Summary of the FY 2005 Batteries for Advanced Transportation Technologies (BATT) Research Program Annual Review

May 31–June 2, 2005
Berkeley, CA

August 2005

U.S. Department of Energy
Office of FreedomCAR and Vehicle Technologies

U.S. Department of Energy
Energy Efficiency and Renewable Energy

August 8, 2005

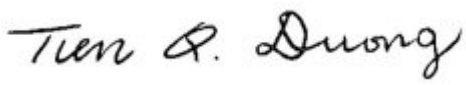
Dear Colleague:

This document presents a summary of the evaluation and comments provided by the review panel for the FY 2005 Department of Energy (DOE) Batteries for Advanced Transportation Technologies (BATT) program annual review. The review was held at the Lawrence Berkeley National Laboratory on May 31-June 2, 2005.

A panel of knowledgeable, independent reviewers assessed the research activities and accomplishments of the BATT program and provided valuable feedback. The recommendations of the panel will be helpful to DOE as it completes plans for the research to be carried out in FY 2006 in support of the U.S. Department of Energy's Office of FreedomCAR and Vehicle Technologies (DOE/FCVT). These efforts are focused on high-performance, rechargeable batteries for use in electric and hybrid electric vehicles (EVs and HEVs).

We would like to express our sincere appreciation to the members of the review panel. We are very appreciative that you were willing to take time out of your busy schedule to listen to the presentations, read the posters, speak with the PIs and provide us with valuable feedback on the program. It is you who made this report and our timely decisions for the new fiscal year possible.

Thank you for participating in the FY 2005 DOE BATT program annual review. Please feel free to provide us with suggestions for improving this annual meeting. We look forward to your participation in the FY 2006 review.



Tien Duong
Vehicle Systems Team Leader
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Executive Summary

The 2005 BATT program annual review was held at the Lawrence Berkeley National Laboratory (LBNL) on May 31-June 2, 2005. The review, at which reviewers both commented on and scored each PI, included poster presentations and panel discussions covering the program's research which addresses fundamental issues that face advanced battery candidates for EV and HEV applications.

The review panel found that the BATT program is making significant contributions to our understanding of advanced batteries and commented on the extraordinary expertise of the principle investigators (PIs) and the power of experimental/theoretical collaborations. The panel also made several recommendations. The most significant recommendations and the planned DOE actions are presented below.

Recommendation	Planned DOE Action
Expand exploratory nature of research.	DOE/LBNL believes there is already a significant amount of exploratory work, and will continue with investigations into advanced electrolytes, high energy composite electrodes, and a new search for advanced materials using first principles calculations.
Expand work into higher energy cells in addition to the high power materials being investigated presently.	As mentioned above, several projects currently focusing on higher energy anodes and cathodes will be continued.
Prioritize requests for cell building support.	LBNL, as part of its BATT program management activities, will work with the cell building team and the other PIs to prioritize current and future requests.
Refocus electrolyte work on materials more relevant to automotive applications.	One PI will focus on ionic liquids and one other researcher will focus on gel polymer electrolytes for use in automotive applications.
Cell development work needs to be strengthened to adequately respond to PI needs.	Additional resources will be allocated to this task. In addition, LBNL will investigate engaging an external supplier to help address temporary bottlenecks and to compare cell performance.
Consider appointing technical coordinators for each task.	BATT program management appointed technical coordinators several years ago and found that the effort did not add significant value.
Identify technologies to "promote" to the Advanced Technology Development (ATD) program or other more applied venues.	LBNL will move future work on the conducting polymer/ overcharge protection materials to a more applied program.
Provide the highest performing PIs extra money to "play" in new and more exploratory areas.	DOE will solicit and evaluate specific proposals from the PIs. For example, Drs. Ceder and Grey will receive additional resources to investigate new materials through modeling.

Reviewers also provided two comments on the review's format and content. Those comments

and recommendations are provided immediately below.

Recommendation	Planned DOE Action
The format was effective, but would be improved by dividing each day of the two day review into ½ day of talks and ½ day of posters. The reviewers would have exclusive access to one of the two poster sessions on each of the two days.	DOE will implement this recommendation.
Hold more frequent reviews, once per year is not enough.	DOE will investigate more frequent information exchanges with battery manufactures and auto companies.

Merit Review of the FY 2005
Batteries for Advanced Transportation Technologies (BATT) Program

INTRODUCTION

The FY2005 annual review of the BATT program was held at the Lawrence Berkeley National Laboratory on May 31-June 2, 2005. The review included presentations on 24 research projects addressing fundamental issues that face all advanced battery candidates for EV and HEV applications.

The objectives of the meeting were to:

- Review and evaluate FY 2005 accomplishments.
- Provide an opportunity for program stakeholders (battery developers and manufacturers, auto makers, etc.) to provide input into the program so that the highest priority technical barriers are addressed.
- Foster interactions among the organizations and individuals conducting the R&D and the program's stakeholders.

The results of this merit review are treated as major inputs by DOE and are used in making its funding decisions for the upcoming fiscal year.

The presentations were reviewed by a panel of experts drawn from a variety of battery-related backgrounds including battery manufacturers, auto suppliers, and universities. Reviewers are listed in Table 1. Several members of the panel have served in prior reviews, providing continuity for the evaluations. A complete list of participants (speakers, reviewers, and general participants) is provided in Appendix A.

Table 1. Members of the Review Panel

Name	Affiliation
Cyrus Ashtiani	Daimler-Chrysler
Bruce Blakemore	Ford Motor Company
George Blomgren	Blomgren Consulting Services, Ltd.
Ralph Brodd	Broddarp Inc
Ahsan Habib, Harshad Tataria[1]	General Motors
Don Murphy	Lucent Technology (ret)
William Tiedemann	Johnson Controls, Inc. (ret)
Ralph White	University of South Carolina

A special thank you goes to the members of the review panel, without their participation this review would not have been possible.

1 Although General Motors had two reviewers contribute comments, their scores were averaged together to provide one reviewer score.

PRESENTATIONS

A list of the presentations, in the order of appearance at the review, is given in Table 2.

Table 2. Presentations Given at the Review

SPEAKER (Affiliation)	PRESENTATION TITLE
Overall Scores and Comments	
1st Panel: $LiFePO_4$ System, System Performance and Analysis	
Vince Battaglia (LBNL)	Cell Fabrication, Testing, and Characterization
Karim Zaghib (IREQ)	Lithium-Ion Polymer Batteries with Low-Cost Materials
Dean Wheeler (BYU)	Design, Optimization, and Fabrication of Li-ion Electrodes for High-Power Applications
Venkat Srinivasan (LBNL)	Modeling of BATT Program Baseline Chemistries
2nd Panel: Improved Cathodes and Their Characterization	
Stan Whittingham (SUNY-B)	Novel Cathode Materials
Marca Doeff (LBNL)	Synthesis and Characterization of Cathode Materials for Rechargeable Li and Li-Ion Batteries
Robert Kostecki (LBNL)	Diagnostics - Electrode Surface Layers
3rd Panel: $LiMn_2O_4$ System, Materials Characterization and System Improvements	
Tom Richardson (LBNL)	Cell Development, Overcharge Protection, Cathode Materials
X.Q. Yang (BNL)	Battery Materials: Structure and Characterization
A. Manthiram[2] (UT)	Cathodes - Superior Capacity Retention, High-Rate Spinel Manganese Oxide Compositions
4th Panel: $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ System: New Materials and Their Characterization	
Clare Grey (SUNY Stony Brook) and Gerd Ceder (MIT)	First Principles Calculations and NMR Spectroscopy of Cathode Materials
Mike Thackeray (ANL)	Novel Cathode Materials
J. Goodenough[3] (UT)	Conducting polymer cathodes combined with iron redox couples for lithium batteries
5th Panel: Li-Ion Systems, Performance and Lifetime Limitation	
J. Newman (LBNL)	Performance and Failure in Lithium-ion Batteries
A.M. Sastry (UM)	Modeling and Experimentation-Electrochemical Materials
Tom Devine (LBNL/UCB)	Corrosion of Aluminum Current Collectors
6th Panel: Li-Ion Systems, Anodes	
P. Ross (LBNL)	Diagnostics, Interfacial, and Reactivity Studies
M. Thackeray (ANL)	Non-Carbonaceous Anodes
S. Whittingham (SUNY-B)	Novel Anode Materials
7th Panel: Electrolyte Materials and Their Characterization	
Nitash Balsara (LBNL/UCB)	Physical Characterization of Polymer Electrolytes
John Kerr (LBNL)	Electrolytes – R&D for Advanced Lithium Batteries
Peter Fedkiw (NC State U)	Composite Polymer/Gel Electrolytes for Lithium and Lithium-Ion Batteries

2 J. Choi presented for A. Manthiram who was unable to attend the meeting.
3 Y. Huang presented for J. Goodenough who was unable to attend the meeting.

SPEAKER (Affiliation)	PRESENTATION TITLE
G. Smith (U of Utah)	Molecular Modeling Electrolytes and Solid-Electrolyte Interphase
Steve Creager (Clemson U)	New Battery Electrolytes Based on Lithium Fluorosulfonate and Fluorosulfonimide Salts

Program Review Forms

The reviewers of the BATT program were provided with two types of review forms on which to record their comments, one for the program as a whole, and a second set that contained a form for each presentation. Copies of those forms are shown in Appendix B.

The program and project specific comments were provided based on the criteria from the evaluation forms. The questions that were used by the reviewers to provide feedback on the entire BATT program were:

1. Does the program appropriately address the key barriers and thus contribute to the attainment of DOE objectives in the area of advanced batteries for transportation?
2. Is the program organized in an efficient manner to achieve the above?
3. Are there specific areas of the program that require additional emphasis?
4. Are there areas of the program that should be de-emphasized?

The criteria used by the reviewers to provide feedback on the BATT projects were:

1. Relevance to overall DOE/FCVT goals[4] and BATT program objectives
2. Approach to performing the research and development
3. Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goals, and
4. Approach to and Relevance of Proposed Future Research.

The reviewers' ratings of 'outstanding,' 'good,' 'fair,' or 'poor,' (corresponding to scores of 4, 3, 2, 1) were then tallied in a spreadsheet and used to prepare histograms and scores of the reviewers' responses. These histograms accompany each of the summaries and indicate at a glance the scores of the reviewers. This makes it easier for the reader to quickly identify projects or topics that the reviewers judged to be above or below average, controversial, or just poorly understood.

Note that the numerical scores provided by the reviewers did not always match their comments. Some reviewers simply did not provide many comments, which made interpretation of their scores difficult. The comments provided by the panel often did not agree with each other, one might write “future work right on track” while another might write “no future plans given.” The reviewers may have been more likely to provide comments when they felt strongly, either for or against, a particular research project. It is therefore necessary to use the numerical scores to obtain a general overview of the reviewers’ impressions, but to refer to the written comments to find particular items they approved or disapproved of.

4 The FCVT goal associated with energy storage is “Electric Drivetrain Energy Storage with 15-year life at 300 Wh with discharge power of 25 kW for 18 seconds and $20/kW.”

Immediately following this introduction is a summary of reviewer comments. This portion of the report provides a general overview of comments received through the review forms and through the reviewer discussion session held immediately following the formal presentations. Next, the reviewers' scores and a summary of their comments for each presentation, in each of the four review areas, are given.

Summary of Reviewer Suggestions and Comments

The reviewers' scores and comments this year were relatively consistent, and the post-review discussion session with the reviewers and DOE/BATT management highlighted those comments for which there was significant agreement. The reviewers commented that the PIs represented some of the best in the world, and that the work they were doing showed promise for both short-term improvements and long-term revolutionary breakthroughs.

The novel cathode work was identified as one area showing particular strength and promise, and the reviewers expressed hope that the recently enhanced cell development task would be able to achieve the throughput and quality necessary to satisfy the many PIs waiting for cells.

However, some reviewers commented that the program is not clearly addressing the main barriers to commercializing Li-ion batteries[5]. They recommended that the research groups either further focus their work and/or their presentations on how they are addressing these barriers.

The polymer electrolyte research did not score well overall, and it received several negative comments. One of the issues is that the anode and cathode tasks which receive the most attention deal with materials that do not obviously require new or improved electrolytes.

Some of the comments provided by the reviewers on the program overall are shown below.

Overall Program Rating
Very good and significant results for the money spent. Overall, this is an excellent use of DOE's money, but the program is not sufficiently funded. The program has established a world class research group and is well organized. Professor Newman should be congratulated for improving the program.

The program does not appear to be addressing the primary barriers; they are mentioned but are not addressed unless this is happening behind the scenes. The relevance of the polymer electrolyte research was questioned based on the statement that it is unlikely that they will be used in cars[6].

5 Those being cost, abuse tolerance, calendar life, and low temperature performance.
6 Several comments like this were provided by the reviewers. It is related to the fact that polymer electrolytes must be operated at relatively high temperature (~70°C) to achieve the desired conductivity. In the sake of fairness, several fuel cells are being proposed and developed that would operate at 120°C.

Specific **Strengths and Weaknesses**

Strengths: The program represents a unique combination of talents and talented people, with outstanding PIs, and can be used as a format for other efforts. The BATT program is very well organized and overall progress is quite good.

Modeling and cathode development are clear strengths. Assembly of cathode people is off the scale, all the best people, and characterization efforts are good. All aspects are being modeled well and this is the first time that appears to be the case. Perhaps one could coordinate physical (mechanical finite element) and electrochemical modeling efforts.

The program is well positioned in Li-ion technology. The next level of systems will likely involve Li metal with higher energy content, so the program should move into this direction. Polymer electrolytes are the most obvious choice for these systems so work in that area is relevant. The new polymer electrolyte program is super and badly needed for next generation systems.

The modeling at Utah provides a unique insight into conduction in polymers. This, coupled with the S Carolina work on new salts forms the basis for hope.

Weakness: Not much original (exploratory) work which may lead to breakthroughs or truly new materials. In the area of positive materials, seems everyone is limited to the Ni-Mn-Co triangle. Need to have researchers, at least some of them, play more freely in uncharted waters without being afraid of reporting "nothing found." Some view to Li metal could be part of that effort.

I believe a new electrolyte is a must as $LiPF_6$ is a bad actor and LiBOB is not that good. Somebody needs to be in charge of focusing this effort.

There may be too many PIs depending on the cell build task which delays overall progress. The program should consider getting help from MSA to build cells.

Specific **Recommendations/Additions or deletions to the program**

Given the charter of BATT being "long term", would recommend more exploratory work in all areas, but particularly in cathode materials, Li anode protection, and high energy chemistries. Add Li metal research for the EV application. Suggest a broader program in alloy anodes, which is one way to get to EV requirements in a safe battery.

Examine importance of hard polymer development work for the HEV application.

Need more electrolyte work, especially additives to control film formation on the anode and cathode.

The reviewers' recommendations concerning the program, and the preliminary actions that DOE management is considering during fiscal year 2006, are listed in Table 3.

Table 3: Recommendations and Planned Responses

Recommendation	Planned DOE Action
Expand exploratory nature of research.	DOE/LBNL believes there is already a significant amount of exploratory work, and will continue with investigations into advanced electrolytes, high energy composite electrodes, and a new search for advanced materials using first principles calculations.
Expand work into higher energy cells in addition to the high power materials being investigated presently.	As mentioned above, several projects currently focusing on higher energy anodes and cathodes will be continued.
Prioritize requests for cell building support.	LBNL, as part of its BATT program management activities, will work with the cell building team and the other PIs to prioritize current and future requests.
Refocus electrolyte work on materials more relevant to automotive applications.	One PI will focus on ionic liquids and one other researcher will focus on gel polymer electrolytes for use in automotive applications.
Cell development work needs to be strengthened to adequately respond to PI needs.	Additional resources will be allocated to this task. In addition, LBNL will investigate engaging an external supplier to help address temporary bottlenecks and to compare cell performance.
Consider appointing technical coordinators for each task.	BATT program management appointed technical coordinators several years ago and found that the effort did not add significant value.
Identify technologies to "promote" to the Advanced Technology Development (ATD) program or other more applied venues.	LBNL will move future work on the conducting polymer/ overcharge protection materials to a more applied program.
Provide the highest performing PIs extra money to "play" in new and more exploratory areas.	DOE will solicit and evaluate specific proposals from the PIs. For example, Drs. Ceder and Grey will receive additional resources to investigate new materials through modeling.

The reviewers also provided comments and scores on each individual PI. These comments and scores were based on brief 10 minute presentations, followed by a full day of visits to the PIs and their poster presentations by the review panel. Table 4 shows the relative score and ranking of each presentation. This is followed by detailed comments and scores on each presentation.

Table 4. Principle Investigators (PIs), Presentations, and Relative Numerical Scores

PI	Title	Score[7]	Rank
J. Newman	Performance and Failure in Lithium-ion Batteries	107.53	1
V. Srinivasan	Modeling of BATT Program Baseline Chemistries	106.50	2
Ceder, Grey	First Principles Calculations and NMR Spectroscopy of Cathode Materials	104.82	3
M. Thackeray	Novel Cathode Materials	101.00	4
X.Q. Yang	Battery Materials: Structure and Characterization	100.31	5
P. Ross	Diagnostics, Interfacial, and Reactivity Studies	99.48	6
A. M. Sastry	Modeling and Experimentation-Electrochemical Materials	97.60	7
V. Battaglia	Cell Fabrication, Testing, and Characterization	96.58	8
A. Manthiram	Cathodes - Superior Capacity Retention, High-Rate Spinel Manganese Oxide Compositions	96.34	9
M. Thackeray	Non-Carbonaceous Anodes	95.05	10
R. Kostecki	Diagnostics - Electrode Surface Layers	94.73	11
T. Devine	Corrosion of Aluminum Current Collectors	90.53	12
G. Smith	Molecular Modeling Electrolytes and Solid-Electrolyte Interphase	90.33	13
M. Doeff	Synthesis and Characterization of Cathode Materials for Rechargeable Li and Li-Ion Batteries	90.23	14
S. Whittingham	Novel Cathode Materials	89.63	15
P. Fedkiw	Composite Polymer/Gel Electrolytes for Lithium and Lithium-Ion Batteries	88.95	16
J. Goodenough	Conducting polymer cathodes combined with iron redox couples for lithium batteries	88.37	17
D. Wheeler	Design, Optimization, and Fabrication of Li-ion Electrodes for High-power Applications	87.81	18
S. Whittingham	Novel Anode Materials	86.88	19
S. Creager	New Battery Electrolytes Based on Lithium Fluorosulfonate and Fluorosulfonimide Salts	85.59	20
J. Kerr	Electrolytes – R&D for Advanced Lithium Batteries	84.31	21
K. Zaghib	Lithium-Ion Polymer Batteries with Low-Cost Materials	82.63	22
N. Balsara	Physical Characterization of Polymer Electrolytes	81.79	23
T. Richardson	Cell Development, Overcharge Protection, Cathode Materials	80.00	24

Note that there were two reviewers from GM, but only one official score. Thus the scores from these two reviewers were averaged and given an effective weight of ½ each. Two reviewers gave ½ scores in some categories (i.e., they scored relevance 3.5 instead of a 3 or 4). This was represented in the bar charts by adding ½ of a 3 and ½ of a four to the counts.

The following pages provide summaries of the reviewer comments for each project, plus bar charts showing the number of scores in each category.

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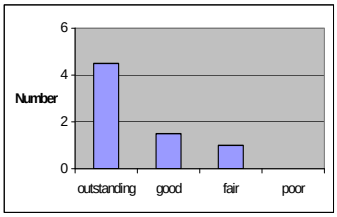
7 The weighted score for each project was calculated in the following manner. The raw score in each review category of a project, e.g., Σ(relevance scores), was multiplied by the total number of reviewers divided by the number who actually provided a score. Thus, if only 6 of 8 reviewers gave a score in the relevance category, the raw relevance score was multiplied by 8/6 to get the weighted score (WS).

The weighted scores for each review area were then summed within each project to provide the total weighted score for the overall project. Total weighted score = WS (relevance) + WS (approach) + WS (accomplishments) + WS (plans), which is what is reported in the table above.

Cell Fabrication, Testing, and Characterization, V. Battaglia -- WS = 96.6, Rank = 8

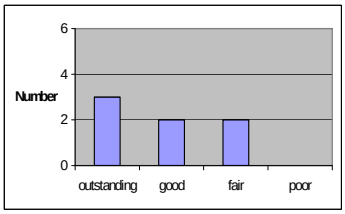
Relevance to overall DOE/FCVT goals and BATT program objectives



Trying to standardize the cell making process is very helpful in comparing material performance**.** The issue of being able to make best in class cells has always been a concern, and this project is addressing this head on.

This team has responded well to past reviewer comments, and have increased focus on the critical issues. Results show that the group is well focused. Project has high relevance and has made great progress.

Approach to performing the research and development

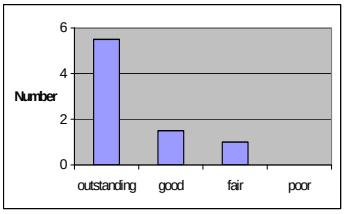


Cell fabrication and testing followed by cell and material characterization are consistent and helpful, the approach is very good and intensity is high.

Need this capability but throughput will be slow and the team may not be able to satisfy all team members. Need time to see how this effort ramps up.

Continue development of coating techniques, need more automation.

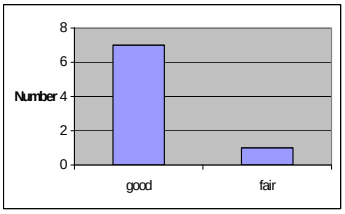
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



They have accomplished a good deal in a short amount of time but it may take 10 years to develop cell fabrication expertise. Outstanding but still preliminary, reproducibility over a longer period of time and greater throughput is needed.

Neither cycle life nor HEV test cycle evaluation are complete.

Approach to and Relevance of **Proposed Future Research**



Given the progress within the last year, it may be unnecessary to seek the support of a cell builder, continue with direction.

Specific **Recommendations/Additions or deletions to the work scope**

Prioritization of needs should be done, as this team cannot be the cell maker for all projects.

Hermiticity of the sealed cells needs to be verified.

Art of cell fabrication should be learned from others or it should be done at MSA facility. Probably should not work on Gen 2 (Al doped nickelate) cells.

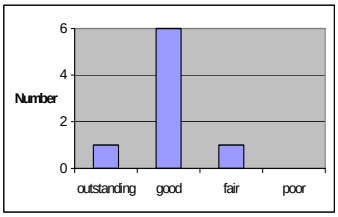
It is not clear that one electrode making technique fits all materials. Once under control, LBNL should identify possible variants for different materials.

Need a dry room to reduce water contamination while making cell construction more reliable.

Need to develop a method for thicker electrodes, at least 50μm, 75-100μm preferably. Commercial cells will need this thickness.

Lithium-Ion Polymer Batteries with Low-Cost Materials, K. Zaghib -- WS = 82.6, Rank = 22

Relevance to overall DOE/FCVT goals and BATT program objectives

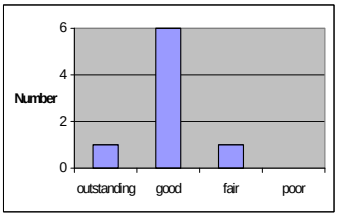


Helpful work to provide other researchers with materials needed by the BATT program, material ($FePO_4$) is critical to future success of Li ion technology. Attention to detail and inclusion of newest binders is a real plus.

Binder work can be useful. 60°C testing is OK for the 1st evaluation but must get low and room temperature data to meet DOE goals and BATT objectives.

Trying to cover too many topics. PI needs to better explain why he's doing this. Value of this project appears to lie in Phostech being a source of $FePO_4$. Work on gel type cells seems to be not very useful, has sealing problems etc.

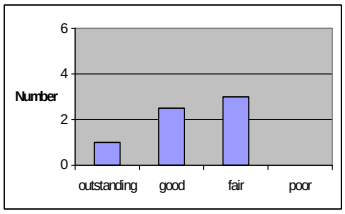
Approach to performing the research and development



The work presented here was a bit helter skelter, some cathode, some electrolyte, some anode.

Identified new lower cost and better performing binder to replace PVdF. Water soluble binder needs to be tested for long term stability.

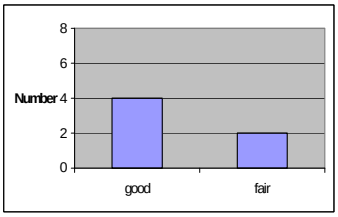
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



The work in cathodes, anodes, and electrolytes is only fair, and would not stand alone with others working in those areas.

Re-inventing the wheel? The utility of the results of many of the tasks is not clear.

Approach to and Relevance of **Proposed Future Research**



Reduce the number of tasks, effort spread too thin.

Specific **Recommendations/Additions or deletions to the work scope**

Water soluble binder needs to be tested for long term stability.

The PI should consider e-beam cross linking rather than UV and IR which require an initiator.

The PI should characterize and compare electrodes with PVDF and WSB.

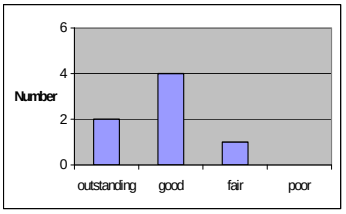
Should consider higher MW acrylates with higher voltage stability. Need to identify reliable pouch materials.

Rather than look for cell assembly at Quallion, the IREQ lab would be a better choice for large quantities of cells for ATD program, seems the price is right and they can make reliable cells.

Strength - Contact with a potential manufacturer. Weakness - Effort spread over too many areas to be effective. Not clear that gel polymers will meet power goals.

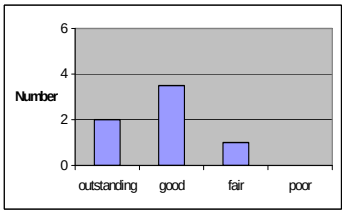
Design, Optimization, and Fabrication of Li-ion Electrodes for High-power Applications,
D. Wheeler-- WS = 87.8, Rank = 18

Relevance to overall DOE/FCVT goals and BATT program objectives



Project has good relevance. Carbon fibers are good to look at as compared to carbon. Shows the importance of different types of carbons.

Approach to performing the research and development

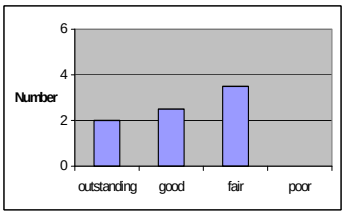


Approach is consistent and seems to be sound.

They have demonstrated advantages for adding carbon fibers to electrodes. The Hall Effect approach to determining transference numbers would be, if successful, extremely valuable, although it looks challenging.

The use of fibers to provide contact and lower resistance is very good.

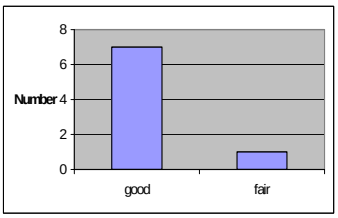
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Progress is satisfactory, early results on fibers look encouraging. Project is in early stage and preliminary experiment with fibers looks promising.

The impact of type of carbon mixing shown but high power aspects of this work are not clear.

Approach to and Relevance of **Proposed Future Research**



Should continue, address practicality of approach, start worrying about fiber cost. It will be interesting to see how the concepts are put into practice.

Specific **Recommendations/Additions or deletions to the work scope**

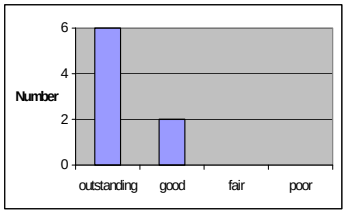
Should continue, address potential cost, and concentrate on high power verification. Need translation to practice in realistic cells.

Perhaps a collaboration with Kostecki could produce fibers via microwave with catalyst and a gas feed on a premade electrode.

Strength - PIs are sharp and realistic. Weakness - Too early to tell concepts are good.

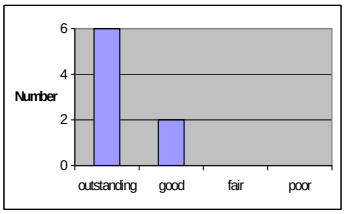
Modeling of BATT Program Baseline Chemistries, V. Srinivasan-- WS = 106.5, Rank = 2

Relevance to overall DOE/FCVT goals and BATT program objectives



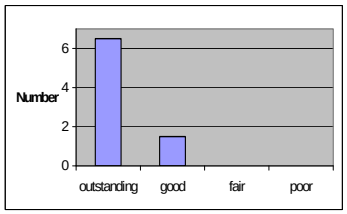
Very high relevance, supported by the fact that a number of other researchers are using the model to optimize materials and cell performance. This approach is essential to developing improvements.

Approach to performing the research and development



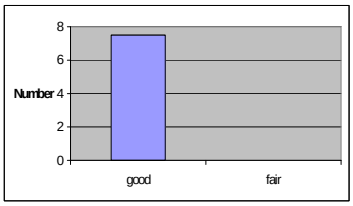
The use of modeling is a very powerful tool to understand performance. The approach has been very successful in comparing systems, continue on this path.

Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Since many researchers are referring to this work and using the model, the accomplishment is excellent. The model has proven its usefulness.

Good insight into the difficulties in $LiFePO_4$ composition depending on history of charge and discharge. High level of accomplishment.



Approach to and Relevance of **Proposed Future Research**

Must continue, but be specific in future tasks instead of asking questions.

Specific **Recommendations/Additions or deletions to the work scope**

Work is a must. Excellent leader and will move things in a good direction.

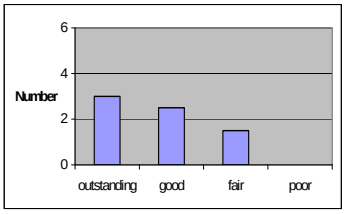
Suggest moving to the next level of detail applied to cathode modeling, particularly for two phase reactions. Consider other approaches such as percolation theory which may add value.

Be specific about accomplishments and how they relate to overall program.

It is curious that the model works better at high and low rates than intermediate rates, the model should be tested at very high rates (>1000W/kg). Should move on to other materials in the program, e.g. those from Ceder, Grey, and Thackeray.

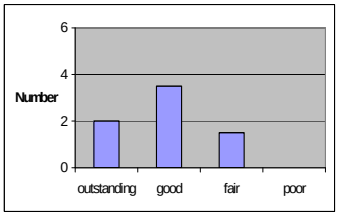
Novel Cathode Materials, S. Whittingham -- WS = 89.6, Rank = 15

Relevance to overall DOE/FCVT goals and BATT program objectives



New electrode materials are perhaps the most useful possible outcome, as higher capacity cathodes are key for future applications. The project is properly focused and executed. New materials with promise have been identified for next generation Li ion batteries.

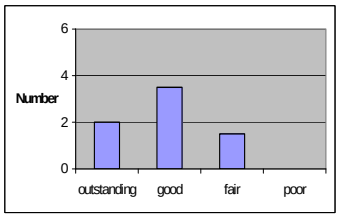
Given the progress by Thackeray, this work does not seem to be very relevant.



Approach to performing the research and development

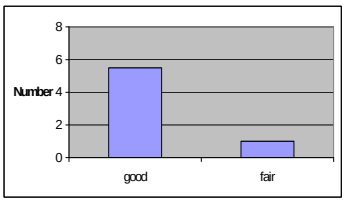
The hydrothermal materials synthesis appears strong; work on layered compounds is proceeding well.

The preparation of the materials is key and emphasis is properly placed. The choice is accurate and based on strong technical knowledge.



Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal

Technical accomplishments are not clear, and progress on materials that may meet overall goals seems to be lacking. But another reviewer wrote “Very solid progress, especially with layered compounds.”



Approach to and Relevance of **Proposed Future Research**

No comments.

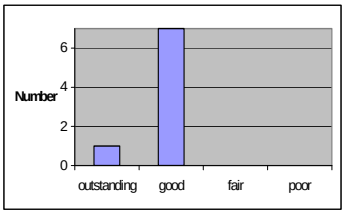
Specific **Recommendations/Additions or deletions to the work scope**

Need better communication with other groups. Modify approach by coordinating with other researchers working on novel cathode materials.

Develop approach to improve lithium diffusion in $LiFePO_4$.

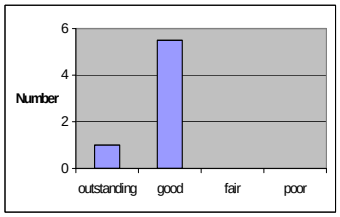
Synthesis and Characterization of Cathode Materials for Rechargeable Li and Li-Ion Batteries, M. Doeff -- WS = 90.2, Rank = 14

Relevance to overall DOE/FCVT goals and BATT program objectives



It is important to develop an understanding of the conductive coating on $LiFePO_4$ and improve it. Project does not seem well defined, a bit hodge podge.

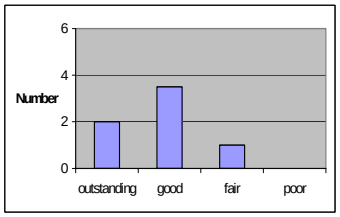
Approach to performing the research and development



Chose to use graphite precursor and graphitize it. The choice of organic is critical. The use of ferrocene also offers the possibility of forming FeC.

Solid approach to improve coating, but it is not very new.

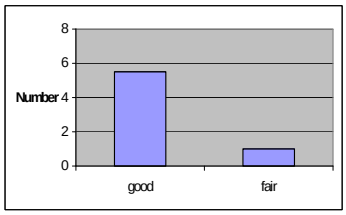
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Synthesis of materials does not seem to bring any new insights, seems to be weak.

Very good progress, work is solid and reliable, but does not really stack up well with the star studded cathode projects. But LBNL does need some in-house effort in this area.

Approach to and Relevance of **Proposed Future Research**



Some good ideas on generating carbon coatings or fibers, cell cycling is essential.

Specific **Recommendations/Additions or deletions to the work scope**

Need to better utilize resources. Probably would be best to examine a system, rather than one component. Perhaps emphasize characterization of materials that have been synthesized differently.

Determine optimum particle size distribution.

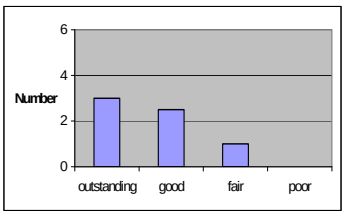
Would like to see microwaving applied to PMA with and without graphitization promoter.

Review Singer and Lewis graphitization study for other compounds that give better graphite characterization. Need cell cycling to prove concept is viable.

Strength - Thorough, interactive, knowledgeable. Weakness - Ability to leap frog existing technology is not evident.

Diagnostics - Electrode Surface Layers, R. Kostecki -- WS = 94.7, Rank = 11

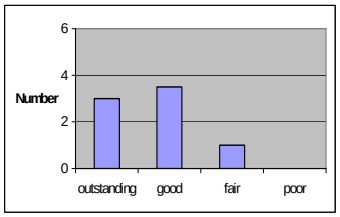
Relevance to overall DOE/FCVT goals and BATT program objectives



Excellent, subject is highly relevant to current issues of interest in the industry. Diagnostics and carbon coating are both needed for a successful program.

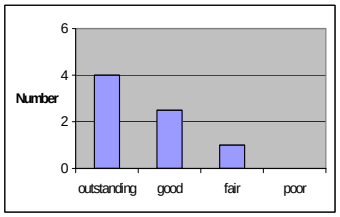
The microwave treatment of carbon coating has a broad application and should be pursued. Good contract is essential to produce low resistance active mass, although it's not clear that the approach is possible from a cost point of view.

Approach to performing the research and development



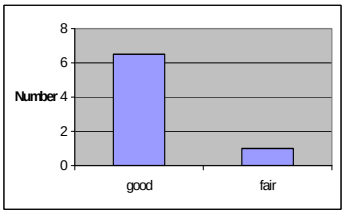
Excellent, PI's approach of using microwave treatment is very innovative and looks to have a high potential.

Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Excellent prospect for application, great coating technique. Carbon coating work looks good but is preliminary, need to see some cells and reproducible results.

Approach to and Relevance of **Proposed Future Research**



No future work proposed in specific tasks.

Depends on whether carbon coatings pan out. Will be interesting to try the process on 1/3 compound to see how much improvement is possible.

Specific **Recommendations/Additions or deletions to the work scope**

Investigate whether heat treatment of electrode also helps power capability at cold temperatures (-20, -30°C).

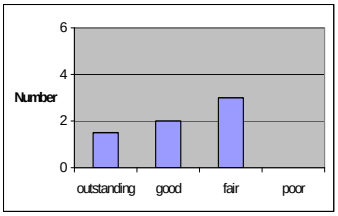
Perhaps work with Doeff to use other precursors and possibly make carbon fibers in electrodes. Must develop ability to produce stable electrode structures for investigation.

Suggest moving quickly to test performance of coatings to optimize microwave heating process.

Strength – Creativity.

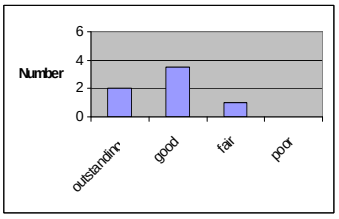
Cell Development, Overcharge Protection, Cathode Materials, T. Richardson -- WS = 80.0, Rank = 24

Relevance to overall DOE/FCVT goals and BATT program objectives



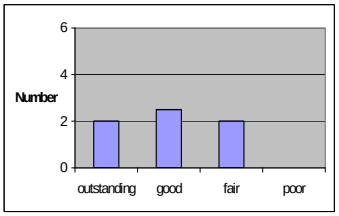
There is a need to limit charge voltage to maintain long term reliability. The use of a redox polymer is very innovative. Not clear if this would eliminate the need for external cell monitoring and control.

Overcharge protection continues to be a main issue with Li ion batteries, but no interest has been shown by battery producers, perhaps because they don't want to add new things to cells that may lead to unanticipated problems.



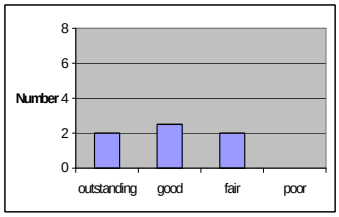
Approach to performing the research and development

Use of conductive polymers seems promising. The approach is very creative.



Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal

He has done a great job of demonstrating the principle and feasibility, delivered operational limits for protection and demonstrated efficacy. But have not seen much progress since last year.



Approach to and Relevance of **Proposed Future Research**

Future work not clear, case not made for continuation.

Specific **Recommendations/Additions or deletions to the work scope**

Clarify potential barriers and road blocks to bringing this to practice, devise a plan to address above challenges, demonstrate to battery producers. More aggressive testing may be desirable.

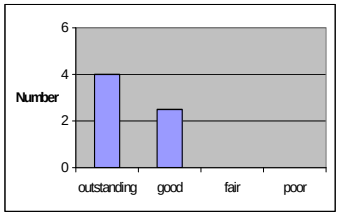
The real need is to make cells (coin, pouch) and test the concept by cycling. Need to understand life of the material and its reversibility in a practical environment.

Lack of progress in interesting battery companies indicates that it may not be ready for development. Time to declare the project complete and move on to something new.

S - Innovative work. W- Time to get a manufacturer to use it or move on.

Battery Materials: Structure and Characterization, X.Q. Yang -- WS = 100.3, Rank = 5

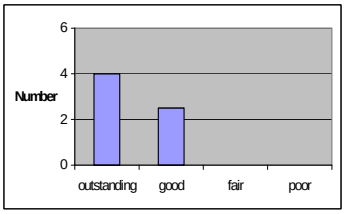
Relevance to overall DOE/FCVT goals and BATT program objectives



Better understanding of electrode structures is critical and is the key to long life high performance cathodes. This project provides useful data for the program. The ability to distinguish between surface and bulk is a valuable feature of the techniques.

Very strong team and skilled PI. Have a very powerful tool and know how to use it. Also have great appreciation for changes that can occur during charge-discharge and storage.

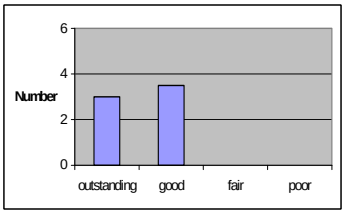
Approach to performing the research and development



In situ XRD capabilities are top notch. Working closely with the top people in the field, the project has available the best and most promising new materials.

The use of high temperature diagnostics adds another dimension to this work and understanding.

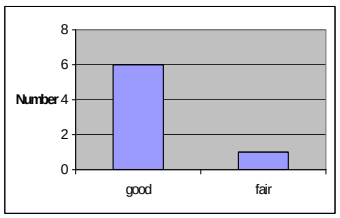
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



The work has observed changes in structure on cycling and oxidation state with state of charge, very good progress.

Lack a connection to a commercial operation and the ability to use commercial quality cell construction for their investigation is a negative.

Approach to and Relevance of **Proposed Future Research**



Basically keep on doing and following the present path.

Specific **Recommendations/Additions or deletions to the work scope**

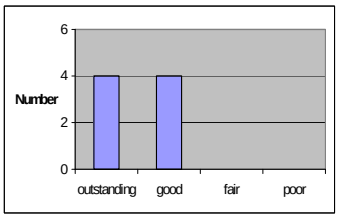
Collaborate with Manthiram project to assess "doped" spinel structures.

Maintain as is, need to better translate insights into practical conclusions for the practitioners.

S - Excellent equipment, W - Can only work with samples others bring to them.

Cathodes - Superior Capacity Retention, High-Rate Spinel Manganese Oxide Compositions, A. Manthiram -- WS = 96.3, Rank = 9

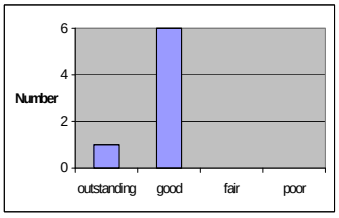
Relevance to overall DOE/FCVT goals and BATT program objectives



Spinel remains a key cathode material of interest. A stable spinel that can cycle well at 55-60°C is very important, and this project offers that possibility.

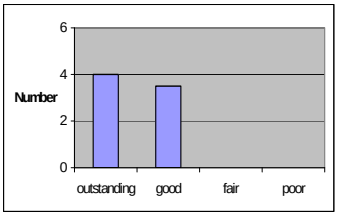
5V materials probably not relevant except for revealing structural behavior of spinels.

Approach to performing the research and development



Promising approach to improving capacity fade of spinel. Would like to see how far one can go with F substitution, it looks promising.

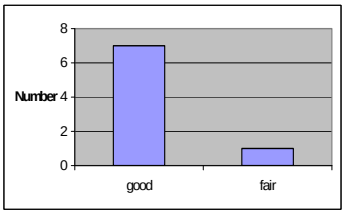
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Results on improved capacity fade are outstanding. Established a relationship between capacity fade and F substituted spinels. The high rate performance is related to the Li diffusion rate in the spinel as well as the cation disorder in the layered structure.

Good results, and has the potential to come up with something very new.

Approach to and Relevance of **Proposed Future Research**



Be specific about the planned optimization of oxyflourine spinels. Need to focus on testing materials at LBNL.

Specific **Recommendations/Additions or deletions to the work scope**

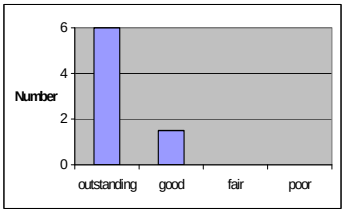
Work with Ceder to explain effect of fluorine.

Look at power fade in addition to capacity fade. It is not clear that 50-100 cycles are sufficient and capture other failure modes that may kick in later on.

Strength - Has some rationale and tries lots of things. Weakness - Does so much he could miss something by not working on it enough.

First Principles Calculations and NMR Spectroscopy of Cathode Materials, C. Grey/G. Ceder -- WS = 104.8, Rank = 3

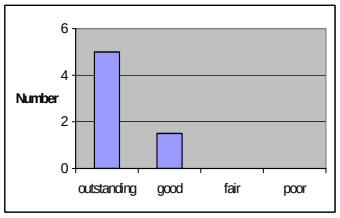
Relevance to overall DOE/FCVT goals and BATT program objectives



Really great work, may lead to new electrode materials. Provides better understanding of positive materials and structural changes during operation and may serve as the basis for developing knowledge to minimize development time.

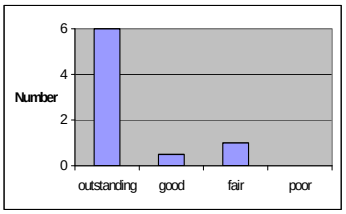
Without question, this is one of the shining projects of the program. The understanding of theory and the relation to practice is seldom found. Both PIs deserve equal credit for progress and understanding that is being developed.

Approach to performing the research and development



The combination of ab-initio calculations supported by XRD and NMR provides an unparalleled capability to understand the foundation of cathode materials as well as the controlling parameters.

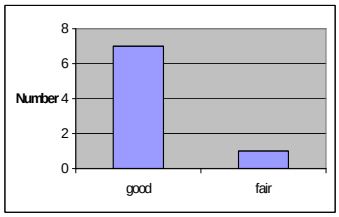
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



This project represents many firsts in the areas of better material development and performance projection. Structure/property connections are very significant. The most coherent and efficient project in the program, perhaps the best project overall.

Utility of approach still not demonstrated.

Approach to and Relevance of **Proposed Future Research**



Future work not defined clearly.

Specific **Recommendations/Additions or deletions to the work scope**

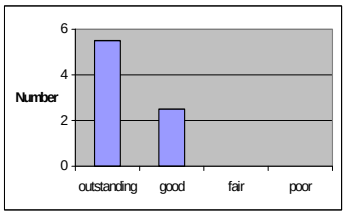
Continue to expand effort, start from what is needed for electrodes then design material accordingly. Perhaps build and test cells to validate findings.

Only weakness is the lack of sufficient resources. Would benefit from exposure to performance in practical cells, such as are available in Japan.

Continue evaluation of $Li(Mn_{0.5}Ni_{0.5})O_2$, but expand search beyond well known triangle of positive materials. This is more of a general comment and not just applicable to this project.

Novel Cathode Materials, M. Thackeray -- WS = 101.0, Rank = 4

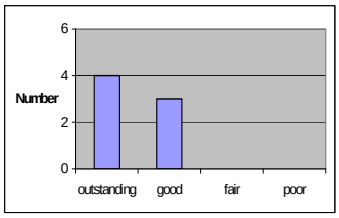
Relevance to overall DOE/FCVT goals and BATT program objectives



May lead to useful electrode materials, high potential for significant advances.

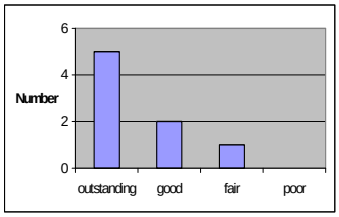
These compounds have relatively low resistance and are available in low cost precursors so this appears very relevant.

Approach to performing the research and development



Creative approach and a first class project.

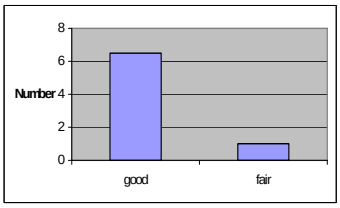
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Good progress on new cathode material. Seems to open up new families of materials for high power batteries.

Have developed base knowledge of Mn compounds and expanded it into new domains. Have high probability of identifying best HEV material.

Approach to and Relevance of **Proposed Future Research**



Be specific about what "optimize" means.

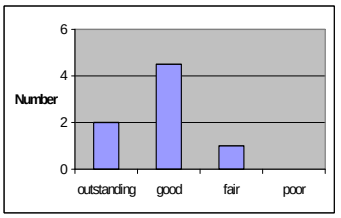
Work scope among clearest and most concise. Have realistic approach to bringing in a new cathode material.

Specific **Recommendations/Additions or deletions to the work scope**

Should continue emphasizing high energy materials.

Conducting polymer cathodes combined with iron redox couples for lithium batteries, J. Goodenough -- WS = 88.4, Rank = 17

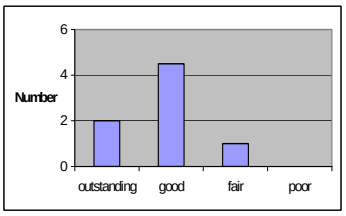
Relevance to overall DOE/FCVT goals and BATT program objectives



This is an area of high interest, and this type of work is needed, but results need to be clarified. This is an exploratory project with potential for better rate and higher energy.

Does not appear to deliver high rate performance compared to other techniques. But track record speaks for itself. This PI has discovered virtually all positive electrode materials in use.

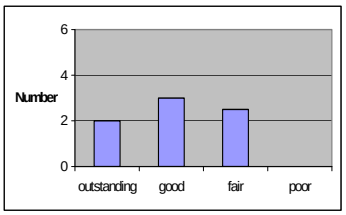
Approach to performing the research and development



This particular project could lead to a new and easier way to make electrodes. I am not sure this approach will be successful, but worth the effort.

Very novel, the use of a conductive polymer with embedded $LiPO_4$ is creative.

Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



The new cathode material shows a lot of promise, results are OK but a better description is required. Preliminary results are encouraging, need more data.

Approach to and Relevance of **Proposed Future Research**

Unclear, be specific about future tasks.

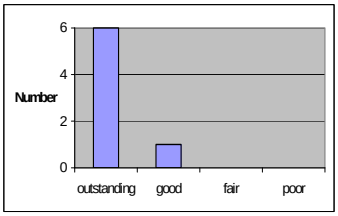
Specific **Recommendations/Additions or deletions to the work scope**

Should check the energy density of the proposed materials.

Consider collaboration with Doeff, Kostecki, and Wheeler, Ceder, Kerr.

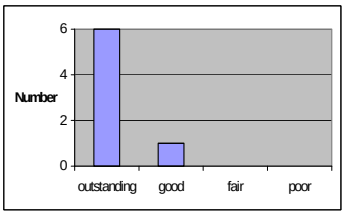
Performance and Failure in Lithium-ion Batteries, J. Newman -- WS = 107.5, Rank = 1

Relevance to overall DOE/FCVT goals and BATT program objectives



Very relevant, world class effort, results of modeling are useful for data analysis. The program needs modeling of real cells and this project provides it.

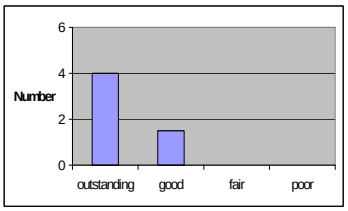
Approach to performing the research and development



Approach is excellent, modeling using properties of materials to identify internal stress and predict particle fracture. Fracture of active materials generally leads to poor cycle life. PI has identified conditions that can lead to early failure of Li intercalation materials.

The term "high potential anodes" is misleading. They actually have a lower unit cell voltage and will require more cells to deliver a set voltage.

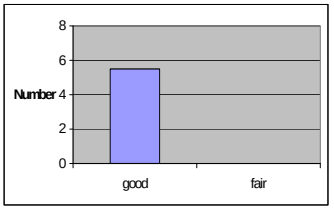
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Many workers use model and predictions to plan their work. Great accomplishments and useful results.

Particle fracture shown to be present. Importance to positive electrode performance is the next step.

Approach to and Relevance of **Proposed Future Research**



No comments.

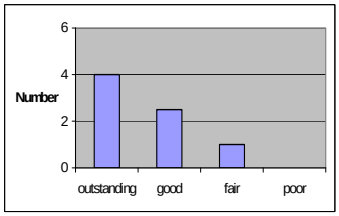
Specific **Recommendations/Additions or deletions to the work scope**

Teach others how to use models. Use modeling to predict Goodenough compound electrode results, optimize.

Strength - Long standing expertise, recognition and leadership.

Modeling & Experimentation-Electrochemical Materials, A.M. Sastry -- WS = 97.6, Rank=7

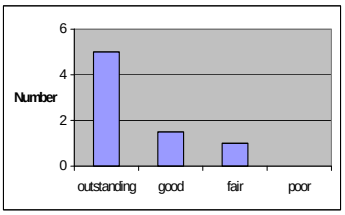
Relevance to overall DOE/FCVT goals and BATT program objectives



Work is cutting edge and highly relevant to mechanical properties of electrodes. This project contributes to an understanding of the physical relationship of materials as opposed to the electrochemical models, both are essential for program success.

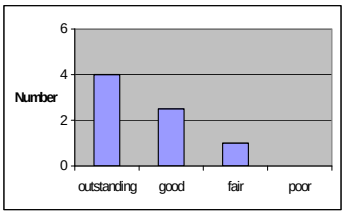
The relevance of this work would be better established if the PI could show this as a predictive tool rather than an analysis tool. Not clear how the results will be used in other projects.

Approach to performing the research and development



Clear, novel, and creative approach. Good, world class effort. Coupling this effort with Newman modeling should yield great success.

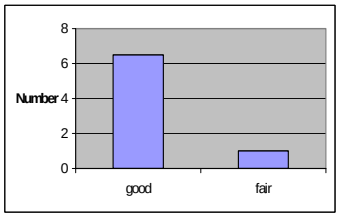
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Has shown how effective packing depends on particle size and distribution, very good accomplishments.

The results clearly agree with what is generally known. This implies that we can now predict behavior. Perhaps the best presentation at the meeting.

Approach to and Relevance of **Proposed Future Research**



Tool can be utilized widely in Ucap industry for optimizing electrode composition with respect to conductive carbon content for best conductivity.

Specific **Recommendations/Additions or deletions to the work scope**

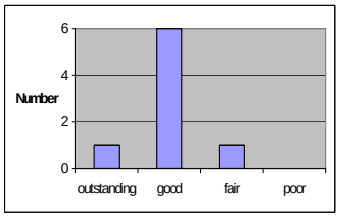
Coordinate more with Newman's approach to mechanical issues, address contact resistance, have Dr. Newman evaluate the utility of the codes.

Focus on measurements which can relate model to actual electrodes. Try to start with a given material composition and morphology and then use the simulation as a means of optimizing for best conductivity, validate findings by test.

Need stronger interaction & cooperation with electrochemical modeling. There seems to be a feeling of encroachment that may hinder cooperation. Include "expanded" graphite from Superior Graphite in experimental work, it can improve conductivity.

Corrosion of Aluminum Current Collectors, T. Devine -- WS = 90.5, Rank = 12

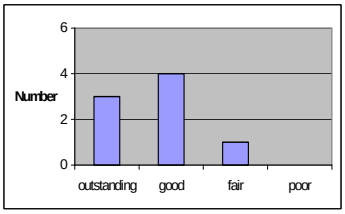
Relevance to overall DOE/FCVT goals and BATT program objectives



Limited utility, Al corrosion problems are a long way off, but anticipation is good.

Corrosion of Al collector is a critical aspect of Li ion batteries. Good addition to overall program. It is essential to have a stable material for long life.

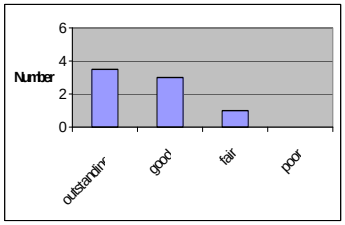
Approach to performing the research and development



Excellent approach and execution, have done a commendable job of attacking the problem at its source.

Should be done by battery engineer.

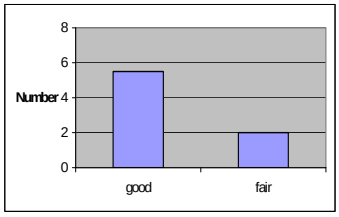
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



The PI reported potentially significant findings in terms of protecting the current collector, problem well studied and conclusions seem sound.

Little progress reported.

Approach to and Relevance of **Proposed Future Research**



Be specific about future plans. Not sure where this project should go in the future.

Specific **Recommendations/Additions or deletions to the work scope**

Results on mixed salt electrolyte should be pursued in actual cells at high rates.

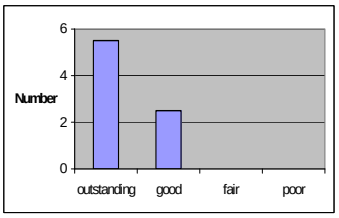
Surface films are one approach and inhibitors (electrolyte additives) are another, both should be explored.

In comparing treated and untreated Al collectors, power is the most critical factor. Look at power first, then capacity.

Assess the cost of the proposed solution.

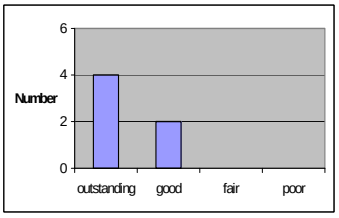
Diagnostics, Interfacial, and Reactivity Studies First Principles Calculations and NMR Spectroscopy of Cathode Materials, P. Ross -- WS = 99.5, Rank = 6

Relevance to overall DOE/FCVT goals and BATT program objectives



The SEI layer that forms on anodes plays an important role, and it's critical to understand impedance growth on negative and positive electrodes. An identification of the components is a first order need.

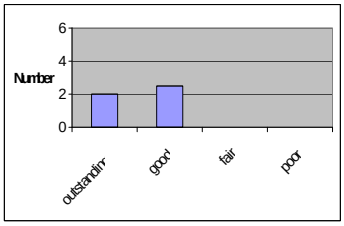
Various diagnostics for SEI and electrolyte stability crucial to program success.



Approach to performing the research and development

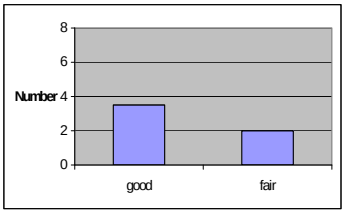
Use of advanced spectroscopic techniques is essential and fruitful as is the ability to use in situ observations.

Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Understanding and confirming Li plating at low temperature is a useful accomplishment.

Approach to and Relevance of **Proposed Future Research**



Be specific about future tasks, not sure what is next.

Specific **Recommendations/Additions or deletions to the work scope**

Must continue, extend to alloy anodes in collaboration with Newman, work with Ceder to explain SEI. Need to include effects of additives on SEI layer composition and extend work to film formation on cathodes and into other electrolyte compositions.

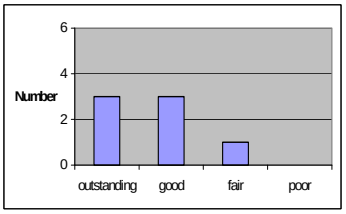
Could be part of a team challenged to make Li work, or vet new generation of electrolytes.

Would be interesting to study and compare present commercial electrolytes and LiBoB.

S - Techniques and competence are valuable. W - Need the next step of what to change.

Non-Carbonaceous Anodes, M. Thackeray -- WS = 95.0, Rank = 10

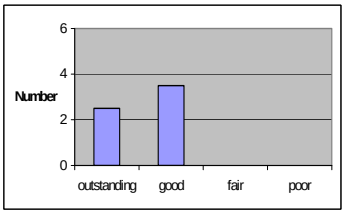
Relevance to overall DOE/FCVT goals and BATT program objectives



This work on non-carbonaceous materials is very useful and may lead to a breakthrough in electrodes and improved additives. Improved anodes are a major need, but question use of Sb and Sn in real hybrid batteries due to cost.

There is a need for higher capacity anodes, and the intermetallics offer good promise. Their use in commercial cells is now confirmed with the Sony product.

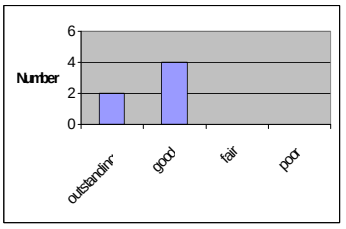
Approach to performing the research and development



Intermetallic displacement reaction chemistry is highly regarded in the community. PI also shows a propensity for being innovative and trying new things, an example this time was the use of LectroTM Max Powder to give anodes a precharge

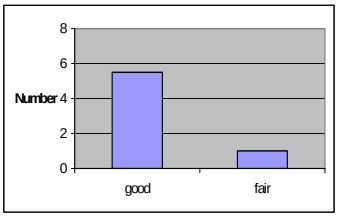
Materials have a volume advantage over graphite, but not a weight advantage.

Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Pre-lithiation method using lithium powder is essential for large ICLs in some intermetallics. But these materials still show a deficiency in rate capability as well as specific energy.

Approach to and Relevance of **Proposed Future Research**



Useful plan for future work.

Specific **Recommendations/Additions or deletions to the work scope**

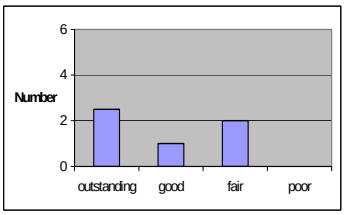
Must continue. Use of the stabilized Li powder opens avenues, such as the use of new materials with high ICL.

Emphasize nanostructural, thin film approach for longer cycle life.

S - Innovative and productive.

Novel Anode Materials, S. Whittingham -- WS = 86.9, Rank = 19

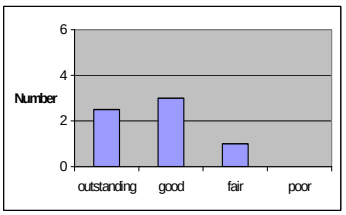
Relevance to overall DOE/FCVT goals and BATT program objectives



Improved anodes are a major need. Current carbon anodes have a limited capacity, need higher capacity anode for improved energy density.

Recent work seems less relevant, foils and grids do not cycle well.

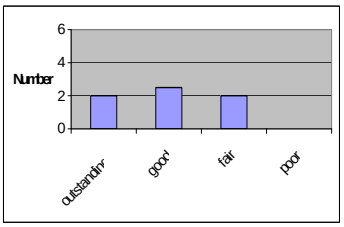
Approach to performing the research and development



The systems examined are on the ordinary side and likely to have mechanical problems. In addition, because of poor cycling, the materials have not yielded much progress.

Explore and synthesize new inexpensive anode structures. Try to select materials approximately .5V vs. Li for greater safety.

Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Volume change is difficult to handle and limits cycle life. Systems have promise but seem to need a matrix for mechanical and or SEI protection.

Screening tests are of little value.

Approach to and Relevance of **Proposed Future Research**

Be specific concerning future tasks. Seem to be chasing what is already done in Japan, rather than leaping over existing technology.

Specific **Recommendations/Additions or deletions to the work scope**

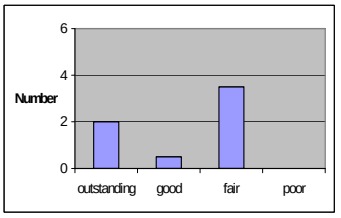
Cost of nano fiber production should be considered.

Clever and innovative PI, has proven track record of invention. But management should challenge him to leap frog known technology, his track record suggests he can do this. Emphasize nanostructure configuration, perhaps on conductive particles that do not intercalate.

S - Great experience, knowledge and contacts. W - Has been more effective on the cathode side.

Physical Characterization of Polymer Electrolytes, N. Balsara -- WS = 81.8, Rank = 23

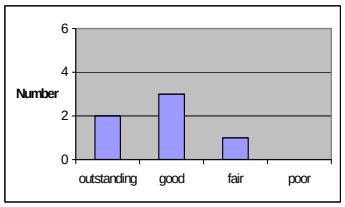
Relevance to overall DOE/FCVT goals and BATT program objectives



This work is high risk and on the edge of technical understanding. Very interesting concept to prevent dendrite formation, and it should be continued. If it were to work, this could be important.

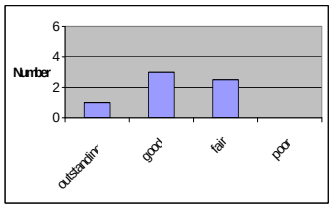
Dry polymer electrolytes are high risk after so much work. This newer approach may be worthwhile but should be reconsidered after a reasonable period.

Approach to performing the research and development



Polyphase polymers are the last relatively unexplored area. If this polymer can successfully stop Li dendrite growth, there is hope for high energy battery applications so it is a good, novel, and risky approach.

Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Concept is good, results are interesting, but practical application is doubtful, little progress.

Results are quite impressive so far, but the conductivity measurements were AC and thus we do not have any information on the true Li transport.

Approach to and Relevance of **Proposed Future Research**

Future work not specified, needs to work with an electrochemist to evaluate materials, worth a good try.

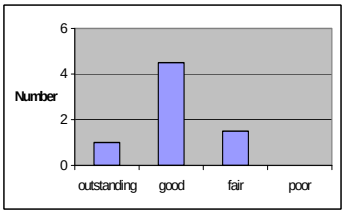
Specific **Recommendations/Additions or deletions to the work scope**

Would acrylates be better choice than PEO? They have similar conductivity, with more freedom of polymer composition (see Sadaway) and properties. The choice of PEO seems overly influenced by past work in polymer electrolytes. Should consider the silica findings and how it impacts theory.

S - Good polymer knowledge and work. W - No experience in conductivity measurements.

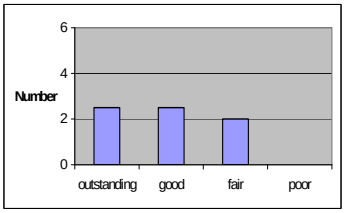
Electrolytes – R&D for Advanced Lithium Batteries, J. Kerr -- WS = 84.3, Rank = 21

Relevance to overall DOE/FCVT goals and BATT program objectives



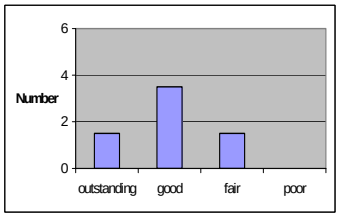
It is not clear that polymer electrolytes will ever by used in vehicles. But trying to make Li metal work is the only way to get to EV battery and polymer electrolytes are the obvious choice for next generation systems. The project shows excellent progress with high hopes for a successful new concept.

Approach to performing the research and development



Classic approach using established materials, excellent combination of techniques.

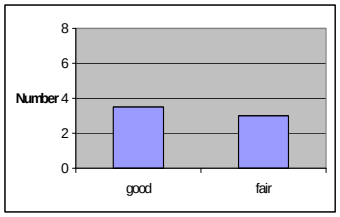
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



TFSO is not a good choice even though PEO gives reasonable conductivity. There has been so much work on PEO that has not measured up that a fresh start is essential. This practical application is doubtful for this polymer electrolyte and progress has been slow.

Little success in getting anything but liquid electrolytes to go smoothly with Li without a large surface impedance.

Approach to and Relevance of **Proposed Future Research**



Specific tasks should be defined, not clear what is to be tried next. Needs to prove the dry or gel ionic electrolyte will be cheaper and or safer than the liquid.

Specific **Recommendations/Additions or deletions to the work scope**

Should determine the relative safety of polymer and liquid electrolytes.

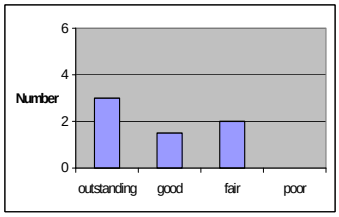
Discuss approach with industrial developers. PEO system has long history of development for EV application, but it is not good for high power, and the V_6O_{13} type cathode will not prove environmentally acceptable. Need to move on either with new approach and/or polymer to meet HEV goals. May be acceptable for stationary apps with neat PEO. Need to consider other gel types such as acrylates with more mobile solvents.

Try some of Dr. Creager's ionic liquids and get modeling guidance from Dr. Smith.

Strength - Has identified the roadblock very well and is open and honest about the problem. Good experience and knowledge base. Weakness - Not sure of plan.

Composite Polymer/Gel Electrolytes for Lithium and Lithium-Ion Batteries, P. Fedkiw -- WS = 88.9, Rank = 16

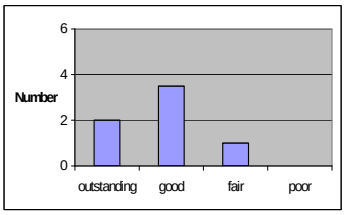
Relevance to overall DOE/FCVT goals and BATT program objectives



Excellent work, fumed silica may be of value as a water getter for long-term battery storage. A gel electrolyte might be very attractive for battery manufacturers. This project has excellent concept and is making good progress.

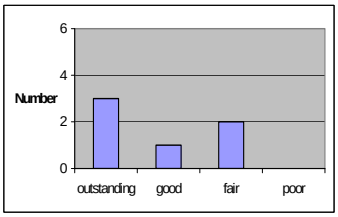
Poor rate capability of the gels studied will limit applicability in automotive applications.

Approach to performing the research and development



The work covers the development of new polymers and gels, including ionic gel systems and single ion conductors. Poised for a real breakthrough.

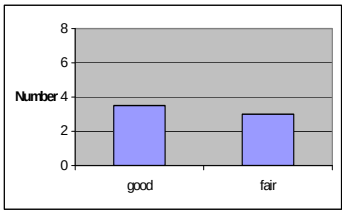
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



Some of these results look very promising, especially suppression of Li dendrites. Whether this would work in real cells remains to be seen.

Results are interesting but limited. Concern about rate capability and poor Coulombic efficiencies.

Approach to and Relevance of **Proposed Future Research**



Plan should be more focused with specific tasks, keep on going in direction.

Specific **Recommendations/Additions or deletions to the work scope**

Need to look at lithium coin cells to assess Coulombic efficiency concern.

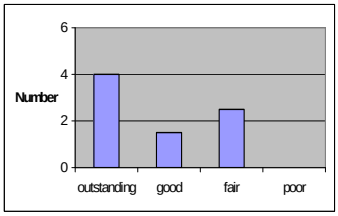
Coupling this work to both cell work and modeling effort (Smith) should be encouraged.

Need to try cycling of Mn cathode material used by developers overseas.

Strength - Good expertise in polymers, gelation etc. Weakness – Use in real cells.

Molecular Modeling of Electrolytes and SEI, G. Smith -- WS = 90.3, Rank = 13

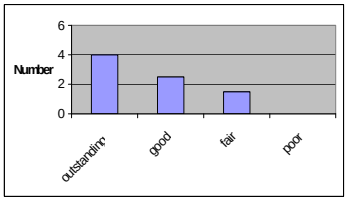
Relevance to overall DOE/FCVT goals and BATT program objectives



Subject is timely and relevant to current Li ion issues, this excellent ground breaking work could lead to improved electrolytes. The methodology will pay off big in the next 3-5 years, but polymer electrolytes may never be used in cars.

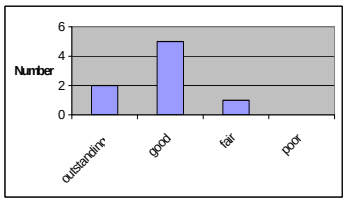
Increases speed of identifying most promising materials for experimental verification. The electrochemical model (Newman) has good success as will this approach.

Approach to performing the research and development



Great level of expertise and MD calculations have good predictive power.

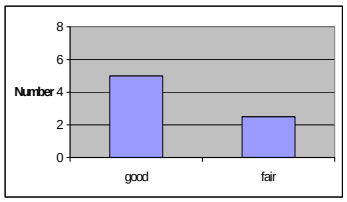
Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal



The agreement between model and experimental results is good, results seem promising. Have been able to match real data, show which parts of the solvent are responsible for transport and worked with experimentalists to guide synthesis.

Identified effect of Li complexation with backbone and suggested additive to improve conductivity. Established a basic understanding for making accurate predictions.

Approach to and Relevance of **Proposed Future Research**



Future work not specified.

Specific **Recommendations/Additions or deletions to the work scope**

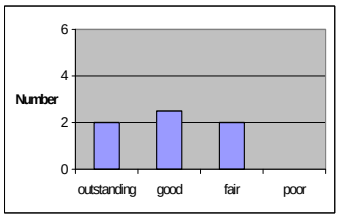
Good understanding of polymer electrolyte structure and expect it to help synthesis procedure. It has not been applied practically yet, some synthesis is needed to confirm postulates.

Need to maintain close liaison with experimental projects.

Strength - Very interactive, productive.

New Battery Electrolytes Based on Lithium Fluorosulfonate and Fluorosulfonimide Salts, S. Creager -- WS = 85.6, Rank = 20

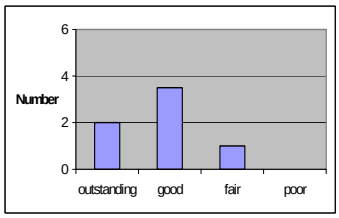
Relevance to overall DOE/FCVT goals and BATT program objectives



Methodology being developed to treat many systems. Good tie in to work of Smith. There is the possibility here for a breakthrough in electrolytes.

Relevance not clear.

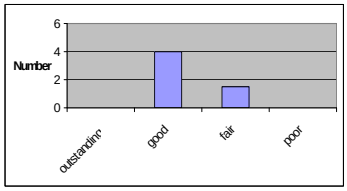
Approach to performing the research and development



Ionic liquids seem a logical choice for electrolytes and the group has an excellent interaction with Smith's modeling. There is a real synergy here.

Not focused well enough.

Technical Accomplishments and Progress toward BATT program objectives and DOE/FCVT goal

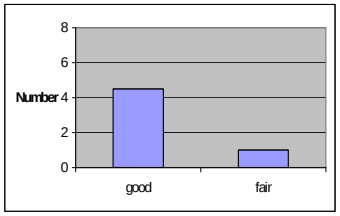


This is one of the few new things in electrolytes. It is promising but has yet to be evaluated in actual cells.

Excellent concept development and synthesis capability. Proven track record of innovation.

The significance of their new salts is not clear.

Approach to and Relevance of **Proposed Future Research**



Should consider some smaller anion synthesis for conventional electrolytes for Li ion cells.

Specific **Recommendations/Additions or deletions to the work scope**

Project direction is excellent, would not change anything.

Make sure some cells get made. Improve cooperation with NCSU and Utah to clarify concepts for faster progress.

S - A much needed synthesis skill set for electrolytes. W - Still have to see if it works in cells.

Appendix A

BATT Attendees

Last	First	AFFILIATION	TELEPHONE	E-MAIL ADDRESS
Abbott	Kim	DOE-Berk. Site Office	(510) 486-7909	kvabbott@lbl.gov
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Salminen	Justin	LBNL	(510) 643-1972	justin@newman.cchem.berkeley.edu
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Song	Seung-Wan	LLNL		
Spotnitz	Bob	Battery Design Inc.	(925) 895-4080	rspotnitz@batdesign.com
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Tiedemann	William	JCI (ret)	(414) 228-2370	slabcreek@yahoo.com
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Webber	Andy	Energizer	(440) 835-7689	andrew.webber@energizer.com
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White	Ralph	U. South Carolina	(803) 777-3270	rew@sun.che.sc.edu
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Yanagida	Katsunori	Sanyo Energy (USA)	(619)661-6620x4169	kyanagida@sec.sanyo.com
Yoon	Won-Sub	BNL	(631) 344-6145	wonsuby@bnl.gov
Zaghib	Karim	IREQ	(450) 652-8019	karimz@ireq.ca
Zhang	Xiangwu	NCSU	(919) 513-1137	xzhang13@unity.ncsu.edu
Zhang	Xueyuan	LBNL	(510) 642-3807	xueyuan@uclink.berkeley.edu
Zhuang	Vera	LBNL	(510) 486-4793	gvzhuang@lbl.gov

Appendix B

Review Forms

Please use this form to provide DOE with your comments on the overall BATT program. Sample questions that can be used as a guide when completing this overall review are:

1. Does the program appropriately address the key barriers and thus contribute to the attainment of DOE objectives in the area of advanced batteries for transportation?
2. Is the program organized in an efficient manner to achieve the above?
3. Are there specific areas of the program that require additional emphasis?
4. Are there areas of the program that should be de-emphasized?

Overall Program Rating

4.	**Outstanding**		**Specific Comments**:
3.	**Good**		
2.	**Fair**		
1.	**Poor**		

Specific **Strengths and Weaknesses**

Specific **Recommendations/Additions or deletions to the program**

Reviewer Name:

TITLE:

PRINCIPAL INVESTIGATOR: INSTITUTION:

Using the following criteria, please rate the **work** presented in the context of the BATT Program objectives[1] to help develop high-performance rechargeable batteries for use in electric vehicles (EVs) and hybrid-electric vehicles (HEVs).

Please provide **specific** comments to support your evaluation.

1. <u>Relevance</u> to overall DOE/FCVT goals[2] and BATT program objectives

4 - Outstanding. The project is sharply focused on promising Li battery materials or on new diagnostic techniques.		Specific Comments:
3 - Good. Most aspects of the project will contribute to significant progress in Li battery systems or related diagnostics.		
2 - Fair. Some aspects of the project may lead to progress but other aspects should be re-directed.		
1 - Poor. The project is not appropriately focused on relevant issues related to Li battery systems or to novel diagnostics techniques.		

2. <u>Approach</u> to performing the research and development

4 - Outstanding. It is difficult for the approach to be improved significantly.		Specific Comments:
3 - Good. The approach is generally well thought out and effective, but could be improved in a few areas.		
2 - Fair. The approach has some weaknesses that should be addressed.		
1 - Poor. The approach is not appropriate to the program's needs.		

3. <u>Technical Accomplishments and Progress</u> toward BATT program objectives and DOE/FCVT goal.

4 - Outstanding. The project has made excellent progress toward the development of advanced Li batteries or related diagnostics.		Specific Comments:
3 - Good. The project has shown significant progress.		
2 - Fair. The project has shown only a modest amount of progress.		
1 - Poor. The project has demonstrated little or no progress.		

4. Approach to and Relevance of **<u>Proposed Future Research</u>**

2 – Good. Future work plan builds on past progress and is appropriately focused.		Specific Comments:
1 - Fair. Future work plan could be improved.		

Specific **<u>Strengths and Weaknesses</u>**

Specific **<u>Recommendations/Additions or deletions to the work scope</u>**

[1] The purpose of the BATT program is to conduct innovative, cutting-edge research on the next generation of lithium battery systems, to investigate advanced materials that promise greatly increased power and energy, and to develop advanced diagnostic tools to investigate failure mechanisms.

[2] The FCVT goal associated with energy storage is "Electric Drivetrain Energy Storage with 15-year life at 300 Wh with discharge power of 25 kW for 18 seconds and $20/kW."