholder members, documenting highlights and preliminary outcomes and helping grow the number of demonstration sites. Excellent participation on space conditioning and plug/process load technology teams, especially at the Better Buildings Summit. Good identification of market barriers around advanced power strip deployment, and tracking of metrics for Advanced RTU campaign. Good analysis of better buildings website statistics to guide improvements, though initial submissions required additional technical editing.
- NREL leads the Better Building Energy Data Accelerator and joined the Better Buildings Challenge on Data Centers and is integral to sharing the Buildings Message (19K lab visitors, 7k Continuum Magazine subscribers).
- Analysis capabilities are strong in support of RBI, particularly the recent Building America program impact analysis, including the development of 10 new BA solution center case studies. NREL team is adept at analyzing clearly defined problems, and leads the field in residential analysis capabilities, such as building performance optimization.
- In Manufacturing Analysis, NREL input should be valuable for the HVAC&R portfolio. Responsiveness has been slow across BTO's project areas (HVAC&R, Windows and SSL)
- NREL is currently challenged with delivering analysis results relevant to deployment program objectives. This will be an increasing focus of RBI initiatives, and NREL management will need to improve the value of fast turnaround results.

Objective 1.3: Demonstrate Relevance and Market Impact

Weight: 30.00% **Score:** 3.5 **Grade:** A-

Objective Evaluation:

1.3.A.1 Implement an innovative partnering program that uses third-party funding to introduce early-stage energy efficiency technologies into the market and replicate the program with other partners or other technology sectors.

- Strong leadership advancing BTO's energy modeling tools portfolio. NREL continues to find opportunities to grow the effort, expand capabilities or collaborate with new groups to help maximize the impact of BTO work for RBI, CBI and ET. This includes the transition of Energy Plus/Open Studio. In

addition to growing the number of utility partners, NREL's OpenStudio team has recruited a number of high-profile Software Development Kit partners.

- NREL's 3rd party investments exceed federal investment by 50%, including: Heliotrope, Tech to Market (IP, licensing) and Deployment (tools, fenestration test facility).
- NREL developed a clear work plan for the Energy Data Accelerator and recruited 20 city-utility pairs in a limited time to join the accelerator. NREL has so far shown success in standing up this new program and coordinating a project team to execute the tasks required.
- Home Energy Rating Score--Communication of management objectives to DOE could be clearer, but capabilities and accomplishments in this area are on track and potentially transformative for the HERS industry.

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score: 3.5 **Grade:** A-

Goal Evaluation:

NREL has state of the art and unique equipment for analyzing a wide spectrum of building energy efficiency technologies and innovations.

Objective 2.1: Effectively Steward the ESIF User Facility

Weight: 50.00% **Score:** 3.5 **Grade:** A-

Objective Evaluation:

2.1.B.1 Metrics for utilization of the Energy Systems Integration Facility meet the targets established in the ESIF Stewardship Plan.

- Volttron infrastructure installation in ESIF is now on track, having resolved early coordination issues with Virginia Tech. Moving forward, NREL should maximize engagement of their leadership/staff regarding Volttron.2.2.B.2 Alliance makes effective use of available resources to sustain the relevance and attractiveness of leading research facilities
- $3.5M of internal, competitively selected LDRD for 6 projects is aligned with BTO work, along with a $0.5M project with internal Strategic Initiative Funds.
- Commissioned the Smart Power Lab with 19 partners (14 states, 4 foreign countries and $4M work).
- Leveraged NREL Work-for-Others includes $10M for building technology demos (Navy), 6 agreements for buildings research and the new windows testing work.

Objective 2.2: Effectively Steward Major Research Facilities

Weight: 50.00% **Score:** 3.5 **Grade:** A-

Objective Evaluation:

2.2.B.1 Metrics of utilization of other major facilities (NWTC, the Biomass and Biosciences Research Facility, and the Materials and Chemical Science and Technology Facility) meet the targets established in the respective facility stewardship plans.

- NREL helped re-strategize the windows testing facility to leverage WFO investments. BTO provides a very small operational budget and NREL funds the rest via outreach to the private sector. They have had quite a number of partners from large to small businesses.
- Wells Fargo selects LiquidCool Solutions for Innovation Incubator in the Thermal Test Facility.

Goal 3.0: Provide Effective and Efficient Program Management

Score: 3.4 **Grade:** B+

Goal Evaluation:

NREL has a high-quality workforce and provides expertise to the Building Technologies Office in a number of key areas.

Objective 3.1: Effective Program Planning and Execution

Weight: 70.00% **Score:** 3.3 **Grade:** B+

Objective Evaluation:

3.1.B.2 Alliance project management practices appropriately manage changes and risks to avoid significant departures from planned performance. Continuous improvement in "voice-of-the-customer", or listening to and heeding input from stakeholders and DOE TMs, will increase their overall effectiveness for BTO:

- NREL has not adequately responded to user needs in order to successfully deploy the Technology Performance Exchange (TPEx). The structure and process that NREL has developed around TPEx has made it difficult and costly for equipment manufacturers to upload required data to TPEx and for 3rd party evaluators to incorporate technology demonstration data.
- NREL has failed to effectively deploy the BuildingSync data format in the market in FY15. NREL did not dedicate enough staff to the project and as a result did not make the expected progress. NREL has lagged in working with FEMP to get FEMP's compliance Tracking System ready to import BuildingSync files and has failed to make adequate progress in working with the

market to get early adopters to use this data format. This has caused the project to fall behind and make less impact than planned.3.1. B.6 Strategic programs and partnership opportunities align with EERE programs.

- NREL did not provide significant new information or exhibit the strategic thinking when asked to examine use cases for Advanced Energy Design Guides that DOE needed to inform our strategy. Despite clear feedback from DOE on a draft, the problem was not rectified. As a result of NREL's ineffective management of this project and poor communication with DOE, the outcome/deliverable was unusable.
- NREL effectively managed RBI work during the transition from the expired 10 Building America team subcontracts to the new FOA-based teams, they are actively managing the technical aspects of 5 new Building America team awards. NREL staff are doing a great job with this complex set of activities, adding value every step of the way, along with significant work to wrap up 5 years of research, publish all the results, and help DOE analyze/quantify results and gaps.

Objective 3.2: Effective Communications and Response

Weight: 30.00% **Score:** 3.6 **Grade:** A-

Objective Evaluation:

3.2.A.1 Alliance works with EERE to significantly strengthen program management practices by adopting standardized, leading practices for reporting milestones and costs that draw data from NREL systems to provide useful information for program managers to monitor status.

- NREL initiated over 40 Change Control actions; completed 99 % of their milestones completed on time; initiated 68 AFTs (down from 115 in FY14).
- NREL provides timely and accurate input into BTO milestone and financial tracking tool

3.2.B.1 Alliance demonstrates effective ongoing communications regarding program status, opportunities, issues and options to resolve, or staffing changes.

- NREL is generally very effective in its communications and response to the CBI program needs.

3.2.B.2 Responses to DOE requests for information are timely.

- NREL staff continuously interact with their BTO counter parts and conduct regularly scheduled tag ups (milestones/budgets) with both the TDM and Operational staff. NREL has been very timely in response to requests for information to support BTO decision makers. In addition, NREL has be very responsive to information requests outside of programmatic scopes particularly in the case of the request for an RBI Legislation Analysis of the CEC Compliance Engine.

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00% **Score:** 3.4 **Grade:** B+

Goal Evaluation:

NREL has effectively provided the necessary leadership and stewardship of the laboratory to support BTO mission and objectives.

Objective 4.1: Laboratory Strategy

Weight: 25.00% **Score:** 3.4 **Grade:** B+

Objective Evaluation:

4.1.A.1 Insights from the Alliance NREL 2025 planning process provide options that are worthy of further exploration or investment by EERE or DOE or that shift the energy dialogue.

- NREL prepared Grid Modernization Strategy documents for transactive control across Electric Vehicles, Water/Wastewater and Home Energy Management. The homes strategy did not demonstrate an effective approach to accelerate vehicle to building integration. To address this gap NREL needs to improve cross-sector dialogue and synergy.

4.1.B.2 Alliance investments develop promising new areas of research, sustain NREL's relevance in current research areas, or validate the potential of new concepts.

- Support of Urban Net Zero Energy Districts and DOE's Big Idea Initiative on Urban Energy Science and Engineering. While NREL worked with the other Labs on this Big Idea, their solution was too academic (largely modeling) and not as market relevant as it might have been. DOE has since re-scoped this work to better align with the needs of the Cities.

Objective 4.2: Steward Core Competencies

Weight: 40.00% **Score:** 3.5 **Grade:** A-

Objective Evaluation:

4.2.A.1 Transformational investments enable NREL to develop and lead new research areas.

- Boschco-funded project with BPA Home Battery System for Cybersecure Predictive EE and DR.
- $1Mof NREL internal funds used to build the Smart Power Lab in the ESIF specifically for Buildings research. Efforts moving forward should focus on

maximizing BTO's benefit from that Lab, the grid integration capabilities and the balance of ESIF facilities. 4.2.B.1 Core and enabling capabilities are strengthened through technical hires, collaborations, or enhancements to research assets to support programs or new initiatives.

- NREL leadership in building energy modeling and simulation work, an important core competency, has resulted in NREL's ability to develop and lead new research areas.

Objective 4.3: Leadership and Lasting Value

Weight: 35.00% **Score:** 3.3 **Grade:** B+

Objective Evaluation:

4.3.A.1 Alliance works with EERE to develop a strong business case for strategic programs and initiatives, builds the stakeholder base, and gains support for sustained investment.

- NREL Strategic Program Partnerships (WFO) funding accelerates and amplifies BTO's mission and goals while increasing influence and impact: $21M, 33 agreements with Wells Fargo $10M of total.
- $3.5M in 9 LDRDs (some Multi-year).

Federal Energy Management Program (FEMP)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 3.8	Grade: A	
Goal Evaluation:		
Objective 1.1: Advance Science and Technology		
Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		
Objective 1.2: Deliver Credible and Objective Analyses		
Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		
Objective 1.3: Demonstrate Relevance and Market Impact		
Weight: 30.00%	**Score:** 3.8	**Grade:** A
Objective Evaluation: NREL was part of the team recognized on October 31, 2014 with a GreenGov Award for providing technical assistance to the Department of Transportation. In addition, NREL has provided analysis for the DC solar challenge by analyzing 18 federal buildings for solar potential. NREL has also evaluated over 7,000 federal sites for renewable energy potential to contribute to the 30% by 2025 renewable goal in EO 13693.		

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score:	Grade:
Goal Evaluation:	

Objective 2.1: Effectively Steward the ESIF User Facility
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A
Objective 2.2: Effectively Steward Major Research Facilities
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A

Goal 3.0: Provide Effective and Efficient Program Management

Score: 3.5 **Grade:** A-
Goal Evaluation:
Objective 3.1: Effective Program Planning and Execution
Weight: 70.00% **Score:** 3.5 **Grade:** A-
Objective Evaluation: 3.1.B.1 and 3.1.B.5 NREL has a strong record of project management and using the AOP process to develop milestones, track project changes, and manage projects.
Objective 3.2: Effective Communications and Response
Weight: 30.00% **Score:** 3.5 **Grade:** A-
Objective Evaluation: NREL has a strong record of communication and responsiveness to requests for information. NREL also has centrally managed the milestone reporting and budget rebalancing processes for strong project management.

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00% **Score:** 3.8 **Grade:** A
Goal Evaluation:

Objective 4.1: Laboratory Strategy
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A
Objective 4.2: Steward Core Competencies
Weight: 40.00% **Score:** 3.8 **Grade:** A
Objective Evaluation: 4.2.B.3 NREL quickly filled the Laboratory program manager position for FEMP with an experienced candidate.
Objective 4.3: Leadership and Lasting Value
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A

Fuel Cell Technologies (FCTO)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 3.8 **Grade:** A

Goal Evaluation:

In FY15, National Renewable Energy Laboratory (NREL) continued their excellent progress in a number of hydrogen and fuel cell areas, including fuel cell manufacturing, tech-to-market efforts and model development and analysis. NREL's most noteworthy and impactful outcomes this year were the completion of the on-line hydrogen-fuel cell electric vehicle (FCEV) refueling station finance calculator/tool (H2FAST) for use by H2USA partnership and other stakeholders, their support of the H2FIRST (H2 Fueling Infrastructure Research Station Technology) project in partnership with Sandia, and their support of the Small Business Voucher (SBV) pilot. NREL also did an excellent job stepping up to coordinate across multiple labs on the H2 at Scale big idea.
NREL continued to provide scientific and technical leadership, and expand its scientific capabilities to meet the goals and objectives of the Fuel Cell Technologies Office (FCTO) and its partners. This was made clear by their ability to improve the working environment at ESIF and identify impactful opportunities and industry participation particularly for component validation relevant for infrastructure development. They exhibited coherent vision and leadership by their ability to collaborate with external stakeholders to advance hydrogen and fuel cell technologies. In FY16, NREL should focus on continuing to:

- strengthen inter-lab coordination, particularly with the new FCTO lab-led consortium model and SBV program;
- leverage other programs (e.g. Office of Science, industry, other agencies) while at the same time creating critical mass in key high priority areas;
- provide feedback and support to all Technology Managers (TMs), Program Managers (PMs), and the Program Director to maximize project effectiveness and timely accomplishment of FCTO goals and should raise any issues/concerns early on;
- implement recommendations from AMR project reviewers and DOE TMs/PMs;
- coordinate assumptions and inputs for analyses with DOE TMs, and improve quality control and review of reports and documents;
- improve project management and communication skills to meet the planned project milestones and deliverables, particularly avoiding cost over-runs and meeting deliverables for CRADAs; and

- notify FCTO of communications/press related activities before they occur and provide a debrief afterwards.

Objective 1.1: Advance Science and Technology

Weight: 50.00% **Score:** 3.5 **Grade:** A-

Objective Evaluation:

- NREL successfully developed automated detection algorithms for fuel cell manufacturing quality control allowing a computer to detect defects in membrane material. NREL also advanced the through-plane reactive excitation technique to create pinholes in membranes with reproducible sizes for fuel cell manufacturing quality control purposes.
- NREL is commended for their leadership in championing a MGI-based design of experiments' approach to the development of high-efficiency photoelectrochemical materials and devices, employing state-of-the-art methodologies for best utilization of theory, synthesis, characterization, analysis and data resources, and the field of fermentative hydrogen production.

Objective 1.2: Deliver Credible and Objective Analyses

Weight: 20.00% **Score:** 4.0 **Grade:** A

Objective Evaluation:

- NREL continues to provide high quality analysis support to FCTO and stakeholders and is well recognized as an expert (attracting more than $3 million in non-DOE funding).
- In addition to a number of other analyses, NREL's most noteworthy and impactful outcome this year was completing the on-line hydrogen-fuel cell electric vehicle (FCEV) refueling station finance calculator/tool (H2FAST) for use by H2USA partnership and other stakeholders.

Objective 1.3: Demonstrate Relevance and Market Impact

Weight: 30.00% **Score:** 4.0 **Grade:** A

Objective Evaluation:

- NREL is commended for its Tech-to-Market (T2M) efforts related to the FCTO portfolio for obtaining partners for its manufacturing program. Their efforts led to 11 new agreements totaling more than $1.4 million. They have been

exceptionally responsive and proactive on EERE T2M activities, including the SBIR TTO by FCTO.

- NREL is to be commended for their significant efforts in coordinating the "H2 at scale" big idea, particularly for interfacing with INL and improving the quality of the AOP.
- NREL is commended for their continued work with commercial electrolyzer companies in efforts to validate operations under intermittent renewable power sources to identify and address associated R&D needs.
- NREL has been extremely responsive and productive on Technology Validation (TV) and Market Transformation (MT) tasks.

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score: 3.3 **Grade:** B+

Goal Evaluation:

NREL has improved the working environment at ESIF to identify impactful opportunities and industry participation particularly for component validation relevant for infrastructure development. Continue to focus on acquiring international participation regarding hydrogen related projects and institute recommendations from AMR project reviewers.

Objective 2.1: Effectively Steward the ESIF User Facility

Weight: 50.00% **Score:** 3.3 **Grade:** B+

Objective Evaluation:

- NREL has improved the working environment at ESIF relevant to component validation testing which had previously been continuously delayed. Operations appear to have stabilized as exhibited by the commencement of component testing at NREL in support of important infrastructure/station R&D projects.
- NREL needs to acquire industry participation within relevant hydrogen projects that support the deployment of hydrogen infrastructure, especially at the component level. This feedback was received from the AMR reviewers but NREL has not yet responded to this input.

Objective 2.2: Effectively Steward Major Research Facilities

Weight: N/A **Score:** N/A **Grade:** N/A

Objective Evaluation:

N/A

Goal 3.0: Provide Effective and Efficient Program Management

Score: 2.8	Grade: B

Goal Evaluation:

NREL efficiently and effectively integrates and expands it scientific capabilities to meet the goals and objectives of the Fuel Cell Technologies Office (FCTO). NREL also provides feedback and support for all Technology Managers (TMs), Program Managers, and the Program Director for maximizing individual project effectiveness and timely accomplishment of FCTO goals. Continue to focus on the projects that have experienced delays, reach agreement with the TM on a new schedule, and then keep the project on schedule. Also, focus on coordinating analysis assumptions and inputs with DOE TMs, and quality control and review of reports and documents

Objective 3.1: Effective Program Planning and Execution

Weight: 70.00% **Score:** 2.6 **Grade:** B-

Objective Evaluation:

- NREL has improved their organization, presentation and reporting of R&D results for photolytic and fermentative hydrogen production and the Wind to Hydrogen projects, and improved coordination and communication towards goals with FCTO managers in both Production & Delivery and Technology Validation.
- NREL is encouraged to minimize the practice of modifying milestones in responses to unexpected delays or problems. Milestone modification should be coordinated with DOE managers to develop a plan that effectively addresses the root cause of the delay or problem, and to adjust subsequent milestones as needed.
- NREL should continue to focus on improving their long term planning of high risk R&D to accommodate alternative and risk mitigation strategies, and communication of key personnel changes relevant to DOE projects.
- NREL failed to meet to meet the schedule milestones for the GM-CRADA and exceeded the planned budget. As a result, additional funds will be required to achieve the deliverables in FY2016.

Objective 3.2: Effective Communications and Response

Weight: 30.00% **Score:** 3.2 **Grade:** B+

Objective Evaluation:

- NREL is commended for their proactive engagement with the Program Manager and the Technology Managers regarding projects in hydrogen production and delivery, and in hydrogen pathway analysis.
- NREL should improve their quality control and review process to ensure their reports, accomplishments and other documents are accurate and precise, and convey the actual status to outside audiences not familiar with the project.
- NREL performed techno-economic analysis of multiple renewable hydrogen production pathways for Oahu, Hawaii as a first step in understanding the most cost effective way of providing hydrogen infrastructure. NREL should have coordinated the analytical work with DOE to ensure the most relevant assumptions were used for analysis.
- NREL should continue to enhance collaboration and communication with other fuel cell laboratories (particularly LANL) in the area of fuel cell R&D.

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00%	**Score:** 3.6	**Grade:** A-

Goal Evaluation:

NREL continues to provide a coherent vision and leadership as shown by their ability to collaborate with external stakeholders to advance hydrogen and fuel cell technologies. NREL did a particularly noteworthy job on H2USA, H2FIRST and with the Small Business Voucher (SBV) pilot. NREL should focus on close communication with DOE Director and managers to ensure strategic alignment, well documented progress towards milestones and identify critical issues that could negatively impact project progress.

Objective 4.1: Laboratory Strategy

Weight: 25.00%	**Score:** 3.6	**Grade:** A-

Objective Evaluation:

- NREL is commended for an excellent job working with Sandia National Laboratory at the direction of FCTO to establish and leverage key capabilities related to hydrogen fueling (H2FIRST), and in initiating the first set of H2FIRST projects.
- NREL should work to communicate to DOE critical issues occurring within the NREL hydrogen and fuel cells teams that could negatively impact project progress and at the same time, work to address the issues before they become a crisis.

Objective 4.2: Steward Core Competencies

Weight: 40.00%	**Score:** 3.6	**Grade:** A-

Objective Evaluation:

- NREL has successfully incorporated collaborations with other National Labs into recent projects in order to leverage the available expertise and resources to complement their own core competencies.
- NREL is encouraged to further detail and document the scope and uniqueness of the resources and expertise associated with their core competencies, especially in relation to other competing/complementary laboratory facilities.
- Adding to their core competency for hydrogen storage material characterization and validation, NREL developed hardware and test methods for in situ thermal conductivity measurements of solid-state hydrogen storage materials under an operating range of 77K to 400K and up to 150 bar of pressure in a hydrogen atmosphere. The initial results are promising, but further testing is still needed to validate the technique. In addition, NREL developed a detailed manuscript with guidelines for material researchers on various form factors recommended for measuring and reporting volumetric capacity results to help ensure a universal and accurate approach within the hydrogen storage community.

Objective 4.3: Leadership and Lasting Value

Weight: 35.00% **Score:** 3.7 **Grade:** A-

Objective Evaluation:

- NREL has strengthened their stewardship of applied PEC research while improving coordination with more basic research efforts, particularly those specifically supported by BES, and by engaging the international research communities in this technology area.
- NREL provided strong leadership to the subtask of NFPA 2/55 that is defining the setback distances for bulk gaseous and liquid hydrogen storage at the refueling station. This activity was conducted under continuous codes and standards improvement process. The scope of this task group expanded this year to include gaseous hydrogen storage. The plan developed by the task group will produce a new set of setback distances and safety measures for reducing these distances that will appear in the next editions of the NFPA 55 Compressed Gas and Cryogenic Fluids Code and the NFPA 2 Hydrogen Technologies Code. These setback distances present a large barrier to developing larger hydrogen fueling capacity at existing fueling stations or space-constrained fueling sites. The modified setback distance requirements will allow for many locations that were considered non-code-compliant to then be considered as potential hydrogen fueling sites, which will help meet the FCTO objective of facilitating the deployment of fueling infrastructure.
- NREL is commended for their leadership on two separate hydrogen storage collaborations. First, NREL partnered with three other national laboratories on a collaboration effort to bring several new and existing hydrogen storage characterization techniques all together under one effort. The objective is to aid

DOE researcher access to a host of world class resources necessary for hydrogen storage material characterization and validation with a goal to better understand the core process of how hydrogen interacts with solid state materials and provide pathways for increased hydrogen storage capacities, kinetics, and thermal management. Second, NREL coordinated a follow-on effort of the Hydrogen Storage Engineering Center of Excellence to further refine and enhance various material-based hydrogen storage system models coupled with vehicle and fuel cell system models. This collaboration will allow material researchers to predict how their materials will perform from a hydrogen storage system perspective and ultimately how their materials and associated material properties will impact vehicle performance for metric such as range and drive cycles.

Geothermal Technologies (GTO)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 3.4	Grade: B+

Goal Evaluation:

Overall solid effort at managing a wide-ranging portfolio of projects.
Efforts towards collection, synthesis and incorporation of data into the Geothermal Data Repository (GDR) and National Geothermal Data System (NGDS) were top-notch.

Objective 1.1: Advance Science and Technology

Weight: 50.00% **Score:** 3.5 **Grade:** A-

Objective Evaluation:
NREL helped to advance science and technology through a collaboration with Idaho National Laboratory and a three-party Cooperative Research and Development Agreement (CRADA) with Enel Green Power North America. In this effort, the team developed and validated a computer model of Enel's Stillwater Geothermal Hybrid Project in Stillwater, Nevada. The team examined ways to use solar-thermal heat to offset any lack of geothermal resource productivity as well as ways to leverage the benefits of integrating geothermal and solar-thermal heat sources. The analysis highlights how solar thermal systems can be integrated with geothermal plant to boost performance and will be used by Enel to optimize operations at Stillwater. The research identified that low-cost solar thermal collectors and more flexible power cycles that can use higher-temperature solar thermal inputs are required for widespread adoption of geothermal/solar-thermal hybrids in the absence of other incentives.

Objective 1.2: Deliver Credible and Objective Analyses

Weight: 20.00% **Score:** 3.5 **Grade:** A-

Objective Evaluation:
For analysis efforts, NREL and the Colorado School of Mine advanced from modeling the performance of low-permeability sedimentary geothermal systems in idealized systems to incorporating realistic reservoir features, such as heterogeneous properties

and the presence of faults, and developing models of actual sedimentary formations based on well log data.
Productive outcomes were also achieved in the Geothermal Resource Reporting Methodology (GRRM) - this project developed a system that allows for the ranking or grading of a resource on 12 parameters, including geological parameters such as temperature and permeability, technical parameters such as power conversion and drilling difficulty, and socio-economic parameters such as permitting and land access. NREL staff also conducted very credible analysis on "Doubling Geothermal by 2020"

Finally, through its involvement in the Geothermal Vision Study (VS), NREL presented on the methodology used to develop supply curves and perform market penetration modeling for geothermal in ReEDS, including the results of preliminary ReEDS runs for a geothermal improved technology scenario. Over the coming year, NREL's efforts will be key to the overall success of the Vision Study.

Objective 1.3: Demonstrate Relevance and Market Impact

Weight: 30.00% **Score:** 3.3 **Grade:** B+

Objective Evaluation:
The NREL research team has been helping collect and organize data from the GTO Mineral Recovery program, through an effort called the Geothermal Brine Strategic Mineral Recovery Technical Assistance. One significant outcome of this project was the creation of the Mineral Recovery Content Model in the National Geothermal Data System. This publicly accessible content model organizes and structures the mineral recovery data, which is primarily information relevant to the removal efficiency, removal amounts, and locations of rare earth elements found in geothermal waters. This project is helping to assess the potential of geothermal waters to provide value streams beyond the traditional hot-water value stream. Additionally, in an effort to field-test geothermal technologies in oil & gas settings, NREL researchers have identified 4 candidate sites and partners to deploy DOE organic Rankine turbine systems in support of the Systems Analysis & Low Temperature (SALT) program. However, after several years of effort, none of the potential partners have been finalized. The final partners selected will operate them at their sites, and collaborate with NREL to jointly collect data.

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score: **Grade:**

Goal Evaluation: N/A
Objective 2.1: Effectively Steward the ESIF User Facility
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A
Objective 2.2: Effectively Steward Major Research Facilities
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A

Goal 3.0: Provide Effective and Efficient Program Management

Score: 2.9 **Grade:** B
Goal Evaluation: Overall program management was sufficient. Additional detail could be made to providing robust SMART metrics for AOP projects, and more generally in fostering a truly collaborative spirit between the lab and GTO.
Objective 3.1: Effective Program Planning and Execution
Weight: 70.00% **Score:** 2.9 **Grade:** B
Objective Evaluation: Overall program planning and execution were adequate, however multiple milestones were delayed - GRR sustainability plan, some Strategic Analysis relating to the Vision Study, Geothermal Desalination, etc. As in past years, GTO is mindful of the imposition new priorities may create, causing delays to existing milestones, however there were AOP milestones delays that were not the result of any external factors. AOP milestone submissions via entering of SMART metrics into the SharePoint site were marginally satisfactory.

Objective 3.2: Effective Communications and Response

Weight: 30.00% **Score:** 2.8 **Grade:** B

Objective Evaluation:
NREL has been supportive in multiple areas of the Vision Study project and has engaged in design, logistics, communications, and analysis.
Conversely, while communication between NREL staff and GTO occurs regularly and appears open and responsive, it is often difficult to ascertain the impacts of these communications on the direction of projects. Additionally, the allocation of funding for individual projects is not as transparent as would be desired, as the scope between multiple ongoing projects occasionally becomes blurred.

Finally, and as an aside, during discussions relating to project scope and budget for both new projects and modifications to existing projects, talks occasionally take on the air of a negotiation between adversaries rather than a collaboration among partners.

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00% **Score:** 3.2 **Grade:** B+

Goal Evaluation:

Alliance's leadership team appears to do a competent job of stewarding the laboratory, although more outward facing communications could include geothermal perspectives

Objective 4.1: Laboratory Strategy

Weight: 25.00% **Score:** 3.0 **Grade:** B

Objective Evaluation:
Positive developments in this area include increased attention to maintaining prominence of geothermal in planning documents such as the NREL Five Year Plan. Additionally, the NREL research team has helped GTO in developing an outline for the GeoVision study and assisted in forming task forces across the national laboratories to conduct analyses.
In the "other" category, Alliance's focus on its core programs does not always seem to include significant geothermal considerations.

Objective 4.2: Steward Core Competencies

Weight: 40.00% **Score:** 3.5 **Grade:** A-

Objective Evaluation:

NREL has strengthened its core competencies recently - additional staff have improved research capabilities in geochemistry, while new and existing staff have continued to show expertise in data management/curation/assimilation, strategic analysis, resource assessment, regulatory issues, geospatial analysis and reporting methodologies.

Objective 4.3: Leadership and Lasting Value

Weight: 35.00% **Score:** 3.0 **Grade:** B

Objective Evaluation:
Overall, NREL continues to take positive steps in this area: however, while GTO has had meaningful discussions with the Alliance leadership, geothermal is often still omitted from outward facing Renewable Power (RP) communications. This diminished standing sends a message to the renewable energy industry and other stakeholders.
On a more positive note, NREL staff were part of a briefing to congressional staffers as part of the "Energy from the Earth: Practical Geoscience to Inform Energy Legislation" lecture series. This briefing series was well attended by key GTO stakeholders in congress, and helped continue the upward vector of credibility of geothermal with this important audience.

Solar Energy Technologies (SETO)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 2.9	Grade: B	
Goal Evaluation:		
Objective 1.1: Advance Science and Technology		
Weight: 50.00%	**Score:** 3.0	**Grade:** B
Objective Evaluation: NREL had a set of mixed results across SETO topics. Overall, PV subprogram missed 70% of their milestones, but the research time was well-spent in answering some fundamental questions that have had decisive impact on the field, and on NREL's choice of research topics. Some exceptional results also need to be noted, especially in the area of standards and durability (e.g., PVQAT, Qual +). Some areas still continue to perform poorly, especially CSP, where most of the topics had to be down-scoped due to under-performance. BOS had a mixed year and SI, despite major pivots and down-scoping in the prior years, has maintained enough relevant research to pivot to new interesting areas for FY16-18.		
Objective 1.2: Deliver Credible and Objective Analyses		
Weight: 20.00%	**Score:** 3.3	**Grade:** B+
Objective Evaluation: NREL continues to do a breadth of analysis and its service to the community is indisputable. Across the funds spent and the relative importance of topics, some areas are still in need of pro-active approaches. The program's concerns were not adequately addressed in the ATB data collection and the management of the SunShot Vision Study Update resulted in much truncated scope of work with several delays. The work done by the program core support agreements and some of the cost analysis work merits national recognition, demonstrated by wider and wider use of the results in the wider community. The use of SAM for GAO reports was also highly impactful.		
Objective 1.3: Demonstrate Relevance and Market Impact		
Weight: 30.00%	**Score:** 2.5	**Grade:** B-

Objective Evaluation:
NREL's response to Sunlamp resulted in a higher level of industry engagement in the Systems Integration area. In the PV area, none of the research performed moved into the industry nor did the funds-in through CRADAs and partnerships increase, a key indicator for the past 3 years and last year. The SABC project had some impact in the community, but fell short of the expectations for publications, impact, and output.

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score: 2.2	Grade: C+	
Goal Evaluation:		
Objective 2.1: Effectively Steward the ESIF User Facility		
Weight: 50.00%	**Score:** 2.8	**Grade:** B
Objective Evaluation: NREL succeeded in ramping-up activity that occurred through ESIF programs and the pro-active approaches that the management undertook were effective. They met the program challenge on matching the program funds in FY15, although the costing was slow.		
Objective 2.2: Effectively Steward Major Research Facilities		
Weight: 50.00%	**Score:** 1.5	**Grade:** C-
Objective Evaluation: The stewardship of non-ESIF user facilities continues to be a weak point at NREL. The optical characterization facility, solar resource calibration, and numerous PV research facilities (PDIL, etc.) are under-used, less than impactful, or need to have a revamped business model. The delays in building out the PV clean room, caused by the structural issues in the S&TF building are serious and will adversely impact the PV research, as is the fact that the discovery of such issues was not managed or recognized in a timely manner.		

Goal 3.0: Provide Effective and Efficient Program Management

Score: 3.2	Grade: B+
Goal Evaluation:	
Objective 3.1: Effective Program Planning and Execution	

Weight: 70.00%	**Score:** 3.0	**Grade:** B

Objective Evaluation:
NREL increased the quality of program management in some key areas, evidenced by the ability to prioritize and identify higher-impact research areas, especially in PV. This correlated with new leadership in the PV management (Kurtz), who have also effectively coordinated with DOE. The new solar program manager has demonstrated much higher level of effectiveness than her predecessors, and we hope that it continues to be the case. There was an unnecessarily high level of cost, both financial and human, involved in the preparation of Sunlamp proposals. Most BOS projects were not managed in a timely manner, whether with staggered requests for extensions, or with delayed project pivots. Customer-facing programs, such as cell measurement and verification and solar resource calibration, are still lagging in developing sustainable business models, despite years of requests from the program.

Objective 3.2: Effective Communications and Response

Weight: 30.00%	**Score:** 3.6	**Grade:** A-

Objective Evaluation:
The level of communications, and the improved grade in this area, are largely driven by the PV program and the solar program manager. CSP and BOS continue to need improvement in communication quality and more proactive approach. End-of-the year budget number discussions did not provide enough transparency for timely management decisions.

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00%	**Score:** 2.8	**Grade:** B

Goal Evaluation:

Objective 4.1: Laboratory Strategy

Weight: 25.00%	**Score:** 3.1	**Grade:** B+

Objective Evaluation:

NREL solar program has undergone a much-needed, and hopefully highly-valuable process of surveying "the voice of the customer" to help drive its future directions. We commend them for that move. NREL was also reasonably responsive in Sunlamp proposals overall (especially with some innovative grid concepts), even if it lacked in some notable areas (not enough module work in PV).

Objective 4.2: Steward Core Competencies

Weight: 40.00%	**Score:** 2.5	**Grade:** B-
Objective Evaluation: NREL filled the position of solar program manager, but continues to lack flexibility in identifying, hiring, and sometimes retaining top technical talent. The program has attempted to offer tools to help with this activity in the past, but they went unused (new hire fund, etc.). Not enough strategic relationships are formed with industry, and not enough diversity exists among the academic partners.		
Objective 4.3: Leadership and Lasting Value		
Weight: 35.00%	**Score:** 2.8	**Grade:** B
Objective Evaluation: NREL needs to be better at being able to pivot from one area of relevance to next, following, but preferably leading, the field. The feedback from the stakeholders continues to be mixed.		

Strategic Programs (SPO)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score:	Grade:

Goal Evaluation:
In general, over FY15, Strategic Programs has been pleased with the Alliance's management of NREL, and NREL's work on our projects. NREL continues to produce analyses that provide insights on the energy landscapes on topics that are high priorities to EERE, DOE and the White House, while also being useful to outside organizations, stakeholders, and decision-makers.
Some highlights of the work done by NREL for Strategic Programs this year include:

- NREL's leadership of Cities-LEAP, a major project for Strategic Programs over FY15 and into FY16. The stakeholder engagement and communications efforts have been especially noteworthy, and have built a wide coalition of support among organizations focused on city and local issues, and has raised awareness of EERE's efforts on this topic with several key city stakeholders.
- Quick responses on timely and high priority analysis issues, including the recent work developing analyses of the implications of various renewable energy tax incentive extension scenarios. This work was needed with a very quick turnaround and NREL was required to be responsive to several changing requests on specific analyses and assumptions. Besides performing the analysis, NREL also provided invaluable help developing initial briefing documents and ensuring that EERE stakeholders fully understood the implications and nuances of the findings.
- Formal launch of the Clean Energy Manufacturing Analysis Center, culminating with the announcement of a dedicated, full-time Director.
- Timely analysis on renewable energy economic potential, the results of which immediately proved impactful as they were cited in EPA's Clean Power Plan.
- Publication of the RE Futures 3: Subhourly Sensitivity Analysis that demonstrated that not only is it possible to integrate 80% renewable energy onto the grid when examining grid operations at the hourly level, but that the grid could also feasibly be operated at a sub-hourly time scale. This responded to one of the chief criticisms of the initial REF study.
- Issuance of the first version of the Annual Technology Baseline, which created a technology cost and performance database for use across EERE analyses to ensure consistent and transparent assumptions and methodologies. This document has already

proved useful to outside organizations, as several external groups have already begun directly using or have indicated their plan to use this work in their analyses.

Despite these achievements, though, areas remain in which the Alliance could improve its management of NREL:

- **Better communication and transparency around time or cost overruns on analyses.** It's inevitable that time and cost overruns will occasionally occur, due to expanded or shifting scope, challenges in data collection, or just an underestimation of the difficulty or time needed for the analysis. It is essential, though, that NREL clearly communicates revised time or cost expectations as soon as possible. Although this was a problem in FY14 as well, it has improved greatly over the last several months, and new processes have been put in place that should continue to mitigate any lack of communication, so SPIA is very hopeful that this will not be an issue in FY16.
- **Clearer communication of concern or disagreement with analyses.** NREL on occasion appears to be unwilling to voice concerns or disagreements with EERE proposed analyses. This can take the form of not clearly communicating that a proposed approach is too difficult, infeasible, or unadvisable, with the unpleasant discussion delayed until NREL sends EERE a document for review that does not meet EERE's expectations in scope, granularity or tone. Clearer upfront communication is critical. This is closely related to the previous bullet, so SPIA is again hopeful that the steps already taken by NREL will help address this issue in FY16.
- **Progress on CEMAC.** EERE is hopeful that the hiring of Jill Engel-Cox indicates that clear progress will be made to get CEMAC fully up and running. But overall EERE has been disappointed and concerned about the overall pace of activity to date on CEMAC, and that we are still in the planning phase of developing a benchmark annual report that has clearly been EERE's top priority for many months. Significant progress needs to be made on CEMAC over the next few months to come to agreement on the near-term and long-term goals for CEMAC, the development of consistent methodologies and the resource plan for these to be implemented.

NREL's leadership has communicated well with EERE. Members of the management team have been responsive, available, and open to suggestions and recommendations, while providing good constructive feedback to EERE as well. Strategic Programs remains very pleased with the leadership in general, and looks forward to continuing the productive relationship over the next year.

Objective 1.1: Advance Science and Technology

Weight: 50.00% **Score:** **Grade:**

Objective Evaluation:

Objective 1.2: Deliver Credible and Objective Analyses		
Weight: 20.00%	**Score:** 3.5	**Grade: A-**
Objective Evaluation:		
Objective 1.3: Demonstrate Relevance and Market Impact		
Weight: 30.00%	**Score:**	**Grade:**
Objective Evaluation:		

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score:	**Grade:**	
Goal Evaluation:		
Objective 2.1: Effectively Steward the ESIF User Facility		
Weight: 50.00%	**Score:**	**Grade:**
Objective Evaluation:		
Objective 2.2: Effectively Steward Major Research Facilities		
Weight: 50.00%	**Score:**	**Grade:**
Objective Evaluation:		

Goal 3.0: Provide Effective and Efficient Program Management

Score:	**Grade:**	
Goal Evaluation:		
Objective 3.1: Effective Program Planning and Execution		
Weight: 70.00%	**Score:**	**Grade:**
Objective Evaluation:		

Objective 3.2: Effective Communications and Response		
Weight: 30.00%	**Score:** 2.9	**Grade: B**
Objective Evaluation:		

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00%	**Score:**	**Grade:**
Goal Evaluation:		
Objective 4.1: Laboratory Strategy		
Weight: 25.00%	**Score:**	**Grade:**
Objective Evaluation:		
Objective 4.2: Steward Core Competencies		
Weight: 40.00%	**Score:**	**Grade:**
Objective Evaluation:		
Objective 4.3: Leadership and Lasting Value		
Weight: 35.00%	**Score:** 3.2	**Grade: B+**
Objective Evaluation:		

Vehicle Technologies (VTO)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 4.0	Grade: A	
Goal Evaluation:		
Objective 1.1: Advance Science and Technology		
Weight: 50.00%	**Score:** 4.0	**Grade:** A

Objective Evaluation:
The following are examples of R&D activities conducted by NREL that advance science and technology: NREL partnered with ANL, ORNL, Lawrence Berkeley National Laboratory (LBNL), and leading universities to demonstrate the efficacy of advanced coating materials in improving the performance of Li-ion batteries for automotive applications. With renewed funding from VTO in FY15, NREL and its partners established the Advanced Materials Coatings Facility under the Applied Batteries Research (ABR) program. This facility will serve as a hub for studies of advanced coatings based on ALD and act as a resource for the entire ABR program. Work at the new facility has focused on developing coating materials and processes that are compatible with state-of-the-art battery electrode manufacturing, including development of a prototype roll-to-roll ALD system, qualification of a reactor for deposition on flat flexible substrates and processes, and coating ABR standard cathode materials. Plans for FY16 include development of a standard process for coating Li-ion battery electrodes with aluminum oxide. Researchers are using atomic layer deposition (ALD) and molecular layer deposition (MLD) methods to produce polymeric hybrid inorganic-organic coatings covalently bonded to the surface of silicon particles. Improved electrochemical cycling performance, including high-rate capability and durable cycling, was achieved for the ALD/ MLD-coated electrodes. The data from the synthesis and analysis shed light on the importance of surface modification for silicon-based electrodes. The results will inform the new designs for electrode material surface coatings necessary to achieve durable, high-energy-density Li-ion batteries. The thermal management team at NREL has provided technical leadership in evaluating the thermal management requirements of electric-drive vehicle components, vehicle passenger cabin heating and cooling, and complete vehicle system thermal management solutions. Laboratory testing of vehicles over standardized drive cycles reveals

important information about vehicle fuel efficiency, but is unable to predict fuel savings from "off-cycle" technologies such as thermal retention or connected and automated vehicle innovations. To address this problem, NREL generated a thermally sensitive powertrain model (validated by data from ANL), and developed a new analytical methodology to link driving behavior, road network, elevation profile, traffic volume, temperature, and solar radiation data. These tools will make it possible to produce vehicle efficiency estimates based on localized, real-world driving conditions. With this data, both public and private stakeholders will have a way to evaluate the aggregate benefit of off-cycle efficiency technologies, making them easier to commercialize. Early results indicate that real-world benefits for some thermal retention technologies could exceed 1%.If broadly implemented, even a seemingly modest fuel savings would have the aggregate impact of taking 2.5 million vehicles off the road. NREL partnered with EPA to refine drive cycles for GHG certification of medium- and heavy-duty vehicles. NREL's work on this project included completing a national analysis of road grade characteristics experienced by U.S. medium- and heavy-duty trucks on controlled access highways. To perform this analysis, NREL investigated national grade datasets from sources such as Tom Tom and the U.S. Geological Survey, and compared them with a detailed local road grade dataset generated by the Southwest Research Institute. EPA referenced the NREL findings in the Proposed Phase 2 Rule and plans to use the nationally representative road grade profiles that NREL developed as part of its official test procedures. Using actual driving route and fuel consumption data, NREL performed a techno-economic analysis to compare the operating cost and fuel saving potential of plug-in hybrid electric, hybrid electric, and conventionally-fueled transit bus fleets. The analysis indicated that by incorporating wireless power transfer (WPT), a plug-in hybrid electric fleet could achieve lifetime costs comparable to those of a hybrid electric fleet and roughly triple the fuel savings relative to a conventional fleet. WPT technology advancements have made it possible to wirelessly charge a parked vehicle's battery, and transit buses provide an opportunity for early application of quasi-in-motion charging with charging pads placed at select bus stops to extend the electrified driving range of an all-electric or a plug-in hybrid electric bus. NREL is working as a sub-partner with industry prime Mahle Group (formerly Delphi) on a DOE VTO FOA project to improve EV range in cold weather through thermal system integration via a coolant-based network including a heat pump. NREL is assisting in the design of the thermal system through modeling and bench testing. Modeling is being conducted in-house with NREL's CoolSim thermal system modeling tool. The initial stages of modeling included successfully validating a baseline model against experimental wind tunnel test data for warm-up and cooldown. With the baseline validation complete, the effort is now focused on modeling the next-generation thermal system concepts of the UTEMPRA (Unitary Thermal Energy Management for Propulsion Range Augmentation) system. NREL's CoolSim/Simulink thermal modeling framework was integrated with Simulink control algorithms developed by Hanon Systems (formerly Halla Visteon Climate Control)—an automobile heating, ventilating, and air-conditioning (HVAC) system supplier—to study Hanon's advanced thermal management system prototypes. The prototypes included options for energy storage utilizing thermal capacities of power electronics and electric motor heat distribution using either a coolant network or a vapor

compression cycle in a heat pump mode as well as a positive temperature coefficient heater. The model was used to study the system's performance at several ambient temperatures (5°C, -5°C , and -18°C).Optimal cabin heating strategies for each of these conditions used combinations of available heat-delivery modes with the goal of minimizing the total consumed energy and increasing the EV range. In an NREL evaluation of EVs at a Frito-Lay distribution facility, data showed that diesel trucks averaged 7.7 MPG, while comparable EVs averaged 23.3 MPGe at $0.102/kWh. During this time, it cost the fleet $0.50 for every mile driven with diesel trucks, compared to $0.15 for every mile driven by an EV.NREL recently installed a high-speed, transient power quality monitor on the Frito-Lay depot's main utility feed to better understand the facility's total power consumption. Using this detailed facility load data, a facility energy model was created to demonstrate the opportunity for managed plug-in EV charging. Final project findings will be released in FY16. NREL partnered with the California Air Resources Board (CARB), Foothill Transit, and electric bus manufacturer Proterra to conduct a detailed performance evaluation of battery electric buses with 500-kW opportunity charging at Foothill Transit. CARB is funding NREL to collect data and conduct analyses of vehicle operating and maintenance costs, Foothill is providing operational data and access to the vehicles, Proterra provided 8 months of detailed 1-Hz vehicle and component-performance data from 12 EV buses, and NREL is conducting all of the analyses and reporting results. NREL recently conducted a project review meeting with the partners to review data on fuel efficiency, maintenance, duty cycles, detailed battery state-of-charge cycles, charger profiles, and other information. Preliminary results show that the EV buses averaged approximately 4 times higher fuel economy on an energy-equivalent basis compared to Foothill Transit compressed natural gas buses in similar service. Findings on overall fleet performance and cost of operation and a detailed analysis of in-use EV bus and component-level performance will be released in FY16. In collaboration with Ford Motor Company, NREL researchers completed cold-weather, outdoor thermal testing to evaluate zonal heating concepts in a Ford Focus Electric. The test configuration incorporated zonal air flow and heated surfaces for the driver location in the vehicle cabin. The test results demonstrated the potential to decrease energy consumption by more than 28.5% while maintaining driver thermal comfort during warm-up. This energy savings increases the vehicle range by 6.9%–18.7% compared to a vehicle with a baseline heating strategy. NREL's CoolCab project aims to reduce HVAC loads and resulting idling fuel consumption while maintaining driver comfort when long-haul trucks are parked during a rest period. To achieve this, NREL researchers developed a thermal load reduction package that uses ultra-white paint, advanced insulation, and advanced curtains and window shades. Overall, heat transfer coefficient (UA) testing of this package demonstrated a 43% reduction in heating loads, complementing the 35.7% reduction in cooling loads shown previously, and exceeding the 30% reduction goal. Adding an additional layer of advanced insulation improved this to a 53.3% reduction in heating loads. Project partners include Volvo Group, Aearo Technologies, and PPG Industries. A provisional patent has been filed for NREL's advanced curtain design. NREL tested a series of biomass-derived oxygenates in a direct-injected spark-ignition engine to evaluate their potential as drop-in fuel components. The oxygenated compounds are representative of

those found in upgraded biomass pyrolysis oils. Results showed that research octane number was well correlated with knock-limited spark advance and was a good predictor of the anti-knock performance of these blend components. However, researchers also found that oxygenates with boiling points in the upper half of the gasoline boiling range may be slightly less resistant to knock than their research octane numbers would indicate. Researchers predict the reason for this is that in a direct injection engine there is less time available for the fuel to evaporate (compared to port fuel injection), so higher boiling components may be swept into the lube oil instead of evaporating. These high octane components are therefore not present in the unburned fuel-air mixture, making the effective octane number of this fuel lower than the octane number of the bulk fuel that went into the engine. NREL completed fuel property testing of a large set of oxygenated molecules that can potentially be derived from biomass through pyrolysis, acid deconstruction, and fermentation, and used as drop-in fuel components. ASTM standard properties for both gasoline and diesel fuels were measured, as well as additional properties commonly used in the fuels industry. Many of these tested compounds showed promise for use as components of drop-in gasoline and diesel fuels. An important example is methyl aryl ethers such as anisole, which boil in the middle of the gasoline range, are insoluble in water, and have very high octane numbers. Furans such as dimethyl furan also show promise for gasoline blending. In the diesel boiling range, oxygenates had low cetane numbers but high energy density and were able to improve lubricity and oxidation stability. NREL continued its research on particle emissions' effects on biomass-derived oxygenates. Researchers measured particle mass and number emissions from a gasoline direct injection engine. Results showed that biomass oxygenate particle emissions follow trends similar to those seen in conventional fuels: higher levels of aromatic carbon and components with lower vapor pressure result in elevated particle emissions. Researchers also found that fuel oxygen had no observed effect on either the mass or number of particle emissions. High boiling point oxygenates with low vapor pressure produced less particulate matter than predicted by the Particulate Matter Index (a fuel property proportional to aromatic and alkene content and inversely proportional to vapor pressure) because those oxygenates do not evaporate and burn, but instead are swept into the engine lubricant. In collaboration with the Coordinating Research Council, NREL has completed a survey of E51-E83 flex fuel quality. Researchers collected 91 samples over four classes and measured ethanol content, water content, and vapor pressure. Results showed continued problems meeting vapor pressure requirements, as well as notably higher water content compared to previous studies NREL has completed a parametric ignition delay study of ethanol blends with iso-octane in the ignition quality tester (IQT).The resulting datasets span the critical negative temperature coefficient region (NTC) and will assist in the development of improved ethanol blend kinetic mechanisms (in collaboration with Lawrence Livermore National Laboratory).The data also complement research and motor octane numbers to support additional research in advanced spark-ignition and low-temperature combustion strategies, such as gasoline compression ignition (GCI).Other complementary research includes a collaborative project with a University of Michigan Ph.D. candidate to link NREL's low-temperature data with higher-temperature rapid compression machine (RCM) experiments, creating broader sets of experimental

ignition delay data with which to validate kinetic mechanisms. NREL expanded prior research on gasoline direct injection (GDI) single-cylinder engines by exploring knock-limited engine performance for a range of hydrocarbon and oxygenated fuels. These experiments separate heat of vaporization and chemical octane effects for a range of research octane numbers, quantifying which chemical aspects of high-knock resistance fuel contribute to improved engine efficiency. Complementary IQT experiments with the same fuels will enable correlation between the bench-scale ignition studies and the single-cylinder research engine studies. One noteworthy result of this research is an increased understanding of how a lower motor octane number is advantageous in enabling GDI engines to operate at higher loads with retarded ignition timing.

Objective 1.2: Deliver Credible and Objective Analyses

Weight: 20.00% **Score:** 3.8 **Grade:** A

Objective Evaluation:

NREL has delivered credible and objective analysis in support of the VTP. The following are examples of such analysis activities.
Cost-benefit results from reductions in gasoline consumption, EV costs, electricity costs, and other factors have been incorporated into a geographically detailed framework, and preliminary results have been conveyed to DOE and stakeholders from the Edison Electric Institute. Project partners are currently working to obtain more data for certain parameters. This includes using NREL's BLAST-V model to determine the impact of regional trip distance and climate on all-electric vehicle range, and using NREL's Regional Energy Development System model to calculate marginal electricity costs and GHG emissions from regional grids.

Results from a recent NREL consumer study designed to reflect the views of the American public found fuel economy at the bottom of the list of five important vehicle attributes, with just 13% rating it "most important." This is a change from study results since 2008 that have ranked fuel economy among the top two most important attributes. Dependability took the top spot this year over safety, quality, low price, and fuel economy. Respondents were also asked to provide their choices for best and worst alternative fuels to replace gasoline amongst electricity, ethanol, natural gas, and hydrogen. Electricity topped the list for "best" alternative and ethanol topped the list for "worst."
NREL researchers have compiled NREL's MATLAB-based Automotive Deployment Option Projection Tool (ADOPT) into a stand-alone, license-free application, making the tool available to those who do not have a MATLAB license and laying the groundwork for its online release. A new fuel cell electric vehicle (FCEV) option based on the 2016 Toyota Mirai was added to ADOPT, and DOE technical targets are applied

over time to capture FCEV improvements. The rate of additional FCEV options introduced over the following decade will be based on new powertrain model option introductions. Numerous significant enhancements to ADOPT's accuracy and analysis capabilities include: updates to the model's implementation of Corporate Average Fuel Economy (CAFE) and GHG regulations for high ethanol blend vehicles; an improved algorithm that makes new vehicle sales meet CAFE requirements; new levels of detail including zip code, state, and nation; adjustments to the stock model to align with the U.S. Energy Information Administration's 2014 Annual Energy Outlook; and more result outputs, including fleet vehicle miles traveled and total electricity consumed.

Objective 1.3: Demonstrate Relevance and Market Impact

Weight: 30.00% **Score:** 4.0 **Grade:** A

Objective Evaluation:
The following are examples of how the Alliance has moved NREL to push technology into commercial acceptance.
NREL is leading a technical assistance project to develop decommissioning best practices for vehicles' compressed natural gas (CNG) tanks, which typically have a lifespan of 15–20 years. NREL and DOE met with Washington Metropolitan Area Transit Authority (WMATA) to discuss concerns about soon-to-expire tanks on their CNG buses. Since then a webinar was held with the California Air Resources Board, the U.S. Department of Transportation, tank manufacturers, and transit representatives to discuss the project and get their buy-in on next steps. NREL is working with LA Metro and a number of other transit authorities to develop a best-practices document and to provide near-term assistance to WMATA in establishing its own decommissioning program

NREL is a sub-partner on a DOE VTO Funding Opportunity Announcement (FOA) project led by Gentherm to demonstrate thermoelectric generator (TEG) exhaust waste heat recovery in conventional vehicles. NREL is conducting bench testing analysis of a production-quality prototype TEG exhaust system. The data will be used to validate TEG performance by quantifying electricity generation under a range of operating conditions. The prototype has demonstrated power generation levels of a couple hundred watts of electricity under some operating conditions, with waste heat recovery efficiencies of several percent.

In collaboration with Ford Motor Company, NREL researchers completed cold-weather, outdoor thermal testing to evaluate zonal heating concepts in a Ford Focus Electric. The

test configuration incorporated zonal air flow and heated surfaces for the driver location in the vehicle cabin. The test results demonstrated the potential to decrease energy consumption by more than 28.5% while maintaining driver thermal comfort during warm-up. This energy savings increases the vehicle range by 6.9%–18.7% compared to a vehicle with a baseline heating strategy

NREL kicked off an evaluation of next-generation hydraulic hybrid (HHV) refuse trucks with Parker Hannifin HHV drivetrains in the Miami- Dade County fleet. The 12-month evaluation focuses on collecting and analyzing vehicle performance data (fuel economy, maintenance costs, and drive cycles) from 20 HHVs and 10 conventional diesel vehicles operating in the same service fleet. Miami-Dade County—a member of the Southeast Florida Clean Cities Coalition—recently deployed 29 next-generation HHV trucks, adding to the 35 already in operation. Miami-Dade is providing electronic fueling and maintenance data, as well as access to fleet vehicles for data collection. NREL recently instrumented 16 HHV and baseline trucks and has uploaded the duty-cycle data to the Fleet DNA database for further analysis

In an NREL evaluation of EVs at a Frito-Lay distribution facility, data showed that diesel trucks averaged 7.7 MPG, while comparable EVs averaged 23.3 MPGe at $0.102/kWh. During this time, it cost the fleet $0.50 for every mile driven with diesel trucks, compared to $0.15 for every mile driven by an EV.NREL recently installed a high-speed, transient power quality monitor on the Frito-Lay depot's main utility feed to better understand the facility's total power consumption. Using this detailed facility load data, a facility energy model was created to demonstrate the opportunity for managed plug-in EV charging. Final project findings will be released in FY16.

NREL partnered with the California Air Resources Board (CARB), Foothill Transit, and electric bus manufacturer Proterra to conduct a detailed performance evaluation of battery electric buses with 500-kW opportunity charging at Foothill Transit. CARB is funding NREL to collect data and conduct analyses of vehicle operating and maintenance costs, Foothill is providing operational data and access to the vehicles, Proterra provided 8 months of detailed 1-Hz vehicle and component-performance data from 12 EV buses, and NREL is conducting all of the analyses and reporting results. NREL recently conducted a project review meeting with the partners to review data on fuel efficiency, maintenance, duty cycles, detailed battery state-of-charge cycles, charger profiles, and other information. Preliminary results show that the EV buses averaged approximately 4 times higher fuel economy on an energy-equivalent basis compared to Foothill Transit compressed natural gas buses in similar service. Findings on overall fleet performance and cost of operation and a detailed analysis of in-use EV bus and component-level performance will be released in FY16.

HEVs have strong potential to reduce aggregate fuel consumption, but their higher cost relative to conventional vehicles remains a barrier to greater market penetration. Because energy storage systems are expensive, NREL has worked with partners such as Ford Motor Company, JSR Micro, and Maxwell Technologies to develop an HEV test platform for evaluating lower-energy energy storage system (LEESS) device alternatives. NREL's testing of multiple asymmetric Li-ion capacitor and electrochemical double-layer capacitor (or ultracapacitor) configurations has revealed that non-traditional HEV energy storage devices are able to provide hybrid system performance comparable to that of more traditional battery technologies. Having demonstrated the viability of increased competition from novel technologies in the HEV energy storage space, if LEESS device suppliers are able to achieve long-term, high-volume cost reductions, then LEESS devices could help improve the overall hybrid vehicle benefit-versus-cost relationship, ultimately leading to stronger HEV sales and greater aggregate fuel savings.

Conventional high-temperature bonded interfaces within the power electronics module face coefficient of thermal expansion mismatches between materials and layers, resulting in thermomechanical stresses. This can cause failure from adhesive or cohesive fracturing, which poses reliability problems. Bonded interfaces based on sintered silver, in principle, offer the possibility of good reliability during high-temperature (greater than 200°C) operation of power electronics packages. NREL is testing low-pressure sintered-silver bonded samples synthesized by ORNL to evaluate the thermal resistance and mechanical properties of this interface material. Accelerated testing to evaluate long-term reliability is also being performed. A fracture-based lifetime model is being developed to capture the relationship between stress concentrations and the crack initiation and growth rate. Results from this work will enable design improvements to make lead-free, high-temperature power electronics more compact and efficient.

Research performed by NREL has demonstrated that ribbon electrical interconnects have excellent reliability for high-current-density power electronics packaging. Ribbon electrical interconnects offer several advantages over traditional round wire interconnects, including higher current densities, lower inductances, and lower loop heights. To compare reliability, NREL conducted accelerated temperature elevation, temperature cycling, corrosion, and vibration testing on ribbon interconnects of different geometries. The ribbon interconnects showed similar reliability to wire interconnects under thermal and corrosion tests. A key finding from this work is that minimizing the span length of the ribbon electrical interconnects is critical to maximizing their lifespan under high vibration conditions.

In partnership with ORNL, NREL conducted a series of tests to study ways to more effectively cool motor end-windings with transmission fluid. These tests included characterizing the thermal resistance of end- and slot-windings and the thermal

performance of automatic transmission fluid jets impinging on target end-winding surfaces. The results, as well as details of the unique testing approach that NREL developed to measure through-stack motor lamination thermal conductivity, were shared with motor industry representatives, leading to further discussion and collaboration around developing improved electric-drive technologies. An outcome of this work is that preliminary measurements of the slot-liner to slot-winding interface thermal resistance were obtained for the first time. The measured thermal resistance was higher than initially expected and is as significant as the slot-liner insulation alone. The measurements provide valuable data for motor designers and manufacturers in their efforts to develop a motor thermal model from the component level up to the full motor system.

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score: 4.0	Grade: A

Goal Evaluation:

Objective 2.1: Effectively Steward the ESIF User Facility

Weight: 50.00% **Score:** 3.9 **Grade:** A

Objective Evaluation:

The Alliance has provided a framework for VTP to utilize the ESIF in support of its program goals and objectives. For example:

The EVGI team continues to use NREL's award-winning Energy Systems Integration Facility to test functions of early V2G-capable vehicles, including BMW's Mini E. The Mini E's 19kW of bidirectional powerflow capability is managed through an aggregator software tool. NREL uses a grid simulator to create various electrical network environments to test the response of the vehicle and infrastructure. The experiments characterize performance that lays the foundation for future grid simulations and gives utilities confidence in the technology.

Plug-in electric vehicle loads can, in some cases, represent a portion of a building's metered aggregate load. Future buildings may become brokers for more flexible, transactive exchanges of energy between vehicles and grid operations. For example, by integrating information from drivers, electric vehicles, charge stations, and local photovoltaic (PV) power, grid loads can be scheduled to occur at the most beneficial times. This research will lead to an integrated vehicle-to-building (V2B) system. NREL demonstrated these concepts to an industry audience at NextEnergy with a live operating system featuring two Fiat vehicles, two controllable chargers, and data stream integration through a building energy management system.

The EVGI team leveraged the BLAST-V tools developed by the energy storage program to include a vehicle-to-grid (V2G) functional scenarios assessment that offers consistent forecasting of grid integration opportunities and battery life impacts. The team showed

that in a diverse mix of driving styles, roughly 80% of the drivers should participate in V2G activities to maximize utilization of their battery and 20% would benefit from managed charging to achieve the lowest cost of operation

Objective 2.2: Effectively Steward Major Research Facilities

Weight: 50.00% **Score:** 4.0 **Grade:** A

Objective Evaluation:
NREL does an excellent job of ensuring that research facilities are available and used by the RD&D community. The following are examples of the use of these facilities.
NREL has been testing the cycle life of battery cells and packs used by SunPower for backup storage in residential applications. The goal of the project is to develop a model that will accurately predict the cycle life of SunPower's battery packs under different temperatures and usage profiles. NREL originally developed the life models with VTO funding and is applying these models to vehicle and grid applications. Under an ARPA-E AMPED project with Utah State University (USU), Ford Motor Company, and the University of Colorado, NREL initiated aging tests of a prototype battery management system with a unique active balancing system employing heterogeneous cell controls. The control strategy seeks to bring cells to a common end of life, almost eliminating differential cell aging that occurs due to temperature gradients throughout a battery pack. The balancing system also supplies vehicle 12-V auxiliary loads, replacing the high-voltage converter with a 12-V DC-DC converter. NREL's Battery Lifetime Analysis and Simulation Tool for Vehicles (BLAST-V) model predicts that the USU pack will achieve 20%–50% longer life than that of today's passive balanced packs and reduce the need to tightly control temperature gradients in a pack (e.g., via liquid cooling).Researchers are in the process of conducting studies to confirm this predicted performance. NREL partnered with ANL, ORNL, Lawrence Berkeley National Laboratory (LBNL), and leading universities to demonstrate the efficacy of advanced coating materials in improving the performance of Li-ion batteries for automotive applications. With renewed funding from VTO in FY15, NREL and its partners established the Advanced Materials Coatings Facility under the Applied Batteries Research (ABR) program. This facility will serve as a hub for studies of advanced coatings based on ALD and act as a resource for the entire ABR program. Work at the new facility has focused on developing coating materials and processes that are compatible with state-of-the-art battery electrode manufacturing, including development of a prototype roll-to-roll ALD system, qualification of a reactor for deposition on flat flexible substrates and processes, and coating ABR standard cathode materials. Plans for FY16 include development of a standard process for coating Li-ion battery electrodes with aluminum oxide. NREL partnered with Pacific Gas and Electric (PG&E), Altec, Inc. ., and Efficient Drivetrains, Inc. (EDI), to evaluate the performance of plug-in hybrid electric utility trucks in service for PG&E. Altec's Jobsite Energy Management System reduces fuel use and emissions by electrifying power take-off functions, while

the prototype EDI trucks can export up to 120 kW to the grid to power a neighborhood while repairs are being made. NREL collected on-road performance data from 20 PG&E Altec vehicles and developed representative drive cycles for chassis dynamometer testing at NREL's Renewable Fuels and Lubricants Laboratory (ReFUEL). Researchers also used the thermal chamber and research electrical distribution bus system at NREL's ESIF to test and better understand EDI vehicles' export power mode under a range of conditions. PG&E used the findings to inform the specifications of its second-generation vehicles, which are scheduled to be built later this year. NREL completed fuel property testing of a large set of oxygenated molecules that can potentially be derived from biomass through pyrolysis, acid deconstruction, and fermentation, and used as drop-in fuel components. ASTM standard properties for both gasoline and diesel fuels were measured, as well as additional properties commonly used in the fuels industry. Many of these tested compounds showed promise for use as components of drop-in gasoline and diesel fuels. An important example is methyl aryl ethers such as anisole, which boil in the middle of the gasoline range, are insoluble in water, and have very high octane numbers. Furans such as dimethyl furan also show promise for gasoline blending. In the diesel boiling range, oxygenates had low cetane numbers but high energy density and were able to improve lubricity and oxidation stability .The oxygenated compounds are representative of those found in upgraded biomass pyrolysis oils. Results showed that research octane number was well correlated with knock-limited spark advance and was a good predictor of the anti-knock performance of these blend components. However, researchers also found that oxygenates with boiling points in the upper half of the gasoline boiling range may be slightly less resistant to knock than their research octane numbers would indicate. Researchers predict the reason for this is that in a direct injection engine there is less time available for the fuel to evaporate (compared to port fuel injection), so higher boiling components may be swept into the lube oil instead of evaporating. These high octane components are therefore not present in the unburned fuel-air mixture, making the effective octane number of this fuel lower than the octane number of the bulk fuel that went into the engine.

Using NREL's unique R&D 100 Award-winning Isothermal Battery Calorimeters and infrared thermal-imaging equipment, NREL measured thermal characteristics (heat generation, heat capacity, and thermal images) of batteries and ultracapacitors developed by the U.S. Advanced Battery Consortium (USABC) industry partners. In addition to its work with USABC, NREL supports the Energy Storage Technical Team by participating in working groups, such as those from LGCPI, SK Innovations, Saft, Maxwell, and Johnson Controls, Inc. The thermal data and calorimetry results are being used by the manufacturers to design their thermal management solutions and strategies. By testing the batteries in the prototype stages, we are able to assess which thermal strategy will best enhance the life of the battery pack. NREL performed testing on the motor of a Nissan Leaf electric-drive vehicle to better understand the motor's thermal management system. Researchers measured the thermal resistance and component thermal properties of the motor, developed a computational fluid dynamics model of the cooling jacket, and developed a thermal finite element analysis model of the motor stator. The model was built from the component level up by applying material thermal

properties and thermal contact resistances measured as part of DOE-funded motor thermal research activities. The model results matched full motor stator experimental data, confirming material property and thermal interface measurements performed at the component level. The validated model was then used to identify the thermal bottlenecks within the system.

Goal 3.0: Provide Effective and Efficient Program Management

Score: 4.0	Grade: A

Goal Evaluation:

Objective 3.1: Effective Program Planning and Execution

Weight: 70.00% **Score:** 4.0 **Grade:** A

Objective Evaluation:

The Alliance program management leadership and practices have provided effective plans that demonstrate understanding of requirements for impact and align with program goals. These efforts have for the most part been accomplished with industry input as evidenced bellow.

During FY15, NREL led a major DOE and multi-lab effort to assess the potential benefits of fuel and engine co-optimization. The Optima initiative has identified near-term (gasoline spark ignition) and longer-term (advanced compression ignition) strategies that promise to significantly reduce petroleum consumption and greenhouse gas (GHG) emissions related to on-road transportation. In collaboration with nine other national labs, NREL advanced this proposal through the DOE Idea Summit, ultimately resulting in the selection of Optima as a FY16 "Big Idea." NREL has spearheaded stakeholder engagement activities, directing and moderating a widely-acclaimed "listening day" that brought together 26 diverse stakeholders, including light-duty and heavy-duty vehicle original equipment manufacturers (OEMs), energy companies, biofuel producers, regulatory agencies, and consumer groups. Strategic input from these key players has been crucial in establishing the project plan and priority targets needed to accelerate the introduction of significantly improved new fuels and vehicles. NREL

leadership has continued to steer a clear path for this cooperative effort through the FY16 VTO/BETO Lab Call process and AOP development.

NREL has co-led Transportation Working Group efforts (together with Argonne and Oak Ridge National Labs) focused on identifying the potential for connected and autonomous vehicles (CAVs) to dramatically reduce fossil fuel use and significantly cut GHG emissions while also addressing grid demand and electric vehicle consumer adoption issues. These efforts included writing a white paper and initiating activity to more closely define the potential impact of various connected vehicle strategies, including platooning, wireless charging, and technology controls. As a result of these efforts, VTO included CAVs as areas of interest in the FY16 lab call. Since the inception of these efforts, this concept has evolved into a SMART (Systems and Modeling for Accelerated Research in Transportation) Mobility approach, exploring how transportation assets, travelers, and the transportation system interact and influence each other using multi-scale, multi-system models. These efforts, which are being led by NREL, are helping EERE Sustainable Transportation Leadership to identify opportunities to target R&D efforts that accelerate development and deployment of these GHG reduction technology.

NREL played a lead role (in collaboration with Argonne and Oak Ridge National Labs) in developing a white paper addressing the potential benefits of natural gas as a transportation fuel for light-duty applications. This effort, conducted to support the Transportation Working Group's evaluation of "Big Idea" opportunities, identified that the GHG reduction potential is currently too low to merit Big Idea consideration, and helped to affirm that this is not a technology area that merits accelerated R&D at this time. NREL also played a central role in the subgroup's further exploration of infrastructure requirements, fuel standards and specifications, predictive modeling for vehicle design, techno-economic analyses, co-processing of natural gas and biomass, and tri-generation.

John Rugh and NREL Truck Thermal Load Reduction Task Leader Jason Lustbader organized multiple sessions at the 2014 and 2015 TMSS. The meetings bring together manufacturers, suppliers, and others to explore topics central to meeting DOE's fuel consumption reduction goals, including vehicle thermal management, climate control, power electronics and electric motor thermal management, and batteries.

Objective 3.2: Effective Communications and Response

Weight: 30.00% **Score:** 3.9 **Grade:** A

Objective Evaluation:

The Alliance program leadership and practices have resulted in effective communication with key stakeholders that has led to the formation of critical partnerships in support of VTP.
Hosted an automotive OEM industry workshop to share results from current research, and understand the most useful approach for technology transfer to this industry. . Projects identified for possible collaboration include thermomechanical modeling of emerging power electronics packaging configurations and bonded interface materials; the modeling of two-phase cooling on enhanced surfaces; mechanical and reliability characterization; jet impingement-based thermal management for inverters/converters; and the thermal degradation of power electronics. NREL also hosted visits by OEMs and suppliers to showcase NREL capabilities and discuss how the lab can work most effectively with industry.

Representatives from DOE (DAS, BETO, and VTO), nine of the national labs, and stakeholders from 26 companies/organizations met at NREL to provide input on the proposed R&D roadmap for Optima, the new DOE "Big Idea" initiative that will commence in FY16. The stakeholders, spanning a diverse range of organizations including auto and truck manufacturers, oil companies, and biofuel companies, shared a wealth of perspectives on deployment barriers associated with the introduction of new fuels and vehicles. This input has been instrumental in guiding the development of the multi-year Optima R&D plan.

The Workplace Charging Challenge had secured 207 partners by June 2015. WPC has collaborated with Clean Cities coalitions and partners to recruit new members, with some, such as EEI, sending messages at the leadership level to encourage WPC participation. Additional WPC effort included outreach activities such as the annual survey, and exploration of opportunities to make additional enhancements to the programs and maximize ambassadors' efforts.

Presentations to Atieva, Cummins, Cree/Wolfspeed, FCA, Hitachi, Tesla, Toyota, and United Technologies Research Center led to ongoing conversations about potential collaboration with organizations that have not historically been NREL partners on power electronics and electric machines research.

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00%	Score: 4.0	Grade: A
Goal Evaluation:		
Objective 4.1: Laboratory Strategy		
Weight: 25.00%	Score: 3.9	Grade: A

Objective Evaluation:
The Alliances' strategy for NREL ensures delivery on core programs while positioning them to create and execute new opportunities for impact. The following excerpts from the NREL five year plan provide insight into this. Intergenerational trends are changing mobility preferences and patterns as millennials migrate to urban environments, increasingly access services through edge devices, and participate in public transportation and new business models that provide mobility without requiring owning or wholly owing vehicles. Transporting feedstock to manufacturers and products to markets remains an essential part of a vibrant economy. Alliance aims to develop more robust insights by taking a system perspective of mobility, which will guide innovations in vehicle technologies and renewable fuels while creating opportunities for new areas of innovations that can have a large impact on national energy goals. In support of DOE's EV Everywhere goals, NREL will conduct R&D on vehicle electrification, advanced batteries, power electronics, alternative fuels utilization, thermal management, analysis, and modeling (computer-aided engineering for batteries or CAEBAT, real-world applications, and rule-making support). NREL's R&D efforts in vehicles will explore ways to make light-, medium-, and heavy-duty vehicles powered by internal combustion engines more efficient – and reduce barriers to putting more electric, hydrogen, biofuel, and natural gas vehicles on the road. NREL will advance new thermal management strategies in electric-drive vehicle power electronics and battery systems to reduce energy use, lower costs, and meet new regulatory requirements, with an increasing focus on wide bandgap semiconductors. Alliance will also advance technologies that enable cost-effective membrane electrode assemblies (MEA) and MEA component manufacturing, conduct assessments to ensure compatibility of drop-in biofuels with vehicle requirements, develop complex systems communications and control theory to enable vehicle-to-grid technologies, and conduct research to evaluate advanced lithium ion batteries and components. The laboratory will also work to ensure infrastructure compatibility for new fueling options, as well as research fast charge and integration of vehicles with the grid, buildings, and renewable resources. NREL will continue to provide unbiased, third-party testing and data collection on various vehicles technologies including both light-duty and heavy-duty fuel cells, hybrids, plug-in hybrids, and fully electric vehicles. These efforts will help disseminate data to the public sector to understand barriers and enable new innovation breakthroughs. NREL activities will also continue to support the U.S. Drive Partnership and the 21st Century Truck Partnership (21st CTP).

Objective 4.2: Steward Core Competencies

Weight: 40.00% **Score:** 4.1 **Grade:** A+

Objective Evaluation:
NREL has recently expanded their Support Team for the National Clean Fleets Partnership (NCFP). This change is helping us to strengthen our commination with the NCFP fleets, and with the network of Clean Cities Coalitions. It also provides the needed bandwidth to support the NCFP members with their individual AFV deployment

programs, and to the continued growth of the Partnership. NREL has significant industry collaborations in the area of power electronics and electric motors thermal management. This includes a TSA with Toyota in the area of modeling two-phase cooling, CRADA with GM in the area of power module reliability characterization and thermomechanical modeling, collaboration with APEI/Cree as well as John Deere on thermal management and reliability aspects of inverters incorporating wide-bandgap devices, and strategic partnership projects with UQM Technologies and nGimat in the areas of motor thermal management and reliability characterization. All these collaborations and activities have enhanced and strengthened the core thermal management and reliability capabilities at NREL. The Instron electromechanical tester was acquired under an NREL General Purpose Equipment award/purchase. This equipment is very valuable in characterizing the mechanical properties (e.g. stress-strain curves) for emerging materials for power electronics packaging. This information also informs and leads to accurate thermomechanical models for components and development of accurate lifetime prediction models. It has attracted the attention of a large number of companies and may lead to significant Strategic Partnership Projects. This is also strengthening the core capability (as recognized by the DOE Electric Drive Technologies Program) in the area of packaging reliability. In FY15, at least three companies requested NREL for assistance with calibrating physics-based models against experimental data. To address this need, we established laboratory capabilities that extensively characterize the electrochemical/thermal properties of cell components, measuring up to 40 parameters independently at the component level, and a set of guidelines to incorporate experimental data on to modeling software. In the upcoming years, this capability will establish NREL as the go-to place for calibrating the physics-based models. NREL collaborated with Ford Motor Company to identify and execute crash tests in battery cells and modules under tightly controlled conditions. It is extremely difficult to obtain repeatable current-voltage-temperature data under mechanical deformation of the test articles; but this is a significant capability development towards model validation for CAEBAT. NREL worked with engineers at MGA, with input from Ford, to design and implement fixtures that allow capturing displacements as low as a few microns over strain rates as high as several meters per second, suitable sensors for experimentally detecting short-circuit currents across multiple cells within a module, and test conditions that provide for reproducible load conditions (e.g., contact times between the indenter and the test article are well controlled). These capabilities will not only serve as the basis for future MECT work under CAEBAT, but significantly improve the industry's understanding of crash propagation mechanism within battery packs. In collaboration with Ford, Utah State and University of Colorado, NREL has initiated life testing of a prototype battery management system with heterogeneous cell control capability. Today's commercial battery packs utilize passive cell balancing electronics to avoid the higher upfront cost of active balancing systems. In a passive balanced pack, however, cells age in a non-uniform manner due to inevitable temperature gradients and manufacturing variations. This causes premature end-of-life for the system. Simulations have shown active balancing (electrical management) as a viable alternative to liquid cooling (thermal management). The prototype battery pack, built under ARPA-E funding, will serve as a platform for evaluating differential cell control strategies and

provide data needed to optimize the next generation of battery electrical/thermal management systems. NREL Supports Leadership in Key Professional Society. NREL's Brad Zigler has continued to serve on the Executive Committee for the ASME Internal Combustion Engine Division, serving as Division Vice-Chair for 2015-2016. He will serve as Division Chair in 2016-2017. This relationship keeps NREL in the center of advanced internal combustion engine development trends and industry needs. A commercial standard is a prerequisite for marketing of any new fuel and in the United States these are developed and promulgated by the ASTM International Petroleum Products committee. Standards for both conventional and biofuels also under continuous improvement and updating in response to changing technology and environmental regulations. NREL has played a key role in developing and maintaining standards for ethanol, gasoline containing up to 15% ethanol, flex-fuel, biodiesel, conventional diesel, B6 to B20 blends, isobutanol, and other biofuels. NREL staff play a key role on ASTM subcommittee and conduct research to provide data in support of standards development. Additionally, Teresa Alleman of NREL staff serves as a member of the ASTM Petroleum Products Executive Committee. A critical aspect of improving the energy efficiency of automobile climate control systems is maintaining human thermal comfort while using less energy. Chris Massina joined the NREL vehicle team for the summer of FY15. He is pursuing a PhD at the University of Colorado under a NASA funded grant. Chris leveraged is space suit research to assist NREL researchers assess current state of art thermal comfort manikins and models and develop recommendations for the next generation of thermal comfort tools. Enabled by NREL's interagency agreement with the Federal Highway Administration to support the Transportation Secure Data Center (TSDC), NREL recently joined the I-95 Corridor Coalition as an FHWA affiliate, which gives NREL access to detailed road and traffic data from INRIX, HERE and TomTom that helps support NREL's work with the TSDC project on behalf of FHWA and the DOE Vehicle Technologies Office. NREL and its partners are exploring the potential of a complete thermal load reduction system—featuring promising technologies such as solar-reflective paints, advanced glazings and window films, and advanced insulation—to increase electric-drive vehicle range by 20% during operation of the climate control system. Hyundai Sonata plug-in hybrids are being tested for this project, which was funded through an award from the FY14 Vehicle Technologies Program-Wide FOA. Industry partners include Hyundai America Technical Center, Pittsburgh Glass Works, Halla Visteon Climate Control, PPG Industries, Sekisui S-LEC America, 3M, and Gentherm. Technologies that are proven by test and/or analysis will be installed in a production vehicle. The growth of research in electric vehicle grid integration during FY15 necessitated the expansion of staff capabilities. Two new full time engineers were added to the team that brought automotive and battery industry experience to the team. The new staffing was critical to the completion of tasks that included, testing of a PGE V2G utility truck, a Mini-E V2G vehicle with University of Delaware, the completion of the Multi-lab EV Smart Grid Requirements Report, and the development of simulation tools to address V2G battery life impacts. The FleetDNA database saw tremendous growth in medium- and heavy-duty vehicle data storage and application during FY15. The publically accessible database serves as the secure data center for the DOE's Fleet Testing and Evaluations of

advanced technology vehicles and for a variety of other vehicle data collection activities. FleetDNA now contains over 20 terabytes of combined vocational vehicle and component performance data collected from over 1600 vehicles operating at more than 125 unique locations. With additional data for over 8000 new vehicles expected during the first quarter of FY16, the FleetDNA database will have seen over a tenfold increase in the volume of available research data from FY14 to FY15. The continued database expansion is a result of extensive partnership with fleets, industry and governmental organizations and improved project visibility through the FleetDNA project website (www.nrel.gov/fleetdna). FleetDNA has grown to be a valuable national asset as demonstrated by the many contributors and consumers of the resource including the EPA, Oak Ridge National Laboratory, South Coast Air Quality Management District, University of Michigan's Transportation Research Institute, 21Century Truck Partnership, Clean Cities' National Clean Fleet partners, truck manufacturers and commercial fleets and others. NREL has enhanced its collaboration with two of the DOT University Transportation Research Centers through collaborating with professors and graduate student interns at the State University of New York in Buffalo and at the University of California, Riverside. The University of Buffalo project has explored the fuel saving potential from coordinated vehicle and infrastructure traffic control (at signalized intersections). The UC Riverside collaboration has helped NREL to develop a framework model for estimating the national-level impacts from a variety of connected and automated vehicle technologies. Both projects will be wrapping up and turned into research publications in early FY16.NREL collaborated with Ames Laboratory on a proposal on magnetic materials (topic under the Electric Drive Technologies) in response to the FY16 VTO Lab Call. The specific NREL role will be on characterization of mechanical and thermal properties of novel magnetic materials being developed by Ames Laboratory. NREL also is part of the PowerAmerica project - led by North Carolina State University and funded by the DOE Advanced Manufacturing Office (AMO). NREL THSC Center also recently teamed with 6 universities (University of North Carolina Charlotte/University of Minnesota, University of Colorado Boulder, Colorado School of Mines, Virginia Tech, University of Maryland College Park, Texas Tech University) on proposals in response to a solicitation issued by AMO on Graduate Traineeship Program in power electronics/engineering incorporating wide-bandgap devices. NREL also established collaborations with North Dakota State University as well as University of Maryland College Park in area of prognostics. Finally, NREL worked closely with Carnegie Mellon University and Texas A&M University under a DARPA-funded Program to yield novel thermal contact resistance and conductivity measurements for novel materials developed by these Universities with applicability for wide-range of power electronics and energy efficiency applications. NREL has partnered with other national laboratories including ANL, ORNL and LBNL along with leading universities (CU-Boulder) to demonstrate the efficacy of advanced coating materials to improve the performance of lithium ion batteries for automotive applications. With renewed funding from VTO in FY15, NREL and partners have established the Advanced Materials Coatings Facility under the Applied Batteries Research program. This facility will serve as a hub for studies of advanced coatings based on Atomic Layer Deposition and act as a resource for all of the Applied Battery

Research program. Work will focus on development of coating materials and processes that are compatible with state of the art battery electrode manufacturing. NREL and Sandia National Laboratory (SNL) have collaborated for LIB safety study with their world-leading expertise in modeling-NREL and testing-SNL. In FY15, NREL and SNL started a study on thermal runaway propagation in a multi-cell module. NREL received the SNL's test data from both a pouch cell module and a cylindrical cell module. Preliminary model simulation results agree well with the experimental observation. We plan to publish the results together in a peer-reviewed journal. University of Kansas Chemistry Student Completes Summer Internship. EX 6 , a chemistry undergraduate at University of Kansas, spent the summer at NREL researching the impact of iron contaminants in biodiesel fuels on their oxidation stability. His research examined both solid particles of iron or rust as well as dissolved iron. This research discovered that particles have only a fraction of the impact of dissolved iron. Dissolved iron in the form of carboxylic acid salts had a large negative impact on oxidation stability at levels as low as 0.5 ppm. Eindhoven University Doctoral Student Studies Fuel Autoignition at NREL. EX 6 a PHD student at Eindhoven Technical University in the Netherlands spent a semester conducting studies of biofuel autoignition using NREL's one of a kind IQT combustion apparatus. This work complements engine combustion studies she is conducting at her home university. EX 6 discovered that high octane fuels can undergo ignition events that are not autoignition but caused by some other, yet to be explained factor. This has opened up a new avenue of research for trying to understand the most important fuel properties for spark ignited engine combustion. Additional Colorado School of Mines Faculty Joint Appointment Placed. Stephanie Villano, a Research Assistant Professor at Colorado School of Mines (CSM), was awarded a joint appointment with NREL's Advanced Combustion and Fuels research group, the second CSM faculty joint appointment in that group. Stephanie's no-cost joint appointment provides her access to competitively awarded time on NREL's Peregrine and related NEXUS high-performance computing resources to perform ab-initio calculations for detailed kinetic modeling of low-temperature alkane oxidation, including high-pressure rate rules for diesel range fuels. The joint appointment complements other fuel ignition kinetic modeling research NREL conducts, and leverages Dr. Villano's funding for ab-initio kinetic development funded by the Office of Naval Research. The University of Michigan's Transportation Research Institute (UMTRI) recently provided an extensive set of regional haul vehicle data from its collaboration with Con-Way Freight to the FleetDNA database. This valuable set of high-frequency vehicle performance data from the UMTRI / ConWay Integrated Vehicle-Based Safety Systems program helped to extend the FleetDNA data on regional haul trucking. This data can be applied to DOE / industry partnerships such as 21st Century Truck and the National Clean Fleet Partnership to help understand the operational characteristics of regional-haul trucking and evaluate the energy savings potential in this vocation. NREL is working with newly established partners at the University of Maryland (which hosts the I-95 Corridor Coalition database) to develop a joint research project that is anticipated to be supported by the coalition in FY16 and FY17. The project would also include partners from INRIX, HERE and/or TomTom and would support enhancements to the currently available data from those vendors to

include improved estimates on real-time turning and traffic volume. These enhancements will be valuable in their own right, as will closer collaboration and relationship building with the University of Maryland and with these major traffic data vendors. The EVGI team engaged with University of Colorado-Boulder during the past year to open collaboration in the area of wireless power transfer. An Electrical Engineering program graduate student joined the EVGI team to support simulation of WPT applications to the NREL campus shuttle. This student involvement will support continued engagement between the two organizations on advanced WPT concepts that include capacitive wireless power transfer for future electrified roadways.

Objective 4.3: Leadership and Lasting Value

Weight: 35.00% **Score:** 3.9 **Grade:** A

Objective Evaluation:
The Alliance leadership and engagement has delivered strategic mission value as evidenced by the following. DOE Laboratory Collaboration Examines Expanded Utilization of Natural Gas for Transportation. An initial collaboration with ANL and ORNL grew to an ANL/NREL/ORNL leadership role in a larger collaboration with INL, LBNL, LLNL, NETL, PNNL, SNL, and SRNL to explore significantly increased use of natural gas (NG) for transportation in consideration of a DOE Big Idea Summit proposal. The team was assembled from key technical area experts and operated under the DOE Transportation Working Group. The natural gas for transportation initiative examined key research and development challenges in distribution and refueling, on-board storage, distributed gas-to-liquids and liquefied NG production, vehicle end-use, and cross-cutting impact assessment. The analysis included projections of petroleum displacement and greenhouse gas (GHG) impacts for a proposed large-scale initiative to extensively utilize NG for transportation. Outcomes included a path to displace half of imported petroleum by 2040. But GHG projections showed near net-zero offset from a baseline scenario, guiding DOE to consider investing elsewhere for larger GHG impacts. The EVGI team worked to form collaborations across internal laboratories and programs at NREL. In particular, the Buildings program delivered a report on EV Building integration needs and opportunities. The EVGI team provided critical insights and content to the final BTO deliverable. In addition, our team reaches out to the solar program activities for generation data streams and forecasting capabilities that integrate with EVSE charge management scheduling research. University of Michigan Doctoral Student Studies Fuel Autoignition at NREL. Cesar Barraza-Botet, a Fulbright Scholar and Ph.D. candidate at the University of Michigan (UM) was awarded a collaborative appointment at NREL to study fuel ignition kinetics in NREL's IQT-based research platform. The experiments focus on ethanol/iso-octane blends, providing critical data to improve kinetic mechanisms of key surrogates for advanced gasoline engine development. The IQT studies complement experiments Cesar performed on UM's rapid compression facility (RCF). The IQT data span adjoining experimental parametric space than the RCM data, with the combined datasets permitting greatly improved insight to improve kinetic models supporting advanced GDI engine and gasoline

compression ignition (GCI) engine development. Cesar's research at UM is funded in part by a DOE FOA award, with NREL's collaborative appointment providing additional leverage of DOE resources. Fuel Ignition Studies Advance Gasoline Compression Ignition Research. A new collaboration with Dr. Steve Ciatti (ANL) complements his research on gasoline compression ignition (GCI). GCI is a promising low temperature combustion (LTC) engine combustion strategy that offers high efficiency with low emissions. Ciatti's research has focused on GCI engine hardware and controls to develop the combustion strategy, which is controlled through both fuel mixing and ignition kinetics. NREL has begun testing fuels used by Ciatti using temperature sweep techniques for ignition delay measurements with the IQT. These data will offer much greater insight for correlation to engine performance than traditional research or motor octane number (RON or MON) measurements, and help determine how GCI engine technology can be developed to adapt to a wide range of fuel blends. NREL recently collaborated with Auburn University under a research program funded by the Federal Highway Administration to evaluate truck platooning with the goal of saving fuel and decreasing traffic congestion. Under the collaboration an NREL engineer from the Fleet Test and Evaluation team installed dataloggers on vehicles being tested by Auburn at the Transportation Research Center in Ohio. In exchange, Auburn will provide data from the track testing. This collaborative exchange of information and resources will help further NREL's research with Lawrence Livermore on truck platooning technology.

Wind and Water Power Technologies (WWPTO)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 3.6	Grade: A-

Goal Evaluation:

NREL has met the majority of their milestones per the FY2015 AOPs for Wind and Water. Where milestones were missed there were plausible reasons provided accompanied with timely communication of the delay; and the NREL team has worked with the HQ Program Managers and Technology Managers to ensure that relevant work is still completed.

Objective 1.1: Advance Science and Technology

Weight: 50.00% **Score:** 3.7 **Grade:** A-

Objective Evaluation:

- NREL served as the co-manager for work on International Energy Agency Task 35: Full Size Ground Testing for Wind Turbines and Their Components – to improve the fidelity of rotor test methods and exploring component-level test strategies that can enable increased levels of blade reliability. Work in this area will ensure more reliable wind turbine components by developing test methods that more accurately reflect real world conditions. NREL managed U.S. participation in international standards committee proceedings, ensuring that U.S. knowledge developed under the DOE Wind Program, was included in the standards deliberations. In addition, NREL ensured this project represented U.S. industry needs in the standards development process while maintaining an independent role and facilitating consensus.
- NREL has developed the Simulator for On/Offshore Wind Farm Applications (SOWFA), a high-performance computing research tool that models the atmospheric boundary layer and the complex flow interaction between wind turbines. SOWFA is providing many new insights into wind turbine wake interactions and the possibilities for increasing wind plant power production through different control strategies. Most significantly, industry has started to adopt SOWFA as a tool to improve the performance of wind plants. SOWFA is a prime example of a national lab providing new, cutting edge analysis capability to the industry.

- NREL led the Experimental Measurement Campaign (XMC) for Planetary Boundary Layer (PBL) Instrument Assessment (XPIA) experiment, a field-test campaign that included DOE national laboratories, NOAA, universities, and industry, the first collaborative project under the Atmosphere to Electrons initiative. The experiment provided an independent assessment of existing field measurement instrumentation to determine accuracy, resolution, and robustness, and has been a huge success.
- Across the board NREL has done a good job of managing grid integration related projects for the WWPTO. In the face of considerable uncertainty of future project scope and overall tasking, coupled with substantial requirements to respond to a Lab Call associated with DOE's Grid Modernization efforts, NREL has strived to meet FY'15 milestones. Additionally, NREL has worked to address concerns about mid-level management issues and emerged in a stronger position going forward to respond to DOE's needs in moving forward with the Grid Modernization Initiative. While some issues have arisen which have delayed some deliverables, NREL staff has been extremely communicative in explaining the cause of the delays and work directly with HQ to develop a path forward.

Objective 1.2: Deliver Credible and Objective Analyses

Weight: 20.00% **Score:** 3.7 **Grade:** A-

Objective Evaluation:

- NREL has been exceptional in the case of performing analysis for the Wave Energy Prize and on the Levelized Cost of Energy projections that may result from the Wave Energy Prize to support DOE MHK Program priorities.
- NREL, in collaboration with SNL, has done an impeccable job of ensuring numerical codes produced under the WECSim project are industry relevant. Already these codes have seen significant use by the Wave Energy Prize qualified teams, by FOA awardees mandated to deliver numerical projections of device performance. The Program expects to see additional and continuing benefits out of this exemplary project once the numerical model validation tank testing data set is made publically available on the NREL developed MHK Data Repository.

Objective 1.3: Demonstrate Relevance and Market Impact

Weight: 30.00% **Score:** 3.5 **Grade:** A-

Objective Evaluation:

- NREL has done an excellent job building partners and connecting with some wind and water stakeholder communities. For MHK regulator workshops, NREL did an outstanding job connecting with and bringing in key players for

their second workshop. The Wind environmental portfolio always works well with the broader wind stakeholder community and is very well connected in that space. Under an extremely tight budget and timeline (and while juggling a number of requests for proposals from HQ for future work), NREL's wind deployment team delivered a highly successful Collegiate Wind Competition Engineering Challenge in that provided a great experience for students and faculty from the participating universities, as well as engaged industry members. Fantastic work by all involved. The wind energy Regional Resource Centers also met nearly all of their performance targets and achieved 1.2 million stakeholder touchpoints, engaged 22,000 key stakeholders (county commissioners, legislators, PUC staff, etc.), and drove the inclusion of RRC targeted wind energy information in 60 state or local government or utility policies or plans nationwide.

- The Gearbox Reliability Collaborative (GRC) has been a project which delivers highly relevant testing and analysis and the annual GRC meeting offers a valuable venue for technology transfer; however, the GRC projects have suffered from significant cost overruns and schedule slippage. NREL management needs to monitor this effort and take corrective action when necessary to ensure future success.
- NREL has also engaged MHK Stakeholders to receive early feedback to inform the approach and products to be developed out of NREL to ensure their relevance (MHK Hotspot identification and characterization project)

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score: 4.0	Grade: A

Goal Evaluation:

NREL continues to provide a suite of world class testing capabilities for utility, offshore, and distributed wind technology at the National Wind Technology Center. NREL continues to develop new and innovative test methodologies for both wind and water Finally, NREL is implementing a long overdue facilities improvement plan that will improve the image of the center for visiting companies and executives

Objective 2.1: Effectively Steward the ESIF User Facility

Weight: N/A	Score: N/A	Grade: N/A

Objective Evaluation:
N/A

Objective 2.2: Effectively Steward Major Research Facilities

Weight: 50.00%	Score: 4.0	Grade: A

Objective Evaluation:

- NREL continued to provide a suite of world class testing capabilities for utility, offshore, and distributed wind technology at the National Wind Technology Center. Testing infrastructure supports design and performance testing, as well as research, such as validation of wind turbine design codes, reliability testing, and wind turbine wake and plant airflow analysis. Test facilities are critical for testing innovative components and systems prior to wide scale deployment, and for important understanding of wind turbine failure modes.
- NREL continued to develop and improve methods for blade testing to better reflect the real-world load conditions experienced by wind turbine blades. NREL continued to successfully manage the blade test partnership with the Massachusetts Wind Technology Testing Center, with technology transfer and frequent communication regarding blade testing methods and lessons learned at both facilities.
- NREL drivetrain testing experts collaborated with Clemson to transfer testing know-how and processes between the two facilities, to ensure safe and efficient dynamometer operations.
- NREL testing and controls experts provided support to SNL for the restart of the Scaled Wind Farm Test Facility. SNL requested the support based on NREL's long history in developing and performing test procedures of wind turbine components.
- NREL ensured the safe and efficient operation of DOE's world-class test facilities located at the NWTC. NREL conducted work in accordance with all DOE/NREL Quality Assurance requirements. NREL ensured compliance with all overarching DOE, NREL, and OSHA operating and safety requirements, including safety reviews and inspections, and compliance with National Environmental Policy Act requirements.
- NREL characterized the operation of the Controllable Grid Interface (CGI) hardware installed at the NWTC, an innovative capability that allows for evaluating the impacts of electrical faults on wind turbine components. NREL initiated a series of increasingly demanding tests, beginning with tests using a wind turbine test article located in the 5 MW dynamometer and ultimately progressing to field tests using a Row 4 turbine.
- NREL invested resources in making the National Wind Technology Center more conducive to visitors. The dynamometer facility control room was modified with control stations, conference tables, and viewing windows.
- NREL has developed working relationships with the Massachusetts Wind Technology Testing Center and the Clemson University Research Institute for testing wind turbine blades and drivetrains. NREL should continue to work with these partners to develop state of the art testing methods and safe operating procedures. An example of this is continued development of dual axis testing for wind turbine blades.

- NREL is implementing an improvement plan for spaces frequented by visiting companies and dignitaries in response to DOE requests. NREL should continue to look for low or no-cost opportunities to improve facilities (e.g. cleanup and stowage, management of old test articles) to better reflect a world-class research facility.

Goal 3.0: Provide Effective and Efficient Program Management

Score: 3.3	Grade: B+

Goal Evaluation:

Objective 3.1: Effective Program Planning and Execution

Weight: 70.00% **Score:** 3.3 **Grade:** B+

Objective Evaluation:

- NREL management has responded to the redirection of the FAST project in a professional manner. This has been a tough transition, but leadership should be commended for making tough decisions and getting the project aligned with DOE's missions.
- NREL leadership has done a commendable job in realigning tasks to match the priorities of the A2e initiative.
- NREL management has been very responsive and engaged with National Labs and other external organizations to develop collaborative research plans in support of the A2e initiative. DOE has seen real, measurable improvements in NREL's engagement with other national labs. DOE encourages NREL management to continue to reinforce this change in culture to their staff.
- NREL has been supportive of both creative new ideas presented to HQ MHK Program (Structured Innovation) while also receiving feedback from HQ and incorporating this feedback to ensure that the work plans and work products from new start efforts are in strong alignment with program goals.

Objective 3.2: Effective Communications and Response

Weight: 30.00% **Score:** 3.2 **Grade:** B+

Objective Evaluation:

- NREL serves in a facilitation role in the wind environmental space and does an excellent job in this capacity. The lab worked incredibly hard to ensure the success of their second MHK regulatory workshop and worked very closely with

DOE to ensure that expectations were met. The workshop received stellar feedback from participants and was highly impactful, though follow-up on deliverables after the workshop has been delayed. However, regarding development of the RAPID Toolkit for Hydropower, interactions with external stakeholders and key agencies – the core audience for the tool – have been poorly managed. A workshop to get national stakeholder input was not well-facilitated and a separate workshop to get input on the Vermont state roadmap attracted only 3 participants due to a lack of planning and oversight by the project team. Regarding Wind Exchange & Wind Regional Resource Centers, poor communications led to the leak of a key program deliverable by a subcontractor.

- NREL and DOE HQ MHK Program are actively working to identify opportunities for improvement in communications to actively manage projects with transitioning team members, and ensuring that a single accountable entity at the lab is identified and empowered to ensure AOP milestones are met at high quality. This will avoid challenges from projects that have multiple tasks rolled up into one project that each have individual team members working different tasks.
- NREL continues to struggle with project management in the area of Distributed Wind. Steps have been made to improve and correct, but work remains in meeting project deliverables on-time.

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00%	**Score:** 2.9	**Grade:** B

Goal Evaluation:

Objective 4.1: Laboratory Strategy

Weight: 25.00%	**Score:** 3.0	**Grade:** B

Objective Evaluation:

- Together NREL and HQ continue to improve interactions to ensure smooth and impactful shaping of the portfolio in communication and development of outyear strategy. DOE HQ MHK Program has informed NREL of opportunities for lab staff to provide input the program strategy and approach for development of future year lab project. Similarly, NREL has provided DOE HQ MHK Program of NREL process for vision and strategy development that allows opportunity for DOE HQ MHK Program input.

Objective 4.2: Steward Core Competencies

Weight: 40.00% **Score:** 3.0 **Grade:** B

Objective Evaluation:

- NREL has been responsive to the Wind Program's request for increased collaborative projects across National Labs and has shown a marked improvement in their approach to developing these collaborations.
- DOE HQ MHK Program has identified areas for NREL to go above and beyond and really help the nation succeed in tackling LCOE reduction in an entirely different way than sectors that proceeded this newer renewable energy. NREL has embraced some concepts and run with them (WEC-Sim open development platform, Wave Energy Prize), but has lagged on proposing initiatives/taking the reins and running with others (Data Repository, dissemination of work the US and NREL are doing to engage international collaboration and avoid duplication of effort.)

Objective 4.3: Leadership and Lasting Value

Weight: 35.00% **Score:** 2.8 **Grade:** B

Objective Evaluation:

- NREL excels at bringing the wind environmental community together; however, the lab does not serve as well as independent thought/research leaders in this space to the degree that a national lab could. As a result, the quality and timeliness of the work products is often dependent on the willingness and availability of external experts to contribute their time to NREL efforts. For example, a wind mitigation protocols guidance document was delayed and its quality was dependent largely of a group of external experts both creating and vetting the content. We would encourage NREL to develop more of a research leadership role in the wind environmental space.
- NREL continues to struggle with technical/R&D leadership in the area of Distributed Wind. Steps have been made to improve overall project management capabilities and communications but work remains in effective technical leadership and in meeting project deliverables on-time.
- NREL needs to involve WWPTO leadership in the decision making process and critical funding decisions when engaging EERE Leadership. Third party communication over critical issues in FY 2015 led to frustration, confusion and inefficiency in meeting critical funding needs at the end of the fiscal year. Line Program Managers should be empowered to engage (and be the main point of contact) with the Program on all issues impacting funding.

Science - Biological and Environmental Research (BER)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 3.5	Grade: A-

Goal Evaluation:

NREL is a significant partner in the BESC activity, and contributes valuable expertise in high-throughput technologies for characterization and analysis in the biomass to biofuels pathway. NREL scientists are good performers but there does not appear to be any higher-level laboratory attention paid to provide coherence, vision, or synergy between various performers. This lack of cross-laboratory leverage is a lost opportunity.

Objective 1.1: Advance Science and Technology

Weight: 50.00% **Score:** 3.5 **Grade:** A-

Objective Evaluation:
NREL is a major contributing partner to the Bioenergy Science Center (BESC) led by ORNL, one of BER's Bioenergy Research Centers. NREL researchers continue to make solid scientific contributions as part of BESC in the areas of imaging technology and detailed and high-throughput identification and characterization of the new cellulolytic enzymes for biomass deconstruction. NREL continues to demonstrate strong support for SC-supported bioenergy research and remains a valued and critical scientific partner within BESC.

NREL's Biofuels Science Focus Area (BSFA) project has been productive over the past year examining the detailed metabolism of hydrogen production in microalgae. An NREL-developed high-throughput biosensor-based assay has been used to discover microalgae strains with increased hydrogen output as well as to analyze enzymes modified to be less sensitive to oxygen, a major hurdle in biological hydrogen generation.

NREL researchers are recognized experts in enzyme characterization for plant-based biofuel production. The association with BESC has proven to be an effective collaboration where insights gained from a basic science understanding of new enzyme cocktails can have a more direct impact on commercial efforts to produce biofuels from

biomass. NREL serves as a unique link between basic science efforts ongoing within SC and applied technology demonstration within EERE and industry.
Objective 1.2: Deliver Credible and Objective Analyses
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A
Objective 1.3: Demonstrate Relevance and Market Impact
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score: **Grade:**
Goal Evaluation:
Objective 2.1: Effectively Steward the ESIF User Facility
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A
Objective 2.2: Effectively Steward Major Research Facilities
Weight: N/A **Score:** N/A **Grade:** N/A
Objective Evaluation: N/A

Goal 3.0: Provide Effective and Efficient Program Management

Score: 3.3 **Grade:** B+
Goal Evaluation: NREL has a number of partnerships with other academic institutions; if there is a strategic vision to coordinate or leverage across those partnerships it is not explicit or obvious.

Opportunities for cross-laboratory fertilization would increase the impact of individual NREL scientists.
Objective 3.1: Effective Program Planning and Execution
Weight: 70.00% **Score:** 3.4 **Grade:** B+
Objective Evaluation: NREL maintains an effective and productive scientific partnership with other researchers within SC as a part of BESC. NREL researchers play an active role in developing the annual strategic scientific goals and milestones for BESC. NREL's BSFA is currently addressing concerns about how the project goals integrate with DOE-SC mission objectives and are attempting to refocus the subprojects to better address BER's scientific priorities.
Objective 3.2: Effective Communications and Response
Weight: 30.00% **Score:** 3.2 **Grade:** B+
Objective Evaluation: NREL is responsive to HQ communications. NREL continues to maintain the BESC collaboration as a high priority project for the lab, and is responsive to requests for research highlights and accomplishments.

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00% **Score:** 3.4 **Grade:** B+
Goal Evaluation: There has been little engagement of NREL senior management with BER HQ. The appointment of a new laboratory director who has a strong track record as a performer for BER will hopefully increase the dialogue in the future.
Objective 4.1: Laboratory Strategy
Weight: 25.00% **Score:** 3.4 **Grade:** B+
Objective Evaluation: NREL continues to be an effective partner with BER for bioenergy research. The collaboration with BESC continues to be very productive scientifically and serves as a good example of lab-lab collaboration. It is clear that NREL management recognizes this partnership as an important activity. It remains important for DOE to understand NREL's goals and visions for basic bioenergy research and what role it will play in translating basic research to the commercial bioenergy sector.

Objective 4.2: Steward Core Competencies		
Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		
Objective 4.3: Leadership and Lasting Value		
Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		

Science - Basic Energy Sciences (BES)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 3.4	Grade: B+

Goal Evaluation:

Objective 1.1: Advance Science and Technology

Weight: 50.00% **Score:** 3.4 **Grade:** B+

Objective Evaluation:
Three BES-MSE supported projects at NREL were reviewed in FY 2015. Research on novel compound semiconductors was found to be high impact research that takes advantage of unique laboratory resources. Research on cation stability and membranes for hydrogen fuel cells was seen as a fundamental research success story as the goals of this project are complete and ready for transition to more applied programs in EERE. A third project focused on charge transfer in organic polymers was terminated due to low productivity.

An Early Career award on the development of a unique MBE machine should closely monitored to ensure that research results are published promptly in the open literature.

NREL leads the BES-EERE supported "Solar Energy Research Institute for India and the United States" (SERIIUS) which is co-led by the Indian Institute of Science (IISc)—Bangalore, India. The research is conducted through a partnership of university, industry and DOE National Laboratories. The project is well aligned with the laboratory mission and is seen as performing well in terms of milestones, publications and developing strong collaborations between the U.S. and India.

The BES-CSGB supported projects in Solar Photochemistry and Photosynthetic Systems were reviewed in FY 2015. The basic research on solar photoconversion in molecular and polymeric semiconductors is considered to be at the forefront of science in this area. Efforts in the study of quantum-confined nanocrystals and in solar fuels similarly make use of unique strengths at NREL to address important questions in photoconversion. However, the solar fuels project could be strengthened by including a strong theory component. The Photobiology and Photobiohybrid projects continue to

provide new insights into biological hydrogen production and energy transduction in model photobiohybrid and photobiological complexes.

In FY 2014, BES made a new award to NREL for the Center for Next Generation Materials by Design (CNGMD), an Energy Frontier Research Center (EFRC) that aims to transform the discovery of functional energy materials. NREL management and leadership of this center is off to a strong start, producing impactful scientific results in the area of "materials by design." NREL researchers also participate actively as partners on three other EFRCs led by LANL, Montana State University, and Purdue University.

Objective 1.2: Deliver Credible and Objective Analyses

Weight: 20.00% **Score:** 3.3 **Grade:** B+

Objective Evaluation:
Scientific analyses of fundamental research directions are consistent with overall BES expectations. The SERIIUS project is making significant progress on project milestones, and was proactive in redirecting part of the research to focus on the stability and large area, thin film deposition of the newly discovered perovskite PV materials. The efforts in Solar Photochemistry are considered world-leading and highly productive. Efforts in the Photobiology and Photobiohybrids are also making good progress in the fundamental understanding of hydrogen production, hydrogenase structure/function, and photosynthetic electron transport.

Objective 1.3: Demonstrate Relevance and Market Impact

Weight: N/A **Score:** N/A **Grade:** N/A

Objective Evaluation:
N/A

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score:	Grade:

Goal Evaluation:

Objective 2.1: Effectively Steward the ESIF User Facility

Weight: N/A **Score:** N/A **Grade:** N/A

Objective Evaluation:
N/A

Objective 2.2: Effectively Steward Major Research Facilities

Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		

Goal 3.0: Provide Effective and Efficient Program Management

Score: 3.4	**Grade:** B+	
Goal Evaluation:		
Objective 3.1: Effective Program Planning and Execution		
Weight: 70.00%	**Score:** 3.4	**Grade:** B+
Objective Evaluation: The NREL mission has elements that are well aligned with the BES programs with an emphasis on basic science. Management of the SERIIUS project is a notable success, as is the research on compound semiconductor research. Management and program planning of the Solar Photochemistry and Photosynthetic Systems research has been effective for current and planned research addressing BES-relevant basic science questions in solar photoconversion and photosynthesis. Productivity of BES-supported research should be monitored to ensure impact at expected levels.		
Objective 3.2: Effective Communications and Response		
Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00%	**Score:**	**Grade:**
Goal Evaluation:		
Objective 4.1: Laboratory Strategy		
Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		

Objective 4.2: Steward Core Competencies		
Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		
Objective 4.3: Leadership and Lasting Value		
Weight: N/A	**Score:** N/A	**Grade:** N/A
Objective Evaluation: N/A		

Reimbursable Work (U.S. Navy)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

Goal 1.0: Efficient and Effective Mission Accomplishment

Score: 3.7 Grade: A-		
Goal Evaluation:		
Objective 1.1: Advance Science and Technology		
Weight: 50.00%	**Score:** 3.7	**Grade:** A-
Objective Evaluation: None		
Objective 1.2: Deliver Credible and Objective Analyses		
Weight: 20.00%	**Score:**	**Grade:**
Objective Evaluation:		
Objective 1.3: Demonstrate Relevance and Market Impact		
Weight: 30.00%	**Score:**	**Grade:**
Objective Evaluation:		

Goal 2.0: Efficient and Effective Stewardship and Operation of Research Facilities

Score: 3.7 Grade: A-
Goal Evaluation: Ability to express value proposition to external partners led to DON collaboration, increasing the use of NREL facilities and analytical capability.
Objective 2.1: Effectively Steward the ESIF User Facility

Weight: 50.00%	**Score:**	**Grade:**
Objective Evaluation:		
Objective 2.2: Effectively Steward Major Research Facilities		
Weight: 50.00%	**Score:**	**Grade:**
Objective Evaluation:		

Goal 3.0: Provide Effective and Efficient Program Management

Score: 4.0	**Grade: A**	
Goal Evaluation:		
Objective 3.1: Effective Program Planning and Execution		
Weight: 70.00%	**Score:** 4.0	**Grade: A**
Objective Evaluation: Program management experience allowed NREL staff to step in as co-leaders on a complex testing project onboard MARAD owned ships operated by maritime academies.		
Objective 3.2: Effective Communications and Response		
Weight: 30.00%	**Score:** 4.0	**Grade: A**
Objective Evaluation: Talented in summarizing complex technology development and integration strategies that could benefit DON energy goals.		

Goal 4.0: Provide Sound and Competent Leadership and Stewardship of the Laboratory

Weight: 20.00%	**Score:** 3.9	**Grade: A**
Goal Evaluation:		
Objective 4.1: Laboratory Strategy		
Weight: 25.00%	**Score:** 3.7	**Grade: A-**

Objective Evaluation: Team has done well to demonstrate current capability and translate that into opportunities for partnership with other organizations.
Objective 4.2: Steward Core Competencies
Weight: 40.00% **Score:** 4.0 **Grade: A**
Objective Evaluation: Team member helped shape an industry-wide approach to testing of early stage maritime energy technology. Buildings experience has been valuable in creation of new testing networks.
Objective 4.3: Leadership and Lasting Value
Weight: 35.00% **Score:** 4.0 **Grade: A**
Objective Evaluation: NREL has been a core contributor in a cross-agency effort to create tech validation capability for early stage maritime efficiency technology.

Golden Field Office (GFO)

National Renewable Energy Laboratory
FY 2015 Performance Evaluation
Office of Energy Efficiency and Renewable Energy

GOAL 5: ENVIRONMENT, HEALTH, AND SAFETY MANAGEMENT

The contractor's performance relative to this goal should demonstrate that environment, health, and safety (EHS) is a priority; that processes and practices are established to effectively identify and manage risks to protect NREL workers, the local community, and the environment; and that the laboratory complies with all applicable DOE requirements, regulations, laws, and laboratory policies and procedures.

The contractor has notably exceeded expectations within the purview of Performance Objective 5.1: *Alliance maintains a safe and healthful workplace through continuous improvement of its integrated safety management systems*. Areas of performance have – or have the potential to – improve the overall mission of the laboratory. Minor deficiencies noted are more than offset by positive performance within the purview of the overall objective being evaluated and have no potential to adversely impact the mission of the laboratory.

PERFORMANCE OBJECTIVE 5.1: Alliance maintains a safe and healthful workplace through continuous improvement of its integrated safety management systems.

Grade = 4.0, A

5.1.A.1: The days away, restricted, or transfer (DART) rate for NREL workers is at or below 0.25.

The contractor has met the A+ and B+ 5.1 performance objectives for the days away, restricted, or transfer (DART) rate. The FY15 NREL supervised worker DART rate was 0.20, which was half of the most recent whole-year DOE contractor average DART rate of 0.4. The contractor has also met the A+ and B+ 5.1 performance objectives for the total recordable case (TRC) rate. The FY15 NREL supervised worker for NREL supervised workers was 0.60, while the most recent whole-year DOE contractor TRC rate was 1.0.

5.1.A.2: The total recordable case (TRC) rate for NREL workers is at or below 0.65.

See comments directly above.

5.1.A.3: Facility managers implement work planning and control process to support implementation and enhancement of Integrated Safety Management (ISM) and environmental protection goals and objectives.

NREL Facility Managers (FMs) ensure that all activities conducted in their facility fit within the safety envelope of each facility by way of establishing and maintaining Hazard Analysis Reviews (HARs) or similar appropriate document (authorization basis) to define the safety envelope of a specific facility. Alliance used a risk based approach to prioritize the development of NREL Facility HARs and has completed or plans to complete a total of 14 HARs. In FY15 Alliance completed and published the ESIF HAR and has drafted HARs for IBRF, SERF, S&TF, Mesa Top facilities, and Building 16. The Golden Field Office (GFO) recognizes progress toward developing HARs for research facilities and other facilities with significant hazards; however, the completion of one HAR of the 14 planned leaves all but one facility without a documented over-arching work planning and control process (WP&C) – i.e., a documented HAR to define the facility safety envelope.

NREL FMs are responsible for the implementation of change control within the configuration management (CM) program. A CM program is currently in development and is a topic of discussion when planning work; however, the NREL CM program is still in the developmental stages and Alliance has yet to implement a site-wide change control process capable of maintaining consistency among DOE design requirements and NREL physical configuration.

Facility Managers successfully implemented work planning and control processes to support ISM goals and objectives. This was achieved through integration of the Facility Managers with other Operations and Science and Technology staff. Further enhancements included the additions of: Facilities Management Council, Facility Managers Sub-Council, and Engineering Sub-Council.

5.1.A.4: Complete site-wide electrical equipment inspections according to NREL Project Management Plan dated March 17, 2015.

Alliance completed electrical equipment inspections outlined in the Project Management Plan (Rev.3). Of the 772 inspected systems, 547 systems passed, 175 systems failed-in-use, and 45 systems failed for safety. GFO commends Alliance's vision and dedication necessary to train individuals, to prioritize and complete the site-wide electrical inspections, and to track inspection results to closure.

5.1.A.5: Maintain Occupational Health and Safety Advisory Services (OHSAS) 18001 certification.

NREL's management systems were reviewed and verified as continuing to meet the ISO and OHSAS standards through an annual third-party surveillance audit. The team identified 22 system strengths. Example programs and practices that were noted include: 1) Electrical safety panel and ESO qualifications programs, 2) ergonomics program, 3) lessons learned pilot, and 4) the SOURCE system for collecting and managing employee safety concerns. Five minor non-

conformities were identified. NREL has completed a causal analysis, and corrective actions were identified and are being implemented.

5.1.B.1: The DART rate for NREL workers is at or below the DOE contractor average.

The contractor has met the A+ and B+ 5.1 performance objectives for the days away, restricted, or transfer (DART) rate. The FY15 NREL supervised worker DART rate was 0.20, which was half of the most recent whole-year DOE contractor average DART rate of 0.4. The contractor has also met the A+ and B+ 5.1 performance objectives for the total recordable case (TRC) rate. The FY15 NREL supervised worker for NREL supervised workers was 0.60, while the most recent whole-year DOE contractor TRC rate was 1.0.

5.1.B.2: The TRC rate for NREL workers is at or below the DOE contractor average.

See comments directly above.

5.1.B.3: Actively identify potential health and safety risks and modify practices accordingly.

Alliance has identified, prioritized, and modified a multitude of potential health and safety risks throughout FY15. The following examples highlight Alliances dedication to maintain a safe and healthful workplace at NREL:

1. Alliance has earned an experience modification rate (EMR) of 0.64 from the HARTFORD compensation insurer.
2. Alliance recognized the need to improve the quarterly inspection process and has done so by identifying, designing, and piloting process enhancements.
3. Alliance recognized the need to improve the pedestrian \ bicyclist \ vehicle interface on construction sites and has done so by implementing NREL Temporary Traffic.

Alliance actively identified potential health and safety risks and modified practices accordingly. NREL improved the EHS inspection process by identifying, designing, and piloting process enhancements in the MCST and ESIF centers. NREL rolled out a successful "Buy Listed or Get it Inspected" campaign for electrical safety and also added Electrical Safety Officers to support Quarterly Lab Inspections. Under NREL's Hazard ID & Control program, all activities that may present hazards were reviewed during a Safety Assessment (SA) prior to conducting work. NREL developed an ESIF Research Electrical Distribution (REDB) one-line diagram, allowing the entire system to be viewed at once to enhance understanding of configuration, enhancing electrical and LOTO safety.

5.1.B.4: Demonstrate continuous improvement of OHSAS 18001 management system.

Alliance improved the Integrated Issues Management System by implementing workflow software, thereby eliminating 106 non-value-added steps. The new workflow software (EtQ) allows for the integration of assessments, events, and corrective action plan management. This

improved process has allowed Alliance to consolidate information and strengthen its trending capabilities.

PERFORMANCE OBJECTIVE 5.2: Alliance systems are effective in providing environmental protection and environmental compliance.

Grade = 3.7, A-

5.2.A.1: Demonstrate continuous improvement in the integration of environmental planning into NREL programs, laboratory, and site operation processes and projects by incorporating an environmental review of projects, environmental participation in project reviews, and revising the GPP/GPE process to include a discrete environmental review.

The Alliance addressed environmental considerations and engaged appropriate DOE and EHS staff throughout project life-cycles, such as with the NWTC electrical upgrade and the PDIL clean room. In addition, they revised the GPP/GPE process ("GPI process") to include formal integration of environmental planning when appropriate. They incorporated an environmental review of the Ten-Year Site Plan and Five-Year Plan. An exterior design review committee was established to review projects to minimize environmental impacts. This integration has led to a more pro-active approach to including environmental planning into NREL programs, laboratory and site operations.

5.2.A.2: Implement an enhanced National Environmental Policy Act (NEPA) program.

The Alliance EHS office actively pursued the development of an enhanced NEPA program. Increased staffing was implemented as workload dictated and deliverables have been met per established schedule. This task required considerable effort, including extensive evaluations of P-card purchases, Purchase Orders and work orders to ensure consistency in approach. It also required extensive collaboration with the DOE NEPA Compliance Officers and Environmental Stewardship staff to develop new criteria.

5.2.A.3: Maintain International Organization for Standardization (ISO) 14001 certification.

A third-party auditor hired to review ISO 14001 standards identified 22 system strengths. Examples of Alliance's programs and practices noted in the audit include: 1) Electrical safety panel and ESO qualifications programs, 2) ergonomics program, 3) Lessons Learned pilot, and 4) collecting and managing employee safety concerns. NREL has completed a causal analysis and corrective actions were identified and are being implemented.

5.2.B.1: Actively identify potential environmental risks and modify practices accordingly.

The Alliance has quickly and effectively responded to and managed all spill incidents and has exceeded compliance of environmental regulations. They increased training in the areas of spill control and universal waste management to their staff. They also enhanced their natural resource monitoring process.

5.2.B.2: Demonstrate continuous improvement of ISO 14001 management system.

The Alliance recertified NREL's environmental management system to the ISO standard. The laboratory implemented corrective actions and opportunities for improvement from the ISO recertification audit to ensure the ISO 14001 certification was maintained. The Alliance also developed and successfully implemented a certification maintenance plan, and completed several environmental internal assessments.

5.2.B.3: Ensure procedures and controls are in place and implemented to comply with environmental regulatory requirements to minimize receiving written notifications, such as Compliance Advisories, from an outside regulatory agency regarding a non-compliance with a schedule or requirement.

The Alliance did not receive any non-compliances from regulatory agencies. They continued to work with subcontractor staff to ensure they understood and complied with environmental regulatory requirements. They revised their desk procedure to address Waters of the State.

GOAL 6.0: BUSINESS OPERATIONS

The contractor's performance in this area should demonstrate efficient, effective business operations that are functioning at minimum cost within a continuous improvement environment and in compliance with DOE requirements, laws, regulations, laboratory policies, and procedures.

PERFORMANCE OBJECTIVE 6.1: Alliance develops, enhances, operates, and maintains risk-based business systems and processes to support RDD&D.

Grade = 3.9, A

DOE IP counsel participated with NREL in the Third Party Agreements VSA event in May. To increase DOE's efficiency in reviewing Technology Partnering Agreements (TPAs), IP counsel continues to work with Tech Transfer Office and legal counsel to improve the quality of agreements sent to DOE for review (e.g., consistent highlighting of tailored language and standard option language, and notation of changes already reviewed). DOE IP counsel has seen an improvement in the quality of requests to assert copyright. However, DOE IP counsel would like to see an improvement in the quality of requests to use Alternate IV (e.g., a more thorough discussion regarding development of software).

6.1.B.3: Complete all required internal annual audits; perform risk-based internal audits based on the approved annual audit plan; and provide timely, effective responses to all management requests.

100% of required internal audits were completed. Completed the risk based audits on the annual audit plan as required with 3 audits approved for carryover to FY 2016. Coordinated on 7 management requests related to external IG/GAO audits including starting the next SCIC audit. Internal Audit supported the NREL FY 2015 A-123 process with testing saving over $30K in contracting resources. Internal Audit supported the Biennial Pricing Review developing a methodology and testing FY14 projects. The Internal Audit group also coordinated an independent external peer review and hosted the review team on-site. The Internal Audit group received the best rating and generally conforms with the IIA (Institute of Internal Auditors) Professional Standards.

6.1.B.4: Establish and monitor predictive (leading) and actionable performance indicators for operations offices to support the needs of the office and executive management.

NREL has been very helpful/responsive to DOE in researching Employee Concerns. Alliance has been willing to meet to discuss issues and explain their processes, and also keep their SOP and contact information up to date. Alliance's Employee Concerns program is managed well and maintains good control for dealing with issues that surface for the employees at NREL.

PERFORMANCE OBJECTIVE 6.2: Alliance operates and maintains effective financial systems that support RDD&D management and enable fiscal responsibility.

Grade = 3.9, A

6.2.A.1: Financial systems support the ESIF technology user facility for cost collection, tracking, and billing.

NREL's financial systems supported the ESIF technology user facility for cost collection, tracking, and billing.

6.2.A.2: Financial systems continue to support accounting for site-wide costs from direct-funding allocations.

NREL's financial system supported accounting for site-wide costs from direct-funding Allocations, and NREL successfully continued work although full site-wide funding was not received until September.

6.2.A.3: Financial systems support funding allocation and reporting process in response to AOP funding process(es) directed by EERE.

NREL's financial systems support funding allocation and reporting processes in response to AOP funding process(es) directed by EERE. In addition, NREL was an integral partner during the 6-month Funds Distribution Pilot resulting in implementation of some 'quick win' process improvements (e.g., coordination meetings & no work authorizations for non-federal SPP).

6.2.A.4: Continue to enhance lab-wide planning and cost estimating as demonstrated by actual direct costs and commitments being within 95% of planned direct funds approved in the FY 2015 Cost Proposal, subject to accounting for material funding and other variances outside the direct control of Alliance.

NREL OCFO continued to enhance lab-wide planning and cost estimating as demonstrated by actual direct costs at 94% of planned direct funds approved in the FY 2015 Cost Proposal – $413.3M cost proposal base and $388.4M actual costs. In addition, OCFO provided adept and responsive forecasting support during multiple EERE iterations of Workforce Restructuring using new Lab Guiding Principles of 25% Carryover. OCFO exhibited commendable performance regarding implementation, analysis, and communications on the new lab-wide FY 2016 PCAF.

6.2.A.5: In partnership with DOE, establish a baseline funds distribution process from apportionment request at DOE HQ, to contract modification at the Golden Field Office, through to the commencement of work at NREL. Determine potential process improvement opportunities and, to the extent possible, identify process improvement opportunities for non-federally funded work.

In partnership with DOE, NREL had commendable performance for two LEAN process

improvement events including Funds Distribution and Strategic Partnership Projects. These events established baseline processes and recommended potential process improvement opportunities. Over 30 recommendations resulted from these two LEAN events. Nearly 1/3 of the SPP recommendations are complete and pilot Funds Distribution operations began in FY 2016.

6.2.B.1: Financial reports reflect current funding and commitments to fully assess the pace and quality of NREL program and project execution.

NREL's financial reports reflect current funding and commitments to fully access the pace of NREL program and project execution.

6.2.B.2: Conduct pricing and rate reviews at least three times a year. For material changes to rates, notify the DOE Contracting Officer within 30 days of NREL identifying a need for a material change to pricing rates for DOE review and approval.

NREL conducted multiple discussions on the new FY 2016 PCAF model, implementing new pricing approaches, and supported Golden in conveying impacts of PCAF on D.C.-stationed staff.

6.2.B.3: Manage to the aggregate direct labor multiplier as reflected in the FY 2015 cost proposal.

NREL successfully managed to the aggregate direct labor multiplier (DLM) as reflected in the FY 2015 cost proposal as DLM in FY 2015 came in under the FY 2015 cost proposal.

6.2.B.4: Continue to enhance lab-wide planning and cost estimating as demonstrated by actual direct costs and commitments being within 90% of planned direct funds approved in the FY 2015 Cost Proposal, subject to accounting for material funding and other variances outside the direct control of Alliance.

NREL OCFO continued to enhance lab-wide planning and cost estimating as demonstrated by actual direct costs and commitments were 94% of planned direct funds approved in the FY 2015 Cost Proposal.

PERFORMANCE OBJECTIVE 6.3: Alliance procurement processes support mission goals and DOE socioeconomic efforts.

Grade = 3.9, A

The Alliance met their B targets and exceeded or met a majority of the A targets. The Alliance exceeded the goal of awarding at least 53% of subcontract/purchase order dollars to small businesses with a rate of 54.7% and exceeded their small business socioeconomic goals. The cycle-time goals for subcontracts less than $150,000 of 25 days was exceeded with 16.2 days, while the cycle time for subcontracts greater than $150,000 of 35 days was met with 34.7 days.

77% of subcontract dollars and 73% of contract actions were awarded competitively, which exceeded the goal of awarding 70% of the dollars and 55% of the actions competitively. The target for cost savings was 4% of spending, as established by the contractor supply chain council – this was significantly exceeded with 14%. The laboratory met the new protégé business goal by awarding a mentor protégé task ordering agreement for communication and cabling services. All ARRA-funded subcontracts and purchase orders were closed-out prior to April 30, 2015.

PERFORMANCE OBJECTIVE 6.4: Alliance human resource management systems are effective in providing the talent needed to implement the NREL mission.

Grade = 3.9, A

The Alliance met all the B targets associated with this goal, in addition to the A targets. The Alliance continues to provide passive candidate sourcing model and outreach programs to attract leading experts and distinguished researchers in key roles to support mission activities with their Research Participant Program providing more than 200 post docs, graduate and undergraduate intern employees, and NREL's director's postdoctoral fellowship programs and the GEM fellows in the bioscience center. The Alliance has maintained the median time to fill all open requisitions to an average of 66.4 days, exceeding the goal of 90 days. NREL enhanced management attendance at "Diversity & Inclusion" training with Senior Staff completing the course and 12% of managers attending diversity training. In addition, 95% of NREL Managers completed "Legal Issues in Managing Employees". On June 14, 2015, the Alliance deployed Workday Human Capital Management (HCM), thus providing real-time payroll and timekeeping data for staff and managers.

GOAL 7.0: INFRASTRUCTURE STEWARDSHIP AND SITE OPERATIONS

The evaluation of Alliance's performance with respect to this goal focuses on effective use of resources to provide a capable, efficient, and mission-focused environment that enables the laboratory to fulfill its mission, while providing a leadership example for sustainable energy that sets the bar for others.

Improvement of Alliance's project scoping process for GPI projects has been identified as an ongoing issue. Current projects are experiencing scope creep that is impacting the ability to plan for future projects. Scope creep draws funding away from future projects in the priority queue which could have an adverse impact of near-term research mission goals. Initial scoping should be agreed upon by the user and Site Ops before a final scope is baselined. This was identified by a GO surveillance on GPP Project Management Plan Development and validated by the FY15 mid-year performance assessment of PEMP Goal 7.1. A Corrective Action Plan has been submitted; however, no close-out of the issue has occurred as of the end of FY15.

Improvement of Alliance's cost estimating abilities and change control process has been identified as an ongoing issue. Projects are going through a loosely managed change control process that is leading to cost escalation of projects and impacting the ability to implement additional projects from the priority listing of GPI needs. Initial cost estimates are too far out of range and need to more accurately reflect the initial scope of the project.

Formalized Risk Management identification and mitigation processes need to be developed and implemented to accurately reflect risk / management reserve / contingency requirements to improve baseline budgeting for GPI projects as identified by the GO surveillance on the GPP Project Management Plan Development and validated by the FY15 mid-year performance assessment of PEMP Goal 7.1. A Corrective Action Plan has been submitted; however, no close-out of the issue has occurred as of the end of FY15.

Evidence of greater risk identification and cost estimating processes integrated into the project planning phase will be a priority for GFO in 2016.

A recent influx of proposed sustainability projects indicates that Alliance needs to involve GFO in the pre-planning stage to get buy-in of project scope prior to moving ahead. Use of available land is especially of concern. Additionally, it is recommended that life-cycle cost and/or return-on-investment/pay-back analyses should be performed and used as part of the discussion prior to approving improvement projects to move forward.

PERFORMANCE OBJECTIVE 7.1: Alliance effectively maintains research and support infrastructure.

Grade = 3.6, A-

7.1.A.1: Real property asset value is maintained at or above industry standards. Operation and management expenditures are prioritized using a risk-based profile.

Alliance met this target with a DOE real property Asset Condition Index (ACI) of 0.99. This reflects a very low deferred maintenance backlog that remains easy to manage. The real property value for NREL is $517 million with a deferred maintenance backlog of only $1 million. This gives NREL a very favorable standing with OMB when working to justify our budget requests to maintain real property assets in support of EERE technology research activities.

7.1.A.2: Project renovation status of approved lab upgrades is available through a collaboration application platform.

Alliance met this target with the on-line Active Project Status Report. Projects that have a construction component are shared with GFO monthly. The report is updated by the individual project managers on a monthly basis and verified by GFO project managers during project reviews and building area engineer planning meetings. Site Operations project managers are always available to field questions on project status and to address issues when brought to the attention of the GFO project management staff.

7.1.A.3: FY14 and prior years' general plant project and general purpose equipment funds are at least 70% complete, with remaining funds 80% allocated.

Alliance has costed 70% of FY 2012 through FY 2014 general plant project and general purpose equipment funds. 99% of remaining FY 2012 through FY 2014 GPP and GPE funds have been allocated. Alliance also met this target for FY 2015.

7.1.A.4: FY15 GPP and GPE funds are at least 80% allocated if funds are received by July 1.

Alliance met this target for FY 2015. GPP and GPE funds are at least 80% allocated even though only 75% of the funds were allocated by July 1, 2015. A great job by the Site Operations staff.

7.1.A.5: FY15 GPP projects are planned, managed, and reported to project cost, scope, and schedule baselines using tailored Earned Value Management System (EVMS) and other risk tools.

Alliance continues to use a graded EVMS methodology on general plant projects to maintain proficiency in the EVMS techniques. However, insufficient design review and inaccurate cost estimating has caused a significant delay (10 months to date) and cost overrun (112% - $265,000 TPC now estimated to date) to the RSF Data Center Return Fans Project. Constructability issues, as evidenced by numerous project RFI's, indicate an insufficient, or absence of, design review prior to bid. Construction activity opened the labyrinth floor of the RSF to the outside before progress halted through the summer and fall of 2015 for a re-design. The project's minor objective – to reduce the operation of the second back-up fan in the warm months of the year – is not supportive of the resources now required to restore the facility's integrity.

A continuous Commissioning Review was conducted by Alliance that identified some issues with project management. A project management Corrective Action Plan (CAP) was developed after the review from which nine project management areas that could be improved have been identified. The improvements are planned to be addressed in the next update of the Site Operations Project Management Manual.

7.1.B.1: FY15 GPP funds are 70% allocated by end of FY15.

Alliance exceeded this target as addressed above.

7.1.B.2: FY15 GPE funds are 70% allocated by end of FY15.

Alliance exceeded this target as addressed above.

7.1.B.3: Real property and corporate equipment is inventoried and assessed against risk-based standards to prioritize investments and to support the timely development of future budgets.

Alliance met this target. Alliance successfully managed 10,600 personal property items, and 99.7% of the sensitive property inventory was located during the annual physical inventory. Only 26 Alliance and 10 GFO property items were not located. During the physical inventory, Alliance located 100% of the high-risk property and 100% of the capital personal property. 21 inspections of operating and storage areas were conducted to identify idle or unneeded property. As a result of the inspections, nearly 1,032 items were excessed to property management for disposal. Site Operations effectively supported an excess property initiative at the NWTC in 2015. The nature of the work at this field site often results in large, unique, excess property whose traits make final disposition challenging. GFO encourages the continuance of excess property disposition at the NWTC in 2016, and reinforces that negotiated agreements (WFOs, CRADAs) contractually consider how property will be disposed of at the conclusion of the agreement.

7.1.B.4: Baseline change control procedures are implemented for all GPP projects.

Alliance met this target. Alliance has enhanced governing documentation in the Site Operations Project Management Manual, and project managers have been trained. Changes that trigger a Baseline Change Proposal (BCP) now require review and approval by a full change control board consisting of all members of the project's Integrated Project Team. The BCP form was modified to include a concurrence by the DOE GFO Federal Project Director. Advanced EVMS techniques including the use of Planning Packages are now employed where appropriate. For each BCP, the project's PMP is now required to be updated with all changes and routed to the Change Control Board for review and approval along with the BCP. The Executive Management Team's roles and responsibilities have been formalized, particularly as it applies to the application of management reserve funds.

7.1.B.5: Alliance is fully prepared to support annual Facilities and Infrastructure Program budget development and defense at the end of the first quarter of the fiscal year.

Alliance met this target. Alliance developed and submitted a five-year plan in January 2015. This plan addressed investments needed to support critical EERE research activities at NREL. The FY 2015 Facilities and Infrastructure budget crosscut was developed and the actual costs to budget plan are reported quarterly to GFO. The direct-funded site-wide annual operating plan status updates were submitted quarterly. The FY 2016 Facilities and Infrastructure AOP was submitted to GFO in early September 2015, in time for the development of the FY 2016 AOP plans.

7.1.B.6: Maintain EVMS certification.

Alliance met this target. To meet the terms and conditions of maintaining the Alliance's certification for its EVMS system, a contractor surveillance was successfully performed April 21-23, 2015. An electronic copy was uploaded to the DOE APM PARS II Database on May 28, 2015, to ensure certification is maintained. A graded EVMS methodology is used on general purpose plant projects to maintain proficiency in the EVMS techniques.

7.1.B.7: Alliance develops a ten-year site plan to sustain state-of-the-art research and support capabilities.

A much improved FY 2016-2026 Ten-Year Site Plan (TYSP) was collaboratively developed with GFO staff and was submitted and approved ahead of schedule. It includes programmatic and general capital investments, a recapitalization plan, and a sustainability update. A fully developed priority investment list for FY 2016 was also included.

PERFORMANCE OBJECTIVE 7.2: Alliance demonstrates NREL leadership in sustainable laboratory operations.

Grade = 3.5, A-

7.2.A.1: Comprehensive energy data for the NREL campus is collected and analyzed in support of a coordinated and comprehensive energy management strategy.

Alliance met this target. In FY 2015, Alliance produced approximately 17.8% of NREL's total electricity use from on-site PV and on-site wind.

Alliance is actively meeting requirements for ISO 50001 Energy Management, seeking certification for ISO 50001 and is investigating certification in DOE's Superior Energy Performance program.
Alliance has commenced several initiatives in support of development of an energy management strategy including Project Haystack, developing a draft energy management plan, and working towards a strategic energy management plan.

7.2.A.2: NREL National Wind Technology Center and South Table Mountain electrical metering infrastructure accurately measures energy use and generation in support of efficient and effective site operations and cost/revenue allocations.

NREL has invested significant efforts this year to address GFO's concerns from previous years, and to identify and resolve outstanding issues with existing meters and data quality. While it proved to be too costly to replace some of the meters, various methods were initiated to continuously review meter data and immediately address any anomalies. As a result, we now have a process in place that produces meter data from the NWTC that is sufficiently consistent and reliable that it serves GFO's analyses needs. GFO is very appreciative of the creative efforts by certain individuals to make such significant improvements in this Target during FY 2015.

7.2.A.4: Complete the annual update of NREL's Site Sustainability Plan for EO 13514, provide progress on goal achievement, and meet the plan targets.

Alliance met this target. Alliance completed the NREL Annual Site Sustainability Report in July 2015. The report covered greenhouse gas emission reduction, clean energy technologies, energy management, water management, environment, pollution prevention, and stakeholder initiatives. Alliance continues to support other DOE sites with the development and implementation of renewable sustainable technologies. Their support is sought after by several non-Government partners as well. NREL is meeting 22 out of 24, FY2015 and FY2020 goals.

7.2.A.5: Support DOE HQ Sustainability Performance Office-funded objectives including Climate Change adaptation planning.

Alliance met this target. Alliance completed a Climate Change Resilience Plan and submitted it to GO. NREL's sustainability group also assisted the DOE Sustainability Program Office in the development of a Climate Change Resilience Planning Guide for other DOE facilities. The guide is scheduled to be finalized in FY 2016. Alliance continues to exceed goals and be a leader for DOE climate change planning and documentation.

7.2.B.1: Comprehensive operational data for the Research Support Facility (RSF) are collected, analyzed, and disseminated to DOE and other audiences to support validation of the RSF I and II design, and further refinement of ultra-high energy efficiency building design and operation.

Alliance met this target. Alliance collected comprehensive operational data for the Research Support Facility that was analyzed and disseminated to GFO and others to support validation of the RSF design and further refinement of ultra-high energy efficiency building design and operation. The installation of additional on-site PV for the RSF is being actively pursued via a Sustainability Program Office FOA.

7.2.B.2: Achieve carbon neutrality for Scope 2 greenhouse gas emissions within budgetary constraints.

Alliance met this target. Alliance completed a new subcontract with Western Area Power Administration to purchase renewable energy credits to achieve carbon neutrality for FY 2015. They continue to evaluate other options for purchasing RECs.

7.2.B.3: Continue to coordinate sustainability and resiliency activities with outside organizations and local governments.

Alliance met this target. The Alliance continues to lead by example in sustainability and has engaged with a variety of outside stakeholders and local agencies on sustainability. One such example is NREL participation in the WEST Sustainability Group with DOE, GSA, City of Lakewood, and Red Rocks Community College, which provides the community with information, videos, tips, and links on how to save energy, conserve resources, and use environmentally friendly products.

The Alliance also convened the Colorado Resiliency Working Group, which includes FEMA and the Colorado Recovery Office, and organized activities with the Sustainable Buildings Council of Colorado, Battelle Sustainability Group, US Green Building Council and the Jefferson County Sustainability Board.

7.2.B.4: Maintain NREL's vehicle fleet at or below the DOE approved ceiling.

Alliance met this target. NREL's vehicle fleet is at the DOE-approved level of 42. The Alliance completed the process of a new competitive contract for shuttle bus services.

7.2.B.5: Initiate and complete at least two pollution prevention/waste minimization projects.

Alliance met this target. Alliance completed two pollution prevention/waste minimization projects for FY 2015. The first was the "bag bank" program, which created a recycling and reusing receptacle for plastic bags for each kitchen throughout the laboratory. The second was the implementation of a lab-wide polystyrene recycling program. In addition, a full-day waste audit of the FTLB was completed on August 14th, 2015.

GOAL 8.0: SECURITY AND EMERGENCY MANAGEMENT

Alliance's performance against this goal must demonstrate that security and emergency management programs and practices enable the mission, while ensuring that threats and vulnerabilities are assessed and managed, computer networks and information are properly protected, and response to emergencies is immediate and appropriate.

Alliance creates a secure work environment based on identified and assessed security vulnerabilities and threats, and manages programs to avoid or mitigate these risks.

PERFORMANCE OBJECTIVE 8.1: Alliance creates a secure work environment based on identified and assessed security vulnerabilities and threats, and manages programs to avoid or mitigate these risks.

Grade = 4.0, A

8.1.A.1: Maintain risk management-based security programs, plans, policies, and procedures based on U.S. Department of Homeland Security Interagency Security Committee Standards and U.S. DOE Graded Security Policy.

Alliance developed and published the NREL Site Security Plan based upon emerging threats to address vulnerabilities and mitigate impact to operations and mission. This plan provides multiple layers and protection in depth to enhance the ability to detect, deter and deny threats for access to personnel, information and facilities. A focus on addressing risk allowed Alliance to utilize resources in an efficient and effective manner, and in many cases, broaden and increase essential service.

8.1.A.2: Maintain and expand the DOE-wide Enterprise Mission Essential Task List as the basis for Protective Force training and operations.

Alliance's Mission Essential Task List (METL) for security personnel, in FY 2015, consisted of six primary tasks that support the overall mission: Mission Command and Sustainment, Detect, Deter, Deny, Respond, Reconstitute/Recover. The six primary tasks are supported by 47 subtasks that form the basis for day-to-day operations as well as the training program for security personnel who conducted over 350 hours of on-shift training to develop and maintain core competencies in primary tasks. Additionally, Alliance conducted 13 drills and exercises, including the national-level Exercise Eagle Horizon, which reinforced primary skill sets and tested procedures to ensure they aligned with the need to respond to a wide range of risks.

8.1.A.3: Maintain NREL's Information Security (INFOSEC) Program with integrated Operational Security (OPSEC) pertaining to physical, cyber, and information programs through oversight, education, and outreach.

Alliance's INFOSEC Program was expanded through a multi-pronged approach for training and education. INFOSEC topics were prevalent in both the NREL Cyber Security Annual Training

and the NREL Annual Site Security and Emergency Preparedness training, reinforcing the key elements of protecting Official Use Only, proprietary, business sensitive and CRADA. Alliance Security staff were available to provide NREL workers with guidance on questions related to the identification, marking and release of Official Use Only information. This emphasis on awareness and individual responsibilities enhance the overall objectives of the INFOSEC Program.

8.1.B.1: Implement measures based on risk to mitigate security incidents, and security incidents are self-identified and reported in a timely manner, with measures taken to preclude recurrence and mitigate impacts on mission.

Alliance's risk-based approach supported NREL's overall mission objectives by providing a safe, secure and supportive work environment. Focus on detection, deterrence and denial of threats while enhancing capabilities to respond quickly and professionally when detected allowed Alliance security professionals to move expeditiously on a threat of an employee with a firearm in April 2015. Security personnel, along with partners from law enforcement, quickly isolated the threat, in what DOE Office of Energy and Science and Office of Energy Efficiency and Renewable Energy executives lauded as action "that may have saved lives" in response to a threat of work place violence.

8.1.B.2: Conduct self-assessments with timely correction and close-out of findings and identified lessons learned and consideration of opportunities for improvement.

Alliance conducted self-assessments and completed the biannual vulnerability assessment that supported security planning and updates to the Site Security Plan. The updates were supported by changes and revisions to policies and procedures that were implemented through the DOE-accredited training program for security personnel.

8.1.B.3: Host and support a DOE Periodic Security Survey and address results in a timely and effective manner.

In April 2015, the Alliance was notified that DOE EERE Golden Field Office, NREL's Cognizant Security Office, would conduct a Periodic Security Survey of NREL in August 2015. Alliance provided all requested documents and information associated with the Survey by the end of June 2015. Alliance was notified in July 2015 that the GFO postponed the Survey until 2016. In support of the Survey, Alliance conducted a self-assessment to identify gaps in security requirements in accordance with DOE Orders 470.1 and 473.3; no areas of concern identified.

8.1.B.4: Enhance coordination with DOE Counterintelligence to include participation in Insider Threat Working Group and quarterly briefings.

Alliance created an Insider Threat Working Group (ITWG) in accordance with DOE Order 470.5 Insider Threat to establish responsibilities and requirements to deter, detect, and mitigate insider threat actions in support of the overall mission of the lab. The ITWG charter focused on

protection of information, cyber assets and personnel, supported by the identification of concerning behaviors that could indicate a possible workplace threat. Additionally, Alliance met regularly with DOE Counterintelligence to address issues and concerns tied to Foreign National Visits and Assignments, cyber-security, INFOSEC and foreign travel security.

PERFORMANCE OBJECTIVE 8.2: Alliance protects computer information networks and proprietary business-sensitive information.

Grade = 1.9, C

Continuous Authorization (ATO) issues have caused NREL to be denied their yearly reauthorization two continuous times in 2015. Packages of required documents were incomplete and inaccurate as discussed at weekly meetings.

Despite repeated direction to reference all security weaknesses and deficiencies on the Plan of Actions and Milestones (POA&M), NREL has still not done so. Ref NIST 800-65, Section 2.5. NREL has stated that current items on the POA&M are poorly and inaccurately stated in weekly meetings.

Out of approximately 33 milestones on NREL's System POA&M, NREL had to extend the planned due dates on 15 of those. Out of approximately 12 milestones on NREL's Program POA&M, NREL had to extend the planned due dates on 8 of those. This indicates an inability to properly plan I.T. resources.

NREL has numerous I.T. policies and procedures that need updating, and possibly don't exist at all based on the fact that policies and procedures that have been requested have not been delivered. This is an oversight concern as well as an internal concern to the NREL I.T. staff. A common repository of procedures will help ensure that all staff members are following agreed and approved procedures.

Despite giving NREL two years to become compliant with the RMA/CAS Program, NREL is far from being in compliance. At numerous meetings in that time frame, the GFO Oversight Office was assured that they would finish this project on time. It wasn't until 30 days from completion date that we were told they would not meet this date, and it will have to be significantly pushed forward. NREL did not properly execute the program and failed in timely communications to the Oversight Office.

NREL implemented an upgraded physical security system and assigned it to a system enclave, but failed to inform the Federal Authorizing Official of its existence. This was discovered by an audit from HSS. The system was installed using servers running Windows Server 2003. This operating system soon passed the Microsoft End of Support date before being replaced by a more current operating system that Microsoft supports. During that time, no updates or patches were available to those servers which put them at a significantly higher risk level. In addition, NREL failed to notify the Federal Authorizing Official of a significant system change that may affect their security posture.

NREL was late in migrating other Microsoft Windows Server 2003 in other enclaves.

NREL was late in updating the Windows Desktop XP operating system past its End-of-Support date, as well leaving them in at an increased state of vulnerability.

8.2.A.3: Number of internal moderate Windows servers in compliance with an approved security baseline is 95% to 100%.

Specifically regarding PEMP 8.2.A.3, NREL was graded on the percentage of Windows Servers that were in compliance with a standard security baseline. The records produced by NREL were detailed and indicated success; but numerous times during 2015, NREL reported finding servers that it didn't know existed before. For reasons unknown, the network scanning was not complete. Therefore, they were in compliance with the servers they knew about, but admitted there were additional servers they didn't know about in weekly meetings. Not knowing an accurate inventory will increase their risk of keeping machines patched and updated.

PERFORMANCE OBJECTIVE 8.3: Alliance mitigates potential site emergencies and effectively responds to actual emergencies.

Grade = 4.0, A

8.3.A.1: Continuous improvement of emergency plans, procedures, and response based on self-assessments, internal NREL assessments, and surveys and surveillances conducted by DOE.

Alliance conducted updates of all emergency plans and procedures in FY 2015 following self-assessments, validation from drills and exercises, and the feedback and expectation of the DOE client. These updates include the comprehensive NREL Emergency Management Manual, 26 facility-specific Occupant Emergency Plans, and 27 Emergency Notification System plans that tailor response actions specific to identified threats and hazards. Alliance's emergency management system was reviewed by the external auditor conducting an ISO/OHSAS recertification of NREL, resulting in two identified strengths/best practices tied to response plans and cyber threat preparedness.

8.3.A.2: Full execution of FY 2015 Emergency Readiness Assurance Plan, including all scheduled drills, exercises, and daily validation of operations.

Alliance set aggressive goals for outreach, education, drills and exercises in the FY 2015 Emergency Readiness Assurance Plan (ERAP) to support overall culture change at NREL, as well as to develop and sustain core emergency response capabilities in accordance with DOE Order 151.1 Comprehensive Emergency Management System. Alliance completed all aspects of the FY 2015 ERAP, and exceeded the number of planned drills and exercises, including the conduct of peer-requested Cyber Security and Facility Emergency exercises.

8.3.A.3: Prepare and execute three primary emergency response actions.

Alliance's emergency preparedness and incident response management focused on planning, education and training focused on three primary actions: evacuation in response to an internal hazard or threat in a facility; shelter-in-place in response to an external hazard or threat; and lock-down in response to an active security threat. Alliance conducted 36 evacuation drills, 17 shelter-in-place drills and two lock-down drills focused on socializing and building confidence in staff to respond quickly and effectively.

8.3.B.1: Update the Emergency Response Assurance Plan.

Alliance updated the NREL COOP in FY 2015, focused on improvements determined during assessments and validation of key processes that must be sustained to minimize impact. Alliance focused efforts on information and business systems in FY 2015 to ensure continuity and reliable services in response to probable disruption scenarios to ensure essential services could be restored quickly and effectively. In April 2015, NREL participated in Exercise Eagle Horizon, a Nation-wide continuity-of-government exercise, a first for NREL. Additionally, Alliance emergency management professionals planned, coordinated and executed an Emergency Operations Center table top exercise for the NREL OCIO focused on a data center fire to test and validate response and recovery capabilities as well as to identify gaps and corrective actions for restoring essential services.

8.3.B.2: Conduct ongoing assessment of the Continuity of Operations Plan (COOP) and incorporate improvements, including specific plans for laboratory spaces, based on an analysis of business impacts and emerging threats.

Full participation response exercises are designed to test NREL's ability to respond and reconstitute to a wide spectrum of threats and hazards. Alliance utilized the Mission Essential Task List (METL) as the basis for emergency response programs and operations as these tasks, supported by sub-tasks, must be performed under a variety of conditions to ensure they provide an acceptable level of capabilities and competencies. Alliance assessed the METL at the trained / proficient level by participating in four full participation exercises during FY 2015, to include a high-angle rescue scenario at the National Wind Technology Center in October 2014, the national-level Exercise Eagle Horizon in April 2015, a lock-down scenario exercise in June 2015, and the Joint-Explosive Detection Canine Training Exercise in July 2015.

8.3.B.3: Conduct full-participation emergency response exercise that supports Mission Essential Task List of Mission Command, Detect, Deter, Deny, Respond, and Reconstitute in response to natural and manmade hazards and threats.

Alliance reached out to partner agencies such as the Jefferson County Sheriff's Office, Colorado State Patrol, West Metro Fire Department, and Department of Homeland Security to develop enduing relationships for training and opportunities for drills and exercises hosted at NREL, the aim of which was to ensure interoperability during emergency response. The NREL Office of Security and Emergency Preparedness hosted law enforcement explosive detection canine teams from local and federal law enforcement agencies at the Joyce Street Facility in July 2015. In

partnering with this group and providing a training location, Jefferson County Sheriff's Department agreed to provide training and exercise support to assist NREL's readiness.

8.3.B.4: Develop new partnerships and strengthen existing relationships with external agencies and response organizations in support of NREL emergency preparedness programs and operations.

Outreach and education of NREL staff were the focus of Alliance's efforts in planning, preparing and responding to probable threats and hazards in FY 2015. 96% of NREL staff completed their annual Emergency Preparedness training through NREL's on-line Learning Management System. 100% of cleared staff received their mandated Annual Security Refresher Briefing. Additionally, Alliance emergency management professionals conducted face-to-face new employee orientation training for nearly 500 employees and subcontractors, familiarization training in all NREL facilities on shelter-in-place and lock-down procedures in response to external hazards and threats, and re-certification of 85% of Fire Marshal Team members and Building Emergency Coordinators.