2. Energy Storage Technologies

Introduction

Energy storage technologies, especially batteries, are critical enabling technologies for the development of advanced, fuel-efficient, light- and heavy-duty vehicles, which are critical components of the U.S. Department of Energy's (DOE's) Energy Strategic Goal: "to protect our national and economic security by promoting a diverse supply and delivery of reliable, affordable, and environmentally sound energy." The program's vision supports the development of durable and affordable advanced batteries covering the full range of vehicle applications, from start/stop to full-power hybrid electric, electric, and fuel cell vehicles. Much of this work will transfer to energy storage for heavy hybrid vehicles as well. Energy storage research aims to overcome specific technical barriers that have been identified by the automotive industry together with the Vehicle Technologies Program. These include cost, performance, life, and abuse tolerance. These barriers are being addressed collaboratively by the DOE's technical research teams and battery manufacturers.

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

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Battery Pack Requirements and Targets Validation FY 2009 DOE Vehicle Technologies Program	Dan Santini (Argonne National Laboratory (ANL))	2-8	3.00	3.40	3.00	3.00	3.20
PHEV Battery Cost Assessments	Brian Barnett (TIAX LLC)	2-10	2.50	2.50	2.25	2.50	2.47
United States Advanced Battery Consortium	Kent Snyder (Ford Motor Company)	2-13	3.25	2.75	3.00	2.50	2.88
Review of A123's HEV and PHEV USABC Programs	Ric Fulop (A123Systems)	2-15	2.33	2.33	2.00	2.67	2.33
Plug-in Hybrid Battery Development	Cyrus Ashtiani (Enerdel)	2-17	2.67	2.67	2.33	3.50	2.73
JCS PHEV System Development	Scott Engstrom (Johnson Controls-Saft)	2-19	2.00	1.75	2.67	1.75	1.93
USABC Program Highlights	Mohamed Alamgir (Compact Power)	2-21	3.00	3.00	2.67	2.67	2.92
Celgard and Entek - Battery Separator Development	Harshad Tataria (Celgard and Entek)	2-23	2.75	2.50	2.00	2.50	2.50
Energy Storage Testing and Analysis High Power and High Energy Development	Tim Murphy (INL, ANL, and SNL)	2-26	3.40	3.50	3.75	3.60	3.52
Testing USABC Deliverables/Benchmarking	Ira Bloom (Argonne National Laboratory (ANL))	2-28	2.33	2.33	2.67	2.33	2.38
Abuse Testing of High Power Batteries	Peter Roth (Sandia National Laboratory (SNL))	2-30	3.60	3.75	3.75	3.25	3.65
Thermal Management Studies and Modeling	Ahmad Pesaran (National Renewable Energy Laboratory (NREL))	2-32	3.25	3.25	3.25	3.50	3.28

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
International Collaboration With a Case Study in Assessment of World's Supply of Lithium	James Barnes (US DOE/ ANL)	2-35	3.00	3.60	3.60	2.60	3.33
Overview of Applied Battery Research	Gary Henriksen (Argonne National Laboratory (ANL))	2-37	3.60	3.60	3.60	3.40	3.58
Overview of the Batteries for Advanced Transportation Technologies (BATT) Program	Venkat Srinivasan (Lawrence Berkeley National Laboratory (LBNL))	2-40	3.50	3.25	3.50	2.75	3.28
Electrode Construction and Analysis	Vince Battaglia (Lawrence Berkeley National Laboratory (LBNL))	2-43	2.80	2.80	3.20	2.80	2.85
Microscale Electrode Design Using Coupled Kinetic, Thermal and Mechanical Modeling	Ann Marie Sastry (University of Michigan)	2-46	3.25	3.25	3.00	3.00	3.19
Analysis and Simulation of Electrochemical Energy Systems	John Newman (University of California - Berkeley)	2-48	3.40	3.20	3.20	3.40	3.28
Low Cost SiOx-Graphite and Olivine Materials	Karim Zaghib (Hydro-Quebec)	2-50	3.33	3.00	3.00	2.67	3.04
Layered Cathode Materials	Michael Thackeray (Argonne National Laboratory (ANL))	2-52	3.40	3.40	3.20	3.60	3.40
The Role of Surface Chemistry on the Cycling and Rate Capability of Lithium Positive Electrode Materials	Yang Shao-Horn (Massachusetts Institute of Technology)	2-54	3.25	3.00	2.75	3.00	3.03
The Synthesis and Characterization of Substituted Olivines and Layered Manganese Oxides	Stanley Whittingham (SUNY-Binghamton)	2-56	3.20	3.00	3.40	3.20	3.13
Stabilized Spinels and Nano Olivines	Arumugam Manthiram (University of Texas at Austin)	2-58	2.75	3.25	2.00	2.25	2.84
Olivines and Substituted Layered Materials	Marca Doeff (Lawrence Berkeley National Laboratory (LBNL))	2-60	3.40	3.25	3.80	3.00	3.33
Phase Behavior and Solid State Chemistry in Olivines	Thomas Richardson (Lawrence Berkeley National Laboratory (LBNL))	2-62	3.25	3.00	3.25	2.75	3.06
First Principles Calculations (and NMR Spectroscopy of Electrode Materials)	Gerbrand Ceder (MIT/SUNY-Stony Brook)	2-64	3.50	3.00	3.50	3.00	3.19
First Principles Calculations and NMR Spectroscopy of Electrode Materials	Clare Grey (SUNY-Stony Brook)	2-66	3.75	3.75	3.50	3.00	3.63
Characterization of New Cathode Materials using Synchrotron-based X-ray Techniques and the Studies of Li-Air Batteries	Xiao-Qing Yang (Brookhaven National Laboratory (BNL))	2-68	3.60	3.50	3.60	3.00	3.48
Search for New Anode Materials	John Goodenough (University of Texas at Austin)	2-71	3.50	3.50	3.00	3.00	3.38
Nano-scale Composite Hetero-structures: Novel High Capacity Reversible Anodes for Lithium-ion Batteries	Prashant Kumta (University of Pittsburgh)	2-73	3.00	3.00	3.00	3.00	3.00

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Intermetallic Anodes	Michael Thackeray (Argonne National Laboratory (ANL))	2-75	2.75	3.25	3.25	2.75	3.06
Nano-structured Materials as Anodes	Stanley Whittingham (SUNY-Binghamton)	2-77	2.50	2.25	2.25	2.25	2.31
Interfacial Processes Diagnostics	Robert Kostecki (Lawrence Berkeley National Laboratory (LBNL))	2-79	3.50	3.75	3.75	3.25	3.63
Model-Experimental Studies on Next-Generation Li-ion Materials	Venkat Srinivasan (Lawrence Berkeley National Laboratory (LBNL))	2-81	3.67	3.33	3.00	3.33	3.38
Nanostructured Metal Oxide Anodes	A.C. Dillon (National Renewable Energy Laboratory (NREL))	2-83	3.00	3.00	3.25	3.00	3.03
Investigations of Electrode Interface and Architecture	Nancy Dudney (Oak Ridge National Laboratory (ORNL))	2-85	3.33	3.00	3.00	2.33	3.00
Development of Novel Electrolytes for Use in High Energy Lithium-Ion Batteries with Wide Operating Temperature Range	Marshall Smart (California Institute of Technology)	2-87	3.00	2.00	2.67	2.67	2.42
Polymer Electrolytes for Advanced Lithium Batteries	Nitash Balsara (Lawrence Berkeley National Laboratory (LBNL))	2-89	2.75	2.25	2.50	2.50	2.44
Interfacial Behavior of Electrolytes	John Kerr (Lawrence Berkeley National Laboratory (LBNL))	2-91	2.00	1.33	2.67	2.33	1.79
Molecular Dynamics Simulation Studies of Electrolytes and Electrolyte/Electrode Interfaces	Grant Smith (University of Utah)	2-93	3.00	3.00	3.00	3.00	3.00
Bifunctional Electrolytes for Lithium Ion batteries	Daniel Scherson (Case Western Reserve University)	2-96	2.60	2.67	2.40	2.80	2.63
BATT Program- Summary and Future Plans	Venkat Srinivasan (Lawrence Berkeley National Laboratory (LBNL))	2-98	2.67	2.67	2.00	2.67	2.58
Electrochemistry Cell Model	*Dennis Dees (Argonne National Laboratory (ANL))*	*2-100*	*3.50*	*3.50*	*3.00*	*3.50*	*3.44*
Diagnostic Studies on Li-Battery Cells and Cell Components	*Daniel Abraham (Argonne National Laboratory (ANL))*	*2-102*	*3.00*	*2.67*	*3.00*	*2.67*	*2.79*
Statistical Design of Experiment for Li-ion Cell Formation Parameters using Gen3 Electrode Materials: Final Summary	*Kevin Gering (Idaho National Laboratory (INL))*	*2-104*	*2.60*	*2.40*	*1.80*	*1.33*	*2.24*
Low Temperature Performance Characterization & Modeling	*Andrew Jansen (Argonne National Laboratory (ANL))*	*2-106*	*3.00*	*3.00*	*2.67*		*2.58*
Electrochemistry Diagnostics at LBNL	*Frank McLarnon (Lawrence Berkeley National Laboratory (LBNL))*	*2-107*	*3.00*	*3.00*	*2.50*	*3.00*	*2.94*
Diagnostic Studies to Improve Abuse Tolerance and the Synthesis of New Electrolyte Materials	*Xiao-Qing Yang (Brookhaven National Laboratory (BNL))*	*2-109*	*3.50*	*3.33*	*3.33*	*3.00*	*3.33*

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Abuse Tolerance Improvement	*Peter Roth (Sandia National Laboratory (SNL))*	*2-111*	*3.50*	*3.50*	*2.50*	*3.50*	*3.38*
Engineering of High Energy Cathode Material	*Khalil Amine (Argonne National Laboratory (ANL))*	*2-112*	*3.67*	*3.67*	*2.67*	*3.33*	*3.50*
Developing New High Energy Gradient Concentration Cathode Material	*Khalil Amine (Argonne National Laboratory (ANL))*	*2-113*	*3.67*	*4.00*	*3.67*	*3.67*	*3.83*
Developing a New High Capacity Anode with Long Life	*Khalil Amine (Argonne National Laboratory (ANL))*	*2-116*	*2.50*	*2.00*	*2.00*	*2.50*	*2.19*
Streamlining the Optimization of Li-Ion Battery Electrodes	*Wenquan Lu (Argonne National Laboratory (ANL))*	*2-118*	*3.67*	*3.67*	*3.00*	*3.00*	*3.50*
Design and Evaluation of Novel High Capacity Cathode Materials	*Michael Thackeray (Argonne National Laboratory (ANL))*	*2-120*	*3.33*	*3.67*	*3.00*	*3.33*	*3.46*
Development of High-Capacity Cathode Materials with Integrated Structures	*Sun-Ho Kang (Argonne National Laboratory (ANL))*	*2-122*	*3.50*	*3.00*	*3.00*	*3.00*	*3.13*
Novel Electrolytes and Electrolyte Additives for PHEV Applications	*Daniel Abraham (Argonne National Laboratory (ANL))*	*2-124*	*3.00*	*3.33*	*3.33*	*3.00*	*3.21*
Develop Improved Methods of Making Intermetallic Anodes	*Andrew Jansen (Argonne National Laboratory (ANL))*	*2-126*	*3.50*	*3.50*	*3.50*	*3.50*	*3.50*
Lithium Metal Anodes	*Jack Vaughey (Argonne National Laboratory (ANL))*	*2-128*	*2.50*	*2.50*	*2.50*	*3.00*	*2.56*
Structural Investigations of Layered Oxide Materials for PHEV Applications	*Daniel Abraham (Argonne National Laboratory (ANL))*	*2-129*	*3.00*	*3.33*	*2.33*	*2.67*	*3.04*
High Voltage Electrolytes for Li-ion Batteries	*Richard Jow (Army Research Laboratory)*	*2-131*	*3.00*			*3.00*	*1.13*
New High Power $Li_2MTi_6O_{14}$ Anode Material	*Khalil Amine (Argonne National Laboratory (ANL))*	*2-132*	*3.00*	*3.00*	*2.00*	*3.00*	*2.88*
High Energy Density Ultracapacitors	*Patricia Smith (Naval Surface Warfare Center)*	*2-133*	*2.50*	*2.75*	*3.75*	*2.75*	*2.81*
Develop & Evaluate Materials & Additives that Enhance Thermal & Overcharge Abuse	*Khalil Amine (Argonne National Laboratory (ANL))*	*2-135*	*3.50*	*3.00*	*4.00*	*3.00*	*3.25*
Screen Electrode Materials and Cell Chemistries	*Wenquan Lu (Argonne National Laboratory (ANL))*	*2-137*	*2.50*	*3.00*	*2.50*	*2.50*	*2.75*
Fabricate PHEV Cells for Testing & Diagnostics	*Andrew Jansen (Argonne National Laboratory (ANL))*	*2-138*	*3.33*	*3.00*	*3.33*	*3.00*	*3.13*
OVERALL AVERAGE FOR ENERGY STORAGE			**3.13**	**3.03**	**3.02**	**2.85**	**3.03**

NOTE: Italics denote poster presentations.

Overview of Energy Storage: Dave Howell, U.S. Department of Energy

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

A reviewer stated the projects were covered very well. The program has expanded over the years and now covers the area very well. The program has also expanded to include collaborations between investigators. These cooperations need to be encouraged. Both benefit and it leads to a greater understanding of the problems and potential solutions. Another reviewer commented yes, the presentation clearly describes the energy storage program and its three components that range from basic research to advanced technology development and finally to the mature technology implementation efforts from the battery industries under the USABC program. The significant technical challenges related to the batteries for hybrid vehicles, plug-in hybrids and electric vehicles have been clearly listed. Also, the recent progress made in several areas to fill in the technology gaps between the desired performance characteristics and the current technology metrics has been adequately described. Finally, the upcoming opportunities in the energy storage program have been mentioned. Another reviewer said the Sub-program is well organized and described with clear views about issues and challenges. The progress is synthetically presented with limited comparison at goals level. There were five reviewers, who answered yes, with one saying the program was comprehensively covered.

A reviewer stated the sub-program was well covered including summarizing the technical and business challenges. The reviewer could not make comments relative to previous year - however it was well organized and presented accurately following the outline. Clearly the sub-program is addressing the most relevant technology gaps in vehicle technology. The reviewer believes a gap exists in the transfer of technology created to U.S. implementation - whether materials, cell, battery or automotive applications. They also think the USABC effort is positive in addressing and the recent recovery act will make a big difference here. Another reviewer noted the energy storage R&D program covered today's most important issues and challenges. Its charter, targets, and goals are clear and well defined.

Main challenges identified during the presentation are around reducing cost, extending life, improving safety, and developing materials with higher energy densities, which are clearly the key challenges towards commercialization. There are some additional challenges that were not addressed in the program (see more details in the answer to question 2). The reviewer went on to say the three areas of focus in this program are battery development, applied, and fundamental research. Progress was reported along these three areas. Based on the report, HEV requirements are met with the help of DOE funding, although cost targets have not been met yet. Based on DOE goals, both labs and companies are shifting efforts into PHEV developments and are showing good progress, especially from applied and fundamental research perspectives. Although the overall progress has been clearly presented, some of the presenters in this program (mostly from the industry) were lacking technology data and specs to support their progress claims. Since their talks were often not detailed enough, reviewing some of these talks was challenging. Comments from another reviewer answered yes in terms of next steps. The need to emphasize higher energy systems for PHEV was well covered and is logical in view of the success in the recent cell technology to meet most of the goals for HEV. Progress on the HEV program was glossed over a bit, no doubt due to time constraints. Good review of big picture.

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

A reviewer stated no obvious gaps in the program; plans include the main issues to advance the technology. Another reviewer commented the research strategies to address the needs of the near-term HEVs, PHEVs and the long-term electric vehicles have been identified and the technical challenges have been highlighted. There are no visible gaps in the project portfolio, especially for the HEVs and PHEVs. The long-term solutions are understandably more speculative and hence are not as comprehensive. One reviewer said yes the plans are identified for addressing issues and challenges and no there aren't any gaps in the project portfolio.

A reviewer stated the plans are well focused on key issues and challenges putting the right emphasis on lithium costs and safety. The activities on alternative electrochemical couples are present but not wide enough in the Fundamental

research: this seems to the main gap. Another reviewer commented the recovery act is an excellent example of addressing one of the primary gaps - establishment of US capabilities to meet automotive needs. Additionally USABC efforts reviewed in this forum are well aligned to focus resources on establishing relevant US capabilities and addressing technology gaps. While almost all of the research reviewed was relevant to vehicle technology objectives there is a gap that should be addressed. Specifically, establishment of U.S. based technology and capability should be encouraged. This reviewer went on to say a large concern here is that much of the technology development at Argonne National Lab, sponsored by the DOE, while relevant to vehicle objectives is not addressing the gap of supporting US capabilities and industry. It appears from posters and presentations that Argonne, in the name of "return on tax payer $" is licensing technology to, partnering with and promoting non-US companies technology. Additionally the aggressive non U.S. activity on licensing and promotion of materials is actually detrimental to U.S. companies. Addressing this gap by promoting work that encouraged U.S. based partnership and benefited U.S. would be beneficial. Fund the technology development but focus the licensing activity to the benefit of U.S. industry. Comments from another reviewer said they see two gaps; PHEV work should be transitioning into application engineering and the level of EV work should be increased and accelerated. This is already taking place within some of the automobile companies. One reviewer stated yes, plans are identified for addressing issues and challenges. The apparent lack of further significant focus on energy storage for HEV applications, as opposed to focus on PHEV only is a gap which should be addressed. Another reviewer stated it looks good. Low temperature performance issue is a little unclear. In the past this was cited as the limiting design factor in sizing the battery, which affects performance and cost. They have never understood why there was a requirement to design the battery around a -30C power limitation. In later discussions with ANL staff it now seems that the low temperature performance requirements are being deemphasized and will be addressed with engineering controls and/or maybe compromising on the goals. This seems a very reasonable approach to me. The cost implications of trying to run these batteries at -30C are prohibitive and not really necessary in their view.

A reviewer stated most areas of the program demonstrated innovative plans and solutions for achieving the DOE HEV and PHEV goals. Plans were identified from cell to packs, from battery development to applied research, both from empirical and theoretical aspects. Some of the labs may benefit from establishing closer collaboration with industry which may help their plans be more focused and applicable. The project portfolio is thorough and broad around HEV and PHEV. However, it may be helpful to add near term goals and allocate budgets towards research for developing higher capacity batteries for EVs. This is particularly important given the industry shifts to pure EVs and latest announcements of various OEMs around the world (including conservative companies such as VW and Mercedes) to join venture with battery vendors on pure EV projects. This reviewer went on to say in addition, it will be helpful to add to the portfolio some research focused on building appropriate infrastructure. A well-designed charging (and battery exchange) infrastructure and new business models may address some of the major technology and cost barriers and enable a faster transition from ICE to pure EVs. With current recovery act to add significant manufacturing capacities in the US, it may be helpful to allocate some budgets towards deeper manufacturability studies promoting high yields and efficient processing. It may be also helpful to add to the program industry leaders in capital equipment for battery manufacturing. Other R&D studies can be added such as optimization of charging technologies, battery-to-grid capabilities, recycling and packaging. Another reviewer commented Howell commented in the presentation that HEV type batteries are likely suitable also for low range PHEV 10 and 20 batteries. At the same time Santini clearly showed that an average use of any batteries, including PHEV 10 and PHEV 20, are used more in energy mode than in power mode. One other reviewer noted more material companies need to be grown in US; hopefully VTP can cover the area. Also manufacturing engineering for lithium ion cell, materials and equipments are lacking in US.

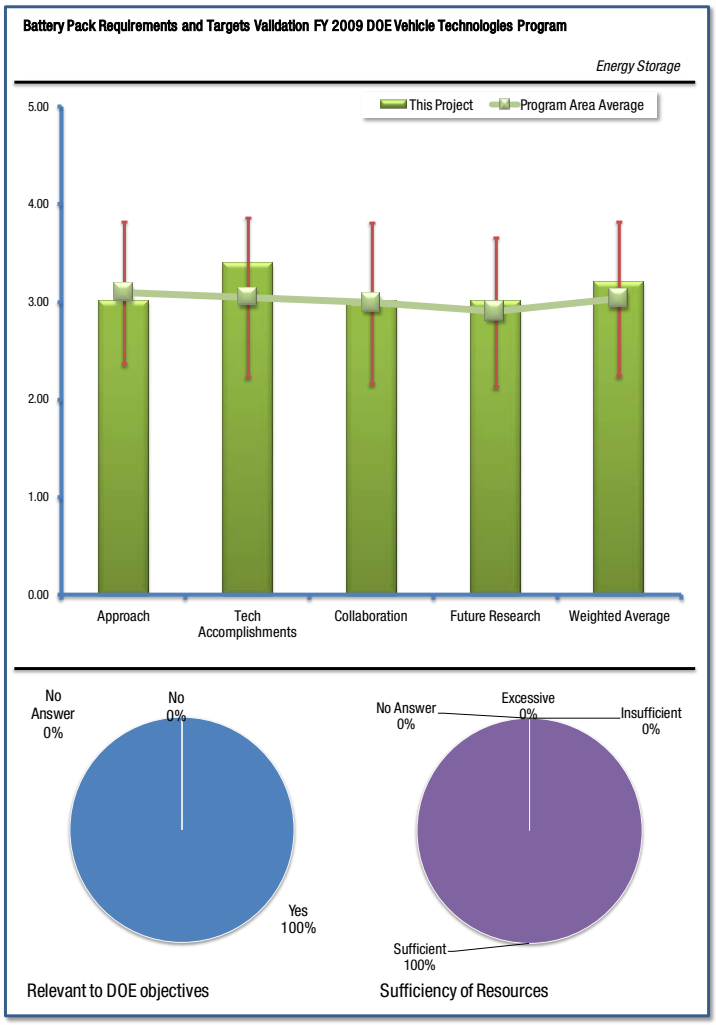
3. Does the Sub-program area appear to be focused, well-managed, and effective in addressing the DOE Vehicle Technologies Program R&D needs?

A reviewer stated the program is focused. It needs to continue the venture into new areas on an exploratory basis. Another reviewer commented the sub-program is focused on the critical technological issues in developing batteries for three types of vehicles. To ensure success and to mitigate risk, it is developing various candidate Li-ion systems with different cathodes (and anodes). It is being managed quite effectively and efficiently with good coordination among academia, National Laboratories and industry, while utilizing all the available resources nationally to fulfill the needs of the DOE VTP. One reviewer noted the Sub-program is well organized and adequately managed with a good structured approach to meet VTP goals. Comments from another reviewer stated yes almost all presentations were relevant to addressing technology gaps that will better enable the vehicle technologies mission. Concern as noted above on actual benefit to U.S. of Argonne development and licensing activity and detriment to U.S. based industry. Six other reviewers all answered yes, with one also stating the EV targets for performance and cost will need to be revisited. Another reviewer who answered yes also said the only thing they would add is that it might be good to show a list of who is working on which material - some of the PIs are working on the same areas and it's not always clear if they are or even should be cooperating more (some competition within the program is OK as well).

4. Other comments:

A reviewer stated the DOE developments efforts in the energy storage program do not appear to be as well tied to the industry efforts in some areas, to facilitate a more rapid incorporation of the technology developments for facilitating the PHEVs and EVs. Also, there are substantial efforts being undertaken by other government agencies (e.g., in battery testing) which may provide some leverage to the DOE researchers, for example in performance assessment and modeling. Another reviewer commented they were very impressed with the breadth and quality of the reviews. One thought and because they have not been asked to represent at a review, but they wonder if there could be a list of what should be covered (ideally keyed off of areas reviewers are asked to comment on) in each presentation sent out to presenters so they could present their technologies in a fashion that would allow for better assessment/review of the technologies. Most presentations were excellent, however, some seemed to be less reviewable and more like sales pitches. They believe the above could help keep content relevant for review. One other reviewer noted with growing DOE funding opportunities supporting multi lab R&D efforts, advancements and innovations in the battery area will hopefully keep emerging in the USA. Significant applied and fundamental research progress has been made in the last few years (from MIT, ANL, BAAT, NREL, etc), and the industry is expecting it will make its way into commercialization in the next five years. To be competitive with the evolving battery industry in Asia, closer interaction between academia and industry is imperative in the US. This reviewer went on to say it may also be helpful to promote R&D collaborations with Asian battery vendors or research labs. In summary, cost and energy density of lithium ion batteries are still a challenge although most fundamental materials and basic science aspects have been resolved. With some engineering work, and establishment of the right charging infrastructure, the first generation batteries are ready to be implemented in vehicles. There is clearly much room for improvement for next generation batteries which should keep key topics DOE R&D programs. Another reviewer commented cost goals for PHEV are frankly beyond aggressive. Some more realistic discussions on long term costs need to be going to ensure that we don't stop work in an area due to an unrealistic cost constraint. Things like costs with subsidies, higher cost of gasoline down the road need to be factored in. Just meeting the performance goals is going to be tough. Also, while they realize it doesn't help reduce US oil consumption, if the inventions end up being implemented in other countries with a higher gas price base, then at least we could all benefit from the reduction in greenhouse gas emissions. Comments from another reviewer noted the project portfolio could more clearly open after lithium electrochemical couples while starting with some basic studies. One reviewer stated that it was a very nice presentation, while another reviewer said the target costs are unrealistically low.

Battery Pack Requirements and Targets Validation FY 2009 DOE Vehicle Technologies Program: Dan Santini (Argonne National Laboratory (ANL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this is quite relevant since this project yields a cost/benefit analysis for the various xEVs being developed. Another reviewer noted the goals of the study were not clearly defined. One reviewer commented it provides a view of the characteristics of cost/performance to help set goals for batteries for transportation. Comments from another reviewer mentioned the project shows various objectives were not all well described. The presentation is very dense with some difficulties in following clearly the huge amount of results and the basic hypotheses. However, the conclusions derived from the various simulations are clearly analyzed. Another reviewer stated work focused on the cost of this technology path and the impact of blended operation.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the data presented seems scattered and that goes with not having a well-defined objective up front. Another reviewer noted there is a good approach aimed at analyzing the needs for a wider application. One reviewer commented it was very traditional in concept then went on to add the following observations from the presentation:

- Net present value benefit estimates
- Driving –dense urban to intra-city limited access highways
- Examine design of PHEVs to fit existing infrastructure
- Overnight charging @ 110 V standard plugs, some 220 V
- Distribution of existing garages and carports
- Evolution of dwelling units –garages per new dwelling unit
- Examine design of PHEVs to match pattern of driving
- Fully deplete battery on nearly all days after overnight charge, best 2/day charge options
- Engine downsizing in cars vs. constant peak engine power in trucks
- Interaction of charging strategy with generating unit type

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated a lot of good results have been obtained which are very useful for understanding the various vehicle/gas price/kWh scenarios. Another reviewer commented that good data was presented. One reviewer noted there was good progress to separate out the differentiation in various vehicles, EV, PHEV HEV etc. and the

differences in each were highlighted. Comments from another reviewer said the results are very interesting and favor the discussion on the ways batteries can be better used in new hybrid vehicles.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the team members were knowledgeable in the various works in the area. They were knowledgeable in the organization and the people working in the area and their publications. Another reviewer noted the Electric Power Research Institute and the IEA HEV and EV Implementing Agreement. One reviewer commented the collaborations are adequate. Comments from another reviewer said EPRI was the only other institution mentioned, but it was not clear how well coordinated it was based on the presentation.

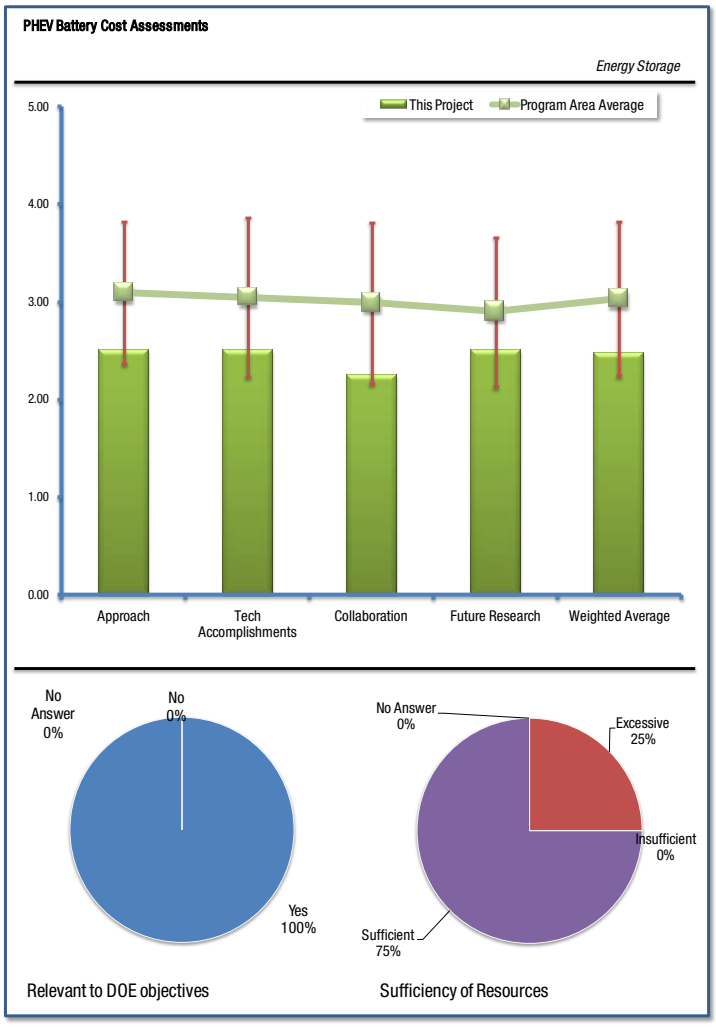
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they would be interested to see the effect on these studies on any residual value of the batteries at the end of their useful life. Another reviewer commented it was not clearly laid out. One reviewer mentioned marketability, cost, various tradeoffs of cost, range, and other characteristics. The cost benefits analysis points towards the future directions. Comments from another reviewer noted the future plan is well consistent with the achieved results. Another reviewer stated future cost/benefit work should include separate a separate assessment of societal costs to contribute to the development of effective climate change policy. This should include estimates that have been established for the social costs of carbon, which are currently estimated to be $68/ton @ 2% discount or $40/ton @ 3% discount rate.

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

A reviewer stated it was difficult to judge as there was little discussion on the details of gathering data for the study. Another reviewer noted the resources seem adequate.

PHEV Battery Cost Assessments: Brian Barnett (TIAX LLC)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the project addresses the critical need of "estimating the battery costs" for HEVs and PHEVs. Cost is an important parameter in determining the widespread use of these advanced Li-ion batteries in the energy-efficient and environmentally-friendly automotives (HEVs and PHEVs). Replacement of conventional gasoline-based vehicle with these vehicles will considerably bring down the consumption and demand on petroleum and decrease our national dependence. Another reviewer noted the business case for selecting a battery and a supplier depends on the cost of the batteries. One reviewer mentioned the project involves battery cost assessment for PHEV. This study may assist DOE in understanding cost barriers for vehicle electrification implementation and will potentially help the industry identifying battery components, materials, designs, and manufacturing processes in which cost optimization is inevitable. Comments from one reviewer mentioned it seems to them that the current Li-Ion technology is actually quite capable of meeting many of the goals for the program, although safety and lifetime metrics are maybe not as clear. However, the real killer to market introduction is simply cost and, in view of the vast scale of the consumer electronics business, they do not expect that costing to get much of a boost from the additional HEV market. Thus, this type of study is critical to setting realistic direction.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the project is well designed, focused and integrated with other efforts and developments. It does contribute to understanding the impact of one of the crucial barriers (cost) and is being well implemented. However, it could be expanded and improved further to make it widely applicable. Another reviewer noted the model (detailed and assumptions are not described) depends upon inputs and outputs. One reviewer mentioned TIAX developed a unique cost calculation platform and assessed evolving battery cost at a high level view. The goal was to evaluate the benefits of alternative chemistries which are a critical decision to battery vendors when planning for high capacity manufacturing plants. Comments from one reviewer said a broad range of input parameters were used and implemented in order to build practical analysis via multi-variable sensitivity approach. Some inaccuracies in the model may be related to some critical fixed and variable costs components that are not clearly discussed in the model (e.g. R&D, energy input, plant maintenance, depreciation, sales, admin, and others). Those components may add up to %tens and can change the price range per KWh. The capital costs assumptions were not discussed. Another reviewer stated it's not a bad approach and they realize that a lot of actual hard data is unavailable. However, their slides states that they do not expect some of their designs to meet the stated power requirements. Shouldn't this just

result in them specifying a larger and more expensive battery to meet the goals? The approach is based on sizing the battery for energy whereas power seems to be equally if not more important.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that some interesting findings emerged from this cost analysis; i) the cost of the material (cathode is not as significant as the electrode thickness and ii) the speed of cell fabrication and the separator cost are more critical. However, there are a few shortcomings as well in this approach: i) the cost analysis was performed on 18650 cells which are not quite the prototypic model for HEV and PHEV batteries either in size, quantity or manufacturability; ii) the analysis included several performance targets such as capacity fade (life), and power (a thick cathode is not an option if it doesn't meet the required power) which are being independently tracked in the program. This reviewer went on to say a better analysis, they believe, would be the cost of the battery at the beginning of life, with no reference to its life and how often it needs to be replaced in a lifetime of the vehicle. Instead it should focus on the cost variations arising out of availability or modification of materials, either in composition or processing (e.g., surface coatings). Another reviewer mentioned a calculated sensitivity of single input which will help with battery development projects. One reviewer noted technical barriers are addressed to a good degree. The model is thorough and could potentially be applied to different battery designs. The choice of cathode chemistries and loadings was well analyzed. Other important costs parameters were evaluated such as "made in China" and processing speeds. Some inaccuracies in addition to the missing cost components (see above question), include:

- Assuming 80% SOC for all chemistries is inaccurate. In practice, optimal SOC may vary to a larger extent in between the alternative chemistries while lifecycle is directly correlated. Both SOC and lifecycle are important cost components which have not been analyzed deeply
- The cell design studied in this model is cylindrical. Although the model verifies existing cost numbers for those cells (mostly used for consumer electronic) the results are not practical for future PHEV, HEV, and EVs.
- Manufacturing costs are influenced by energy density, total energy capacity and the ratio of power to energy. Will be helpful to add those factors to the model when discussing the effect of alternative chemistries

Comments from another reviewer said some of the points seem interesting and it's a worthwhile independent view of costing. Certainly, there is value in pointing out that reducing costs does not necessarily mean working on the cheapest materials - it's value not cost that is the critical factor. However, the level of detail they can include in such a study is too limited in my view. What you really need is an estimate of the cost for the size of battery to meet the DOE power and energy goals (and others) and this doesn't do that. Another reviewer stated they fear that the conclusions are simply wrong because of the oversimplification involved. For example, some of the lower cost cathodes also seem to have great power, cycle life and safety and these all help reduce cost. But on an energy basis, which TIAX used to size the battery, they get unfairly clobbered.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the project needs to collaborate more with the current USABC battery manufacturers to get their inputs into the cost model. As well, the analysis model (being paid by the DOE) will have to be available for the battery companies for their use in the HEVs and PHEVs batteries. Another reviewer commented they need more coordination with battery developers. One reviewer noted no collaboration has been mentioned and collaboration with industry is critical in this case for the practicality of the study. Comments from another reviewer mentioned it was nice to see some real costs of these materials as such data is hard to come by.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

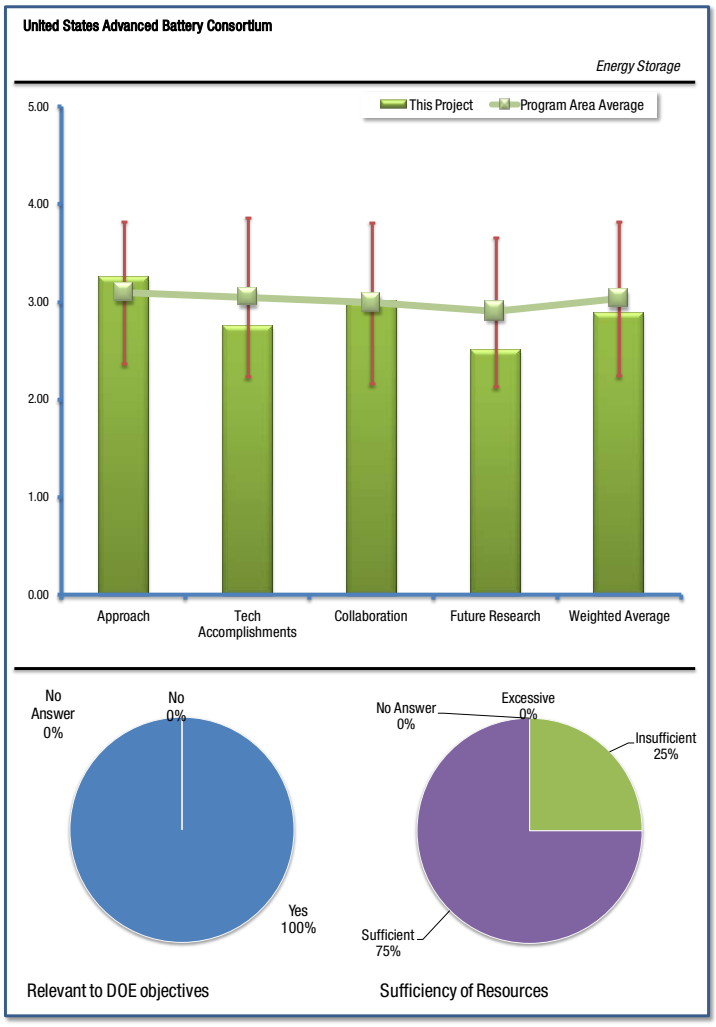
A reviewer stated the planned extension to the prismatic cells is acceptable. As well, it should be extended to the likely designs/chemistries of the PHEV batteries. Another reviewer noted the project should include all costs

associated with battery and system manufacturing to align with DOE system goals. One reviewer commented the future research directions have not been directly pointed during the presentation. It may be useful to evaluate the cost of prismatic cells, different sizes of particles, loads, and more advanced chemistries. As mentioned above, the effect of increasing the energy capacity of packs, and manufacturing throughputs on the battery cost is critical to the industry and be useful to investigate it. It will be interesting to see the cost evaluation for EVs. Comments from another review mentioned if this work is to be continued/expanded, they must do more to get more realistic estimates of the required battery cost for each system. The reviewer thinks this is far more important than looking at other cell sizes. They will never be able to get accurate estimates and that isn't even the goal, but without a much more realistic estimate and attempt to size the battery for the DOE power goals, these estimates are so far of they are misleading and dangerous.

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

A reviewer stated the resources are adequate. Another reviewer noted while this was an interesting first step, they think it needs more focus on factoring in real design constraints before expanding this to other cell sizes, etc. Only if they can get a more reliable estimate of the impact, or lack of impact, of the cathode chemistry on costs, this would provide very valuable guidance to the program. As it stands now, they don't have a high level of confidence in their conclusions. Unless they can undertake to address my concerns, the reviewer would not fund this work. Wrong answers are worse than no answers in their view.

United States Advanced Battery Consortium: Kent Snyder (Ford Motor Company)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated a co-operation of the vehicle manufacturers with the government in a partnership operation. Sometimes have unrealistic outlook on the real problem areas and set unrealistic goals. Another reviewer commented the project is a key support to the overall DOE objectives. The USABC clearly contributes to identify technology requirements and ways to measure them. One reviewer mentioned it supports improved efficiency through increased electrification of drive systems. Comments from another reviewer noted PHEV vehicles in particular can lower use of gasoline and limit CO_2 emissions. This program develops batteries for those applications.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated there is a need to include the battery industry in the operations and program development, not just the car manufacturers. Also need a "systems approach" to developing an improved battery performance not piecemeal outlook at single variables/materials. Another reviewer mentioned the USABC activities are well focused with an adequate approach to the main aspects of an applied research aimed at developing battery for practical and cost-effective use in vehicles. One reviewer commented very good progress on HEV battery development. Comments from another reviewer noted given the environmental concerns and government subsidized electrified vehicles, USABC should consider revising the cost goals upwards, while these programs are in place. Cost goals are intended to be such that PHEV and HEV are made competitive in the market place. The subsidies will offset cost of vehicles and therefore cost goals can be adjusted in short term. The relative improvements in last year appear not significantly better/different than previous year activities. The same issues exist and have not been resolved. This reviewer went on to say it is noted that PHEV development is being emphasized showing alignment with DOE goals and that is a sound direction change. However, the fitting of HEV type batteries for PHEV without significant change is a bit disappointing as much more can be done in terms of optimizing designs towards high energy. This force fitting that is pursued within the program for systems having intrinsically low performance are a high risk in the PHEV segment.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated they have established performance criteria for the various vehicle types. Need more emphasis on electrochemical capacitors for the longer term. It is encouraging to have a more realistic approach to batteries than in the past. Another reviewer commented the results of USABC projects are a reference for any battery developer of battery for vehicle applications. The progress has been interesting with continuous update of the technical and

economical targets for various battery applications. The relation to the assessment studies at ANL and TIAX is not clear to better tune battery requirements. The technical progress is well described with respect to the technology targets. One reviewer noted little progress in last year towards PHEV goals and new ideas need to be pursued.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated it has greatly improved over the past. They have moved from a dictatorship that does not listen to the technology developers to listening to the real world and some co-operation. Past projections for costs and performance have been unrealistic and based on wishes and not facts. This is changing, but slowly. Another reviewer mentioned there is a very balanced contribution of key stakeholders. The roles of each participant are effective and well coordinated with an effective example of good public-private partnership. One reviewer noted the battery companies should be more tightly integrated into this partnership. Comments from another reviewer said very little progress has been made that shows significant progress towards the PHEV goals which seems to be main focus of DOE efforts. Verification measurements do show progress, while no fundamental progress has been made towards fundamentally higher energy. It would be nice to see improvements/change of direction that allows more of a step change and not "more of the same" as what has been done when focus was on HEV. It is understood that it is hard to change direction quickly, but if PHEV goals are to be achieved the program should consider take into considerations more designs geared toward energy rather than power. The PHEV goal of 150Wh/kg is significantly behind and still the consortium is betting on technologies that are at those numbers on the cell level, so a fundamental change will be needed in order to reach the target set. This might take a new look at available materials and cell design.

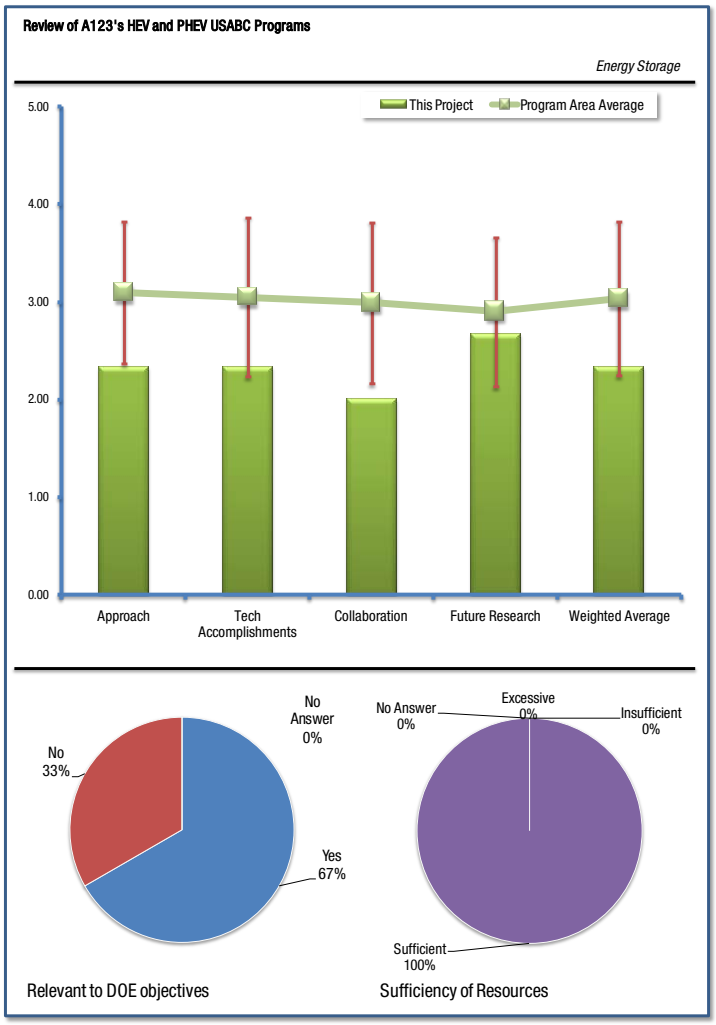
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the project has improved but now a more realistic view of is emerging. Another reviewer mentioned there is a perception of the main challenges and barriers but there is not a clear description of the future plans to overcome them, even if new projects have been granted. One reviewer commented a shift in focus of battery research from HEV/PHEV to PHEV/EV is entirely appropriate and is consistent with broad direction that the battery development is heading within the industry, particularly considering the 2011-2013 introductions of 100-mile range EV LDV platforms from Nissan, Mitsubishi and Ford and the introduction of the GM Volt PHEV. EV battery targets should be substantially updated. The current AABC cost and performance targets would be different if chosen today. Comments from another reviewer noted fundamental changes are needed to meet the PHEV goals. Right now the program is betting on chemistries that on cell level are at about or less than the 150WH/kg stated. Unless the goal is changed that direction will ultimately lead to a failure and hence a "poor" rating is given.

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

A reviewer stated the battery manufacturing for vehicle applications espoused by the USABC exists to a very limited extent in the U.S. It will be 2 - 3 years before the effect of the stimulus package will be felt. Another reviewer mentioned there is an intuitive evaluation of the resources by considering the new projects funded. One reviewer noted an increase in the funding levels might be necessary to keep on track with the new emphasis on PHEV/EV energy-optimized battery development.

Review of A123's HEV and PHEV USABC Programs: Ric Fulop (A123Systems)



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated Li-ion batteries utilizing the nano-phase $LiFePO_4$ cathode have impressive performance characteristics (calendar life, cycle life) and safety and are viable candidates for electric vehicles, especially HEVs and possibly PHEVs. A123 systems successfully developed this technology for commercial applications (power drills) and are in the process of developing suitable cell/module designs for the HEVS and PHEV that would meet the DOE objectives for Energy Storage technologies under the VTP, which is aimed at reducing the consumption of petroleum and thus our national dependence on its (foreign) sources. Another reviewer mentioned the presentation shows no actual data that is reviewable, else than pictures of modules. There is only relative data, but no actual numbers and therefore the relevance cannot be assessed. One reviewer commented A123 is developing batteries for HEVs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the use of nanophase (and suitably doped, as being claimed) LiFePO4 as cathode has resulted in substantial gains in the power density over the oxide counterparts, albeit at low specific energies. Also, partly due to reduced (oxidative) degradation of electrolyte at the (low) charge potentials of $LiFePO_4$, the cyclic stability and calendar life are equally impressive. These attributes combined with the safety make this approach attractive for HEV needs. For PHEVs, however, the requirement is a higher specific energy, which makes this approach less attractive. An improvement of ~ 30% has been accomplished in the recent cell design, mainly by modifying the anode. Details on the latter haven't been presented. Another reviewer noted the program manager shows that issues exist with anode degradation. In particular for deep discharge scenarios, this is the use case for PHEV. This anode degradation leads to excessive lithium available in system and is a very big safety concern, since phosphate runaway reactions are very quick during overcharge, in particular. These need to be addressed to properly address safety before work on optimizing separators and other less important areas are addressed. This is fundamental to Li-ion design and is especially important for long cycle life systems. One reviewer commented it is not clear that A123 is doing what is necessary to overcome the gaps they identified that exist between their current capabilities and the FreedomCar 25 kw goals.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated significant technical accomplishments include an impressive cycle life of ~ 10,000 (at 50% DOD), good calendar life, pulse power capability and low temperature performance in cylindrical cells. The battery system using such cells meets or slightly exceeds the DOE targets for the HEV in performance, but falls short in mass, volume

and cost (even after 40% reduction in the cell cost). Prismatic cell design with higher capacity (20 Ah) and modular stack designs are being developed for PHEVs, which may marginally improve the specific energy. An unspecified modification of the will improve the specific energy by 30%. It is unclear what the targeted specific energy of the PHEV cells. Also unclear are: i) whether the large format cells need to have (additional) safety features or ii) if the PHEV cells can be operated without individual cell-level charge control, especially since the deep discharge cycling causes greater cell dispersion. No details were provided on the redox shuttles mentioned as proven. Another reviewer mentioned it was impossible to assess as no actual numbers only relative numbers, are given in presentation. This does not allow the reviewer enough insight into the data. However, it is well known that LiFePO4 systems have issues in reaching the 150Wh/kg and volumetric targets that USABC and DOE is developing against. PI show no progress or direction towards how those goals will be achieved. PI also stated that they are reaching the cost goals, but that was later discredited by DOE representative, which again gives no insight on how to assess progress toward cost goals and puts in question the validity of other data, which again was not shown.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated yes, good collaborations exist with the auto manufacturers and national laboratories, though more interactions are to be established. Another reviewer noted no information on this, so have to assume it does not exist. One reviewer mentioned A123's work with Sandia is good and the same for their work with NREL. However, A123 is apparently not working with anyone to overcome the gaps identified by A123.

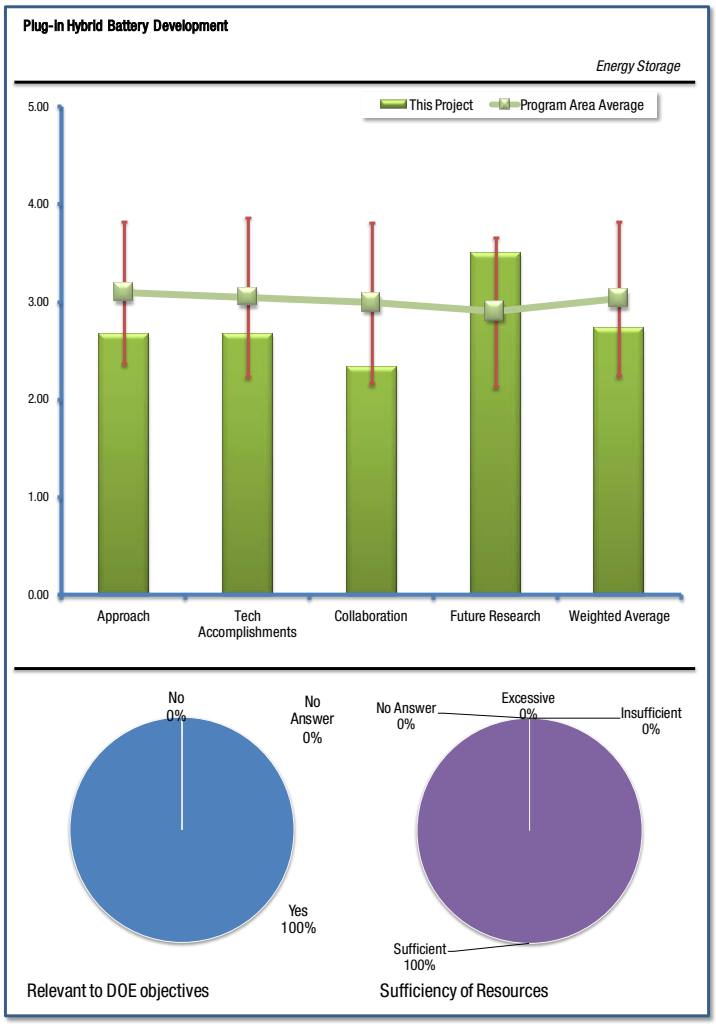
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the future work on large format prismatic cells and the modular stack designs are encouraging towards improving the specific energy for the PHEV needs. However, the issues associated with large cells and the need for suitable charge control for deep-discharge cycling need to be addressed. Also, it is important to establish that the (marginal) 30% improvement in specific energy achieved with modifying the anode will not pose additional safety or performance issues. Another reviewer mentioned it is a good idea to work on anode cycle life. However, the PI should consider working with other materials or maybe blend in other materials, as capacity is too low for the DOE goals for electrification of longer range. One reviewer commented A123 did not present sufficient information about their future plans to predict what success they might have. However, they have made significant progress in the past and will probably continue to improve their batteries.

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

A reviewer stated the resources are adequate. Another reviewer commented A123 is apparently making progress based on the awards that they have received recently. The funding they have received appears to be sufficient.

Plug-in Hybrid Battery Development: Cyrus Ashtiani (Enerdel)



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the energy for a titanate anode system is relatively low compared to a graphite anode system due to the low voltage of the system. However, the system can make up for this deficiency if the cycle life is sufficiently high and the power capability is high enough. This barrier makes the likelihood of success considerably lower than with other chemistries, however. Another reviewer commented the project is developing batteries for PHEV.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The effort does not seem to make a strong effort to overcome the limitations mentioned above. The HEV cell has in the Gap Analysis only 34 Wh/kg, while the specific power is only 1300 W/kg. These values are lower than the presently used NIMH, while the costs and safety properties are not as good. The values are considerably lower than any other lithium ion chemistry using graphite as an anode. Another reviewer commented that they need to develop full size HEV cells (~4-6Ah cell), demonstrate performance, demonstrate life, demonstrate safety, and provide cost basis and module design & development.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the system work (scale up in size) is nearly complete according to the contract, but the properties are still far from being defined for either the HEV or PHEV batteries. Another reviewer mentioned cell scale up proved that a ~5 Ah cell fully meets/exceeds USABC HEV requirements. The scale up to ~5Ah Gen2/Gen3 accompanied with a 14% performance improvement. It has the best-in-class low temperature performance and unparallel abuse-tolerance with the full size cell. It also has ~13 years life projected at RT. HT calendar life enhanced. One reviewer commented good cold-crank HEV performance. There wasn't sufficient information on battery life.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the collaborations seem to be limited to the USABC and DOE administration. Another reviewer mentioned that co-operation was mainly with ANL. One reviewer commented good coordination with National Laboratories - they would like to see more involvement with automotive OEMs. They would also like to see how EnerDel will be integrating their cells on a pack level and/or see better coordination with a systems integrator for cell integration into packs.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

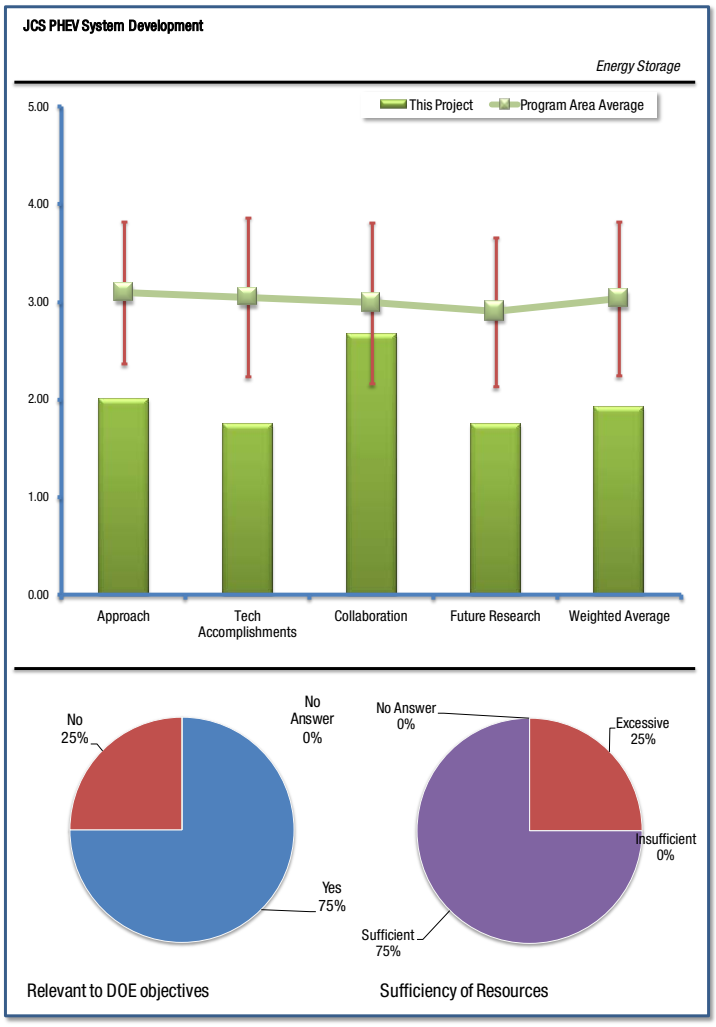
A reviewer stated continued focus on titanate anode with higher energy density cathode may lead to a substantial breakthrough for PHEV/EV batteries. This is exactly the sort of high-risk, high-payoff work that should be focused on. Another reviewer mentioned the following things:

- Task 1 –Cell development
- Gen 3 of 4 cell generations (Gen2, -3, -4)
- Use gen2 testing for benchmarking & assessment
- Gen3 design & development in parallel
- Gen4 design & development from mid-program using latest findings
- Determine-Safety / Life, Abuse testing, Cycle & calendar life testing
- Prismatic pouch life testing assessment
- Module Design & Development
- Preliminary module design & development
- Will use latest available cells (Gen3)
- Modules will be subjected to performance characterization (INL), thermal characterization (NRL)

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

A reviewer stated the resources seem to be well designed for the challenges of the program. Another reviewer mentioned they were reasonable for level of effort. One reviewer commented while the funding is likely sufficient for the planned work, EnerDel is making good progress in a relatively unique area - titanate anodes. A funding increase would likely accelerate work in this area.

JCS PHEV System Development: Scott Engstrom (Johnson Controls-Saft)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated Li-ion batteries are being developed by Johnson Control-SAFT, with their impressive cycle life, calendar life and more importantly high specific energy densities are strong candidates for PHEVs. This technology displayed impressive performance characteristics, durability and reliability in several non-vehicular applications. Their batteries show good promise in meeting the DOE objectives for Energy Storage technologies under the VTP, and can contribute to a significant reduction in the consumption of petroleum, and thus in our national dependence on its (foreign) sources. Another reviewer noted JCS has shown good progress towards functional HEV systems and PHEV is early yet. One reviewer commented the work is targeting the demonstration of cells and system designs to meet USABC targets. Optimizing thermal management solutions and cathode materials are critical challenges in the process of battery implementation in PHEV. Comments from another reviewer said in principle it does support DOE objectives, but in practice this effort seems to be so ineffective that it is not actually supporting the DOE program at all. This reviewer recommends killing this program.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach being adopted by JCS appears sound and feasible. Among the various options available for the cathode and anode materials, lithium nickel cobalt aluminum oxide (NCA) and graphitic carbon form the most durable system with possibly the highest specific energy, in large format cells, as required for the PHEVs. Though JCS optimized the cylindrical cell designs for the early use, prismatic designs are being developed as well for improved packaging. Further developments are in progress to boost the specific energy and reduce the cost. Another reviewer commented JCS will have some issues as batteries start storing at high voltage, required for PHEV applications. Ni-based chemistries have traditionally been shown to have issues with high temperature performance. The presentation does not show that progress toward the storage is being worked on and is a high risk issue as the calendar life degradation would prohibit long life and be a warranty issue risk in commercialization. This reviewer went on to say abuse tolerance testing should be expanded to internal short similar to what is Japanese law (PSE test)and extended overcharge periods, likely to be adopted by rest of world for Li-ion batteries. This could otherwise be a significant commercialization hurdle down the road. Earlier presentation by this group has shown more data, but this particular presentation showed no progress or no data, so rating becomes low due to this. One reviewer mentioned the approach is not very clear. The presenter mentioned optimization work on cells, systems, and manufacturing levels without getting into much quantitative/experimental details on procedures and analysis. One of

the few examples given during the talk was JC-SAFT work on chemistries besides NCA, such as LiFePOx but with no technical specs supporting it. Comments from another reviewer said it was hard to answer as the talk was so vague, but their disclosure that they are working on $LiFePO_4$ and NMC instead of their NCA chemistry is encouraging.

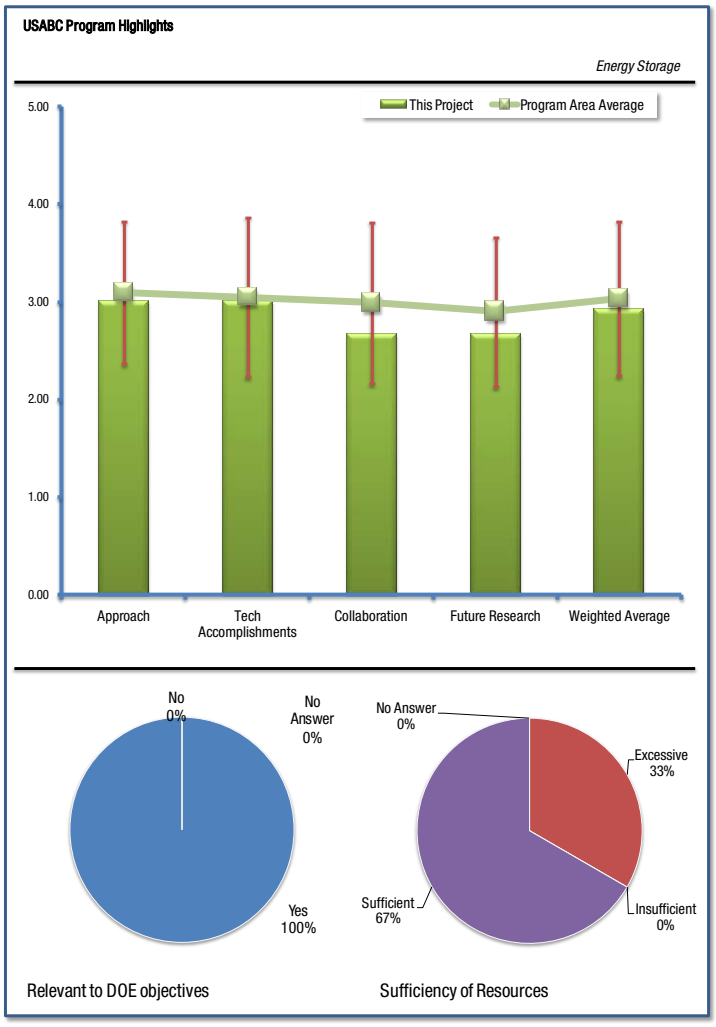
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated specific details haven't been lacking on the technical accomplishments. However based on their earlier presentations, it is clear the JCS (SAFT) cells have impressive specific energies, cycle and calendar life and low temperature performance. Further improvements in the performance and costs are being pursued. As well, system level safety and thermal issues are being addressed and the cell assembly processes are being improved. It would have been helpful, if JCS presented the technology gaps between their current progress and targeted performance. Another reviewer commented JCS gives no data for which technical achievements can be measured and hence a poor rating. This was essentially a waste of reviewer time, unfortunate for what appears to be a solid effort. One reviewer commented accomplishments and progress were mentioned, but the presenter sounded somewhat pessimistic with regard to meeting battery cost and volumetric energy density targets. Assessing general thermal abuse tolerance with USABC, developing testing and abuse methodologies with failure analysis for PHEV was achieved. The status of the other accomplishments such as core system software development, thermal management models, cost model, assembly process improvement, and new cell chemistries was not reported clearly enough to be properly evaluated. Comments from one reviewer said they saw no evidence of any real accomplishments presented at all. The speaker stated that they cannot meet the cost, weight or volume goals. While the cost goals are very aggressive (maybe unrealistic), at this stage of development they should be able to meet the size and weight goals. Since SAFT has shown data in technical talks with very high power capabilities, they are very disappointed that they have not made more concrete progress in meeting the DOE goals. At the very least, they could have showed data for how their systems compared to the DOE goals.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated yes, they do collaborate with the auto manufacturers and the USABC partners. They also have a more direct collaboration with the SAFT facility in US and benefited from the advancements made at SAFT-France. More collaboration with the national labs would be helpful. Another reviewer mentioned that it was not reviewed as no information was given in presentation. One reviewer noted they collaborated with USABC. Comments from one reviewer said they seem to be working well with Sandia. Also, cost information and goals being discussed with DOE.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the future research is focused on further improving the specific energy, reducing the cost and delivering the product for the PHEV-10 and PHEV -40 demonstrations. Another reviewer commented again - very little specifics, it appears program is ending? One reviewer mentioned since all aspects of the project are still "in progress" and has not yet met DOE goals; at this point there is no room for future research. It may be helpful to refine cell performances for 10 and 40 miles systems and work on getting closer to the DOE cost targets. It will be helpful to present experimental data at future meetings. Comments from another reviewer noted they were equally vague about their future plans.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the resources are adequate for the contracted efforts. Another reviewer commented unless there's a whole bunch of good stuff they are doing that they cannot present in an open forum, they see absolutely no technical justification for continuing to fund these companies. They just seem to be poking about or trying to play catch-up rather than moving the technology forward. The reviewer was very disappointed in the presentation.

USABC Program Highlights: Mohamed Alamgir (Compact Power)



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the program directly impacts the PHEV program to provide a full performance battery system. The combination cathode gives the required energy storage capability. Another reviewer noted the activities are clearly addressed to batteries for vehicle applications. One reviewer commented that while they believe this work meets the over goals and CPI certainly has developed their cell, module, pack and BMS to a level sufficient to generate confidence of a major US OEM PHEV application (GM), they are concerned that there should be more of a focus, a secondary goal if you will, of promoting the development of battery IP and manufacturing in the U.S. The reviewer's concern is that U.S. tax dollars are funding development of automotive battery technology by a wholly-owned subsidiary of LG Chem and the impact that this may have on the development of a domestic, advanced automotive battery industry. Based on the speaker's response to questions, LG Chem does not appear to have a significant interest in producing batteries in the U.S. absent high levels of public funding and subsidization of manufacturing.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the project objectives are looking at key barriers: life, cost and abuse tolerance. The approach seems reasonable but not clearly described. Another reviewer went on to mention the following:

- Battery Pack Production and Support
- Battery Program Management for US Customers
- Pack-level Analysis, Validation, and Verification
  - Prototype development and qualification Battery Pack Concepts and Designs
  - Power & Signal Architectures
  - Packaging
  - Thermal Management
- Battery Management Systems
  - Charge control algorithms (State-of-Charge estimation)
  - Vehicle interface Diagnostics (State-of-Health estimation)

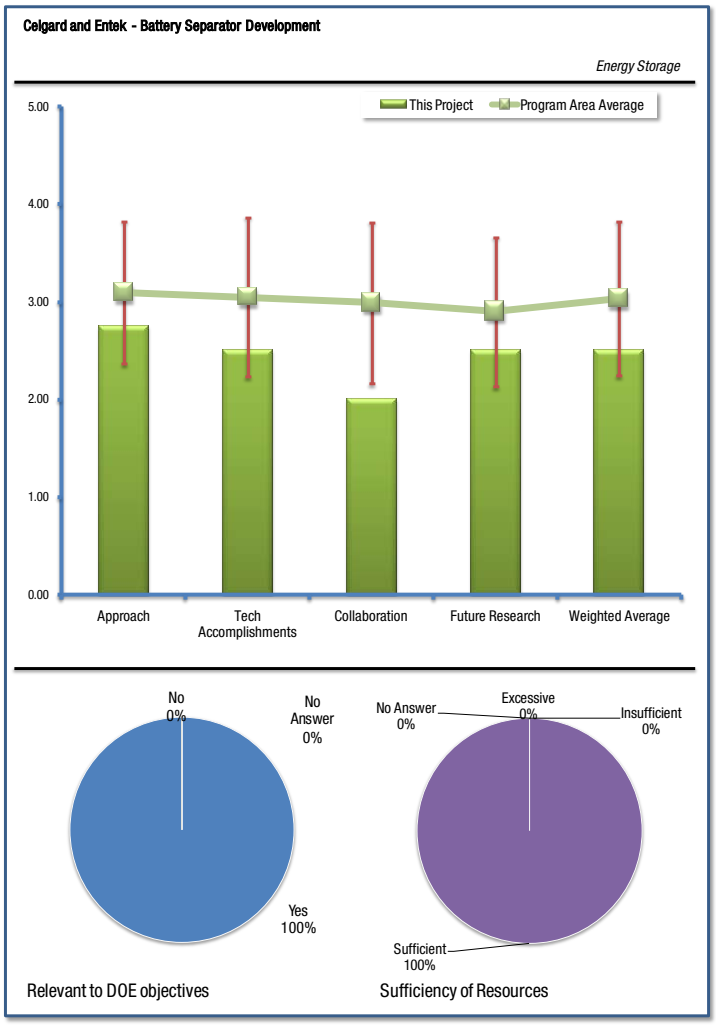
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated GM selected LG Chem to be the cell as well as the electronics supplier for the Volt program (January 2009). GM will produce the packs in high volume. The initial packs will be manufactured by CPI/LGC and will launch November 2010. Another reviewer mentioned the significant progress of the previous HEV project has not been similarly presented for the ongoing project. Safety measures such as thermal management are well analyzed and developed. There is a clear appraisal of the technical barriers. One reviewer commented good progress on HEV battery life, PHEV and HEV packaging and BMS and with improving Spinel cathode chemistry.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated they collaborated and coordinated with USABC. Another reviewer noted the collaborations are not well presented and may be extrapolated from some references in the presentation. The coordination seems adequate. One reviewer mentioned coordination with National Labs mentioned, but outside collaboration with U.S. OEMs seems limited to GM.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the project should translate the development work into a production mode. Another reviewer commented the future work requires better specifications and details: no specific indications are given in describing the next year plan.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the budget and resources seem quite appropriate with some collaboration from national labs, which must be better clarified and improved. Another reviewer commented while CPI is making good progress, they would like to reiterate that they are concerned that U.S. tax dollars are funding development of automotive battery technology by a wholly-owned subsidiary of LG Chem of South Korea and the impact that this may have on the development of a domestic, advanced automotive battery industry. The reviewer would like to see this work redirected towards US Tier 1 suppliers unless there is a greater commitment from LG Chem to invest in U.S. battery production. Based on the speaker's response to questions, LG Chem does not appear to have any significant interest in producing batteries in the U.S. absent high levels of public funding and subsidization of manufacturing.

Celgard and Entek - Battery Separator Development: Harshad Tataria (Celgard and Entek)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated for a wide spread use of Li-ion batteries, it is crucial to have adequate safety established and demonstrated. It is well known that the polymeric separator (that insulates the anode and the cathode) tends to shrivel and crumble at high temperatures, which exacerbates the thermal runaway problem. Mechanically robust separators mitigate this problem and enable the use of batteries in PHEVs, which reduces the petroleum dependence. Another reviewer mentioned low cost separators with increased safety towards, especially, internal puncture shorts are very important to meet the goal of DOE. One reviewer commented optimizing mechanical integrity of lithium ion battery separators at elevated temperatures is the key to ensure cells safety, which is part of DOE requirements implementing high performance batteries in PHEV and HEV. Comments from another reviewer noted Celgard and Entek are working together to develop a separator with mechanical integrity at high temperatures (220°C). This characteristic may provide separation between the electrodes after melting of Celgard's polymeric separator.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach looks feasible and involves i) the use of inorganic fillers to improve mechanical properties at high temperatures', ii) develop standards for the assessing the separators, especially for High temperature melt integrity, iii) establish correlation between the membrane properties and cell performance and iv) develop new separators. Another reviewer commented mechanical stability, shrinkage, is important. However, puncture strength is even more important for battery manufacturers and no data presented here about this property and not even mentioned as a property for testing, which is alarming. For program size, good value, but performance factors needs review. One reviewer mentioned it is not clear which FreedomCAR barrier is being addressed in this project. It appears that the development of this separator is for safety purposes. However, the specific characteristics of the desired separator are not clearly defined. Comments from another reviewer noted the following:

Entek: Good quantitative approaches. Tested wide range of filler materials (did not mention which materials specifically) while incorporating interesting experimental validation techniques. Issue may be related to the current environmental conditions tested, which are somewhat impractical as it does not represent real life conditions of a battery.

Celgard LLC: Testing approach is thorough. Important work in developing standards HTMI testing (mechanical, strength, stability) which is critical for the industry. The approach and plan for correlating film tests to battery performances (temp and mechanical) was not clear.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated the technical accomplishments are sufficiently significant. With the incorporation of inorganic filler (~50%), good mechanical integrity and reduced thermal shrinkage demonstrated at 200°C. Further preliminary results have been generated in formulating standard evaluation tests for separators, especially relative to high temperature melt integrity and in comparing different polypropylene microporous separators. Their performance in Li-ion cells is yet to be established. Another reviewer noted there were promising first results on shrinkage for 200°C. One reviewer commented Celgard and Entek have made progress toward using a filler material for Celgard's separator. However, the details of the testing used to establish the success of their project were not presented clearly. It would be useful to see a comparison between their proposed separator and those from others on the market (tonen, eg). Comments from one reviewer mentioned development activities are at very early stages and went on to state the following:

Entek: High filler loadings achieved, good mechanical integrity achieved. The results are very preliminary, work needs to be done to optimize separators at extreme conditions and inside a practical prismatic cell to ensure mechanical stability during cycling. Overall, detailed technical results are missing: will be helpful to focus on modeling cell characteristics at various environments.

Celgard: Overall accomplishments and work progress is fair, again not much technical data has been shown.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated Entek has collaboration with the Portland State University, while Celgard hasn't listed any collaboration. Another reviewer noted there were none available to review. One reviewer mentioned that there is collaboration with Portland State University and EMI for processing equipment. There will be collaboration with USABC battery vendors on future integration and testing. It may be helpful to start collaboration with battery vendors/industry at an earlier stage. Comments from another reviewer said it is not clear that any interaction has occurred with other interested parties such as battery manufacturers.

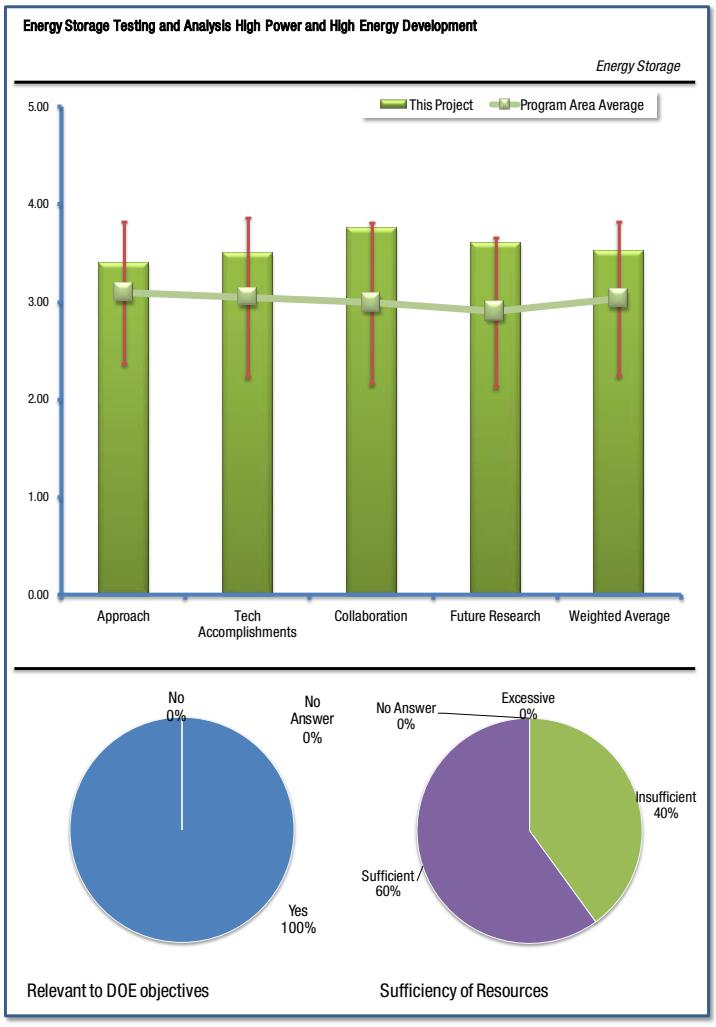
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the future activities include: i) scale up of the fillers-based membranes to commercial production, ii) supply of the sample to USABC partners, iii) Assessment of Celgard polymers in cells and correlate the separator properties to cell performance. Another reviewer commented the future should focus on puncture strength, qualification, comparison with competition and improvement of deficient factors found in this benchmarking. Celgard has some development in other products with regards to this, but not reflected in this work with DOE. Apparently this was captured under Z direction strength, but no properties given for this so hard to assess this very important factor in this presentation, which leads one to believe it is severely deficient with this method. One reviewer mentioned their plans have not presented clearly. Comments from one reviewer said the following:

Entek and Celgard LLC: Additional mechanical testing at high temp conditions, while correlating film characteristics to cell performance are required. As minor mechanical deformations during operation may cause severe lifecycle degradation, this aspect needs to be tested more extensively.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the resources are adequate both at Entek and Celgard. Another reviewer noted the project seems to have proper funding level. As the pilot phase is entered, funding will need to increase and also staffing. One reviewer

commented the resources are sufficient for both. Comments from one reviewer mentioned this is a new project, which is funded at a sufficient level at this time.

Energy Storage Testing and Analysis High Power and High Energy Development: Tim Murphy (INL, ANL, and SNL)



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated absolutely, INL provides the best independent evaluation of batteries in the US. Another reviewer commented it is critical to establish reference for testing & benchmarking technologies. One reviewer mentioned the group has taken the lead in developing the critical tests for performance and lifetime in vehicle applications. The only difficulty is the lack of dissemination of data produced by the group due to proprietary restrictions placed by submitters. Comments from another reviewer noted it provides the basis for battery powered vehicles. Another reviewer stated standardized battery testing provides an important, neutral "yardstick" by which we can measure progress in the development of advanced automotive batteries.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated INL has continuously improved their methodologies and approaches to characterize batteries. Another reviewer mentioned the only item that reduced the rating from outstanding is TLVT. There's a critical need to establish reliable ways of establishing life expectancy. One reviewer commented the approaches to the various measurements seem to be consistent in addressing technical barriers. It would be useful to the battery community to establish state of the art in the various properties. This could be done without violating security of the submitters. Comments from one reviewer noted surveys and evaluations of usage data while another reviewer said the only improvement they can think of is to expand program resources to allow more testing.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the group continues to make good progress on DOE goals. Actual progress of manufacturers in achieving DOE goals might be able to be disseminated. Another reviewer noted benchmark testing of available batteries and systems, diagnostic testing for USABC, etc. life testing, and battery monitor development.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated it's a great lab to work with. Another reviewer commented INL and Argonne seem to have very good coordination and complement each other in the various types of measurements. One reviewer mentioned excellent coordination of work with other National Labs, USABC and battery manufacturers. Comments from another reviewer noted the following:

- Argonne National Laboratory - Procedures, Analysis, Applied Research, Life Prediction Tools

- Sandia National Laboratories - Abuse Tolerance, Life Validation Methods
- National Renewable Energy Laboratory - Thermal Imaging, Analysis, Models
- USABC- Energy Storage Technical group

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

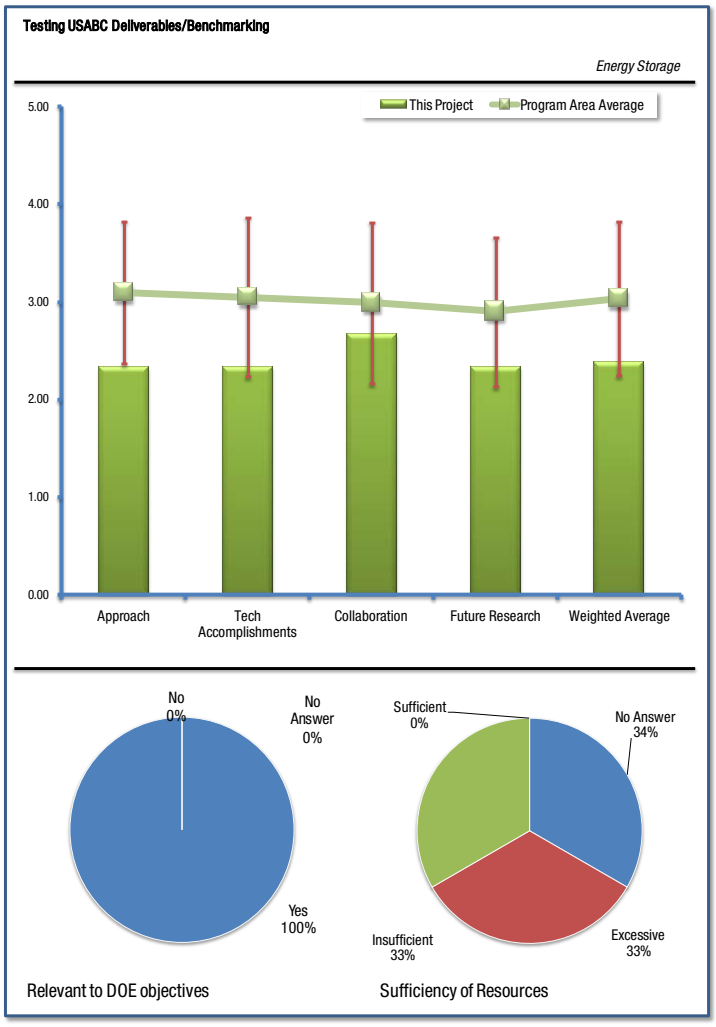
A reviewer stated they have reservations though with respect to electrolyte work. Another reviewer commented future work planned is well thought out, relevant and moves in a direction that will support future automotive battery development. It sounds like INL will continue improving the available "toolbox" for automotive battery benchmarking. One reviewer noted manuals for Testing, Analysis, and Life Predictions focused on supporting technology development aimed at meeting the DOE/United States Advanced Battery Consortium (USABC) Technical Targets for batteries. This reviewer went on to mention the following:

- Plug-in HEV procedures manual (rev. 0) published 2008
- Testing of Program Energy Storage Device Deliverables
- Annual testing status report on all testing projects to DOE in November.
- Quarterly testing status reports to USABC Tech Team.
- Diagnostic Testing and Applied Research activities
- Reported under Applied Battery Research

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

A reviewer stated they always had issues with channel allocations at INL. Now that DOE is awash with funds, maybe it is the time to add those channels. Another reviewer noted the resources are reasonable. One reviewer mentioned funding is likely sufficient for the planned work, but funding should probably be increased to allow an expansion of independent analyses of competitive Li-ion and DCL energy storage devices, test development and diagnostics development.

Testing USABC Deliverables/Benchmarking: Ira Bloom (Argonne National Laboratory (ANL))



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated performance assessment of prototype cells and battery modules either from the USABC contractors or from other sources (termed here benchmarking) is a critical step (precursor) for incorporating such batteries into the vehicles. Such assessment and understanding the calendar and cycle life implications will pave way for a rapid insertion of these technologies in the desired application and thus minimize the petroleum consumption and dependence. Another reviewer commented its critical work to get an independent estimate of how the batteries being developed by developers/partners really work and also to track the state of the art from other manufacturers. One reviewer noted Bloom et al. are attempting to determine the life of cells and batteries.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach involves; i) standardizing the assessment procedures and preparing manual either for benchmarking non-DOE battery technologies or to assess the contract deliverables from the USABC partners, ii) performing assessment tests on cells and battery, modules, iii) Identifying appropriate acceleration methods for calendar life and cycle life and iv) developing models to understand the experimental trends and predict performance. It wasn't clear as to how comprehensive this test program is, i.e., details are lacking on how many cell/modules are being tested from what manufacturers and under what test conditions. Another reviewer mentioned the system seems to be very well thought out using a "stress test" to get a quick picture of a technology rather than relying on industry standard tests that take too long. Eventually, you obviously need both types of tests, but the stress test approach is much better suited for screening and exploratory work. Use the standard tests for validating performance of winners and a few key benchmarking studies. They really liked the efforts to understand the data using differential capacity plots and reference electrodes, rather than just reporting curve shapes. One reviewer commented Bloom et al. apparently do not incorporate the work of others in their work. It appears that they do not work closely with Dees at ANL for example. Bloom et al. should improve their approach to analysis. It seems that INL is doing what Bloom et al. are trying to do.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated some interesting test data are emerging, but nothing yet that correlates clearly with the requirements of high specific energy, good cycle life and long calendar life (and even the tolerance to high temperature, low temperature performance, safety) as derived in PHEVs. Also, it wouldn't be helpful for the reviewers, if cell details were not presented. Some of inconsistent conclusions are i) the ASI doesn't change with cycle life, yet the capacity at

high rate drops gradually (almost linearly with cycling). More extensive data are being generated in aerospace labs at partial DOD cycling than presented here (termed as LEO cycling) - worth comparing the notes. Attempts to correlate capacity fade to peak shifts in dQ/dV data from half cells is a rather low TRL (too academic) effort for this task. Another reviewer noted if, as they claim, they can tailor the stress test to the particular chemistry, this is a very important ability. This presumably permits them to focus in on the most critical test for a particular chemistry to more quickly see if the new cells are truly improved. One reviewer commented Bloom et al. are behind the work being done at INL. Consequently, Bloom et al. should work closely with personnel at INL to update Bloom et al.'s approach at ANL so that Bloom et al. can accomplish more. It seems that Bloom et al. are not familiar with the open literature where explanations exist for the data they have obtained. Bloom et al. should present arguments supporting their interpretation of their data relative to explanations of similar data published by others.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated yes, collaborations with national labs (DOE) appear reasonable. It may be extended to the laboratories from other agencies. Another reviewer commented they are obviously working hand-in-glove with Idaho. They are doing a good job of balancing confidentiality with a multitude of clients. They sem to have interlab reproducibility well established, which is very hard to do and maintain. One reviewer noted Bloom et al. should work more closely with others at INL to help them analyze their data to a greater extent.

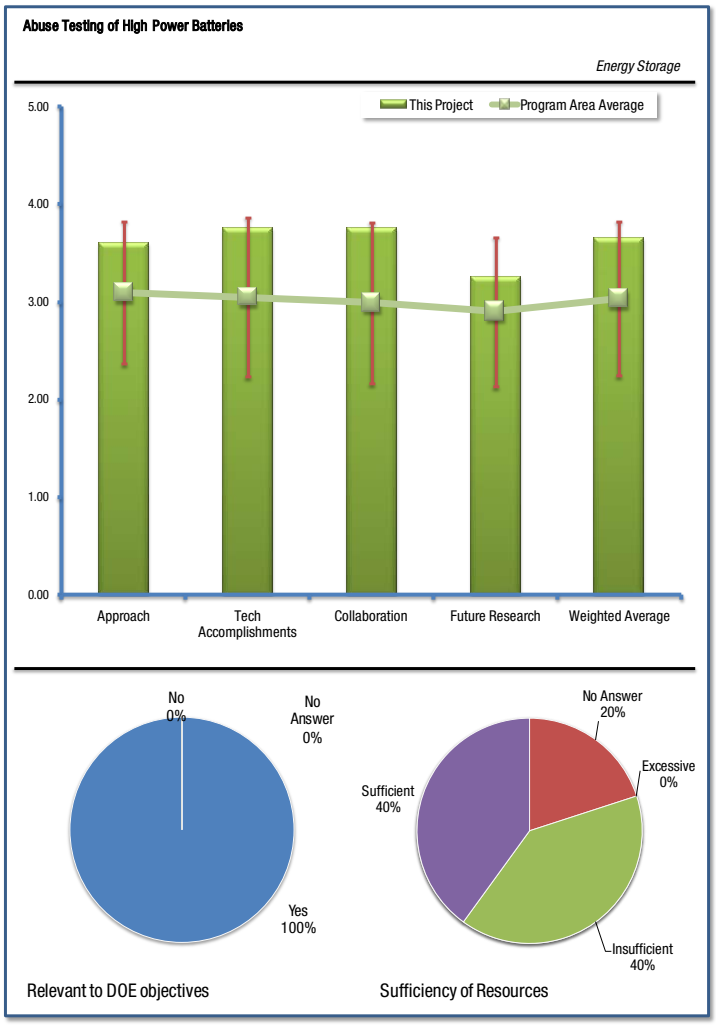
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the proposed future activities are on the same lines and include: continued testing of the (HEV and PHEV) contract deliverables and benchmarking batteries from different non-USABC battery manufacturers. As mentioned above, this is an important activity, which needs to be continued for several years, as the battery technologies are fast changing. Another reviewer mentioned going forward, they would ask that they summarize and publish the general cell behavior they observe by chemistry. For example, is the sqrt(t) relationship they showed common to some, most or all chemistries? This would be very helpful for developers. Basically, if they could share how they tailor the testing for different materials, then the materials companies and cell builders could do a much better job at screening their own cells before the cells even reach ANL/Idaho. (It may even reduce ANL/Idaho's workload.) They did not see any linkage between the fade behavior they observe and the cell modelers. This presumably happens behind the scenes. One reviewer noted Bloom et al. have not formulated a plan to work more closely with others who could help them analyze their data more completely.

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

A reviewer stated the resources are adequate for a comprehensive test program. Another reviewer commented if you currently have to delay testing or pick whose cells to test, they suspect this will only become more limiting as this business gets closer to implementation. Thus, they would expect testing needs to increase not decrease. One reviewer mentioned Bloom et al. are being supported to do work that is being done better at other labs and by others (Dees) within ANL.

Abuse Testing of High Power Batteries: Peter Roth (Sandia National Laboratory (SNL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this project is very relevant. SNL provides the most unbiased evaluation of abuse-tolerance of cells and batteries. Another reviewer mentioned this is an integral part of any Li-ion battery development – Critical. One reviewer commented the safety area is very important to DOE goals. The limits of safety for each battery type are important to obtaining guidelines for DOE uses. This group does a wide range of safety and abuse testing. Comments from another reviewer noted abuse testing is central in battery development and in DOE program objectives. The role of an independent testing laboratory is functional in verifying technology maturity for electric transportation modes. Another reviewer stated safety is a significant issue for automotive Li-ion batteries, particularly as these expand to larger PHEV and EV formats. Sandia provides the tools and expertise to independently evaluate Li-ion safety.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated SNL is at the cutting-edge of abuse-testing. They are actually coming out with innovative ways to carry out these tests. Another reviewer noted SNL is unquestionably the leader in Li-ion battery abuse testing. One reviewer mentioned the approach is clear and well supported by confidentiality reasons with technical barriers included in the test protocol. Feedbacks to battery developers may help in overcoming limitations. Vibration tests do not seem to be used for abuse analysis.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated there are always high quality results. Another reviewer mentioned the achievements may be evaluated extremely interesting even if presented in general terms for confidentiality reasons. The statistics used in abuse testing is not analyzed and the number of cells and modules described seems not adequate to cover all testing sequence. One reviewer noted it's a one-stop-shop for cell abuse/destructive testing.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the collaboration is limited to developers and SAE inputs. Collaboration with accelerated testing laboratories would be beneficial in better defining deterioration mechanisms and identifying abuse procedures. Another reviewer commented there was good coordination with National Laboratories and USABC.

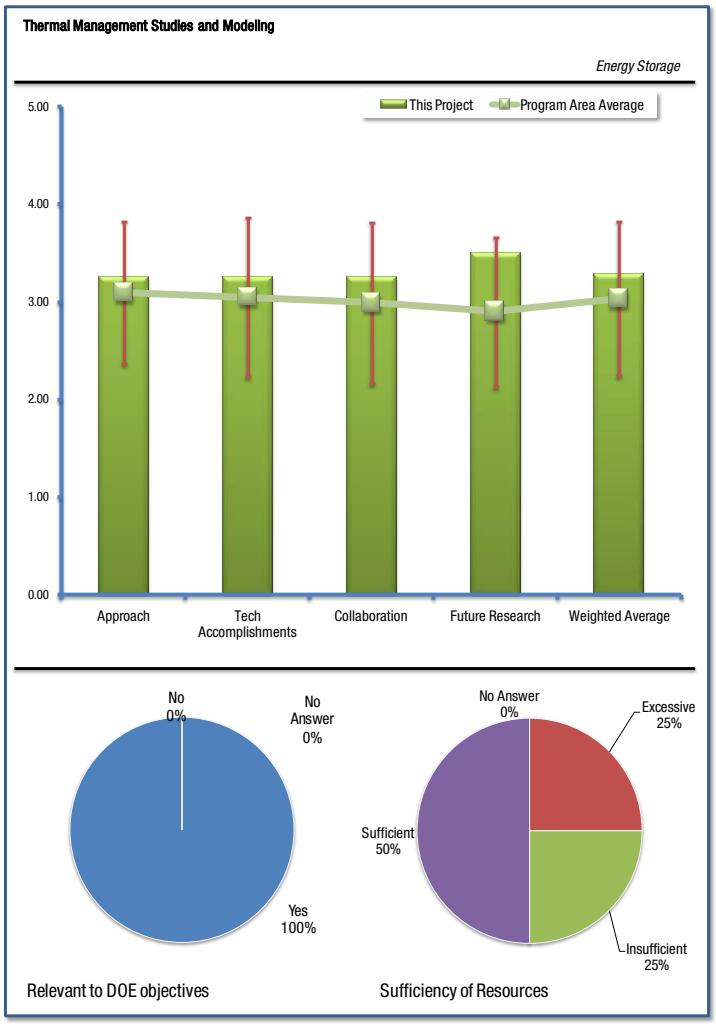
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they would like SNL to be proficient also in testing various platforms of cells such as polymer. Another reviewer noted the description of future work is very limited but substantially depends on new cells availability.

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

A reviewer stated SNL should be equipped with additional analytical tools such as in-line testing of gases and liquids collected during abuse-testing. They should also be able to monitor the mechanical expansion/pressure of the cells during tests. Another reviewer mentioned they need to think about succession and training additional people to carry on the effort. One reviewer added the resources are related to the number of tests to be carried out and there is no clear schedule of cells/module supply from other DOE projects. Comments from another reviewer noted funding is probably sufficient for the work as planned, but work should be funded at a higher level to allow further laboratory upgrades for pack level testing, to increase test throughput and independent testing of competitive battery technology and to continue/further development of standardized abuse and destructive test procedures.

Thermal Management Studies and Modeling: Ahmad Pesaran (National Renewable Energy Laboratory (NREL))



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated in order to understand and predict the life-limiting processes of lithium-ion batteries, it is useful define the thermal environments prevailing inside the cells, since some of the failure originate from thermal non-uniformities. Thermal modeling of Li-ion cells and batteries is thus useful both from performance and safety stand point. Currently, safety is a serious impediment to a widespread use of Li-ion batteries in vehicles, which otherwise would have reduced the consumption and demand of petroleum. Another reviewer commented thermal performances of battery packs are important for long life and high safety. The analysis performed in this program enhances the understanding of battery pack construction and allows construction of better packs having more low temperature gradients and lower general temperatures. This allows higher safety and better life cycles. One reviewer noted thermal modeling seems a critical aspect of pack design and the associated cooling systems. These in turn are critical for ensuring adequate safety and also impact the size, cost and complexity of the battery system. Comments from another reviewer said Pesaran et al. are studying the thermal aspects of battery packs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach is effective and involves detailed thermal characterization (using calorimetry and thermal imaging), performance evaluation, and modeling of cells, modules, and packs received from the USBAC manufacturers and provide appropriate feedback to the developers on battery thermal management and performance. Some of the possible improvements could be: i) extend the thermal imaging to cells or modules cycled sufficiently. Upon cycling (use) the impedance will increase which in turn increases the heat generation within the cells/modules. ii) thermal modeling seems to be redundant in the context detailed thermal imaging and characterization, iii) Performance models are to be substantiated with adequate cell/module test data, iv) the thermal modeling needs to be coupled with the performance (electrochemical) model to describe the thermal effects on capacity fade, v) the modeling of "internal shorts' is rather vague, especially with ceramic coated electrodes/separators. Finally, the modeling efforts across DOE and other agencies (e.g., DOD and industry) need to be better coordinated. Another reviewer commented the program studies effect of cooling methods on performance which is good. Li-ion is typically exothermal during discharge and endothermal during charge. It would have been interesting to see the thermal efficiency during charge/discharge cycles due to these reactions and de convolute how much comes from the chemistry versus IR heating. That could yield further insights into what is going on inside the cell and how easily heat

is transferred on cell level and pack level. This is especially important for polymer cells that could easily overheat at center of construction unless cooling channels are available, especially at higher temperature also with potential for more rapid degradation due to impedance imbalance due to thermal gradients. One reviewer noted there were high quality studies, taking into account such things as heat sink effects from high current leads, etc. It was an interesting use of C/D heat efficiency as a measure of polarization in the cell. Comments from one reviewer mentioned Pesaran et al. are utilizing experimental data and mathematical modeling to "look inside" the cells in battery packs. This information will help battery manufacturers develop batteries that have a longer life since they will be able to design cooling methods to remove the heat from packs.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated significant accomplishments include thermal characterization (calorimetry) and imaging of various cells and modules from the USABC developers, (SAFT and Compact power) which aligns this task well with the overall development. It is useful to be able to characterize large format cells and battery modules. The performance model provides a good analysis of the storage and cycle data available at different laboratories. The approach is empirical as with the models from the manufacturers. Another reviewer noted the thermal modeling tools available could be beneficial for companies developing packs, especially if cell heating models are available. The creation of this tool is important for effective thermal development of packs. One reviewer commented they are providing valuable and practical direction on pack design. Also, they have built a unique capability in their large calorimeter unit. They think the thermal modeling work will become more and more critical as the program moves from cell to pack designs. Comments from another reviewer noted Pesaran et al. have made significant progress and have published their results in the open literature.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated excellent collaboration was shown with USABC developers. Similar collaboration with other model developers, as well with laboratories generating performance data, within or outside DOE would be beneficial. Another reviewer commented it appears that collaboration with companies doing add-on modeling is being made, allowing multi-physical modeling; that is a good development. One reviewer mentioned since getting additional funding for custom work, obviously supplying a valuable service to the battery community. They seem to be trying to link in to ANL and Idaho in developing their model. Comments from another reviewer said Pesaran et al. are working with several battery manufacturers. However, it may be useful for Pesaran et al. to work with INL personnel on the 10^{10} length scale to help bridge the gap between the nano scale modeling and the macro scale modeling.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

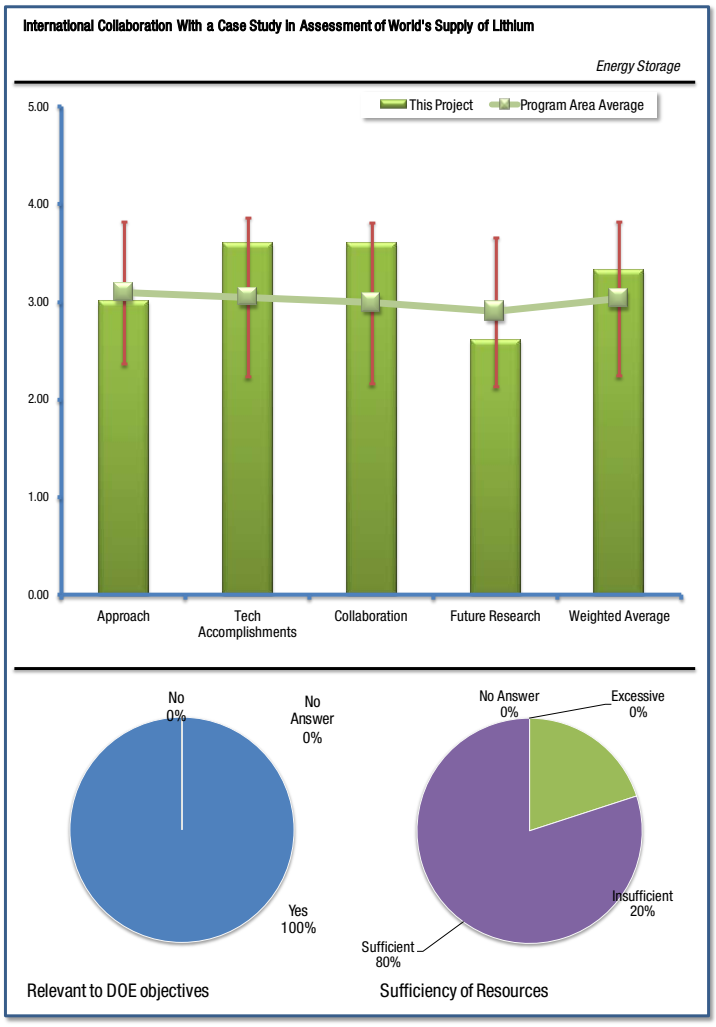
A reviewer stated the future plans to continue the thermal characterization of future cells and models as well as the modeling efforts to understand/predict the lifetimes are quite useful. Simulation of 'internal short' could be a challenge, however. Another reviewer noted it is a good idea to go towards multi-physics models for studying thermal behavior, cooling/heating scenarios, etc. One reviewer likes the approach of getting thermocouples into cells to try and get real internal temperature readings. They think this is especially important as unit cells get larger and case temperatures measurable by thermal imaging cameras become less and less representative of internal temperatures. It's hard to tell how successful their modeling will be - they suspect it will depend in large part on close collaboration with Dees and Bloom at ANL. Comments from another reviewer mentioned Pesaran et al. are planning to continue to improve their understanding of the thermal and life aspects of lithium ion cells.

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

A reviewer stated the resources seem to be slightly more than required for the proposed/on-going efforts. Another reviewer noted the resources appear sufficient and good progress has been made. One reviewer noted they are doing a great job with what they have, and getting additional funding from developers. Comments from another reviewer

mentioned Pesaran et al. are doing an outstanding job and should be funded at a higher level. Perhaps Bloom et al. should spend some time working with Pesaran et al.

International Collaboration with a Case Study in Assessment of World's Supply of Lithium: James Barnes (US DOE/ ANL)



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the project was highly relevant. Another reviewer noted rumors about shortages of Li supply are rampant. An independent study by DOE can put the rumors to rest. One reviewer commented this work is highly relevant and should continue to be refined as more information becomes available. Comments from another reviewer mentioned the availability of Li is key in the implementation strategy for a larger use of electrically powered vehicles using lithium batteries. Another reviewer stated this is important work. Lithium supply and location of lithium supply has been raised as a national policy issue with respect to increased electrification of the automotive fleet. They need to answer the question regarding whether or not we are trading one energy security issue for another.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the barriers were very well addressed. There are some other barriers that were not included such as heavy vehicles such as trucks and buses and use of lithium ion in stationary energy storage, both on and off grid. The model should be refined to include these sources using the best available projections. Another reviewer mentioned Jim Barnes has clearly identified the technical barriers by promoting a systematic study based on some assumptions that should be more extended to various vehicle technologies. A parallel market study should better support and give more data to the supply needs. One reviewer commented it's a very good approach. They would like to see a sensitivity analysis that looks at more and less conservative cases, including the impact of petroleum costs on vehicle size and the truck/car fleet mix.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated it is very nice and pertinent data and very instructive and useful to developers. Another reviewer noted this work has moved quickly and had very sensible results. The program however should be continued to take other uses of lithium into account as noted above. Improvements in the hybrid concept should also be projected as more information becomes available. One reviewer commented the work started in an IEA Annex is growing in a significant way taking into account the time spent and the late start. The progress is interesting.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated excellent collaboration between DOE/ANL. The team will try to suggest developing some type of collaboration with minerals, recycling companies. Another reviewer commented it's a good international breath for

collaboration. One reviewer noted good collaboration has been demonstrated. More information exchange with the battery industry would be helpful, however. Comments from another reviewer mentioned the contribution coming from the other organizations involved in the Annex meeting is not fully apparent even if the IEA channel is a good way to guarantee an international collaboration. Another reviewer stated the work was well coordinated internationally.

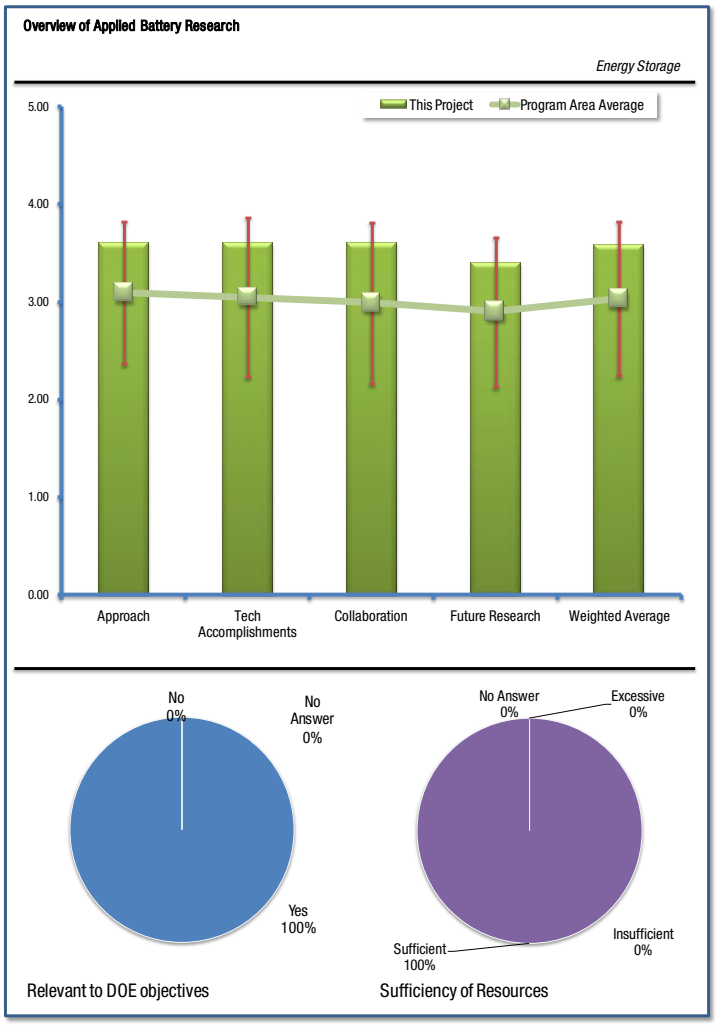
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the future work should model using the lowered vehicle volumes: data in the table assumes 17 million. The vehicle sales this year is only 10 million. Other items will be to use the new 2016 CAFE standard. Also, use an improved fleet mix. Another reviewer commented since this is such a critical topic, it will be useful to continue this project for another year at least to get another iteration of these projections. One reviewer noted the future work was not elaborated on. Comments from another reviewer said it was not clear how much future work will be done on this project, but it seems like it would be quite valuable to refine the model as noted above. Another reviewer stated the future work requires better specifications but the ANL involvement give substance to the prosecution of the project. One reviewer noted they weren't certain how to rate this category - they didn't know if additional work is planned. The reviewer thinks this work should be continued.

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

A reviewer stated if elaborations are in the works, it might be useful to have a modest increase in the size of the effort. Another reviewer commented the resources needed are not yet fully clear because are mostly dependent on the complexity of the study to be performed.

Overview of Applied Battery Research: Gary Henriksen (Argonne National Laboratory (ANL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer mentioned the state of art lithium-ion technology is not quite adequate in meeting the requirements of PHEVs. Significant development in the materials and enhancements in the performance and safety are therefore warranted for making this technology viable for PHEVs and thereby reduce the consumption and demand on petroleum resources. Another reviewer stated the Applied Battery Research has multiple programs that are of very high standards and will lead to new materials important for electrification of vehicles. One reviewer noted it's critical for higher range PHEV and EV cars as current systems don't have the legs to get the range needed. Comments from one reviewer said Henriksen et al. are working on improving the capabilities of the anodes and cathodes for lithium ion cells.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated with the objective of assisting the USABC developers to enhance the specific energy, life, abuse tolerance and cost, the approaches being adopted in the Applied Battery research program include i) development of new electrode and electrolyte materials and demonstrate the performance enhancements in laboratory / prototype cells for understanding the life-limiting processes. The program is quite comprehensive and covers a good variety of research and engineering aspects. The only drawback is that there is no information associated with how and when the ABRP program findings will feed into the developers' manufacturing processes. Another reviewer noted focus in on "next generation" which is a good focus. It will be hard to achieve acceptance for pure Lithium by battery manufacturing companies, as that is seen as a difficult value proposition. The heat generated during redox couples believed to improve overcharge will also be a hard sell for most battery companies. The work on active materials, anode and cathode has traditionally been of high quality and continue to be so. Overall all programs have high standard. One improvement could be to try streamlining the materials selection process and providing hierarchy in how to select continued research, with clear go/nogo gates. The reviewer also said this will lead to quicker research progress from a programmatic goal point of view (certainly easier management), but is a minor comment. More focus on high temperature performance would be prudent, as that seems to be a general limitation for all chemistries, but no tasks for this direct correlation is evident from presentation. One reviewer commented they were very happy to hear that they will be bringing cell making in-house. Relying upon outside companies to supply quality cells in previous years did not work due to "awful" quality control on the part of the contracted companies. The methodology is very clear, logical and well mapped out. They like the clear linkage to modeling and fundamental work. Comments from another reviewer said Henriksen et al. have made

and continue to make significant contributions to the development of lithium ion cells because of the fundamental approach taken by them. It is perhaps worth mentioning that the 15 year lifetime for lithium ion cells in unnecessary and unrealistic. This goal should be reconsidered.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated impressive results have been obtained in several categories: i) High capacity cathodes from in-house studies (210 mAh/g at C rate in over-lithiated metal oxide cathodes) and with several overseas cathode materials being evaluated, ii) further improvements in the Cu_6Sn_5 anodes $BaLi_2Ti_6O_{14}$ and ii) establishment of in-house cell fabrication capability. However, it may be advisable to seek the assistance of industrial partners for the test/prototype cell fabrication, since there are several intricate aspects to the cell manufacturing that DOE should not be bothered about. Another reviewer mentioned they were impressed with how many new possibilities they are working on in terms of higher energy anodes and cathodes (even if only 1 in 10 works out, they should have a winner). One reviewer noted the long list of accomplishments is tremendous and a credit to the PI's and the management. Comments from another reviewer said Henriksen et al. have contributed the titanate anode for example. This anode is currently being used commercially by Enerdel, which is a truly useful accomplishment.

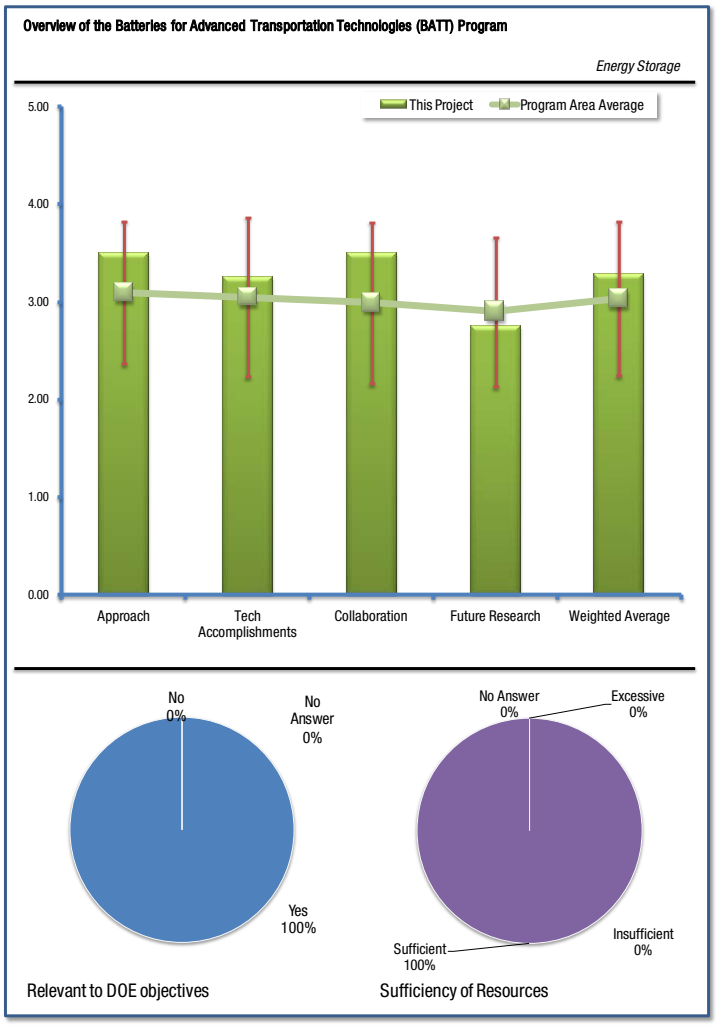
Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated yes, there is indeed good multi-laboratory and inter-agency collaboration (in electrolytes) strategy being adopted here. Another reviewer mentioned collaboration has significantly improved during the past 2-3 years, which is noticeable on results and also more consistent direction between laboratories, still allowing healthy individualism. Probably still some issue, but in large it appears to be very good collaboration with multiple institutions. One reviewer commented a good plan and roles and goals laid out for each institution. Comments from one reviewer noted linkage to material suppliers and vendors is also a key aspect for screening new materials. Developing these relationships is a very important, albeit challenging task. Another reviewer stated Henriksen et al. work closely with other national labs and industry. It may be useful for them to work more closely with the NREL personnel.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the proposed future activities of continued material development, performance assessment and demonstration, and study of life and abuse tolerance characteristics are quite relevant to the overall technology development for PHEV. Another reviewer commented since the laboratory is developing manufacturing capability of cells, a program studying production techniques and how to get high yields is important, even if in pilot mode. Otherwise, there is a very high risk that cells out will have very varying performance, which down the road will be the greatest criticism to such a program. By establishing good quality control parameters for the production line, even performance can be established and actual facts studied without looking at artifacts from manufacturing. The lab should reach out to battery mfg industry to get this expertise or hire staff with this general experience. Rigorous quality gates will be necessary to accomplish good pilot facility. One reviewer mentioned there was a good plan going forward. Comments from another reviewer noted while they may not meet their long term goals any time soon, they seem well positioned with a portfolio of very interesting options, a number of which could significantly advance the field. Another reviewer stated Henriksen et al. are proposing to continue to develop new anodes and cathodes, which should continue to help meet the FreedomCAR goals.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the resources are commensurate with the scope of the program. Another reviewer mentioned the program has increased in funding by a factor of nine, which is a very rapid expansion, maybe a consolidation? Normally inefficiencies come with too much expansion, but future will tell. Streamlined goals with subgroups and expectation setting of increased deliverables with this increase in funding are likely rolled out and there will be an

expectance of some major breakthrough and faster progress next year due to this increase. Funding might appear high, but since the lab has started to make actual cells, these funds will be needed. One reviewer commented they are doing well with what they have. They are a little concerned that the new cell-making ability will require a lot more resources than expected to bring on line. The reviewer thinks it is very important that this longer term work be well-funded, in part because industry can take up any slack for the near term. The longer term, more aggressive performance goals are what the DOE labs are best used for. Comments from another reviewer noted that funding for Henriksen et al. is sufficient.

Overview of the Batteries for Advanced Transportation Technologies (BATT) Program: Venkat Srinivasan (Lawrence Berkeley National Laboratory (LBNL))



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the overall BATT program is certainly relevant to DOE objectives. Some of the programs are more relevant than others, but that will come out in reviews of the individual programs. Another reviewer mentioned that fundamental research is a pillar of the development of breakthrough batteries to achieve DOE objectives. The strict connection between the diverse branches of the sub-program from BATT up to industrial development is instrumental in accelerating the battery development. One reviewer commented the group bridges the areas from theoretical modeling to Li-ion cells, developing new methods for modeling, and new materials. This activity is important for discovering new materials and designs that lead to higher energy density, which is a very important goal for PHEV. Comments from another reviewer noted this project focuses on the four most critical challenges for introduction of Li-ion batteries in automotive market:

- Cost
- Life (especially calendar life is good)
- Abuse tolerance
- Performance

As a general remark, focus on calendar life is good and it is unfortunate that topics is not more developed in related programs.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated this is a comprehensive effort which tries to challenge in a basic way all of the most important problem areas that are poorly understood at this time. The effort is constantly evolving as new problem areas emerge. The team seems to be able to handle this in a strong way. Another reviewer commented that looking at the relation between material and electrode fabrication is important and it is good to see that it is approached here. The move to new materials is interesting but calendar life, cost and performance are not solved for current materials. One reviewer mentioned the technical barriers are well identified with a dynamic adaptation to the new scientific options. The technical targets for the specific materials and components must be better specified to relate them more closely to the battery targets. The approach is adequate from material research to cell development. Comments from another reviewer noted that the materials research performed has discovered many new avenues for improvements. These

ideas appear to have promise for improved systems and the investigators are using good synthetic and testing techniques to verify performance attributes. Approach for studying Li deposition is a great start, but many variances can be done and continuation will be useful for manufacturers and cell designers.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated that not a lot of progress was shown, but it is normal considering the general nature of the presentation. Another reviewer mentioned the scientific and technological results are outstanding with a quick transfer to the industry. There is a very good integration of basic research with an adequate sensitivity of the application implications. One reviewer commented the new materials shows promise, but aren't ready for deployment into real batteries. Investigators should be allowed to take this one step further and try scale reactions so that sub optimization on electrode level (formulation) can assess how far from target the systems are in terms of cycling, hi and low temps, and efficiencies. The modeling on anode extension of 0.5mm is important for battery manufacturers that typically build anode larger than cathode and that overlap has some tolerances in mass production machinery. However this reviewer says, limits are unknown and industry would benefit from sensitivity of thickness or materials loading, plus rate of Li-ion transfer comparisons answering questions such as - will the 0.5mm overlap change when design factors change, a sensitivity analysis. In particular, manufacturing defects can be studied is very useful answering questions such as "what is likelihood of failure, given a certain manufacturing situation, winding, coating, pressing etc., which can all make differences to design targets", very good start here and expansion would be great. The empirical studies of battery electrodes should focus on lowering binder in anode, which is much higher than what industry is using (+10%).

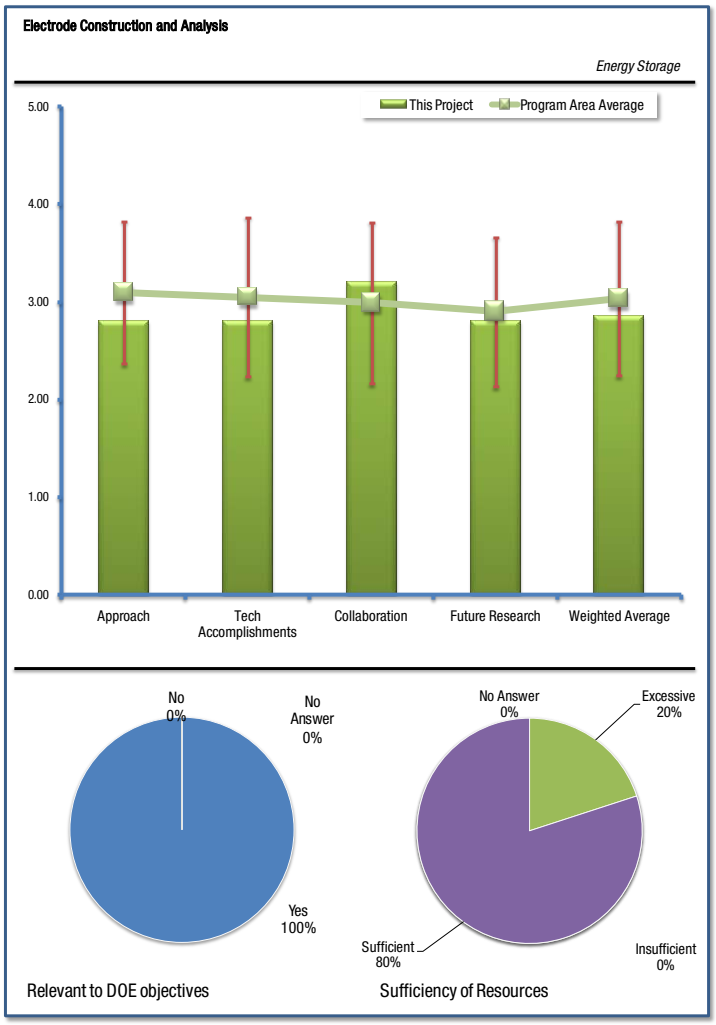
Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated the coordination between PIs is good. Another reviewer noted the presentation has shown a good integration expertise of resources and competence in the BATT structure with a selected distribution of activities. The industry is considered as an end-user of the major activities. One reviewer mentioned it's not clear if the electrode manufacturing and cell making team is fully integrated. They can for instance verify the modeling overlap studies of Li deposition in mismatched cells. They could also work with the actual materials that were research by the materials synthesis efforts (but maybe done?).

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer asked if DOE and National Labs organize brainstorming sessions with some key players. It would be interesting to involve more battery developers to better understand what the product limitations to overcome the barriers are. Another reviewer stated the description has been limited and general in giving comprehensive directions of future activities. The focus on Li-air should be extended to a more general classes of metal-air systems: the long-term exploratory research must be more ambitious with a wider screening of options. One reviewer mentioned that the short term focus is good. Long term Li-S and Li-air is probably too exploratory at this time and should be defocused. The new cell designs are fine. Future work for electrode making group - it would benefit program if they are integrated more into the materials synthesis for promising materials once comfort around the commercial materials have been established, this would allow synthetic efforts to see sensitivity to formulation and maybe also electrolyte variances, which can be good for tweaking materials. Performing some formulation sensitivity analysis and aim at verify some of the modeling efforts, which would allow calibration of unknown parameters or allow the cell making to be improved (as modeling shows a certain result would be expected).

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the presentation has not given sufficient information on such criterion. Another reviewer commented the process of assessing commercial materials is important. It seems like a lot of analysis is made and that is good, to verify material makers claims. If the team has not yet done it, it is recommended that the same process is

used to streamline this analysis. This way multiple materials can be studied from multiple vendors and compared on the same basis and selection for study be made from that initial analysis. For instance, if an impurity is found electrochemical testing should not commence and materials sent back to supplier and ask for next improvement. These types of processes will help expedite more materials to be studied and then focus can commence on those materials of special interest, which is also where PIs time is best spent.

Electrode Construction and Analysis: Vince Battaglia (Lawrence Berkeley National Laboratory (LBNL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the development of alternate (to MCMB) anode materials and development of efficient binders for Si are relevant to the overall DOE objective of developing high specific energy Li-ion cells for PHEVs to reduce petroleum consumption and demand. However, the relevance of this effort of optimizing the electrode fabrication processes in a DOE laboratory is not as clear. Another reviewer commented this work is very relevant to vehicle technologies because it focuses on optimizing commercially viable materials for improved cycle life and ability to meet PHEV requirements. One reviewer mentioned it is important for establishing lifetime for all HEV, PHEV cells and to reach energy/cost goals for PHEV. Comments from another reviewer noted Battaglia et al. are attempting to optimize the fabrication process of the electrodes of lithium ion cells.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach in seeking alternate anode material is well justified, possibly in the context of MCMB not being available from its original source (Japan). However, the effort on optimizing the electrode fabrication process, the ratio of binder to acetylene black, the thickness of coating etc are expectedly done at the manufacturing facility, since there is some specificity associated with the manufacturing equipment. They believe a DOE laboratory should not be involved in such activity, but in the development of advanced materials. Further, VC is being routine used by an industrial partner and trying to establish its electrochemical stability through CV looks out of context. The identification of electro-active binder for Si, on the other hand, is relevant and looks promising. Another reviewer noted the results particularly with regard to binder efforts and laminate thickness support the validity of the approach. There is a need to progress to larger cells to verify. One reviewer commented the work in this project is well-designed and well-integrated with other efforts, and advances general understanding within the confines of the overall BATT program, but much of the work duplicates routine activity which occurs on an ongoing, repetitive and highly efficient basis at viable mass-production suppliers of Li-ion battery technology and many of the findings of this work would be of an obvious nature to current mass-production Li-ion battery suppliers. Comments from another reviewer mentioned that the approach seems very well organized. While the approach is largely empirical, this is how industry does it as well. Another reviewer stated Battaglia et al. are experimentally trying different combinations of conductive additives and binders to find the best capacity retention of a lithium ion cell, for example. They may be able to improve their methodology by extending Newman's models to include the details associated with conductive additives and binders. The use of theoretical models to design experiments is superior to a purely experimental

approach. It is not clear that they worked closely with industry to understand the history of the manufacturing techniques used in practice.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated there are some interesting results in the optimization of electrode fabrication parameters, such as the ratio of binder to the conductive diluents, thickness of the coating etc, (and the coin cell cycle life data are useful in term of material assessment), but it is not clear how far these results are applicable to the battery manufacturer's processes. The studies on VC may be redundant, unless they are for optimizing its content for a particular carbon. The conductive binder for Si looks promising. Another reviewer noted it was very sound work -specifically mapping out electrode parameters, such as thickness, binder influence and VC additive is good. One reviewer commented the focus on columbic efficiency effects of additives for high-energy batteries is good. Comments from another reviewer mentioned the results are very worthwhile in that they state that they can get very high cycle life from their electrodes and that these correlate to larger cells. This is important because much of the prior development work in this program has been hampered by poor electrode fabrication and design. The goal should be to get optimized quality electrodes that can generate reliable and repeatable results, not necessarily to match the best industrial performance. The silicon work is very promising, especially in light of the lack of C-coating on the Si. Some understanding of electrode structure is shown, linking adhesion to cycle life. However, much more in this area is needed as this work goes forward. Another reviewer stated Battaglia et al. have made significant contributions concerning the design and construction of electrodes for PHEVs.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated that some of the collaborations exist across different DDE laboratories. It is not clear however, where such collaboration benefited the present studies. Another reviewer commented it is an excellent laboratory and industrial collaboration - best in class. One reviewer noted Sastry and work at ANL needs to be factored into this and vice versa, which they think is going on. The later talk by Sastry talked about good collaboration with LBNL, but it's really hard to tell. Over the next year, it is very important to roll this work into ANL cell building pilot line and the related work by Jansen and Lu at ANL; also continue working with Sastry. Comments from another reviewer noted Battaglia et al. would benefit from studying the existing manufacturing techniques used to produce lithium ion cells. Also, they may benefit from discussions with Gering at INL.

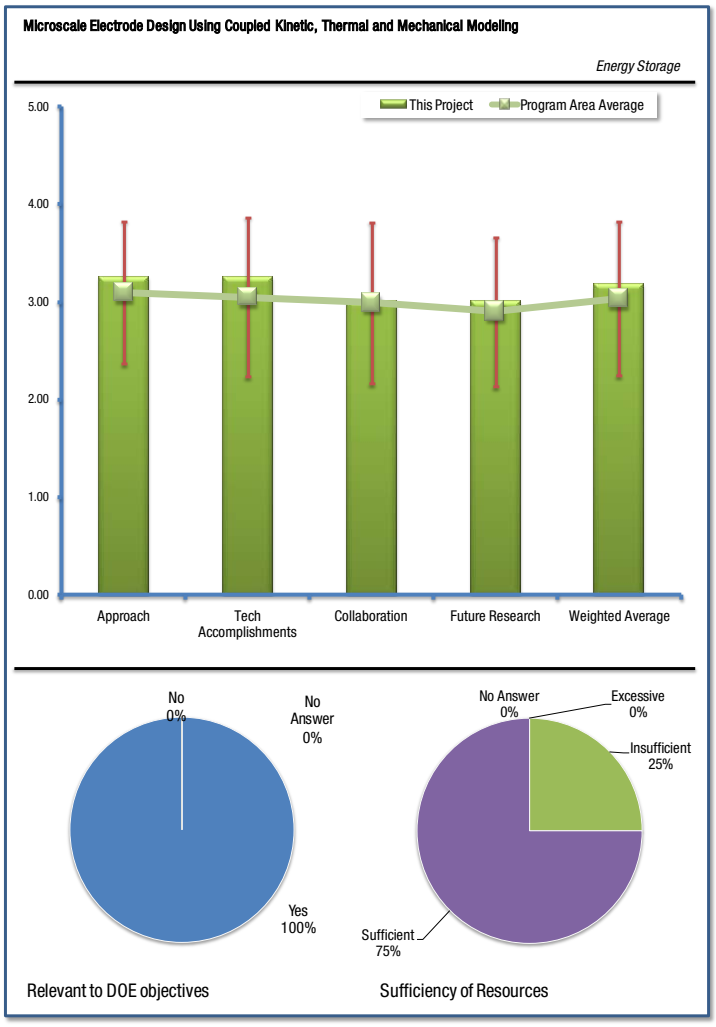
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the future studies on developing new binders (continued work on the conductive binder) are useful. The electrode optimization studies are however not as well justified in a DOE laboratory, especially at a stage where the material selection is not complete and the pursuit for new carbon anodes is still on-going. Another reviewer mentioned that regarding future task 2.1: Study of constant power vs. constant current cycling effects does not seem relevant from an actual vehicle usage perspective, unless the constant current mode will be limited to simulation of the plug-in charging mode (i.e., real-world PHEV's would not be expected to use the battery in a constant current mode during actual driving). Regarding future task 3.1: Determination of oxidation and reduction potentials of VC has surely already been accomplished by others, and has presumably already been reported elsewhere? If so, is there some other reason to duplicate earlier observations? Also, regarding future task 3.2: Determination of VC effects on formation processes has presumably been studied in depth at many other institutions and seems redundant here, but specific focus on the impact on long term efficiency is useful. This reviewer also said slide 14 apparently represents efficiency in an anode/Li half cell. It would be useful to show how this efficiency relates to the overall efficiency in a full cell. It would also be useful to observe any effects of VC or other additives on the rate dependency of the longer-term efficiency in full cells. Movement toward study of SBR and CMC binders is long overdue, but good. T his movement should be accelerated. LBNL surely has other capabilities of value to globally viable Li-ion cell mass-producers or their parent companies, and these capabilities should be offered in order to achieve collaboration with

regards to this project. One reviewer commented while the approach is fine and seems to have been successful; they also think that the group should be using all of the supporting data and analysis to explain in detail WHY good formulations are preferred. They are doing some of that, but need to do much more now that they have gotten a handle on making good electrodes. Very important to roll this work into ANL cell building pilot line and work by Jansen and Lu at ANL and continue working with Sastry. Comments from another reviewer noted Battaglia et al. have listed some plans for next year; however, it is not clear what they hope to accomplish. It would be useful for them to seek guidance from industry and other government labs.

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

A reviewer stated that resources are a little bit excessive, especially due to the non-relevance of the electrode optimization studies. Another reviewer noted in the absence of collaboration with a globally viable mass-production battery supplier, consideration should be given to reduction in project scope and/or or resources, or to increased focus on only niche areas of production-type parameter optimization. One reviewer commented it seems to be making good progress in manufacturing electrodes. Modest progress in understanding and it's quite a large group. They should be able to get an understanding and knowledge creation more in the coming years. Comments from another reviewer noted Battaglia et al. are funded at a sufficient level.

Microscale Electrode Design Using Coupled Kinetic, Thermal and Mechanical Modeling: Ann Marie Sastry (University of Michigan)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the micro scale is an important aspect of electrode design that has not received much emphasis in the past. These studies fit into the overall electrode design program. Another reviewer noted Ann Marie Sastry and al. look at the mechanisms that impact electrodes performance and life. One reviewer commented this project deals directly with understanding the physical and performance of particles, their size and their shape. To optimize the performance of any cathode or anode, this information is critical in arriving at the proper composition, particle size and porosity. Comments from another reviewer mentioned the electrode part is one of the most complicated parts to understand. They don't think this modeling solve all issues but still help understand some issues.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated there are many ways to approach problems of these types with various levels of computational and mathematical difficulty. The work seems to focus more on small sample size problems rather than pushing toward large sample size. The other approach of using large computers for a larger sample size might be worth investigating for the information obtainable. Another reviewer mentioned that looking of how materials self-assemble in electrodes is of critical importance. Usually research tends to omit that aspect of the electrochemistry which is as important as the material themselves. The study looks at the different aspects of the barriers from the particle to the electrode assembly. One reviewer commented the approach to the problem of electrode composition depends on particle shape porosity as well as the transport properties of the electrolyte. The details are studied carefully and thoughtfully. The team has a great grasp of the mechanical as well as the electrochemistry involved. Comments from one reviewer noted that inadequate power is closely related to diffusion and conduction process for sure. However it is not clear why the short lifetime is closely related the electrode composition etc that PI mentioned as barrier. Also it seems difficult to apply this model for life prediction.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that since this is a difficult and novel approach to electrochemistry, the results are ground breaking and have given new insights. Another reviewer commented that their only concern is that they don't really understand how the electrode design optimization will support the battery industry. This seems far from real battery world. One reviewer mentioned the surface, mechanical and kinetic behavior of cathode materials are affected by the aspect ratio of the particles. Investigations indicate the microstructure of the particles have significant influence on

performance in a cathode matrix. The shape, size and physical surface properties determine the cathode performance in an electrode structure. Comments from another reviewer noted the accomplishment is focusing on the power and it is OK for the beginning of life. They haven't seen any data relating to lifetime and there is a need to compare the experimental data and it would be the future work.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated that as a theoretical electrochemical/mechanical approach, the interaction with knowledgeable experimentalists is very important. The PI should continue to try to develop relationships at this level to impact the orientation of the work to important battery related problems. Another reviewer commented that the collaboration is good. Even auto industry is involved (Ford, GM) which is an indication of the high level of quality of the work. One reviewer noted the project works with several National Labs and auto companies to accomplish the goal of understanding particle effects on performance. The work and collaborators in the other institutions are recognized appreciated and acknowledged appreciated. Work with GM labs is especially important as they learn about the practical aspects of battery performance. A comment from one reviewer mentions they can see some collaboration in the presentation. However the cell experimental data is not enough to verify the modeling.

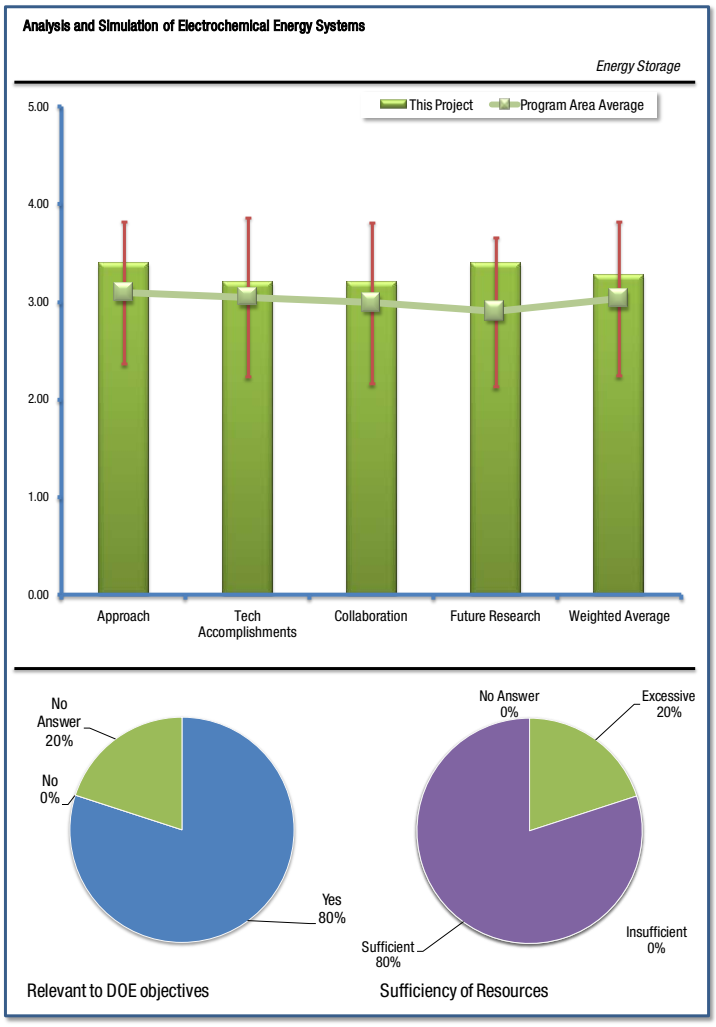
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated that particle aggregation is a very important point. The PI should work with a group that understand electrode engineering in order to help to understand what are the critical parameters that lead to a good electrode quality. Another reviewer noted the inclusion of surface structure and SEI layers on the anode and cathode will be significant as will the study on the effect of intercalation on the properties of the anode and cathode materials. This is a must-do next step. One reviewer commented the cell experimental data is not enough to verify the modeling.

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

A reviewer stated if the author moves in the direction of larger computations, it may be necessary to take advantage of larger computing facilities such as the Oak Ridge supercomputer. Another reviewer mentioned this is a great work that should continue to be well funded. One reviewer commented that resources seem adequate, but the total effort could be increased to the benefit of the project. Comments from another reviewer noted the cell experimental data is not enough to verify the modeling.

Analysis and Simulation of Electrochemical Energy Systems: John Newman (University of California - Berkeley)



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the mathematical models based on first principles are quite helpful in providing a phenomenological understanding of the processes occurring in Li-ion cells under various conditions, including normal and abnormal conditions of operation and will contribute to an advancement of Li-ion battery technology, which is primed to be used in HEVs and PHEVs and helps in the reduction of petroleum consumption and demand. Another reviewer noted that generally relevant electrode design to present lithium plating - shuttle work could be relevant to safety also with regard to overcharge protection. One reviewer commented the type of modeling made will greatly enhance industry in its ability to look at manufacturing tolerances for Li deposition and understand these - are they fundamental vs. temporary manufacturing issues. This type of modeling is very useful. Comments from another reviewer mentioned this project helps to enhance abuse tolerance and reduce failure modes.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach specific to the current effort looks to be effective and involves an understanding of two critical issues: i) the deposition of Li on the carbon anode likely to be favored over Li intercalation at rapid charge as a function of anode/cathode geometries and ii) the effect of redox shuttles, being examined for overcharge protection, on the SEI characteristics. Another reviewer mentioned the sophistication of models presented seems to be way behind the actual implementation knowledge of cell manufacturers to enable progress. One reviewer commented it's a good approach and please do expand on this type of modeling, introducing more parameters, both geometrical design and use scenarios. Comments from one reviewer noted the modeling of Li deposition effects / electrode configuration is of great value, and may be novel (beyond significant applied studies outside of U.S.). Another reviewer stated it explains optimization of negative electrode extension which helps to maximize cell volume efficiency, capacity ratio optimization with different thickness electrodes. Overcharge protection - provides trades off of shuttles reactions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated an interesting finding emerged from the model on Li plating, i.e., the extra length of the anode is helpful to avoid Li plating occurring due to higher concentrations at the edges, more than a higher capacity ratio (in the form of thicker anode). It would be helpful to have quantitative information on the relative kinetics of Li intercalation and Li plating. The results from the redox shuttle simulations, however, are not that clear. For example,

what is the redox shuttle that is being modeled here? Probably more of experimental studies would be helpful here to characterize the SEI in the presence of a redox shuttle. Another reviewer commented that relevancy of actual models presented to making a difference is not obvious - in case of electrodes not sure there is a practical barrier for industry and level of detail of redox shuttle model presented does not seem to enable further material use or design. Trade-off of overcharge protection vs. energy storage presented is questionable. It is also based only on one material system and voltage range which is not universally applicable. One reviewer noted the modeling shows exactly the areas that are suspect from Li-ion tear apart analysis when design is off (which is case from some manufacturers). The work on shuttles is interesting, although shuttles tend to be overemphasized in general by researchers at national laboratories. In industry overcharge protection is normally accomplished by use of current interrupt devices and thermal fuses. The shuttles develop too much heat right now and have stability issues, in addition to being rate limited. Comments from another reviewer mentioned it is unclear if any of the outcomes of modeling of Li deposition effects / electrode configuration have been experimentally verified in any way. Another reviewer commented that the results of longer and thicker negative electrode and shuttle trade-off provide better understanding for the cell design.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated collaborations have been mentioned with several LBL colleagues. It is however difficult to deduce their contributions. Another reviewer commented they could consider including K Amine redox shuttle work to compliment models and make more relevant. One reviewer noted collaboration was mainly internal, but that is ok in this instance.

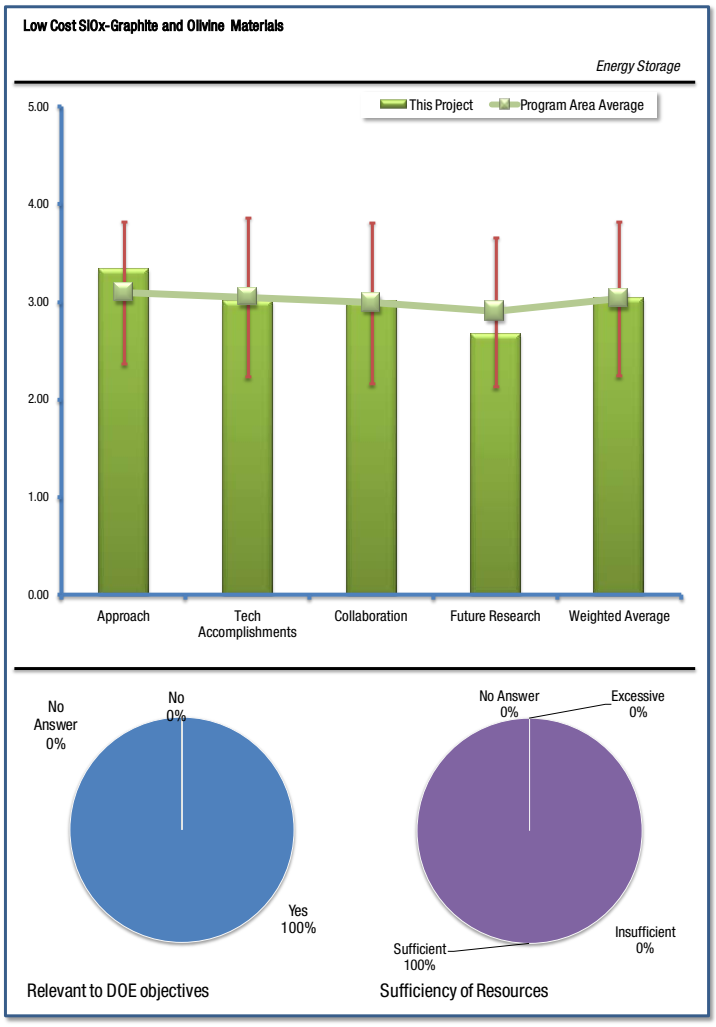
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the future work justifiably focuses more on understanding the transport and kinetics of the redox shuttles and to substantiate with some experimental studies to understand the interface. The proposed work on block copolymers does not seen as well connected with the overall program. Another reviewer noted that lithium deposition modeling is good but potentially could look at other safety issues such as Fe impurities. One reviewer commented the work on Li deposition is important. This work can be expanded to other ions, such as Mn or Fe that can be available as free ions inside a cell. That would provide some answers to one of the biggest concern in the industry, which is what happens when impurities enter the system. For instance, how fast could deposition occur and where should one look to find these impurities and then how could electrode construction prevent that when these items enter the manufacturing stream, likelihood of failure through "hot spots" that these would represent? That would lead to identification of potential points where dendrites (which can short) can be formed and hot spots can be avoided through design techniques, manufacturing and cell design, areas around edges, but also areas around tabs and uneven areas where stack pressure can be slightly higher. Comments from another reviewer mentioned the work involved in developing the 2D model that explains edge effects, N/P ratio, and electrode thickness effects on lithium deposition during charging should be continued and expanded to include other relevant dependencies (effect on rate capability?, effect on efficiency?, effect on temperature gradients at high rates?, etc). Some level of experimental verification of model results of the current or potential future work in this area would be desirable as well. Redox shuttle modeling and verification is useful and should be pursued, but focus on couples other than and more tangible than $TiO/FePO_4$ and $C/FePO_4$ would be desirable. Another reviewer stated that continuation of modeling and more complicated model will enhance cell design.

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

A reviewer stated the resources are adequate. Another reviewer commented that fiscal support seems very high in light of other programs funding relative to, head count, theoretical nature, and output.

Low Cost SiOx-Graphite and Olivine Materials: Karim Zaghib (Hydro-Quebec)



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the project has high relevance because of the practical nature of the studies. If the electrode composition is improved by the work, it will contribute to improved batteries. Another reviewer mentioned that developing new phosphate materials and a better understanding of the SEI layer are key issues in improving Li-Ion performance. One reviewer noted the project is aimed at very key aspects of increased energy and life of LI batteries. The use of abundant and cheap materials is also addressing cost aspects.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach is valid for the barriers as far as can be ascertained. However, the degree of secrecy involved because of the company restrictions make it somewhat difficult to evaluate. For example, the binder studies are sensitive to the exact type of binder as well as the concentration, but the binder types are not disclosed. Another reviewer noted Karim will develop the best way to synthesize $LiMnPO_4$ using high temperature, solid state and molten salt techniques. Surface coating with SiOx to improve performance of phosphate materials as well as evaluate SiOx-graphite with different binders for optimum performance is needed. One reviewer commented the approach is adequate in looking at new anode and cathode materials to solve the identified technical barriers. Carbob coating and the use of new binders is also a good compliment in the process to research new materials and electrode preparations.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated they like the approach, there is a problem in assessing the level of progress without better definition of the actual work because of proprietary factors. However, the data presented gives definite progress on the goals. Another reviewer mentioned that additives and electrolyte composition had a strong effect on the graphite and performance. The SEI was structure was strongly influenced by electrolyte additives. Preparation of $LiMnPO_4$ was explored with the hydrothermal process giving the best results. One reviewer noted there are results promising for SiO_2 based anodes and less for the $LiMnPO_4$ cathodes. The use of different aqueous binders gives interesting results. The potential impact on complete cells with improved performances must be carefully analyzed. Finally, the progress must be better measured with respect to measureable objectives.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated that interactions with LBL, John Goodenough, Pete Roth (SNL) and C. Julien-A Mauger at University of Paris have been made. Another reviewer mentioned the collaboration with other BATT participant is well established with good integration. The feedback from the other participant activities is not evident.

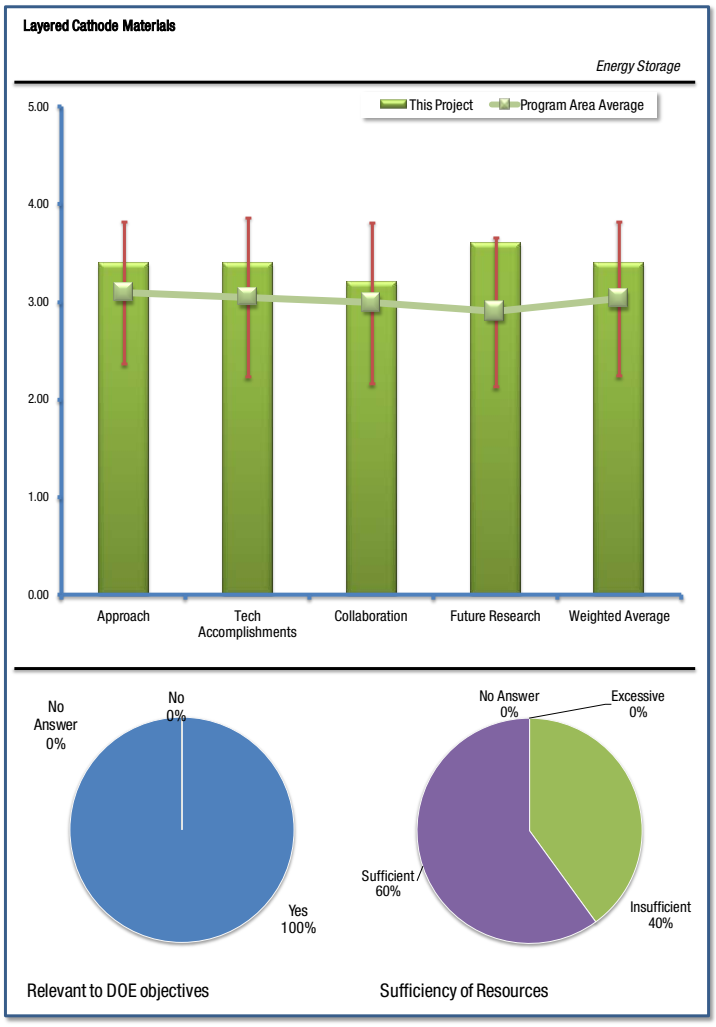
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated future work is to continue studies on the best method to prepare the olivine materials and continue work on SiO-graphite materials as the synthesis of olivines for other investigators, prepare 18650 cells for others on request. Another reviewer noted the proposed plan is quite generic and some choices, particularly on the cathode materials, need better explanations. The low performances of the cathode materials at RT do not open the way to clear progress with the proposed future activities. The proposed activities do not clearly explain how performances for cathode material mixtures may improve the present results also at RT.

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

A reviewer stated the project has efficient operations and the funding is sufficient. Another reviewer commented the level of resources may be more than adequate in view of the in-kind similar contribution put by HQ.

Layered Cathode Materials: Michael Thackeray (Argonne National Laboratory (ANL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that layered positive materials are clearly a topic that needs extensive effort. Another reviewer commented one notable deficiency of the state of art Li-ion batteries is their low specific energy to meet the PHEV-40 targets. A focused development on new cathode (and anode) materials of high specific energy is thus warranted for making the Li-ion batteries viable for PHEVs and EVs and thereby reduces the consumption and demand on petroleum. The present task is therefore well tuned to the DOE's objectives. One reviewer mentioned the objective of cathode materials with > 200 mAh/g is in line with vehicle technologies objectives. Comments from another reviewer noted that energy density, cost and abuse tolerance is critical.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the project has very well defined objectives and ways to achieve them. Prevent oxygen evolution at surface of material as well as stabilization of this surface (dissolution) is of great importance as they impact directly on performance, life and abuse tolerance. Another reviewer noted the approach is sound and effective. This is probably the most plausible approach to develop high specific energy (high voltage as well as high capacity) cathodes. New cathode formulations based on solid solutions of layered ($LiMnO_3$) and layered ($LiMO_2$) compounds are being developed by various researchers elsewhere. Extension of this concept to layers-spinel and spinel-olivine does not seem to be successful. Finally, the approach of stabilizing the surface with a surface coating to improve its rate capability is also consistent with the efforts elsewhere. One reviewer commented that the given capacity accomplishments approach is promising. There is a need to continue exploring cycle life and rate impact of surface modification as planned and presented. Comments from one reviewer mentioned that synthesis and modeling has the synergy.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer asked is there new materials for coating? Is there a new method? $LiFePO_4$ and spinel are both low energy density materials. Spinel-Olivine intergrowth structure does not seem to be the right direction to go. They would suggest doing more storage test instead of cycling and looking at solubility of metal (by post-mortem analysis for example). In a lot of applications, calendar life is more limiting that cycling life. Also there should be a correlation between cycling and storage life. Another reviewer mentioned the capacities obtained with the layered-layered solid solutions are encouraging, but the rate capability needs further improvement. Is this an inherent limitation arising from the surface (being enriched with metal which impedes Li diffusion), or the surface condition being not favorable for Li intercalation due to oxidative degradation of the electrolyte (at high potentials) or the bulk diffusion (for Li+) in

these materials? The results from $LiNiPO_4$ coatings look promising. A better understanding of the surface coatings (should they be solid electrolytes?) would be helpful to design more effective coatings. The modeling effort to understand the solubility of $LiMn_2O_4$ is not connected with the overall objective. One reviewer commented there is good performance at meeting capacity targets and cycling as demonstrated in coin cells - as stated improvement in rate is critical. Comments from another reviewer noted that surface stabilization and integrated olivine spinal structures were implemented.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated that maybe more collaboration with Sastry or Battaglia's group would be useful. Another reviewer noted there are several good collaborations with several researchers within DOE as well as outside. One reviewer commented that a lot of collaborative aspects of this project - modeling, synthesis and evaluation. Comment from one reviewer mentioned that collaboration with major materials supplier or globally viable Li-ion cell mass-producer(s) would be of great benefit for this project, while another reviewer said SUNY, BNL and material supplier adds value to the development work.

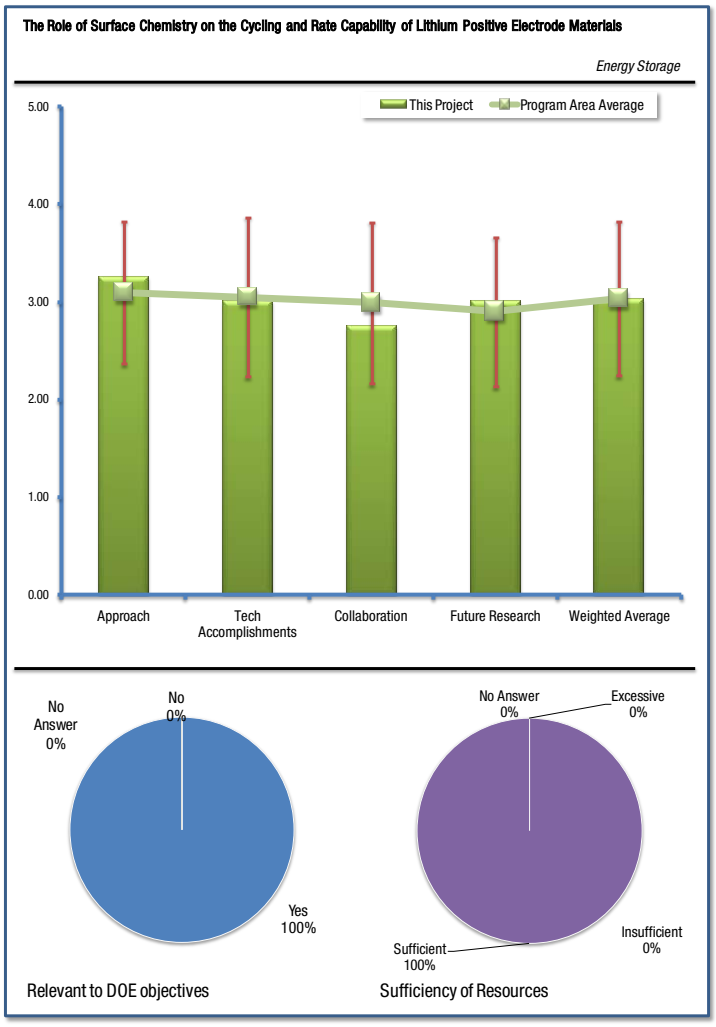
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated that in the future apply modernization to new system to correlate with metal solubilization during cycling or storage. Another reviewer noted the proposed future efforts to continue i) development of new high specific energy cathodes as well as to focus on surface studies to improve stability and rate capability are quite appropriate for the overall objective. One reviewer commented there is a good direction focusing on understanding surface modification impact on cycle life and rate. Also new mfg methods are useful as significant impact on morphology which likely will play a role in addressing rate and cycle life. Comments from one reviewer mentioned the proposed future research is excellent as is. As a suggestion, realizing that future work can further optimize the rate capability of the Li-Ni-PO_4 treated $0.5Li_2MnO_3 \cdot 0.5LiNi_{0.44}Co_{0.25}Mn_{0.31}O_2$ material, it may also be useful to begin investigating differences in the ratio of charge vs. discharge rate capability of the treated or untreated material relative to other more established cathode materials. Collaboration with major materials supplier or globally viable Li-ion cell mass-producer(s) would be of great benefit for this project. Another reviewer stated that synthesizing and improvement of performance, coating enhancement, and cheaper synthesis route will be beneficial.

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

A reviewer stated that material development such as being done here is critical to advance the technology. The resources may be augmented with additional funding (50 %!). Another reviewer noted that funding for this project should be increased.

The Role of Surface Chemistry on the Cycling and Rate Capability of Lithium Positive Electrode Materials: Yang Shao-Horn (Massachusetts Institute of Technology)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the surface chemistry is very important to the stability and long term behavior of battery active materials. These studies bring the most powerful surface sensitive methods to bear on important battery materials. Another reviewer commented that this project is coating cobalt materials to improve their stability. The coated cobalt materials have better performance than the untreated cobalt materials. This project is developing a better understanding of the cathode-electrolyte interface. One reviewer noted Shao-Horn et al. are to improve the cycle life of cathode materials in lithium ion cells by studying the stability of the surfaces of these materials. Comments from another reviewer mentioned the interface between the electrolyte and active material is one of the most important issues.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the use of surface coatings has led to improved performance of a number of materials that are subject to higher charging voltage. Without the coatings, the performance decays quickly with increasing cycles. With the coatings, the performance is maintained for much longer cycling. There has not been a satisfactory explanation of this phenomenon until this work. Now it appears that the surface chemistry is complex and is all important for the behavior of layered structure cathode materials as exemplified by $LiCoO_2$ and $LiMn_{0.5}Ni_{0.5}O_2$. The work should continue with other more promising materials to address the barriers of higher voltage cycling. Another reviewer noted that they are using advanced x-ray photoelectron spectroscopy, etc. to understand the structure and operation of advance cathode materials leading to better materials for Li-Ion batteries for transportation applications. One reviewer commented that Shao-Horn et al. are using various surface probing techniques to establish whether or not mixing Al_2O_3 with the cathode material upon preparation will provide longer cycle life to cell. They are also using standard tests and surface probes to study the preparation technique (quenched or annealed) used to prepare other cathode materials. Comments from another reviewer mentioned the surface of the active material is very sensitive in case the samples are exposed to the air. They believe this is one of the reasons why not a lot of people are using XPS to analyze the surface of active material after cycling. If the PI can develop in-situ surface analysis method, it would be greatly helpful for these studies, but the result seems reasonable.

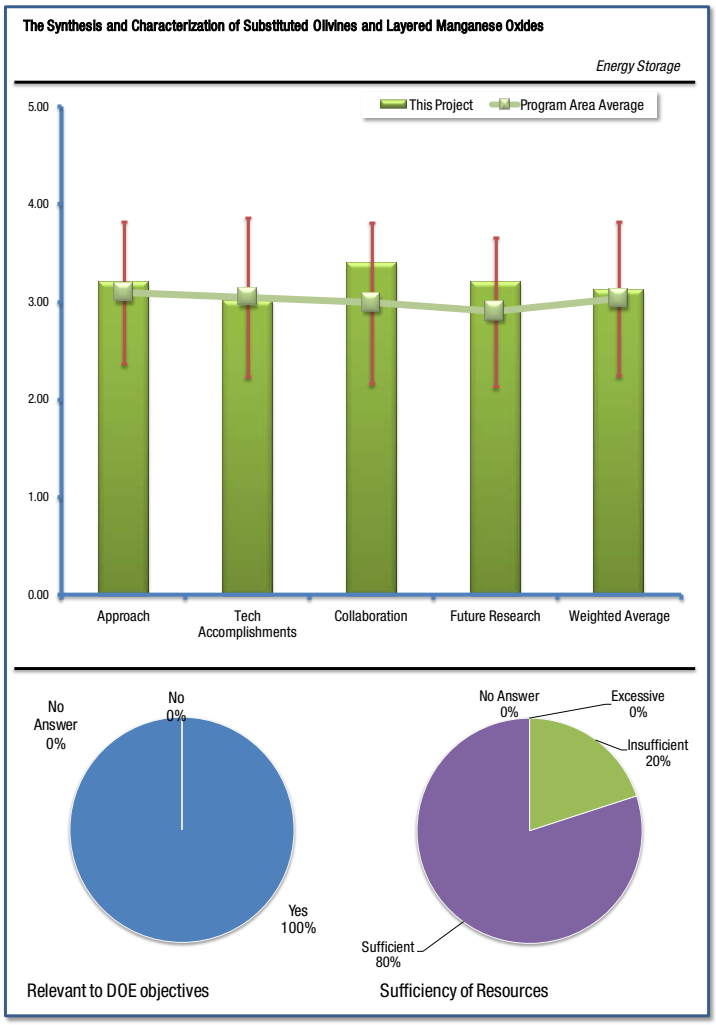
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated the progress is excellent to date on the cathode materials studied. The surface chemistry of these has been well demonstrated. Another reviewer mentioned that surface coatings on cathode materials were shown to improve performance and stability especially aluminum oxyflorides Co-Al-O-F and developed improved surface structure of $LiNiMnO_2$. One reviewer commented that Shao-Horn et al. have obtained results that suggest that using an additive to coat the active material ($LiCoO_2$) leads to longer cycle life. They have also obtained results that indicate that annealing $LiNi_{0.5}Mn_{0.5}O_2$ leads to better cycle life. Comments from one reviewer noted the results for $AlPO_3$ is fine. However regarding to $LiNi_{0.5}Mn_{0.5}O_2$, just comparing quenching and annealing is not new and enough results.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated that this study has been a model of collaborative work, employing the PI with the Naval Research Laboratory as well as DOE workers and workers in Korea. Another reviewer commented that the work with Monsour at Naval Research has been especially successful. One reviewer mentioned that Shao-Horn et al. should consider working with companies to determine if their studies have been considered in practice. It may be that the costs associated with their processing steps may be too costly to implement. Comments from another reviewer noted they cannot see any collaboration in the presentation.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated that in addition to the proposed work, they would like to see further work also extended to more promising cathode materials like NMC and NCA which would allow higher voltage charging and concomitant higher capacities. Another reviewer noted they will continue with surface modifications and functionalized carbon nanotubes to improve performance of cathode materials. One reviewer commented Shao-Horn et al. have proposed work that will probably not yield useful new information. She may want to study instead the calendar life of the materials she has already made. Comments from another reviewer mentioned that if PI can develop in-situ surface analysis method, it would be greatly helpful for this study.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the facilities are sufficient as long as the collaboration goes on with NRL. If that is no longer possible, collaboration with another surface materials lab would be necessary to add or other methods would have to be developed. Another reviewer mentioned the resources are adequate for the project. One reviewer commented that Shao-Horn et al. have received sufficient funding. Comment from one reviewer noted there is a lot of data, achievement and they are reasonable.

The Synthesis and Characterization of Substituted Olivines and Layered Manganese Oxides: Stanley Whittingham (SUNY-Binghamton)



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the objective of the project is to develop low cost and high capacity cathode materials that are also environmentally benign. Such cathodes will contribute to an enhanced specific energy for Li-ion batteries to make them viable for HEVs and PHEVs, which would in turn reduce the petroleum consumption, demand and (national) dependence. Another reviewer noted the improvements of cathode materials are a key factor in reaching DOE objectives. One reviewer commented that lower cost and high capacity cathodes will make the battery pack more affordable.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated this is good to look at different NMC formulation that 1/1/1 and to minimize use of Co. What are the parameters that will help to determine the best composition? Another reviewer commented the approach looks reasonable and feasible, especially the part that focuses on identifying new cathodes with more than one lithium per metal. Specifically it involves manganese–rich and low-cobalt layered oxides and substituted metal phosphate that may help to explore high specific energy lithium metal phosphates. One reviewer mentioned the barriers are well identified and addressed with focus on scientific and practical aspects related to the modifications of cathode materials to improve their performances. The target of more than 200 mA/g gives a way to evaluate effective progress. Comments from another reviewer noted it keeps Co content very low to reduce cost.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the conclusion on capacity fade seems a little "quick". The difference is not significant and the number of cycle low. They should collaborate with people working on electrode optimization. Materials have different conductivity and may require different electrode formulation. It is interesting not to observe capacity fading of LFP material, it needs be assessed vs. a carbon negative electrode. Again, storage is as important as cycle life and don't forget that aspect. The Ah/cc differences shown are due to carbon content... what about tests with same amount of carbon? LFP/titanate does not seem to be realistic system for PHEV or EV applications. Another reviewer commented there a couple of interesting findings on the optimization of Mn, Ni and Co content in $LiMO_2$ as well in the substitution of lithium metal phosphates with vanadium. Even though the capacities are not high enough to be attractive for PHEV needs, the vanadium substitution may allow for the formation nanophases, which may help high specific energy phosphates (Mn) to be feasible. The results on the multi-valence cathodes are not encouraging yet in terms of specific capacity. One reviewer mentioned the progress is significant but not yet reaching the proposed

target, mainly in terms of specific capacity. The work on substituted Mn-based materials is valuable as well as that on olivine, but the options for further improvements to reach target seem not clearly identified. Comments from one reviewer noted that low-cost Olivines will help to reduce battery cost.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated there is on-going collaboration with the University of Maryland. Another reviewer noted the collaborations are well described and partially motivated with good coordination. One reviewer mentioned that collaboration with the universities, National Labs, and material supplier will enhance the value of the development work.

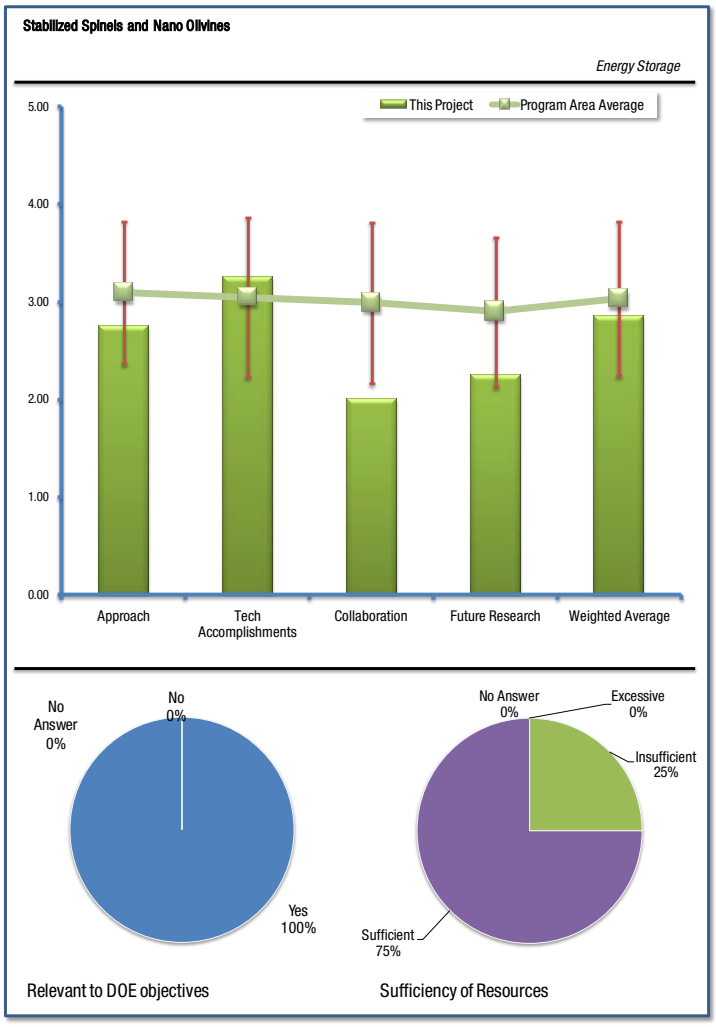
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated it was interesting to see that you are looking at the role of Al. Another reviewer noted the proposed future work on substituted lithium metal phosphates with higher Li content and cathodes with more than one Li per metal looks interesting and relevant. One reviewer commented the future plan is appropriate to reach the main scope of scientific comprehension of some working mechanisms in various cathode materials. Anyhow, the practical improvements aimed at improving the cathode performances require more specifications. Comments from another reviewer mentioned the pursuit of Vanadium-containing compounds should not be pursued, unless it can be shown that better understanding of Vanadium-containing compounds is a very critical key to understanding other compounds which do not contain Vanadium. Focus on further work with $LiMO_2$ forms, new alternatives, and limit/eliminate further significant work on phosphates. Another reviewer stated the understanding of the stability of low-cost cathodes, investigation of other phosphates will help with the cost reduction.

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

A reviewer stated the resources are adequate. Another reviewer mentioned the planned work and the resources and budget declared seem not sufficient to perform the work planned.

Stabilized Spinels and Nano Olivines: Arumugam Manthiram (University of Texas at Austin)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the work on substituted spinels and nano olivenes has the potential of improved cathodes for vehicle batteries. They need further improvement, however, before they will have a real chance for success. Another reviewer noted that higher capacity spinel based materials are relevant to achieving PHEV40 objectives. Also surface modifications which enable higher Voltage are likely to have a very positive impact on vehicle applications. One reviewer commented that Manthiram is developing high voltage (5 Volts) cathodes for lithium ion cells, which may increase the energy density of lithium ion cells. Comments from another reviewer mentioned the continuous study for new positive active material is necessary.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach has given improvements on high voltage Mn-Ni oxides, but they are not yet good enough for commercial use, particularly in cycle life. This is also true of the modified spinels. Concentration on the best coating materials to optimize the coating level would be useful to test the limit of improvement. Another reviewer commented this is excellent work on both composition optimization and surface stabilization - the achievements validate the approach. One reviewer mentioned that Manthiram's approach appears to be empirical without consideration of the work by others such as that at MIT. He may be able to make more progress by working with others sponsored by the DOE. However, he seems to have made progress in his coating work of spinels and his production techniques for olivines. Comments from another reviewer noted the target is vague. What is "acceptable cycle life", "low manufacturing cost" or "increased energy and power"? A more concrete target is necessary.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated there are definite accomplishments during the year, but more focus on promising coatings and substituent's needs to occur. Another reviewer noted this is very good progress with demonstrated results in stabilizing spinel materials both by composition and surface modification impact on Bi_2O_3 very significant. Preliminary work on Microwave assisted olivine synthesis is promising for reducing manufacturing costs. One reviewer mentioned Manthiram seems to have made progress in his coating work of spinels and his production techniques for olivines. However, his use of carbon nano tubes will probably not produce a cost effective cathode due to the cost of carbon nano tubes. Also, it appears that his materials do not have sufficient cycle life. Comments from one reviewer mentioned that regarding to stabilize 4V spinel catode, a lot of research was done and the substitution is well-known. There are a lot of results; however they expected more fundamental research at University.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the collaboration seems to be limited to DOE LBL lab personnel. Another reviewer commented that Manthiram apparently does not work with others at the University of Texas at Austin such as J. Goodenough. Perhaps Manthiram should be encouraged to discuss his experimental work with others. One reviewer noted they don't see the collaboration in the presentation.

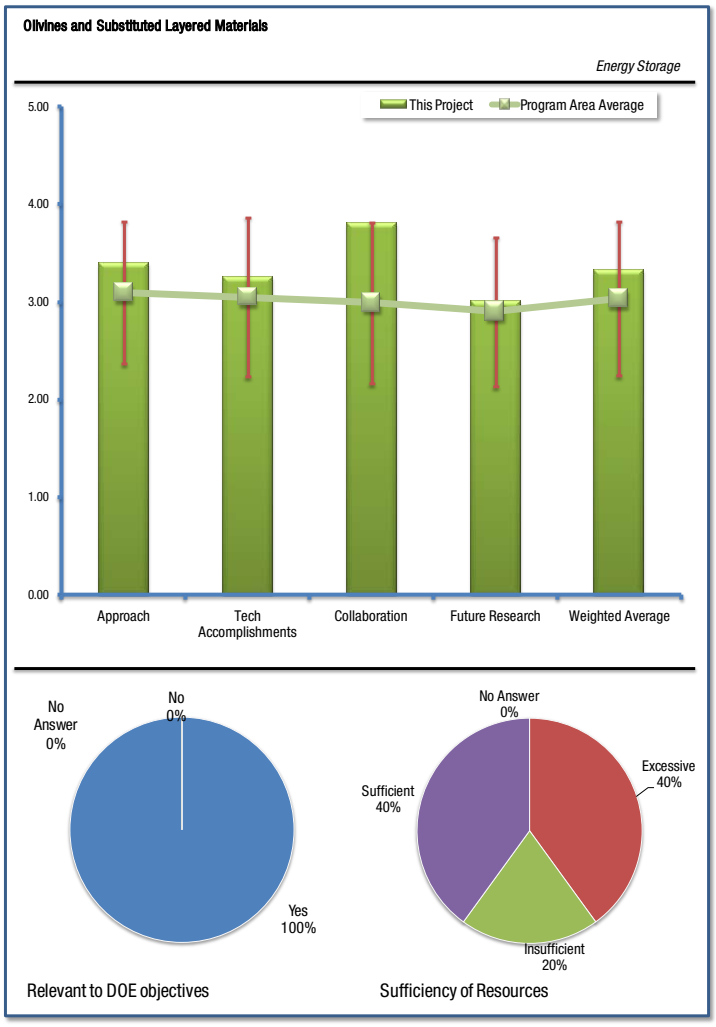
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they need to carefully evaluate the future program to focus on highest likelihood of success areas. Another reviewer mentioned the microwave assistance work is very good and should be applied to new cathode compositions with polyanions. $LiMPO_4$ work is interesting; however, commercial fate of those materials may be on edge. Continued effort on surface coating is extremely promising. One reviewer commented Manthiram is planning to continue his current work next year. It is not clear that his microwave heating approach will be practical for application in industry. Comments from one reviewer noted that they will focus on more fundamental research to understand the mechanism. For example, they want to understand the mechanism of how the coating works, or how F doping works.

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

A reviewer stated this work is very relevant and has yielded strong results - relative to other initiatives it could be funded more, particularly if scope was expanded to evaluate impact of surface modifications on other cathode materials. Another reviewer noted Manthiram has received sufficient funding. One reviewer mentioned the quantity of the results is a lot.

Olivines and Substituted Layered Materials: Marca Doeff (Lawrence Berkeley National Laboratory (LBNL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that low cost, benign and high performance material is what they need. Another reviewer commented the work is directed at developing lower cost materials for Li-Ion batteries that are safer and have higher performance. One reviewer noted the project is aiming to develop low cost (low-cobalt) and high capacity and environmental benign cathode materials, by substituting Co with various other metals. If successful, these studies will result in enhanced specific energy and reduced cost for Li-ion batteries to make them viable for PHEVs, which would in turn reduce the petroleum consumption, demand and (national) dependence. Comments from another reviewer mentioned improvements of cathode materials are essential in reaching DOE objectives. The focus here is on two interesting materials with some interesting results. Another reviewer stated that this project advances understanding of alternative cathode materials for vehicle applications.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated please do not focus on cycle life only but push the material to the limits and look how well it sustains storage. It is good to see a go/no go decision on $LiMnPO_4$. This promising material may remain an eternal promise. Another reviewer noted creative synthesis of new materials, especially the NMC and PO_4 materials. These have good promise to improve the performance of Li-Ion batteries with good safety characteristics. The work uses the appropriate experimental approach to understand cathode operation, Raman, TEM etc. One reviewer commented the approach of substituting Co with several other metals to bring down the cost, and yet retain high capacity, looks feasible, but the capacity improvement isn't substantial. Likewise, there wasn't much success with the nanostructured $LiMnPO_4$/C composites, but the synthesis methods may be applicable to other high space energy cathode materials. Comments from another reviewer mentioned the approach is reasonable and mainly based on the cost, performance and stability proposing some interesting changes in two material classes. The identified barriers and the route proposed are acceptable with complete electrochemical characterization.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated it is very surprising to see discharge rate increase when Al increases. Is it true or is it somewhat an artifact? It would be interesting to see how the diffusion coefficient changes after several cycles. Another reviewer commented the work on Manganese phosphate has shown that it has little promise as a cathode material for use in the HEV, PHEV applications. The NMC compounds show greater promise. The reduction of Co contents shows

good promise to lower cost while improving performance. One reviewer mentioned substitution of Co with Al has been studied in great detail, both from performance and structural points of view. Al substitution in general decreases the capacity, but improves rate at low contents. It also permits charging to higher voltages, which results in a capacity increase, but with increased capacity fade. Not surprisingly, the optimum Al content is 0.05, like in the NCA material It is not clear as to why the diffusion coefficient is lowered upon Al substitution, even though the rate capability if improved. Overall, the three substituent's studied (Al, Ti and Fe) do not seem to be best choices from performance stand point. Comments from another reviewer noted the work on $LiMnPO_4$ seems less interesting with results not positive for a further use of such material. Much more valuable is with work with manganese compounds by substituting Co with other materials. Another reviewer stated there was good progress with substituted NCM's.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated that there are good working arrangements and collaboration with fellow co-workers at LBL. There is also significant co-operation with Whittingham, Grey, and Cairns among others. Another reviewer noted there are a few good collaborative efforts in this project. One reviewer commented the collaborations are well motivated and integrated to support the development of new materials. Comments from another reviewer mentioned via collaboration with SNL or via examination within the project, investigation of the relative thermal stability of the $LiMnPO_4$ material, or of any of the other materials, by DSC or ARC may be a useful additional parameter to consider in further work towards $LiMnPO_4$ or any of the other materials in this project. Collaboration with globally viable battery materials supplier(s) could improve focus and value.

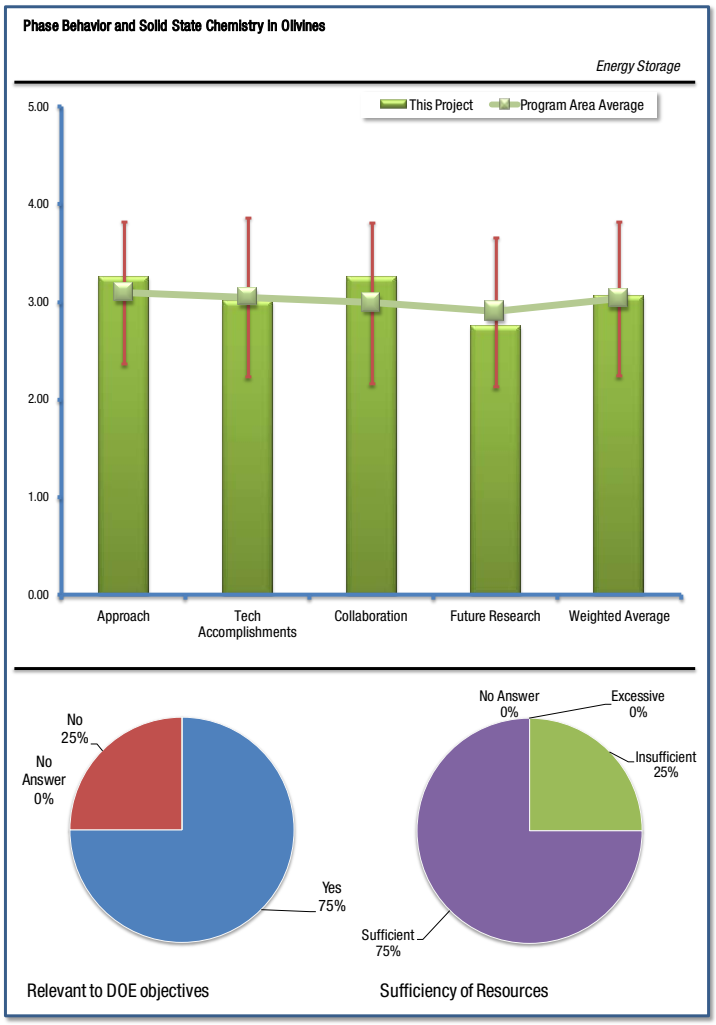
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated there are a lot of interesting results but a lot of questions remain unanswered. Need to be careful about the objective for next year and focus on the main questions. Another reviewer commented the future work clearly understands the direction to go and builds on previous success. Substitutions in the crystal lattice to change properties are the specific area of expertise. One reviewer mentioned the future work is aimed at understanding the structural and functional aspects the substituent's (for Co) to develop low-cost cathode materials, as required for PHEVs. Comments from another reviewer noted the activities on new materials must be further developed with the assistance of the proposed collaborations, as clearly proposed, with emphasis on Al substitution. Technical targets must be better defined eventually separating exploratory work on new materials and research on material improvements. Another reviewer stated the focus on $LiMnPO_4$ should be reduced for now, and focus on substituted NCM's and further tangible improvements to substituted NCM's should be increased.

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

A reviewer stated the project has no resource limitations that are obvious. Another reviewer mentioned the resources are adequate. One reviewer commented the described delays and limited results on one of the materials under investigation make the planned budget overestimated, even if there is no clear view on the way this will be used. Comments from another reviewer noted the project should redirect resources more towards substituted NCM's and/or other new alternative materials and minimize or eliminate effort on $LiMnPO_4$.

Phase Behavior and Solid State Chemistry in Olivines: Thomas Richardson (Lawrence Berkeley National Laboratory (LBNL))



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that barriers being addressed are relevant to DOE applications - capacity, cycle life and stability. Another reviewer noted the energy density improvement will reduce weight and volume of the battery packs. One reviewer commented Richardson et al. are producing new cathode materials that may be useful in lithium ion cells. Comments from another reviewer mentioned this kind of fundamental study is very valuable as the National Lab work.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the investigation of the relationships of structure, morphology and performance of electrode materials, with emphasis on phosphates and intermetallics has some value if the knowledge can be transferred to practice of manufacturing the materials. Another reviewer commented Richardson et al. are using focused experiments and analysis techniques such as XRD FTIR to understand the material that they are producing. Also, Richardson is careful to validate his techniques relative to those of others (Whittingham, eg). One reviewer mentioned it's a very good approach to understand the mechanism for olivine materials. The challenge for Li-Mg is "difficult to make it", "Potential too close to Li" in the presentation but there are more critical issues to be solved for Li alloy anode in the industry.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the results do not stand out except for in -situ lithium preparation from Li_3N with Mg or Al. Another reviewer noted Richardson et al. have made material that appears may have utility as a high voltage cathode material, if stability problems can be overcome. They have also produced interesting new materials which might be useful as anodes. One reviewer commented they can see a lot of data to support the mechanism for the olivine but didn't see so much electrochemical data for Li alloy.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated there is excellent collaboration including industry as well as National Labs. Another reviewer mentioned Richardson et al. have begun interaction with industry, which should help them focus their work to be more supportive of the activities underway by battery companies. One reviewer noted that based on the results, they believe there are some collaboration with others.

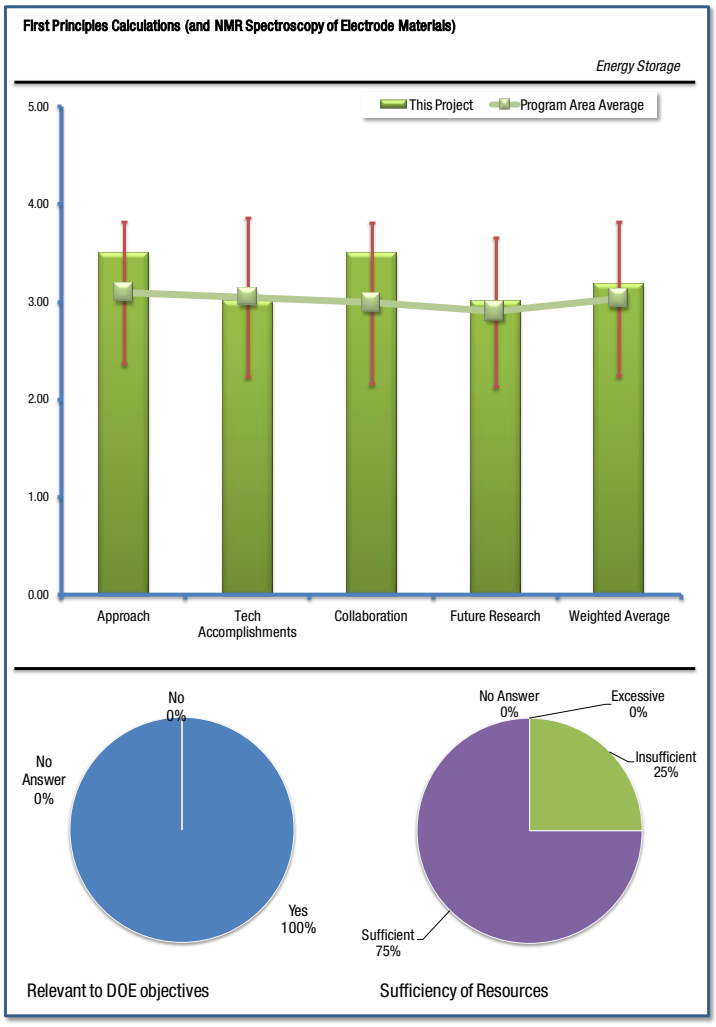
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated Richardson et al. have plans to continue their work in directions that should be useful to lithium ion battery manufactures. Another reviewer commented please complete the olivine study and suggest the approach for the new positive active material. Regarding to anode, please focus on the issues that the industry has.

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

A reviewer stated Richardson et al. are receiving sufficient funding for this project. Another reviewer noted that probably more resource is needed for the anode study.

First Principles Calculations (and NMR Spectroscopy of Electrode Materials): Gerbrand Ceder (MIT/SUNY-Stony Brook)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that for performance, life and stability it is very important to understand electrochemical particles and to predict the reactivity with the electrolyte. This is what that project addresses. Another reviewer noted the first principles calculations will help not only in understanding unexpected experimental observations (such as hysteresis, phase transformations etc) but also in identifying new materials, for example with high specific energy as required by the PHEVs. Replacement of conventional vehicles with electric vehicles will reduce the consumption and demand of petroleum. One reviewer commented the use of calculations to screen materials before their practical production and experimental analysis addresses some key objectives of improved materials for Li batteries. Comments from another reviewer mentioned the presenter understands what the problems are about the battery for vehicle usage. R&D in the battery business usually does not dig into detail about active material itself. In other words, optimization only from DOE (design of experiment) is the normal trial to reach costumer target. This research shows very well about mechanism for each material and the entire research will be a big help to accelerate R&D for battery manufacturers in the US.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated there is a relation between structure stability and rate capability, which enables better prediction of oxidation and reduction. Another reviewer commented the approach is fairly effective, providing clues in understanding stabilities of different structures ay high state so charge, correlation between structure and its electrochemical properties and in identifying newer materials with improved specific energy. One caveat is that some of the successful solutions (e.g., non-equilibrium phases, kinetically stabilized systems. SEI) are not often predictable by theory. One reviewer mentioned the approach systematically looks at key technical barriers by screening cathode materials using computational methods. The selection focuses on key materials features. Comments from another reviewer noted this research approach is very simple and common sense, but many of the research are not following like this research as below:

- find the base and determine the effect from material point of view.
- find and determine mechanism to reach the target.
- provide the new material chemistry based on the result and develop.

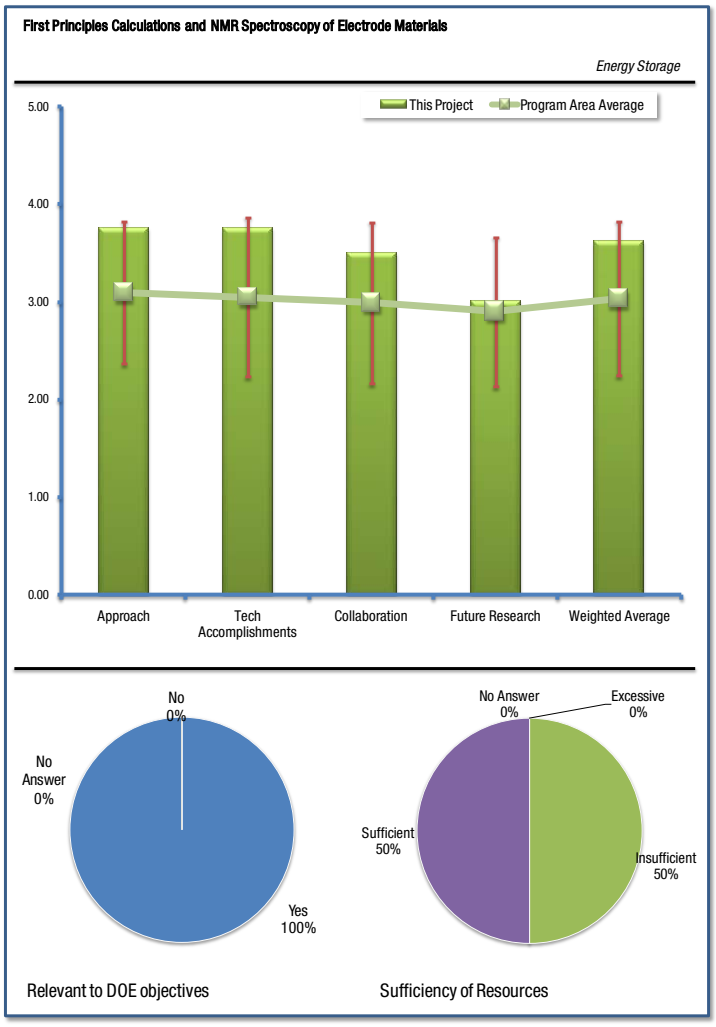
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated the demonstration that nano material with optimized surface treatment has fast kinetics is nice, but what are the true limitations? As far as they know this is true for a lot of other material not only $LiFePO_4$. Does that mean that the true limitation is electronic? Good work showing that synthesis conditions (oxidation condition) lead to different morphology and performance. The theory of lithiation of surface as an interpretation of the extension of solid state surface is interesting. How to demonstrate it by experiment and what does that mean in term of material morphology optimization? Another reviewer mentioned that impressive rates are being claimed with olivine cathodes and a useful simulation model has been developed to study the mixed olivines, especially the plateau potentials and the hysteresis in the FeF3 cathode, among other things. Finally, it is being claimed that both voltages and capacities have computed for several new compounds, though there wasn't any information on them. One reviewer commented the presentation mostly concentrates on describing the methodology with limited space in presenting the most interesting configurations and structures. The use of ab initio calculation must give clear indications in improving existing structures or selecting new ones. Comments from another reviewer noted the information was provided as addressed in the objectives. What is happening to material, why, particle affect what, and possibility of future material? Altogether, this is an excellent result.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated there is good collaboration with the DOE researchers and researchers elsewhere. Another reviewer noted the collaborations presented in one slide apparently do not show up in the presentation of the work. The level and type of collaborations should be better described. One reviewer mentioned which parts was collaboration work and done.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated that understanding the kinetics of phosphate materials does not seem to be the priority now. They think it would be more interesting to look at material structure and surface stability (or other mechanisms) that impact the life. Another reviewer commented the proposed future work appropriately focuses on continuing the modeling approach to identify new materials and understand the effects of nanomorphologies, and also undertake experimental studies to verify one such advanced material. One reviewer mentioned the proposed activities are consistent with the first principle calculation application with integration of experimental work. Comments from another reviewer noted that the future work was addressed based on the result and confirmation work is also mentioned. All of the addressed future works are along with approach and towards target.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the resources are adequate. Another reviewer noted the timely and productive completion of the planned activities is strongly related to the resources of the PI together with the defined collaboration. One reviewer noted to explore new material, this research may need more budget so that the possibility for new material will expand more and may add great value to the US battery business.

First Principles Calculations and NMR Spectroscopy of Electrode Materials: Clare Grey (SUNY-Stony Brook)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated Si based anodes are one of most promising materials to dramatically improve capacity of batteries and also address cost - cycle life is a key parameter and concern with Si materials this work allows both fundamental understanding but also practical way to look at impact of binder. Si and future electrolyte efforts seem more relevant than conversion reaction efforts. Another reviewer mentioned this project is generating a tremendous amount of understanding on new high energy materials and existing key materials. One reviewer noted NMR was not used so much to evaluate the structure but it would be the good especially to understand the amorphous structure.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that coupling ex situ and in-situ advanced spectroscopic techniques is very valuable and particularly relevant to overcoming barriers of addressing system deficiencies and not just evaluating material on its own. It is very nice to see intersection of spectroscopic methods and ability to implement and measure in real cells. Another reviewer commented the PI does pioneering work in NMR methods - world class work. Equally important is that she takes a holistic approach and includes other techniques such as diffraction, X-ray Pair Distribution Function Analysis (PDF) and electrochemistry to try and get a complete picture of what's going on. They appreciate the PI's insistence of taking the time to properly design comprehensive studies on some of these new materials rather than just starting in on data collection. One reviewer mentioned it is a good approach to understand the structure change by NMR.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated they think strong foundation for Si anode work has been laid and will be able to be utilized to speed real applications of Si anode. They also see potential for similar effort results in electrolyte work. Another reviewer mentioned that in a relatively short time frame this group has provided new insight on the charge/discharge of silicon anodes and also cathode coatings. They are very impressed with the speed at which they have addressed new materials; they seem to bring new insight into every area they touch and they expect this to continue. One reviewer noted there is a lot of previous work for Li-Si. If PI can compare the results with the previous work, it would be better.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer suggests seeking additional partners regarding Si based anodes to address key challenges with implementing. Another reviewer stated they think the PI is extremely well connected to the rest of the program and is extremely effective at linking her work to the other National Labs, MIT's modeling work under Gerd Ceder, and other institutions. In terms of completing her own tasks, they would rate this PI's collaboration as outstanding. One reviewer mentioned they do think that the other labs could use her help more to answer their own needs more than they do. With so much of the recent work relying on nanomaterials and coatings, diffraction studies often miss the key features that define system stability and that NMR can offer key insights they need. Comments from another reviewer noted that collaboration with the industry is recommended.

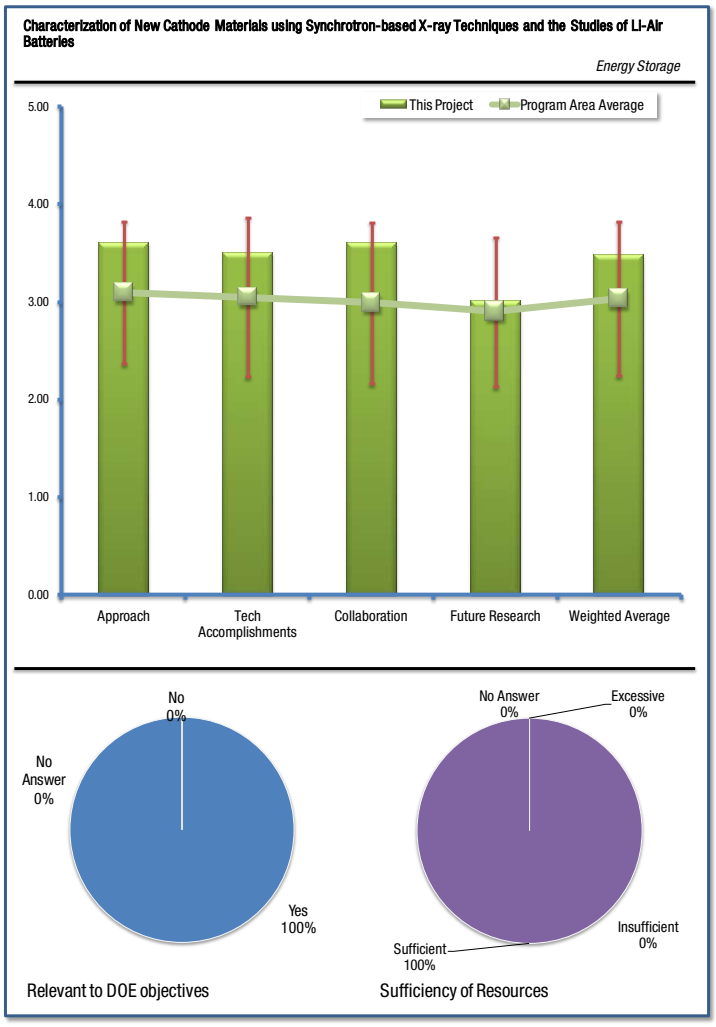
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the impact of binder on Si based anodes has been shown to be critical to cycle life also most Si based anode materials are blended with graphite 1:1 - studying these parameters in system could prove both scientifically valuable as well as worthwhile to applications of Si anode technology. Another reviewer commented the focus on conversion materials is aimed at a new class of materials (at least new for this program), and it is refreshing to see how well the PI has moved onto new topics. One reviewer noted the MRI imaging work looks interesting. They are not sure that the spatial resolution will ever be good enough, but in principle such work could be a tremendous adjunct to the electrochemical modeling and electrode design and characterization. Comments from another reviewer mentioned that if the PI can suggest the improvement on the materials based on the NMP results, it would be good.

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

A reviewer stated that on a relative basis to other work reviewed, they believe accelerating the in-situ work of this group would have large practical benefits and should be considered. Another reviewer noted this PI seems to them to be the most effective at creating truly new understanding on key materials, but yet gets less funding than many others. They strongly recommend boosting her funding to at least $600K/year.

Characterization of New Cathode Materials using Synchrotron-based X-ray Techniques and the Studies of Li-Air Batteries: Xiao-Qing Yang (Brookhaven National Laboratory (BNL))



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the work involves a number of DOE programs and provides unique structural information on changes during charge and discharge. Another reviewer mentioned the X-ray analysis of advanced cathode materials during charge and discharge to understand the reaction products that form and when they form. Has excellent insight of the cathode operations and mastered the experimental techniques. The materials form the basis for Li-Ion batteries for HEV, PHEV and EV applications. One reviewer commented the objective of this project is to develop and understanding on the surface and bulk properties of electrode materials upon cycling, storage and thermal abuse and thus contribute to the development of long-life Li-ion batteries for PHEVs. A widespread use of Li-ion batteries will reduce the petroleum consumption and demand. Comments from another reviewer noted the structural studies of materials are functional to the development of batteries meeting DOE objectives. Another reviewer stated Crystallographic studies of cathode and anode materials are important to study the structure property relationships as materials are charged and discharged. This leads to enhanced ability to design better performing materials necessary for high energy batteries. Also high temperature stability can be studied and improved upon by information gathered through these characterization techniques, allowing tailoring of structures for better high temperature performance necessary in the nickel systems.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the group has access to a unique facility which produces monochromatic x-rays which can be used for diffraction experiments, absorption experiments in a very exact way. The time resolution is much better than any other method so that the structural changes with time of charge or discharge can be measured. The choice of materials seems to be close to DOE goals. Another reviewer commented they are able to use advanced techniques to understand the reaction mechanisms in an efficient manner. Not wedded to one technique but applies the appropriate one. Works well with others that supply new materials and concepts. Focus on understanding specific problems and developing the best techniques to help understand electrode operations. One reviewer noted a combination of in-situ and ex-situ techniques will be utilized to derive information on the solid electrolyte interface, morphological and compositional changes in the electrodes upon cycling. These methods are being used by these researchers and others successfully. In addition, new electrolyte system for lithium-air system (a long-term option) will be designed, using boron-based anion receptors that can dissolve lithium peroxide. Comments from another reviewer

mentioned the approach is very appropriate in using synchrotron studies and other advanced crystallographic studies to characterize the behavior of various Li systems. For Li-air the experimental activities combined with molecular design may give quick answer on the system potentialities. Another reviewer said synchrotron data is utilized to study phase transitions in situ and exsitu. Further temperature dependence and electrochemical reaction paths are studied. This is a great approach to learn about phase transitions in the materials.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the identification of reaction intermediates in the cathode reactions is quick and accurate. Can separate the contributions of each element in the cathode and when it enters the reaction scheme. Electrolyte studies for Li-Air are creative and essential to the eventual commercialization of the system. Another reviewer noted that distinct intermediate phases and solid solutions regions were identified through in-situ XRD in mixed olivine systems Li(Fe,Co,Mn, Ni)PO_4 that are typically absent in pristine $LiFePO_4$ system. The X-Ray near edge spectra provide confirmatory evidence that the extra capacity for $Li_{1.2}Mn_{0.4}Ni_{0.4}O_2$ is not contributed by Ni and that in over-lithiated layered -layered solid solutions, the Li_2MnO_3-like phase activates during first high charge at high voltage. There may be some reservations on the use of TEM and Electron Diffraction, being ex-situ techniques for studying the SEI. The results on the electrolytes for Li-air system are quite encouraging. It may be useful to assess the stability and longevity of the anion receptor TPFPB. One reviewer commented the progress is relevant and well described. The association of in situ measurements and electrochemical behavior is effective in identifying mechanisms and optimizing material composition and cell design. The screening capacity of the methodology is adequately outlined. Comments from another reviewer mentioned that significant progress has been made, but no surprises have been detected. The verification that substitutional chemistry can stabilize up to 5V is a significant progress against achieving high voltage stability. Also the verification of solid solution regions in the phosphate systems is notable.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the group uses a large base of collaborators, both among DOE researchers, contractors and non-DOE contractors. Another reviewer mentioned that most of his work is getting experimental materials from others and helping them define the operation of the new materials. They can work with small samples that are produced in the laboratory techniques. The electrolyte work is quite creative. One reviewer commented there are on-going collaborations on different topics. Comments from another reviewer noted there are effective collaborations on key materials and activities. All the contributions and collaborations are well coordinated.

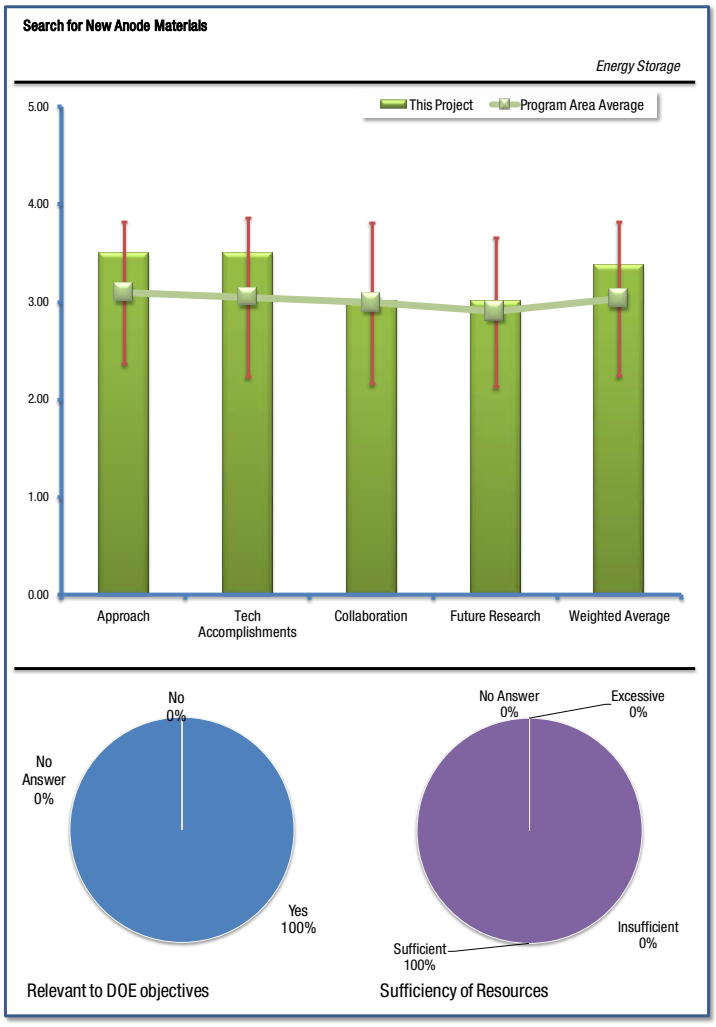
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated a good plan of important projects is indicated. An effort in establishing the structure relationships in $LiFePO_4$ cycling in nanosized materials would be important. Another reviewer commented the collaboration with outside labs to help them understand reaction processes including HydroQuebec materials. Develop new experimental techniques of use with Army Research and UMass for Li-Air development. One reviewer noted the future proposed topics of continuing the diagnostic studies on different anode and cathode materials and in developing novel electrolyte systems (for Li-air) are relevant to the DOE objectives. Comments from another reviewer mentioned the future work plan is quite ambitious and broad but it is substantially based on the application of a continuously updated characterization technique. In addition, the work on Li-air system with the study of new electrolytes may have some positive feedback. Eventually the introduction of a bi-functional air electrode study should be considered. Another reviewer stated the program appears a little bit spread in effort with no clear focus, many systems in play. Coordination with some of the newer systems that show promise could reveal some important information that would overcome barriers for higher capacity materials, rather than stay with the phosphate systems that are lower in performance.

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

A reviewer stated the project can use additional people to assist in the experimental work. Another reviewer noted the resources are adequate. One reviewer mentioned the resources seem hardly adequate to the ambitious work plan, but the use of collaborations may be beneficial in levelizing needs.

Search for New Anode Materials: John Goodenough (University of Texas at Austin)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that new anode materials, particularly intercalation materials which have advantages of cycle life and rate are very relevant to DOE objectives. Another reviewer commented the project is looking for new high energy materials that might enable a paradigm shift in the industry. One reviewer mentioned Goodenough et al. are developing new anode material for lithium ion cells.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated although interesting from academic perspective sulfide based materials would not be practical from a manufacturing cost perspective. Another reviewer noted an excellent understanding and attempts to design and screen the universe of materials, although Cr seems a non-starter on environmental grounds. One reviewer commented Goodenough et al. are utilizing information in the literature to help them focus on finding anode material.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated a lot of sound academic studies completed. Results related to SEI layer blocking Li+ are interesting. Another reviewer added some interesting materials found, such as the high capacity $LiTi_2(PS_4)_3$. While recognizing that solubility issues are important, I would not worry too much about them at this stage. As long as the structure doesn't disintegrate during C/D some kind of "magic" as-yet-to-be-invented coating could help. One reviewer mentioned Goodenough et al. have produced material that may lead them to a new anode for lithium ion cells.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated PI is very aware of what everyone else has done. This program really does not require much collaboration at this exploratory stage. The reviewer recommended that DOE "Just leave him alone to get on with it." Another reviewer noted Goodenough et al. are cooperating with a company to help find a new anode for lithium ion cells.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

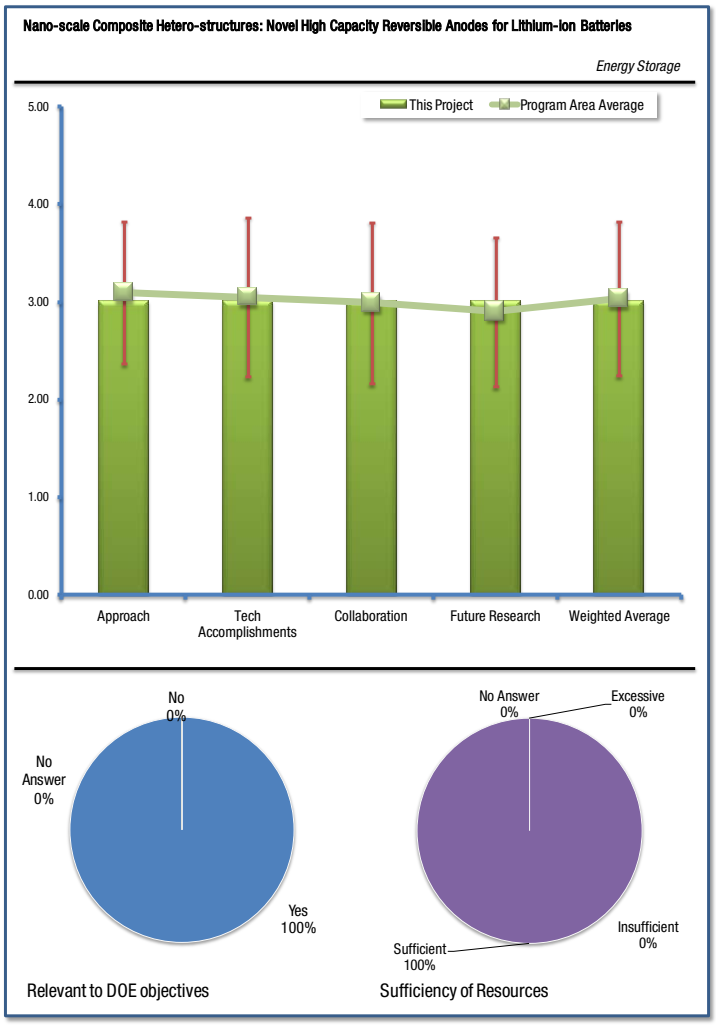
A reviewer stated future work is nebulous - new oxide anodes, new cathodes, and new oxides for both cathodes and anodes. Another reviewer commented while one never quite knows what direction this PI is going to go, they think

that's a good thing. They recommend letting him have a fairly free rein to explore things. One reviewer mentioned Goodenough et al. have proposed to continue their search for new intercalation anode materials for lithium ion cells.

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

A reviewer stated the likelihood of success in such an endeavor in inevitably low. There is a need to go fairly slowly with the current modest level of funding until and unless something pops up that looks exciting. Another reviewer mentioned Goodenough et al.'s funding is sufficient for this project.

Nano-scale Composite Hetero-structures: Novel High Capacity Reversible Anodes for Lithium-ion Batteries: Prashant Kumta (University of Pittsburgh)



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this project has very high relevance because of the high capacity observed and good cycle life to date. This could be a major step forward in lithium ion technology. Another reviewer noted this work is important because we need alternatives to the carbon materials we use today, especially to improve the energy density and decrease the reactivity. One reviewer commented the objective of the present project is to develop new anode materials, alternate to graphite, of high gravimetric and volumetric energy density with the overall objective of enchanting the specific energy of Li-ion cell and batteries and make them viable for a widespread application, such as PHEVs and other electric vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that there is very logical progression of steps as experiments proceed. The work is sharply focused on the barriers as they are developed. The next steps will require substantial collaboration on cell tests made by others using anode materials developed by the PI. Another reviewer commented be careful to identify the right barriers. Specific energy and energy density are the main ones. Irreversible loss and cycle life are secondary. If the new Si based anodes show same irreversible loss and cycle life that current graphite but with two to three times the energy, it is a real breakthrough. One reviewer noted the approach is generally effective and involves the synthesis, characterization and assessment of composite of nanophase silicon and graphite, prepared by high energy ball milling with different amounts of graphite. Also examined are lithiated Si for reduced volume change and improved cycle life and thin film electrodes of amorphous silicon and carbon, which look promising.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the progress to date has been substantial with a number of the goals already reached. Another reviewer commented at the beginning they were confused by charge and discharge nomenclature that is the opposite way that the battery system. These materials need to test vs. a cathode material. What is the efficiency of the system? One reviewer added that useful results have been obtained from the high-energy ball milled composites of Si and graphite with polymer additions for eliminating Si-C formation at the interface. The cycle life is encouraging with low Si content, and the capacity is over 600 mAh/g, which is near 100% gain over carbon anodes. Likewise, the approach to limit the charging to low Li contents in the composite such that a-$Li_{3.5}Si$ formation is prevented for reduced volume

change may be a good compromise between cycle life and capacity. The coatings of a-Si on carbon nanotubes look promising.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated that collaborations with Ford and LBNL have been substantial. It might be useful to look at a subgroup of the anode people in the ES program to meet occasionally and stimulate each other's programs. Another reviewer noted good collaborations are on-going.

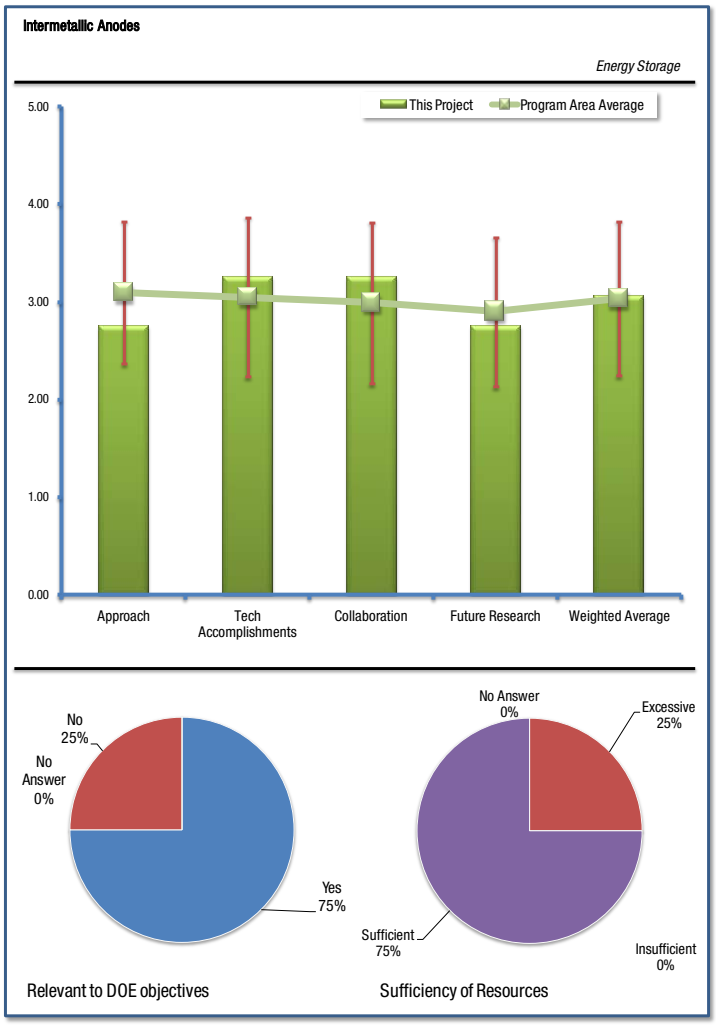
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the full cell testing should begin on materials which meet the energy goals so that a more realistic view of cycle life. Another reviewer mentioned that also stability of the passivation layer on these materials needs to be investigated for both life and abuse tolerance. Some DSC experiment for example would be very useful. If we form SiO_2 at the surface of the material, what is the reaction with HF? One reviewer commented the proposed future work on further improving synthetic methods to get Si-C composites that provide good capacity/cycle life, minimizing the irreversible capacity losses and understanding the interfacial properties of these composite anodes (SEI) are quite relevant to the DOE objectives.

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

A reviewer stated the resources are adequate.

Intermetallic Anodes: Michael Thackeray (Argonne National Laboratory (ANL))



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that improved anode over graphite is important to vehicle applications but high Sn compositions are highly questionable for environmental and cost per capacity reasons. The $LaSn_3$ materials are pyrophoric and use in a manufacturing process seems extremely improbable. Another reviewer noted the high capacity anodes offer the more likely promise of getting to significantly higher energy density systems required for PHEV. (These would also be very useful for high energy consumer applications such as laptop computers, camcorders). One reviewer mentioned Thackeray et al. are searching for better anode materials for lithium ion cells.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the advantages of Cu_6Sn_6/Sn/Cu similar to Na/$NiCl_2$ in regard to volume expansion are accurate; however, environmental, cost and not cutting edge performance make approach less relevant to objectives for PHEV. Same with $LaSn_3$ - cost and theoretical capacity minimize relevance. Also $LaSn_3$ is not suitable for manufacturing. Another reviewer added this is a good study and closure on La system. Other findings seem also quite good in a difficult area. Many problems obviously remain with these types of anodes. One reviewer noted Thackeray et al. are utilizing modeling to help them direct their experimental work. They are trying to find Sn based materials with short diffusion lengths for lithium ions in the solid phases of the material. They are using modern methods and classical methods in their experimental work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that good progress towards objectives laid out in proposal regarding capacity of > 400 mAh/g, but PHEV 40 objectives are really not addressed with current work. Another reviewer noted exploring the La system has obviously taken time away from the Si/Sn work. Nevertheless, this was an worthwhile study that showed this to be a dead end - good study and good closure. Other findings seem also quite good in a difficult area. Many problems obviously remain with these types of anodes. However, the ball-milled material is giving better reversible capacity than other bulk forms of this material. Like Kumta, they are starting to realize the benefits of thin film type materials in "real" materials. They were somewhat disturbed by the rather sharp drop in capacity after 30 cycles or so. If this is related to their anode material, and they suggested it was actually a reflection on their counter electrode, it needs much further study. If it really is a counter electrode issue then it would seem they need a better way to test their materials to get at the longer cycle life measurements of their anodes. One reviewer mentioned Thackeray et al. have produced some interesting materials that may be useful as anode materials in lithium ion cells.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the project is utilizing other organizations and Universities. Another reviewer added it seems like they could do well to work more closely with Kumta and vice versa. Didn't seem much evidence that this is happening, but they could be wrong. One reviewer noted Thackeray et al. are working with others in both industry and universities.

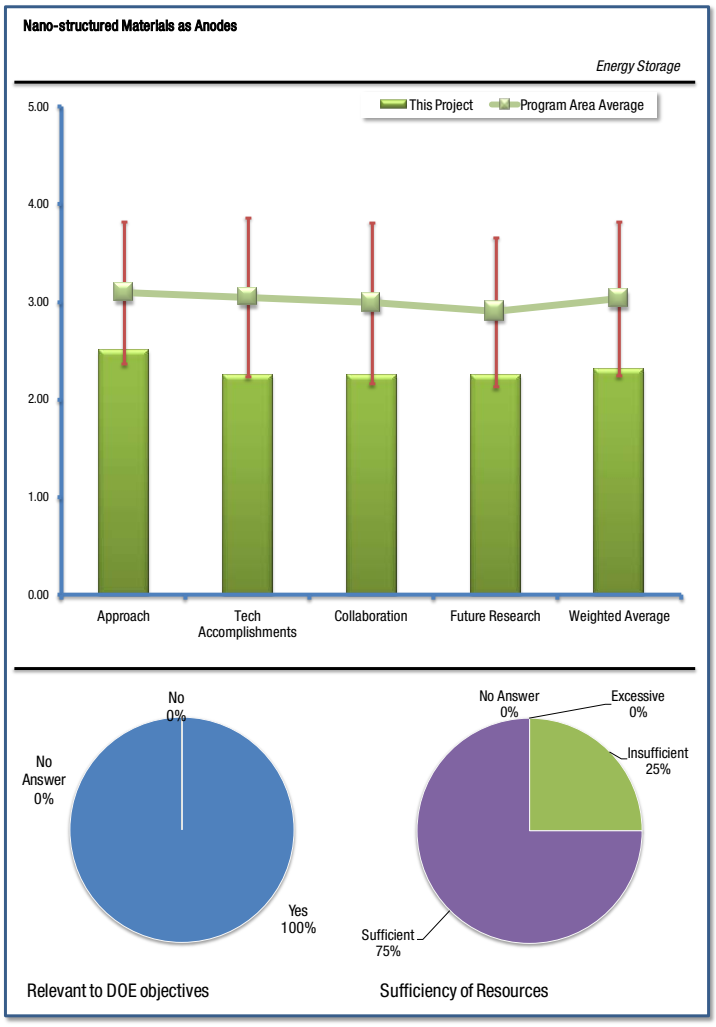
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the project should shift focus to materials and processes that at least theoretically will meet PHEV 40 goals. Another reviewer commented the greatest benefits from the current and future activity by this group may be in improved understanding/discovery of improved active materials. The efforts on substrate development are valuable but may detract from more beneficial work that could be performed by this group in the area of improved active materials at the fundamental level. One reviewer mentioned the new electrode manufacturing system looks very intriguing. Again, this should be shared with and compared to the approaches being explored by Kumta's group. The PI commented on the safety concerns with some of these new anode materials. Agree that some DSC/ARC studies should be done if they have not already been well studied (the reviewer is not that familiar with the literature in this aspect). Maybe look at packing density of these anodes? Comments from another reviewer noted Thackeray et al. have well developed plans for next year. Their plans for the copper foams may produce useful anodes.

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

A reviewer stated that relative to other programs presented this is not a good investment - if not focused on more relevant systems (Si) other programs seem much more promising to meet PHEV 40 goals. Another reviewer noted this is a big task and needs a substantial amount of funding, which it gets. One reviewer commented that funding for Thackeray et al. is sufficient.

Nano-structured Materials as Anodes: Stanley Whittingham (SUNY-Binghamton)



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated because most of the anodes studied are only marginally better than carbon or even poorer than carbon on a gravimetric basis, the emphasis should be made on high gravimetric aspect unless there is an important concept involved. Another reviewer added this work is focused on developing new nanostructured materials to replace current anode materials using carbon. One reviewer noted the development of high volumetric energy density anode compatible with low cost cathode materials is highly supporting the DOE objectives. Comments from another reviewer mentioned that nano and amorphous material comparison is interesting topic.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the comment made under relevance is very important in establishing the approach. The specific capacity of materials that are emphasized should be clearly superior to graphite. This is a much more important property than the capacity density. Most of the reported materials are either deficient in this property or barely better than graphite. Furthermore, the addition of other metals or phases should be included in the weight of the anode to determine the specific capacity, so that a fair comparison can be made. Also, the charging efficiency should be carefully evaluated with each material and this aspect should have a high priority in studies of the most promising materials if the charging efficiency is less than 100%. In full cell studies, charging inefficiency results in rapid capacity loss which is not observed with a lithium counter electrode. Another reviewer mentioned the approach is reasonable with identified barriers but needs better specifications on the materials or solutions that will be investigated. One reviewer commented even though the topic is interesting, they don't think the approach is not proper as well as the results. Please focus on more fundamental things that only academic can focus on to understand the mechanism different between amorphous and nanomaterials.

Comments from another reviewer noted the approach is good is general. The titanium oxide material is probably more suitable for HEV than PHEV and EV applications. In that matter it would be very interesting to see studies about:

- how to reduce the cost of this material
- how those materials behave on calendar life.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the low gravimetric efficiency of most materials studied has limited the progress. There are some good fundamental studies and the effort to find the importance of amorphous structure versus the crystallite size is

important to establish. Another reviewer asked is the lithium deposition on carbon really the main issue for safety? It seems that stability of the passivation layer is the most important. That is why titanate electrode are superior to carbon ones. Study of the stability of the passivation layer on these nanostructed anodes is of great interest and they would like to see more. That passivation plays a role both on life and abuse tolerance of the cell. This reviewer also asked does really Nexelion meet technical needs for PHEV: low T, life, power...?? One reviewer noted the experimental results are quite clear and give indications on the next research steps with focus on better materials and structures (amorphous and/nano). Comments from another reviewer mentioned they were working on amorphous tin 10 years ago. They cannot see any new finding in this presentation.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated there doesn't seem to be a high level of collaboration with other institutions other than DOE labs. It could be quite useful to collaborate with other BATT PIs such as NMR studies with Prof. Grey at SUNY Stonybrook or structure studies with Prof. Shao-Horn at MIT to settle the issue of the importance of amorphous phases. Another reviewer mentioned this work would probably benefit from more collaboration with partner having surface analysis capabilities. One reviewer commented the level of collaboration is adequate to the project with key contributors for completing material characterizations. Comments from another reviewer noted they can see the partners but they cannot see how the collaboration works according to the achievement level.

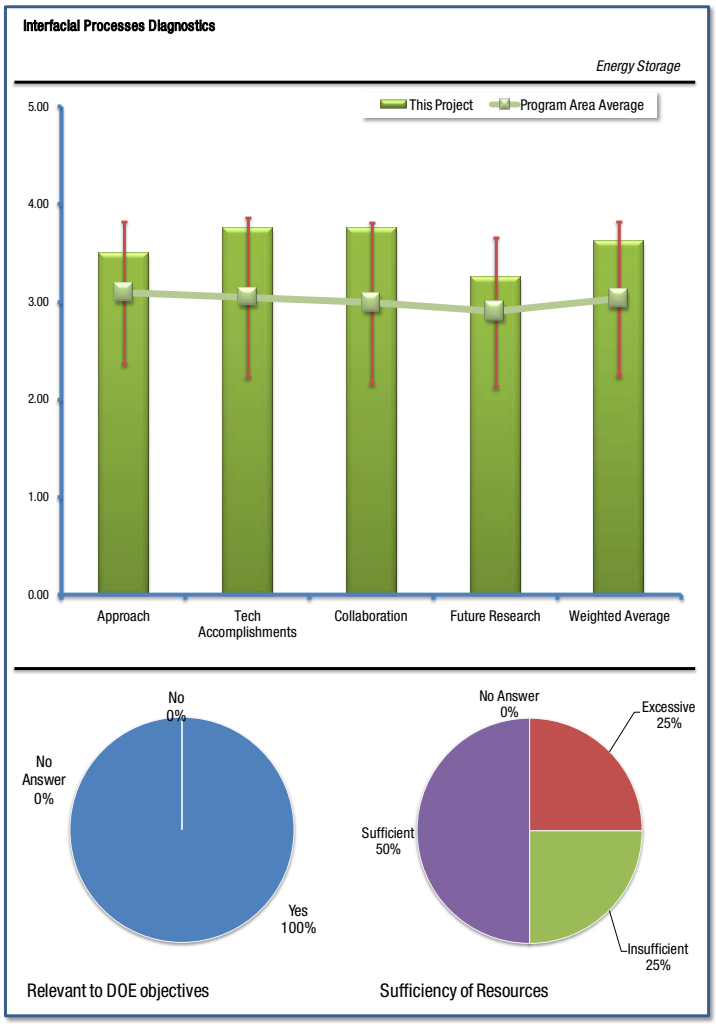
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they would like to see an emphasis on high specific capacity materials in future work. Another reviewer added they don't understand why amorphous nano-tin is the direction to go? Capacity is higher than carbon but not as high as Si. Where is the demonstration that this is safer than carbon? What is the power performance and life in a full cell? What is the cost? These questions need answer before we can say this is the direction to go vs. Si. One reviewer commented the future plan is consistent with the previous year's results. Better materials will be further analyzed and developed for aiming at better performances. Comments from another reviewer mentioned they would like to see a focus on more fundamental research.

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

A reviewer stated the resources are adequate to the proposed activities. Another reviewer noted the test data is just cell cycle data and XRD. This is not enough to discuss about the topic.

Interfacial Processes Diagnostics: Robert Kostecki (Lawrence Berkeley National Laboratory (LBNL))



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the in-situ studies of this work are laying key foundation needed to address new materials with lower cost/capacity and higher capacity materials - very relevant to vehicle technology and DOE objectives of petroleum displacement. Another reviewer mentioned this project helps to diagnose the limiting properties and end of life of electrodes. One reviewer commented diffusion work deals with high rate anodes for HEV/PHEV cells. Surface studies may also provide the key to understanding new anode stability.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated based on successful completion of milestones approach is successful and on time. They applaud ability to implement approach and results delivered by approach. Another reviewer commented the approach involved in the investigation of lithium diffusion in graphitic carbons is good and should be further developed and expanded (to include, for example: determination of diffusion rates for other carbons most importantly, as well as temperature dependency, rate or applied current dependency, other electrolyte compositions, etc). Further with regards to the lithium diffusion investigations, collaboration with a major producer(s) of Li-ion anode carbons/graphites could usefully increase the impact of further work in this area. One reviewer noted the design and use of new cells to study the in-situ transport mechanism is excellent. Comments from another reviewer mentioned the electrochemical method for measuring plane-specific diffusion characteristics is unusual and well thought out. Good approach to the Sn anode work as well.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

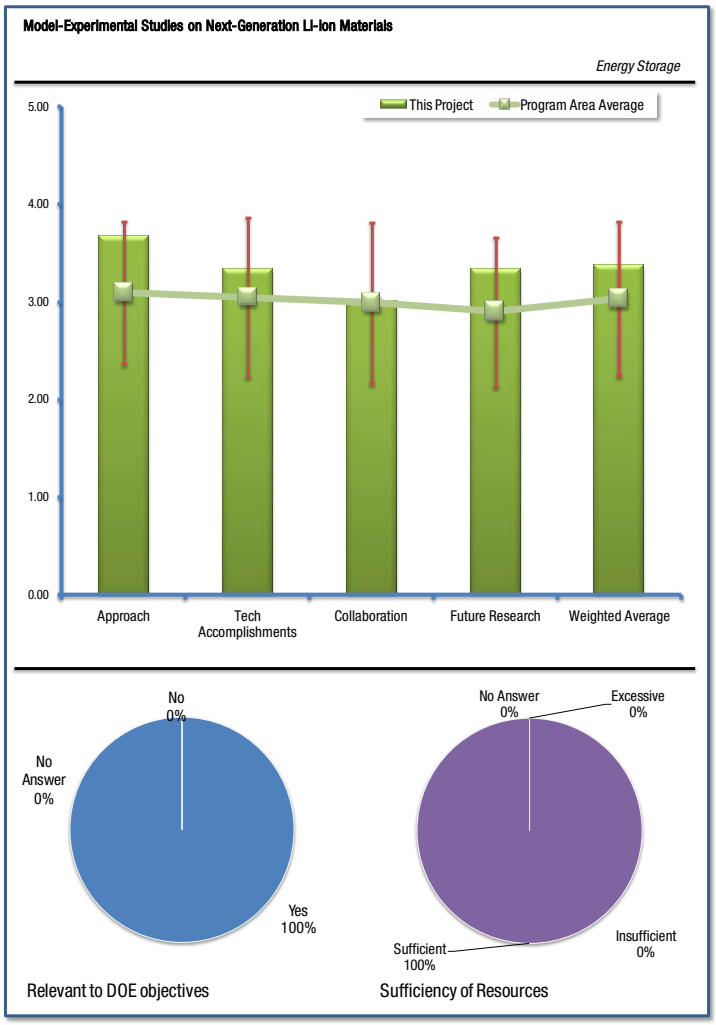
A reviewer states the goals have excellent progress with meaningful results presented - particularly in in-situ work. Another reviewer noted that there is excellent progress in the investigation of lithium diffusion in graphitic carbons and fundamental understanding in this area. One reviewer commented conclusions of the diffusion in graphite which may help with the design of anodes for high rate electrodes. Comments from another reviewer mentioned that the methods used here seem to provide "real" values of diffusion values, although maybe on a limited sample set. Better than the more commonly used methods that seem to provide widely inaccurate values on a wider set of materials. Good fundamental support for carbon anodes. The surface studies on the Sn materials look to provide a key to ensuring long term stability with these materials. This is very interesting and needs a lot of follow up work. On the down side, the accomplishments seem rather modest in view of the effort involved.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated there is a lot of solid collaboration on this project. Another reviewer mentioned that collaboration with the BATT groups is beneficial to the program. One reviewer noted the project is working with ANL and LBNL. They suggest they also start looking at Kumta's materials.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the project really should apply excellent in-situ methods to other common materials particularly Si materials. Another reviewer noted it's a good plan as is. Only suggestion would be to maintain/enhance focus on mass and charge transfer mechanisms in/on the electrode/electrolyte interface in graphite/carbon anode materials as priority over other activity. One reviewer commented the future work is an experimental set up to study kinetics. Comments from another reviewer mentioned it would be good to look at the change in Li diffusion in carbon as a state of charge if possible. Also plans to look at Si surface and stability look promising. The reviewer suggests they work with Kumta as well as ANL. The surface studies could be especially valuable if the work could explain some of the effects noted. For example, why is PC better than EC and/or amorphous Sn better than crystalline Sn? This is obviously much harder to do, and needs a lot of collaboration with other researchers, but in the long run this may lead to better design of materials and systems for long life.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the team is meeting goals on time so resources are adequate for plan however, they think on a relative basis there is high merit to this work and additional funding could increase scope in a positive way. Another reviewer mentioned the funding level seems quite high for this work. The quality of the work is very good, but they are not sure that the pace of this work is really where it needs to be.

Model-Experimental Studies on Next-Generation Li-ion Materials: Venkat Srinivasan (Lawrence Berkeley National Laboratory (LBNL))



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated understanding the limitation of the Si system is very importance to increase the energy density of batteries. Another reviewer noted that constructive characterization and associated modeling of silicon anodes (or other higher capacity anode materials) is useful in considering direction toward potential long-term increases in energy density for hybrid and electric vehicles. One reviewer commented that testing and modeling helps to determine effects of various parameters. This will help to improve the efficiency and energy density.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach is very good. They really like the combination of modeling and experimental data. Another reviewer commented the general approach is good, and focus on silicon is good. However, the planned sole focus on $LiMnPO_4$ as cathode seems too limited. Further work on other candidate cathode materials would be desirable. One reviewer noted the use of a model to optimize battery design and evaluate ability to satisfy vehicular needs is considered to meet the DOE goals.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the corrections for the side reaction via modeling and use of additives. Another reviewer noted that now with such a low energy efficiency at rate as low as C/2 (in half cell), this type of electrode will be difficult to use for EV or PHEV. So it is important to understand what are the true limitations (side reactions or other)? Does that model allow to evaluate the stability if the passivation? Are the side reactions an instability of that passivation layer? This reviewer went on to list the following:

- The study of hysteresis which show the limitations of the electrode is very interesting
- Identification of side reactions: OCV does not collapse
- Can extract kinetics parameters to predict charge/discharge curves
- Hysteresis of the system make SOC management difficult

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated even if number of partner is shown, the interaction with them is not clear. More collaboration is shown for next fiscal year. Another reviewer mentioned some level of collaboration with globally viable battery developers would be desirable. One reviewer commented that collaboration with BATT groups and industry is valuable.

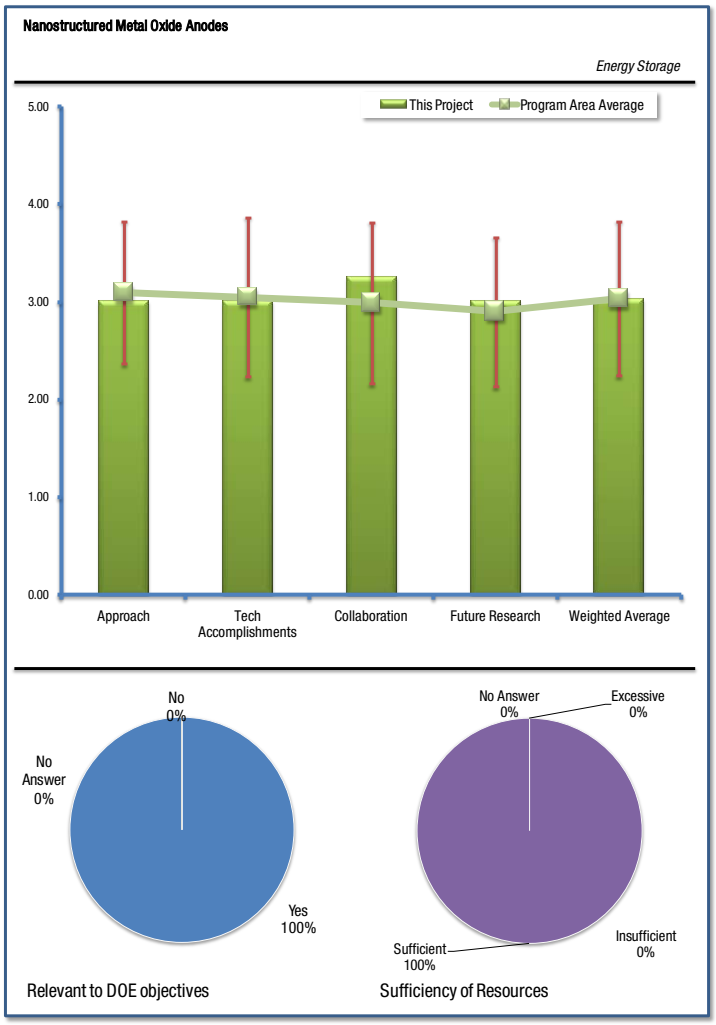
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated it is good to look at the complete cell modeling. Another reviewer noted that greater focus on fundamental rate capability (or rate capability limitations) in Sn anodes (in the place of some of the emphasis on $LiMnPO_4$ cathodes or otherwise) would be desirable. One reviewer mentioned the project will incorporate the kinetic and mass transfer models into a porous electrode model and simulate the performance of a NMC/Si cell under PHEV conditions.

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

No comments were made by the reviewers.

Nanostructured Metal Oxide Anodes: A.C. Dillon (National Renewable Energy Laboratory (NREL))



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this work is different from other anode work in that it uses heavy metal oxides as anode materials and relies on the high valence state of the metal (Mo has a valence of 6 in the example given) in order to have a multiple electron change in contrast to graphite with a small valence change with a light element. This requires a displacement reaction to obtain the high valence change. Another reviewer commented the development of the MoO_3 materials demonstrates a new method to produce small particle-size cathode materials. The project demonstrated cycling of cathode materials from ANL. One reviewer noted Dillon et al. are trying to develop anodes for lithium ion cells. Comments from another reviewer mentioned that the metal oxide negative electrode is one of the candidates instead of graphite negative electrode.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

The approach in using MoO_3 as the material of first choice leads to a low average voltage system with a very large voltage range. This is the only way to obtain the high specific capacity of the material. If a smaller voltage range is used, the specific capacity will be significantly lower. One difficulty with the approach is the low average voltage of the system which leads to a low specific energy. Other studies have used lighter materials such as oxides of iron, cobalt, and chromium to limit the voltage change of the displacement reactions. Another reviewer had several recommendations for activities, including developing hot wire chemical vapor deposition to produce metal oxide, MoO_3, nanostructured electrode materials for HEVs and PHEVs. Compare MoO_3 nanoparticle electrodes to the results for electrophoretically deposited thin film MoO_3 electrodes. Use first principles calculations to obtain better understanding of Li-insertion processes and for the prediction of new materials. Evaluate differences between Li extraction from MoO_3 nanoparticles with Li extraction with other metal oxide nanostructures. Make thin film electrodes for use in coin cells. One reviewer commented Dillon et al. are trying to find nano scale metal oxide materials by using hot wire chemical vapor deposition, which may be too expensive for industry. However, their approach includes the utilization of modeling (VASP) to help direct their development work. Comments from another reviewer asked to please identify what are pros and cons for MoO_3 and what and how you will improve.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that because of the high irreversible capacity and low average voltage of MoO_3 cells, the progress toward materials selection has been modest. The methodology of making nanomaterials is interesting however and should be pursued with a better selection of materials. Another reviewer noted MoO_3 nanoparticles (nano-rods and -

spheroids) have been produced using hot-wire chemical vapor deposition at different reactor pressures. Improved cycling stability was achieved for both cathode and anode by applying the thin Atomic Layer Deposition coatings. Achieve close to theoretical capacity from the ALD cobalt materials. One reviewer commented Dillon et al. have produced metal oxides that appear to have promise as anodes for lithium ion cells. Their thin films (approximately two microns) are yielding outstanding results for a small number of cycles. Comments from another reviewer mentioned the results are very difficult to understand because some of tests were done with CVD electrode and some of test was done with regular electrode. The cycle life for $LiCoO_2$ and graphite without ALD on slide 20 seems too bad. Please conduct more than 50-100 cycles for cycle life test for the full cell.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated ANL electrodes evaluated to establish a baseline performance. The project is working with Fortu (Switzerland) to develop high-voltage cell. A reviewer recommended the team evaluate materials from Whittingham at SUNY and Lee at University of Colorado as well as ANL. Another reviewer commented Dillon et al. are working closely with other national labs and industry. One reviewer noted they can see some collaboration.

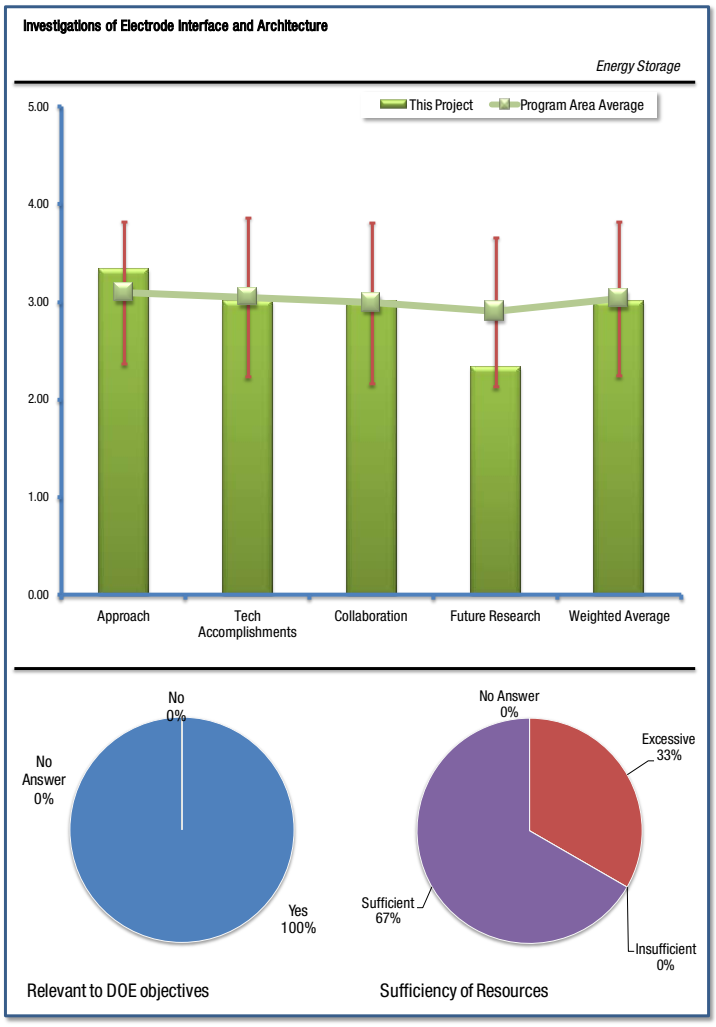
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the different material choices indicated in future work should be emphasized over any elaboration of work with MoO_3. Another reviewer mentioned the project is optimizing full cells with ANL cathodes to improve durable capacity and rate capability. Perform theoretical calculations to understand the hysteresis of the charge/discharge for the MoO_3 nanoparticles. Use theoretical calculations to identify composition and orientation of economical oxide nanopaticles with more desirable voltage profiles. Synthesis of alternative nanostructures made from Fe_2O_3, Fe_3O_4, and MnO_2 will be explored. Inexpensive synthesis routes–including HWCVD, hydrothermal techniques, and electro deposition–will be employed. Apply a protective atomic layer deposition coating on graphite nanoparticles to eliminate surface degradation mechanisms and improve rate capability. One reviewer commented Dillon et al. have a well defined plan for next year. Their planned work with ADLs may yield useful anodes if the manufacturing costs can be shown to be cost effective. Comments from another reviewer noted it is not clear what is needed to optimize MoO_3.

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

A reviewer stated Dillon et al.'s funding is sufficient.

Investigations of Electrode Interface and Architecture: Nancy Dudney (Oak Ridge National Laboratory (ORNL))



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this work tries to improve the efficiency and cost of the Li-ion batteries. Another reviewer noted the work is focused on key technical aspects for favoring a larger use of Li batteries in transport.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated it's an interesting approach to remove current collector. Another reviewer mentioned the technical barriers are well analyzed and addressed with a convincing approach. The substitution of Al current collector is a challenging issue. One reviewer noted the portion of the work on graphite-based current collectors is of value.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the following:

- 2 to 7 cents/g => 20 to 70 $/kg which is still expensive
- The active material loading needs to approach 90% with 30 to 40% porosity
- The mechanical strength of these electrodes needs to be better understood.
- They are not convinced that so much effort should be put understand Li metal anode.

Another reviewer noted the progress is really interesting with good chances to overcome defined technical barriers. The cost aspects needs to be further elaborated as well as the vis-a-vis comparison with conventional Al current collectors. The work on SEI at anode must be compared with similar activities in BATT. One reviewer mentioned the portion of the work regarding Li metal SEI does not appear to be useful to Li-ion or otherwise.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the collaborations are adequate to the needs of the project, particularly on current collector work.

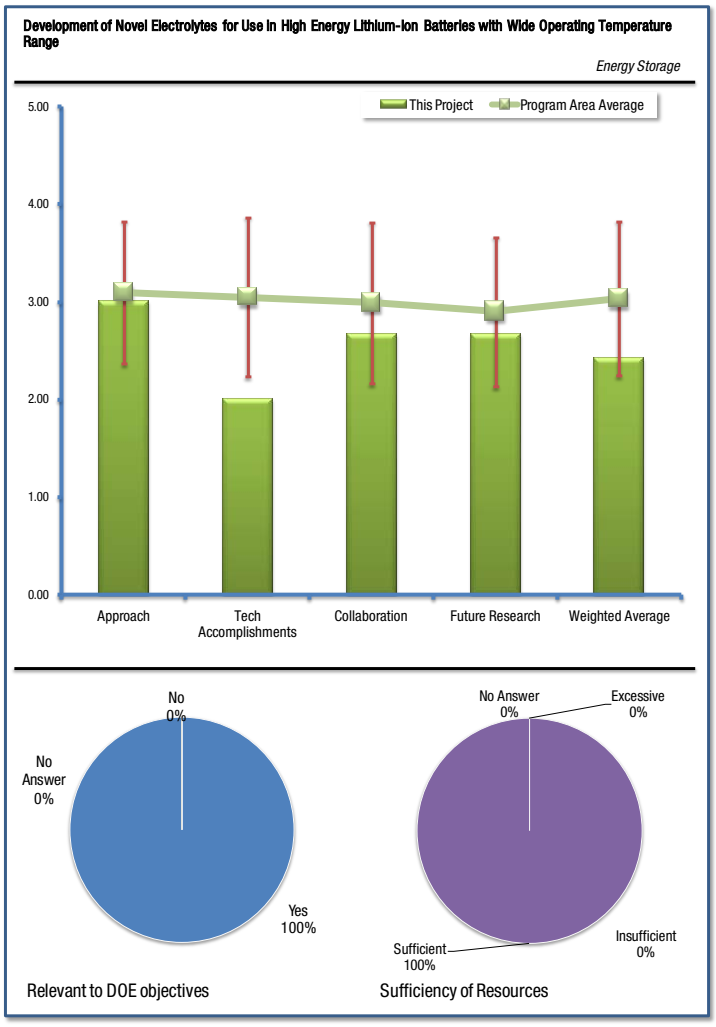
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated again, what is the interest to put so much effort on Li metal? They are not convinced that work done on Li metal is directly applicable to carbon or Me alloys SEI that have different composition and structure. Also Li metal SEI is continuously rebuilt which is not the case of an intercalation material SEI. Another reviewer commented the future work is always limited to investigate the use of the new current collectors with $LiFePO_4$. It would be interesting to experimentally verify the compatibility with other cathode materials. One reviewer mentioned to terminate work on Li-metal interface. Inclusion at least of concepts and preliminary demonstration of some tabbing/attachment method(s) to graphite current collector should be added.

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

A reviewer stated the resources and efforts are sufficiently balanced. Another reviewer noted that there are sufficient resources if re-directed towards graphite current collector and away from Li-metal studies.

Development of Novel Electrolytes for Use in High Energy Lithium-Ion Batteries with Wide Operating Temperature Range: Marshall Smart (California Institute of Technology)



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the electrolyte is a critical phase in determining the capability and stability of lithium ion batteries. This is a new project which is well oriented to make an important contribution to the DOE objectives. Another reviewer mentioned this project supports search for higher voltage cathodes, longer life systems and maybe lowers costs, although they are not optimistic that these new electrolytes will actually lower costs much. Mainly the reviewer sees them as an enabler for higher voltage/energy and better life. One reviewer commented the salt is one of the most difficult to replace. The industry keeps using $LiPF_6$ for long time.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the initial approach looks very promising in accomplishing the objectives and overcoming important barriers in the electrolyte-electrode interface. A lot of work has been done on the active materials, but this program should fill an important gap in battery studies. Another reviewer noted LiBOB is not new electrolyte salt so they are not sure how they can find new things. One reviewer went on to say the following:

Smart: Excellent list of collaborators. The reviewer must question how much can really be gained by relooking at mixtures of carbonates and esters (the latter of which seem to really hurt cycle life). Instead they urge them to try and focus on the more novel approaches they listed. They already have a long history of evaluating electrolytes for the space program and should do well in terms of being able to evaluate new materials. The hard part will be to develop those new materials.

Henderson: The reviewer has some concern about the toxicity of the cyano-containing materials, but assumes they have already considered that. (At least people don't swallow car batteries!) The ionic liquid work seems interesting and worthwhile. While low temperature may be difficult to attain, it offers the potential for being a game changer in terms of cycle life and lifetime. This should be interesting.

Lucht: The reviewer liked the collaboration with Yardney; being so close by is a major advantage. They would prefer to see a focus on high voltage materials to facilitate PHEV goals. The reviewer is also concerned about the search for additives. This can suck up huge amounts of time if care is not exercised. Unless they have a plan to design an appropriate additive, I am pessimistic that this will bear much fruit. Basically, they need to identify before they start

doing lab work what are they trying to accomplish with an additive and what structures are likely to accomplish these goals. Hopefully, they have already done this. If not, they may also want to carefully peruse the patent literature and do some paper studies and reviews before starting in on lab work.

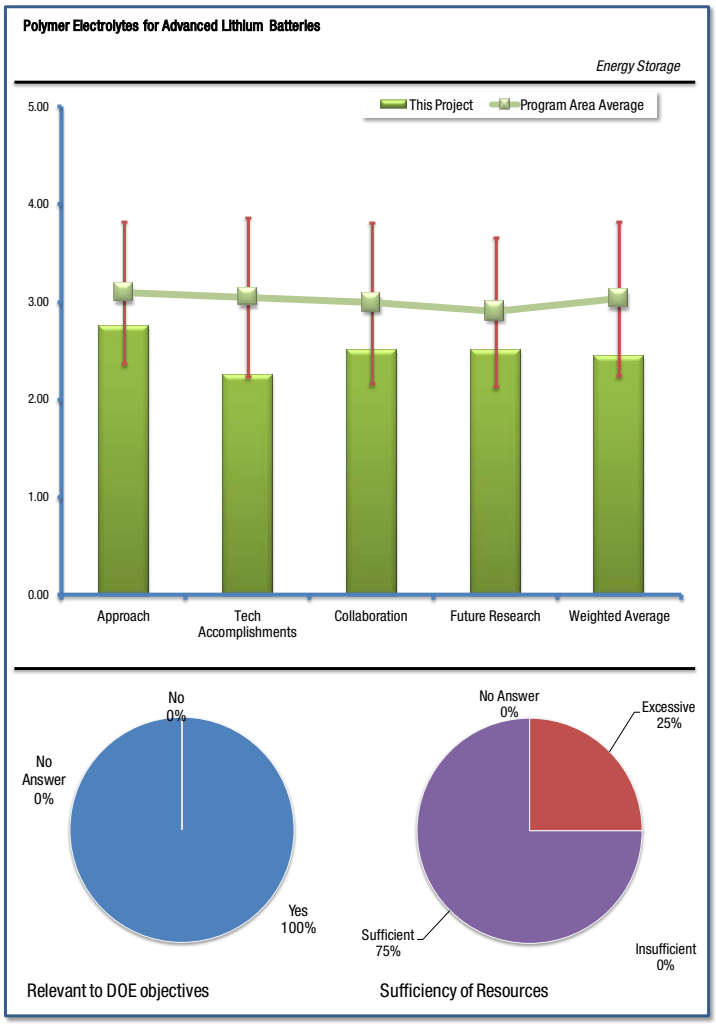
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
All three reviewers noted there was no progress as this is a new program.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated the groups are starting with a good level of collaboration. Another reviewer mentioned not a very high level of collaboration, but they think this is appropriate for such exploratory studies. One reviewer noted the program just started, so there is no progress.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the proposed work is well designed to tackle the problems of electrolytes in lithium ion batteries. Another reviewer noted the program just started, so there is no progress.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated funding a little for an extended period seems very appropriate for such work. We have basically been using the same electrolyte for Li-Ion cells for the past 20 years. Major advances in this area will not come quickly. The project would need a boost if and when they find something.

Polymer Electrolytes for Advanced Lithium Batteries: Nitash Balsara (Lawrence Berkeley National Laboratory (LBNL))



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that electrolyte is part of the limitation of the current Li-ion batteries. It is very important to overcome these barriers. Another reviewer noted that there are new polymer electrolytes with reasonably good conductivity for use in advanced Li- and Li-Ion cells. Polymer electrolytes provide a new dimension for construction of HEV and PHEV battery systems. One reviewer commented electrolyte and separator are one of the key components for cell performance. If battery manufacturers can replace this from conventional separator and electrolyte and this will be impact for them to reduce its cost.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that decouple mechanical and chemical properties is an interesting approach. However they don't understand the concept of stabilization of interface by using polymer electrolyte. The reviewer may have missed something in the explanation. Another reviewer commented it is unclear that fundamental limitations of metallic Li as anode are being significantly reduced in this work. One reviewer mentioned there must be target to accomplish HEV/PHEV requirement for electrolyte and separator point of view, but they did not see any target for this research. Comments from another noted synthesize block copolymers to produce novel materials and electrolytes by self-assembly of block copolymer/salt mixtures. This reviewer went on to add the following:

- Study the relationship between morphology, thermodynamics, and transport (conductivity, diffusion coefficient, transference number, salt activity).
- Understand the thermodynamics of system.
- Predict the behavior of full cells.
- Build full cells and test predictions.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the conductivity is too low for automotive applications. How can we increase it? That material looks more like a separator membrane. Increasing the transference number seems to be the key and it is probably where you want to focus the work. Also, the safety concept needs to be verified in full cell. Another reviewer noted the conductivity of dry nanostructured electrolytes has been determined as well as transference numbers and diffusion coefficients. MW helps. The project developed a solid-state rechargeable batteries system with a block copolymers

electrolyte that can operate at room temperature and below. Initiated the determination of the transport properties including conductivity, transference number and diffusion coefficient of electrolytes. Electrolyte salt precipitates and increases resistivity at high temperatures, a shut-down mechanism. One reviewer commented actual tangible accomplishments of this work are unclear. Comments from another reviewer noted this research result seems like only experimental tests, it needs to dig into more detail exploration to clarify mechanism.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the main interaction is with the start-up. This work would benefit to have more interaction with other teams. Another reviewer commented there is a co-operation with Smith (Utah).

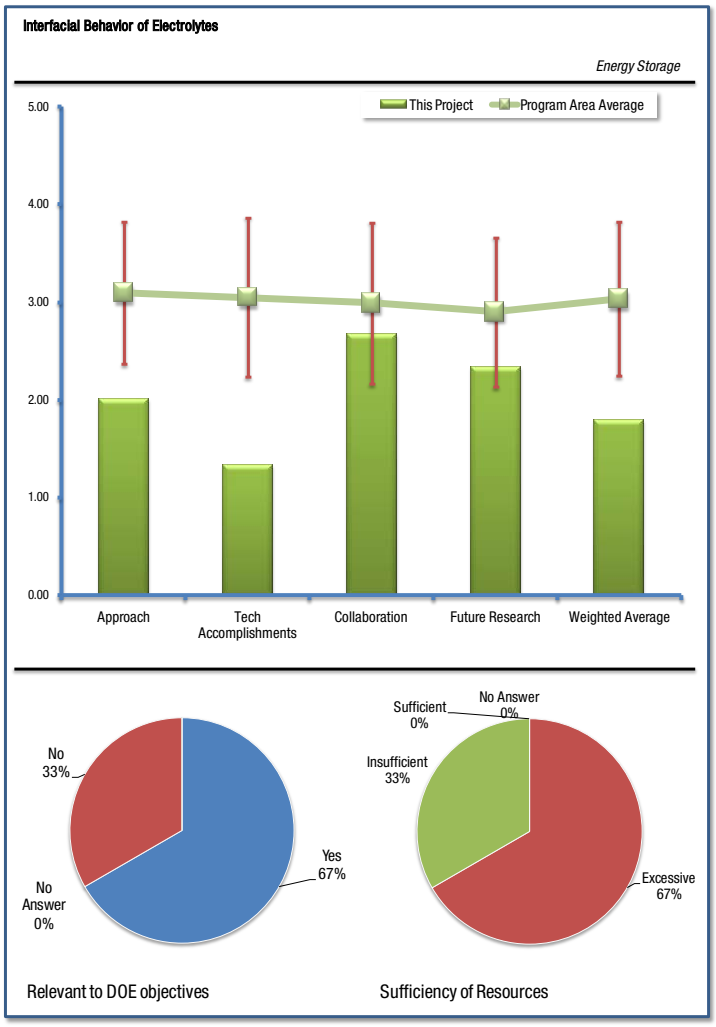
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they are not sure if they have effectively planned future work. This material does not seem to be very different from the work on polymer membrane that has been done so far. They guess the limited quantity of information which had been provided because of confidentiality (which they understand) does not help to have a clear understanding of the future work. Another reviewer mentioned in the future the project will establish the ability to cast reasonable quantities of the polymer films for the first generation of SEEO polymer electrolytes. With the assistance Smith (Utah) establish the basis for the coordination of lithium ions and block copolymer chains and implication on transport, phase behavior. Continue determination of transport properties. One reviewer commented there is no evidence of intent to demonstrate dendrite growth suppression or reduce other fundamental limitations of metallic Li-anode systems. Abuse tolerance improvement is mentioned by there is not significant evidence of viable potential routes to achieve this. Comments from another reviewer noted they felt this research needs to set target. From this experiment, what is the actual problem (i.e. from conductivity, shutdown mechanism) in existing Li ion battery and how this research can be connected to solve it for Li ion battery? This project needs to add to dig into mechanism research not only from experiment, material combination result.

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

A reviewer stated the resources seem reasonable for the project. Another reviewer noted the resources should be reduced.

Interfacial Behavior of Electrolytes: John Kerr (Lawrence Berkeley National Laboratory (LBNL))



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated a better understanding of interfaces could be very useful. Polymer/ionic electrolyte work may now make more sense if the -30C requirements have been relaxed. Otherwise, likelihood of success and applicability seem rather low. The reviewer guesses that they could in principle use polymer electrolytes or ionomers as protective coatings, where conductivity requirements would be less stringent. Another reviewer noted Kerr et al. are studying interfacial phenomena associated with electrolytes in lithium ion cells. Their studies may lead to better lithium ion cells. One reviewer commented they are not sure what we are looking for from this research.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated their focus on the interfacial as opposed to bulk properties of the polymer electrolytes is certainly well-placed. This is a very difficult area to work in. They think their plans to look at three anodes and three cathodes is way too aggressive at this stage. The reviewer suggested they pick one composite electrode of each at most. Another reviewer commented Kerr et al. are using a number of different experimental and theoretical (MD) approaches to gain a better understanding of the reactions at the surfaces of the electrodes. However, it is not clear how they have used MD in their work. One reviewer noted the PI should focus on more fundamental things.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the project spent a lot of time on method development and dealing with effects of water. Unfortunately, they saw few signs of any concrete findings from this work; many of the deadlines have been delayed. Work seems to be plagued by experimental problems, which are not necessarily the fault of the PI of course. Having said that, this reviewer feels overall progress just seems too slow. Also worrisome is that they still have not gotten their method development issues resolved yet. Another reviewer noted Kerr et al. have made some useful observations concerning water content in the electrolyte. However, it is not clear that they have contributed new information. One reviewer added they don't know what the new finding is from the test with wet and dry electrolyte. It is not clear that the expected structure for single ion conductors were successfully prepared.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the PI stated that he needed a lot of help, but it sounds like he isn't getting much, if any? ANL should be able to help with cell design and reference electrode development they would have thought. This seems like a critical gap and needs to be resolved ASAP if this work is to move forward. Talked about collaboration, but not sure

it's really happening, maybe just not enough time to discuss in his 20 minutes. Maybe this is coming in future work? Another reviewer commented Kerr et al. have worked with others, but they have not apparently worked closely with people in industry to help them focus their research. One reviewer noted they can see some collaboration.

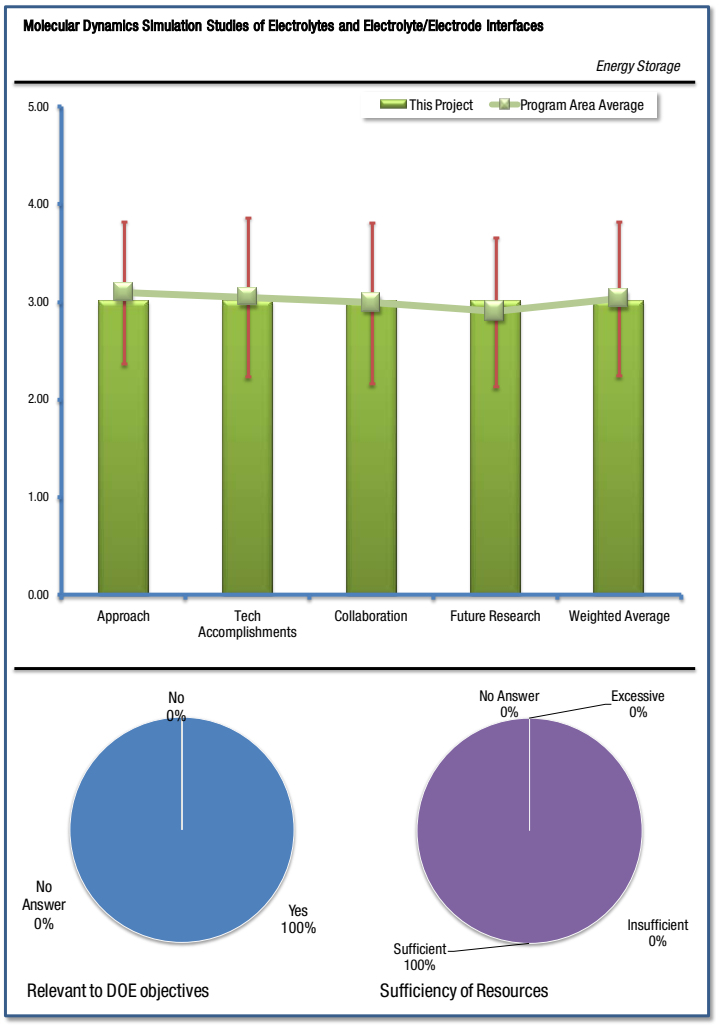
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer suggests the project use a cell with some kind of bridge to isolate the lithium reference from direct contact with the electrolyte contacting the working electrode. With polymers, this separation might only need to be spatial for a short experiment. They are pretty pessimistic about the likelihood of GBL working out well. It has been looked at before and generally leads to poor cycle life. A lot depends on close collaboration with the new PI's being brought on line and resolution of the methods issues this PI has run up against. Maybe use thin film electrodes to avoid the composite electrode complications? Another reviewer added Kerr et al. have plans for next year that is similar to previous work except for their plans to interact with the new groups that will be developing new electrolyte material. This interaction may be fruitful. One reviewer mentioned that based on this year's presentation, all work seems just engineering work and PI should focus on more fundamental mechanism for interfacial behavior.

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

A reviewer stated it is hard to justify this funding level in light of the results to date. However, if this PI is really going cover all he has on his plate, cutting funding isn't going to help and he seems to be an important player in the new electrolyte initiative. So, a better approach might be to keep the funding, but bring in more help and narrow the focus more to enable the PI to generate some concrete results. The team may be spread too thin at present, but really needs to start "delivering" more. Another reviewer noted that Kerr et al. seem to be funded at a level that is higher than necessary. One reviewer commented these results are not enough to determine if the resources are sufficient enough for this project.

Molecular Dynamics Simulation Studies of Electrolytes and Electrolyte/Electrode Interfaces: Grant Smith (University of Utah)



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this project contributes mainly to understanding of the nature of electrolyte problems in lithium ion batteries. Another reviewer noted the project is directed at developing a fundamental understanding of the materials and processes involved in lithium-ion battery chemistry and operation. One reviewer commented that basic research by using advanced simulation models are well part of the sub-program to improve knowledge and key performances of Li batteries to get DOE objectives. Comments from another reviewer mentioned that battery manufacturers need to design cells and confirm the cell performance quickly. Experimental base, actual cell performance result and optimization are always taken at manufacturers. Simulation indication will accelerate the cell design and fewer experiments to finalize the design.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach to the modeling of electrolytes is very sound. It has taken time to evolve, but now seems to be making definite contributions to understanding. Another reviewer added that molecular level modeling is used to predict properties of electrolyte. One reviewer noted that molecular level modeling of structure, transport and mechanical properties: to understand the properties of bulk electrolytes, to model SEI compounds, develop understanding of electrode/electrolyte interfaces and model Li+ intercalation. Comments from another reviewer mentioned the approach is really largely comprehensive of major technical barriers of Li batteries toward which the project proposes to develop and apply a molecular dynamic simulation tool to assist materials, components and cell development. Another reviewer commented that the simulation modeling must be confirmed with actual experiment and used existing commonly known material is ideal to build more accurate simulation modeling.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the evaluation of EC-DMC electrolytes is a substantial contribution. Also, the modeling of SEI formers has shed light on these problems. The modeling of room temperature ionic liquids has led to better understanding. Another reviewer noted there is a good agreement between experiment and simulation. What is the role of EC? Experience shows that we need EC, so what should we do? IL electrolyte is less efficient than organic liquid electrolyte. Mobility of Li at the surface of LFP is very low. What will we learn from this work? It is a very good work but the way it will help battery industry is not clear. One reviewer commented the amount of work is impressive with a large investigation via simulations of various key internal cell mechanisms. There is an unclear

correlation to experimental results with the necessity of model validations. The planned collaboration should be highly functional to confirm most of the simulation results. Comments from another reviewer mentioned the accomplishments reached normal and commonly known results in the battery business. Another reviewer added the following:

- Use molecular simulations to predict the chemical composition and structure of SEI layers and graphite and Sn-based intermetallic anodes.
- Predict temperature dependence and gain molecular level understanding of the structure, mechanical properties and Li+cation transport in SEI layers.
- Gain molecular level understanding of Li+cation transport mechanisms in liquid and ionic liquid electrolytes.
- Gain molecular level understanding of Li+intercalation/de-intercalation from/into graphite anode and model cathode materials.
- Develop and apply simulation methods for electro-active interfaces that allow explicitly for charge transfer processes and controlled potential.
- Develop an atomistic model for simulations of Sn-based intermetallic anodes.
- Provide guidance for design of electrolytes with improved lithium transport, reduced interfacial resistance and/or improved electrochemical stability.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the planned collaborations are essential in completing the simulation work with major role directed toward experimental verification and validation of the simulation results. Another reviewer mentioned the following collaborations this project is working with: U.C. Berkeley CSIRO (T. Hollenkamp); Lawrence Berkeley National Laboratory (J. Kerr, R. Kostecki); Royal Melbourne Institute of Technology (S. Russo); Penn State University (A. van Duin); Army Research Lab (R. Jow); and NCSU (W. Henderson).

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

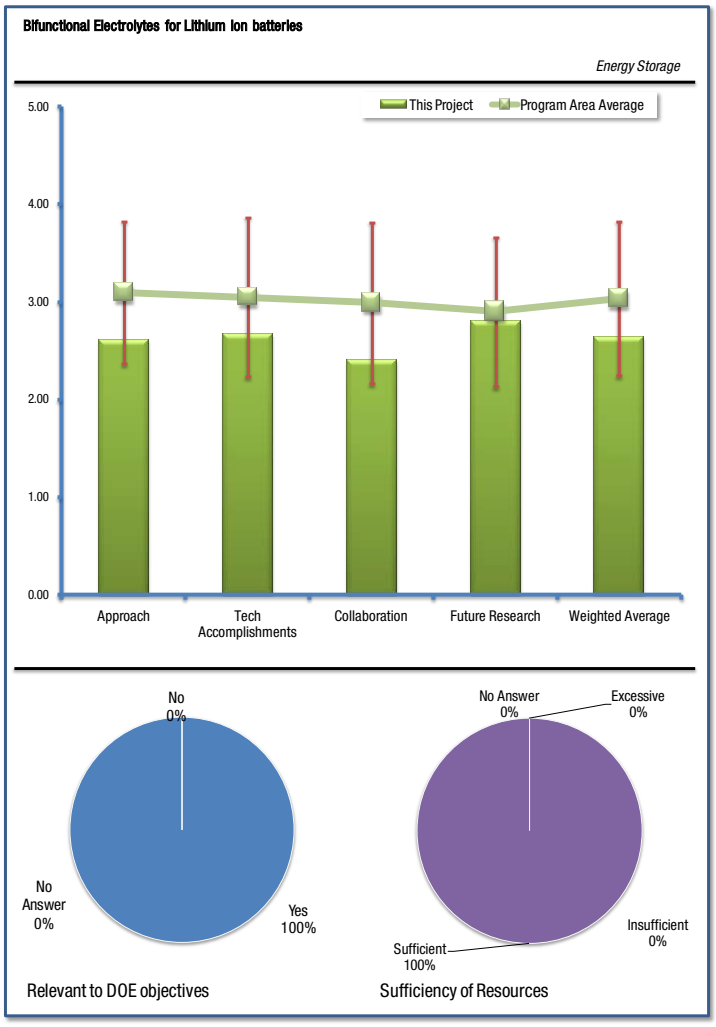
A reviewer stated the proposed work is in important areas of electrolyte research. Another reviewer asked can this work help to understand SEI stability that is crucial for both life and safety? Also the mechanism of lithium deposition would be interesting to investigate as well as the limitation of Li diffusion through the SEI at low temperature. One reviewer noted the planned work is mostly based on the past results but more focus should be more explicitly given to simulation validation. Comments from another reviewer mentioned the project needs to confirm with other material or new material combination to confirm how the simulation is achieved to use in R&D cell design. This result may also be very different based on the electrode quality. Another reviewer added the following:

- Improve $LiFePO_4$ model to allow Li+ intercalation
- Study $Li_4P_2O_7$ coated $LiFePO_4$ interface with electrolytes
- Investigate novel electrolytes in collaboration with NCSU team (Henderson).
- Study trialkyl phosphate-based electrolytes
- Study desolvation for Li+in IL/solvent mixtures at the $LiFePO_4$ interface (Kerr)
- Utilize electroactive interface model with realistic electrodes, electrolytes, and SEI layers to accurately model influence of potential on interface structure and dynamics as well as Li+desolvation and -intercalation with electron transfer
- Study SEI layers (conductivity, mechanical properties) comprised of siloxanes
- Use ReaxFF to SEI layer formation at graphite-based and Sn-based intermetallic electrodes as a function of electrolyte composition (EC, VC, DMC, PC, salts).

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

A reviewer stated the resources are reasonable for the projects. The PI is outstanding in his ability to relate fundamentals of a material of process into computer predictions to extend the knowledge of battery systems. The question is: if he had more resources (money) would he be even more productive? Another reviewer mentioned the resources seem adequate if well integrated with the collaborations.

Bifunctional Electrolytes for Lithium Ion batteries: Daniel Scherson (Case Western Reserve University)



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that looking at abuse tolerance is great! Another reviewer added it is important to archive better abuse tolerance for battery especially used for vehicle. One reviewer noted the project is aimed at addressing improved safety and/or cycle life. Comments from another reviewer mentioned this review is for two projects that are just starting. The first project is at Case Western with Scherson et al. and the second is at ANL with Amine et al. Both projects will probably yield useful results in the quest to develop better electrolytes for lithium ion cells. Another reviewer commented the salt is one of the most difficult to replace. The industry keeps using $LiPF_6$ for long time.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the most important approach is to look at how to stabilize the SEI at elevated temperature. The cycle life and calendar life study can be long, be careful to select only the additives that show clear abuse tolerance improvement. This reviewer went on to add the following: Bi-functional electrolyte have more than one function; flame retardant ions; and flame retardant overcharge protector. Another reviewer noted the project needed to provide more specific information on how this research will be done with which specific material, what is the schedule to archive objective until the end of the date? It is always good to see more specific explanation and presentation instead of only phrases like in page 4 & 5. One reviewer commented it's hard to judge approach in light of level of detail that can be communicated in such short talks. This reviewer also went on to say the following:

Scherson: Seems OK. Some concern that some of the bi-functional materials may end up with high mol. wt. that would result in high cost/mole and poor transport properties at low temperature. However, if the electrolyte is an enabler for a safer cell and/or combines the function of two electrolyte components, this could be very useful.

Curtis: Like the pairing up of modeling and experimentalists. Essential to have good cycling protocols for experimentalists to see advances from additives. It is easy to tell a bad system from a good one, but much harder to tell a good system from a better one. Comments from another reviewer mentioned the two projects are both using novel approaches to solve the problem of finding a better electrolyte. Amine and Curtis may be able to make rapid progress due to possibility of a strong, complimentary interaction. Another reviewer added they cannot tell what kind of chemistry they will focus on yet. There is a lot of study about the oxidation/reduction windows for electrolyte. They hope the study can find new things and propose new electrolyte system.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
All five reviewers agreed that there are no results yet as the program was just started in April 2009.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated there was no collaboration and coordination presented in the presentation. Another reviewer added the following:

Scherson: There is not much sign of collaboration, but then such an exploratory project doesn't need much.

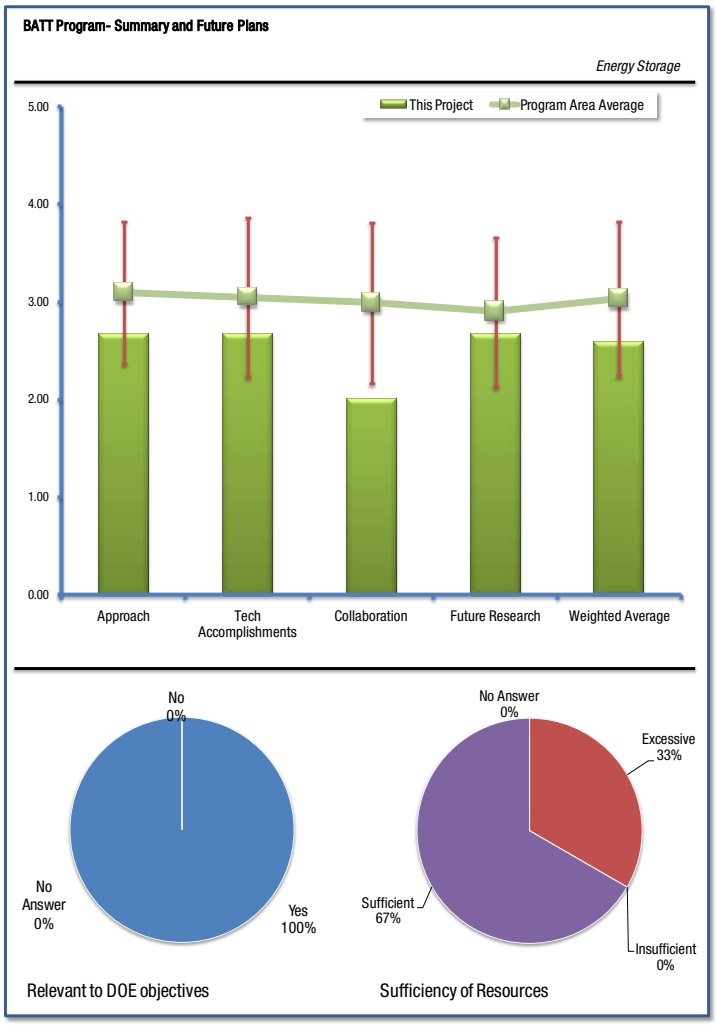
Curtis: Higher level of collaboration, but then the need is greater as it is essential to link up theoretical investigators with experimentalists.

In both cases, collaboration becomes more important for follow-up work. One reviewer noted it is probable that both teams will interact with interested parties. Comments from another reviewer mentioned the program just started, so there is no progress.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated there were not many details given for future work. Another reviewer mentioned that both teams have exciting plans for next year.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated this is exploratory work and LOS must be viewed as rather low. Funding level is fine for such work. This project would need a boost if and when they find something. Another reviewer noted that both teams have been funded at a sufficient level. One reviewer commented the program just started so they aren't able to determine how sufficient the resources are for this project.

BATT Program- Summary and Future Plans: Venkat Srinivasan (Lawrence Berkeley National Laboratory (LBNL))



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the BATT is the exploratory and the most innovative branch of the Subprogram to fully meet DOE objectives. Another reviewer mentioned the BATT program performs fundamental research in support of the DOE to develop batteries for vehicle applications. This work aims at developing a high-energy battery with enhanced safety and long life characteristics to meet DOE goals. Fundamental research related to battery materials and cell design is clearly supporting DOE goals to facilitate advancements in commercializing PHEV and EVs. One reviewer noted the entire research is towards the DOE objectives such as high energy, safe and long life battery development.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the BATT manages a very advanced network of high level expertise covering all the technical barriers. There is the need to better support the identification of more exploratory areas beyond Li systems. Another reviewer commented the program demonstrated strong quantitative empirical and theoretical diagnostic capabilities. State of the art research was conducted by BATT, from basic materials to integration in state of the art electrodes, to cell design. Good choice of critical problems has been identified. However, future goals should be better identified. Closer collaboration with US battery vendors may be helpful in selecting the right materials, optimizing designs, and battery performances.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the results are of high values and well coordinated. Another reviewer added the following comments about the important accomplishments:

- Creating innovative IP and licensing to several spin-outs
- Good range of publications
- Good progress across different battery research themes
- Unique testing and characterization methodologies

Some experimental conditions and cell designs are not very practical, as mentioned above, closer collaboration with industry is advisable. One reviewer noted they must address very poorly especially towards optimization anode work. MCMB has been gone in the battery business (Osaka gas stopped their production and none of the same material exist exactly the same as MCMB; similar material exist). No one picks 15% binder amount in conventional available

battery and the money should not be used for this type of optimization work. Blending existing cathode material is also not research level and research lab must know what the requirements are in Li ion battery business.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the collaborations are very good but they should be further described and made effective in order to increase synergy and accrue project results. Another reviewer noted the PI did not address any other institutions in the presentation.

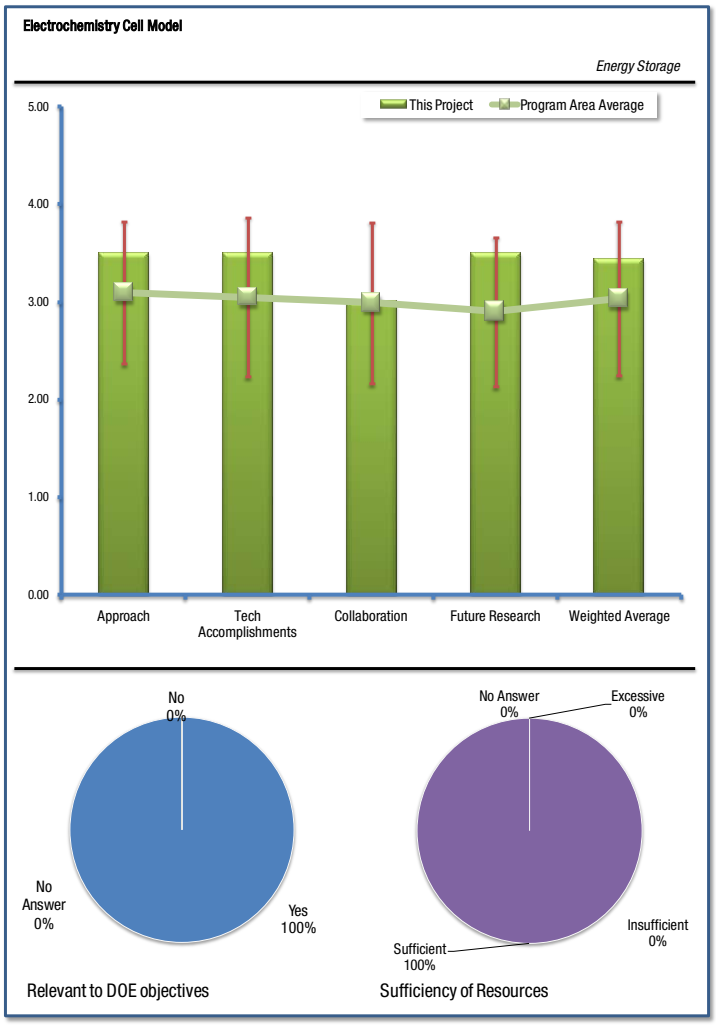
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated BATT still has a clear frontier role in investigating and solving Li systems barriers but the role of exploratory research should be increased in a more systematic way beyond Li. Another reviewer added the BATT Program addresses the fundamental problems of lithium ion batteries and optimize costs, lifetimes, and safety. The proposed four areas of future focus are well defined. Additional details should have been supplied on the research experimental approach. Searching for proposals from the industry and community is a great idea. One reviewer noted the proposed future plan in 10 years is reasonable in Li ion battery. The PI needed to provide how the new system and cell design can add value to battery business.

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

A reviewer stated the resources are quite large and should be adapted to the dynamic evolution of BATT. The coordination work is valuable. Another reviewer commented they did not see any benefit for try and error formulation study for both of anode and cathode.

Electrochemistry Cell Model: Dennis Dees (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this project adds to basic understanding of Li ion electrodes. Another reviewer noted the modeling done in this program is a good complement to the experimental programs on new electrode materials. It provides interpretation of experimental results and gives guidance to electrode development. One reviewer commented the model that Dennis developed to predict cell (battery) performance is very powerful and can serve to accelerate the development of new high power battery systems. Comments from another reviewer mentioned that the actual performance in battery is critical but costly and time consuming - particularly cycle life a key parameter but is extremely long to evaluate - accelerated test methods are a key to speeding up, and this work to develop models and link to accelerated test methods and actual aging is yet another way to increase speed of identifying promising new materials.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the work is very focused on understanding the behavior of Li ion electrodes from ground up. Another reviewer commented the technical barriers are addressed in an improved model. This allows more rapid assessment of parameters and a more adequate data fit. The model is subject to further development. One reviewer mentioned the model is based on first principles. It also uses impedance as a powerful tool for determining the reaction kinetics of the reactions. Comments from another reviewer noted that all theoretical modeling proof is in the pudding after a lot of correlation. Generally however adapting model to PHEV, new material sets and also looking at electrode thickness impact very positive approach.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that Dennis has made consistent progress in analyzing/determining the various parameters that dictate the performance of the electrodes. They are puzzled though by his counterintuitive finding that with higher loading the ASI of the electrode goes down (slide 10). Another reviewer added the program has already given interesting results on electrode thickness related to electrode impedance for NCA electrodes. It has also given a reasonable interpretation of two phase behavior for graphite electrodes. These studies should be valuable in designing electrodes for a desired level of capacity versus power. One reviewer commented the preliminary trials have given good results and confirmed the accuracy of the system. Good correlation of predictive power and actual cell performance. The project developed an equivalent circuit model to speed correlations and a new diffusion model to

better understand concentration phenomena. Comments from another reviewer mentioned that correlation will be the key and they really like the extension of work to multiple materials.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated they would suggest additional collaboration with university or commercial partner (under an NDA). That would really allow the author to test the validity of the models in real life products. Otherwise, this is an open-ended research. Another reviewer noted the level of collaboration needs to be continued at a high level so as to make the most of the theoretical developments. One reviewer mentioned the models are a personal thing. Dennis has built on the work of others doing similar work at LBL, but the model is his. They particularly like the inclusion of impedance as an added tool to include an experimental measure of the parameters.

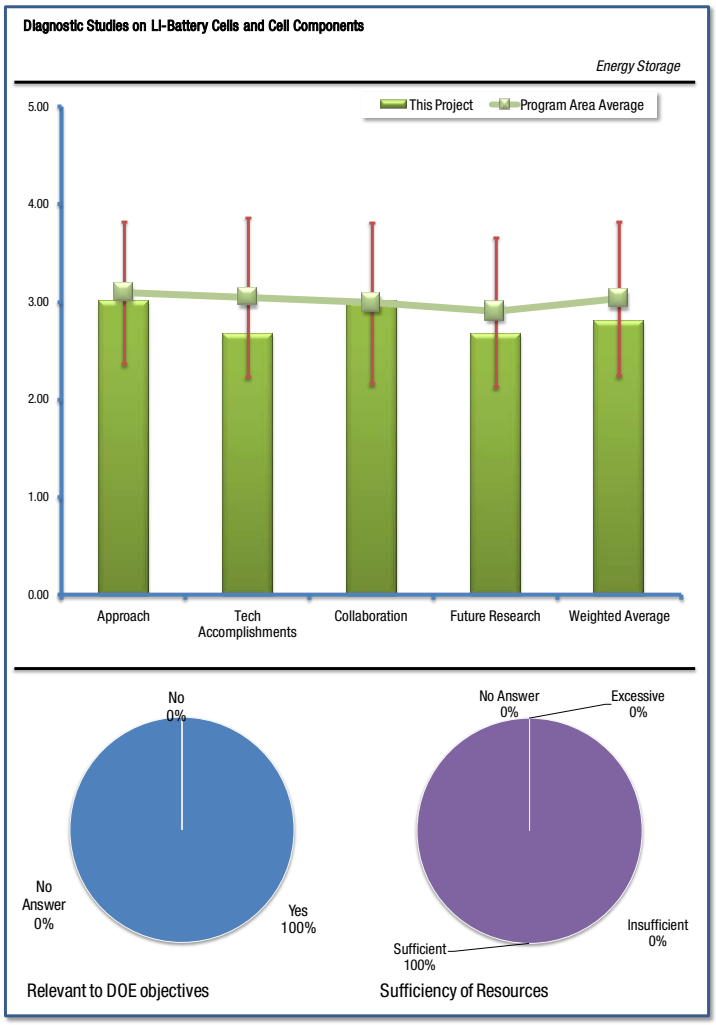
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they would like to have few additional items addressed: 1. Clearly identify the processes corresponding to the various arcs/semicircles on the impedance plots. 2. Model behavior of electrodes having nanophase materials such olivine. Another reviewer added the plans for future research are appropriate. One reviewer noted the work will complete the parameter fitting methods and develop a two phase active material model development, as well as continued development of PHEV focused models. The application of the model will accelerate the progress of the program. Comments from another reviewer mentioned the project is looking for model refinement and correlation to actual performance data.

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

A reviewer stated the resources are minimal as a good computer and an active mind are all that is needed.

Diagnostic Studies on Li-Battery Cells and Cell Components: Daniel Abraham (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the work is focused around identifying and understanding processes to optimize cell life and performance by reducing degradation processes. The work is part of the DOE basic research objectives aiming at the improvement of battery materials and optimizing lifecycle and reducing cost. Another reviewer mentioned knowing the material properties to confirm what the root cause for cell performance such as cycle life.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that given the limitations of working with Gen3 materials rather than materials/electrodes from a viable industrial battery partner, the effort has produced valuable results and methodology which should be useful for general application. Inclusion of multiple cell configurations should be very valuable, but there is no apparent reporting of observed differences between cell configurations. Partnership with a globally viable battery producer would have been/be desirable. Another reviewer noted the work has been designed very well. Various cell structures have been tested. Wide range of experiments and characterization techniques were used to evaluate cell degradation mechanisms. This is an interesting, but not so innovative approach to shed light on aging formation mechanisms. The approach is empirical, may be useful to add modeling for deeper dive and prediction of other again mechanisms. One reviewer commented the approach studies material properties before and after cycle life to find the difference is OK but need to analyze how it can be protect with suggestion. There is no detail explanation how this study/survey can be used for improvement.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that useful progress has been made towards improved general understanding of failure mechanisms and isolation of failure mechanisms within cell. Another reviewer added the work progress is good, focusing around demonstrating the feasibility of the inspection technique. It also includes preliminary analysis and testing on various surface films. However, the cells were not tested in real cycling conditions and only a restricted number of chemistries were investigated.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated there is a great collaboration with academia, will be helpful to work closely with industry and analyze real cells. Another reviewer commented that material investigation has been done with involving other institutions.

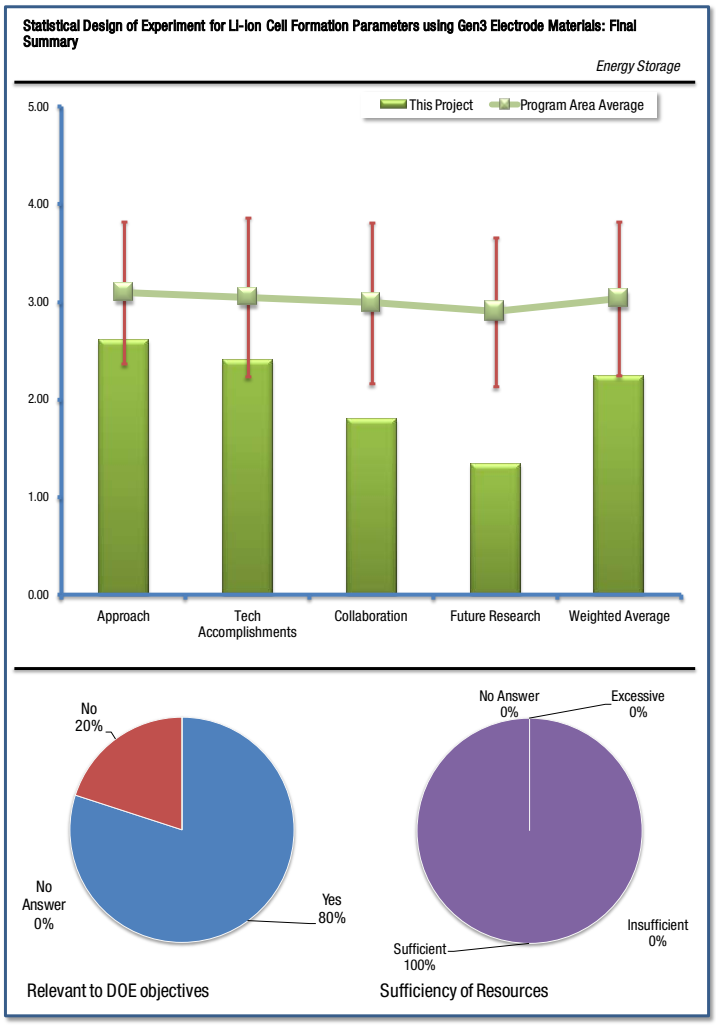
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated a partnership with a globally viable battery producer and with electrodes/cells outside of DOE would be beneficial. Inclusion of observed differences among different cell configurations would be extremely valuable for future! Another reviewer commented the project is looking into aging mechanisms across wide range of chemistries, cell structures, and real cycling conditions, is critical to identifying factors that contribute to cell performance, and degradation characteristics. One reviewer noted the project only addressed investigation material analysis for PHEV cells in the future. There is no specific items listed "How to suggest to improve cell performance"? Need to add why and how the material was formed and effect cell performance, how it can be removed for better cell performance? Only the material analysis cannot provide suggestion for improvement.

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

A reviewer stated this is sufficient to the analyses work to know the material composition.

Statistical Design of Experiment for Li-ion Cell Formation Parameters using Gen3 Electrode Materials: Final Summary: Kevin Gering (Idaho National Laboratory (INL)) - POSTER



Reviewer Sample Size

This project had a total of 5 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that from cell design point of view, design of experiment will help to decide which condition is the suitable for cell formation. This may accelerate for decision making about condition to provide faster delivery time finally. But, if the objectives are improvement for cell performance including cost and pack volume, they would say this is not following objectives from my understanding. Another reviewer noted this project addresses important issue of relating formation procedure to cycle life. One reviewer mentioned that Gering is using a statistical method of experimental design to determine optimum conditions for formation of lithium ion cells.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that given the limitations of working with Gen3 materials rather than materials/electrodes from a viable industrial battery partner, the effort has produced useful results and methodology which would be useful for general application. Partnership with a globally viable battery producer would have been desirable and would allow for comparison with practical real world formation parameters. Another reviewer mentioned the approach had better tried with other formulation of at least two. One reviewer commented the approach seems very complete and organized design of experiments to what is typically studied in purely empirical manner. Comments from another reviewer noted Gering's approach is apparently directed toward reducing the cost of lithium ion cells by finding optimum conditions for cell formation. His approach could be enhanced by utilizing the modeling efforts.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the project provided a target as set. 186 cells for study since 2005 must be built limited assembly ability. Providing only one formulation result is not outstanding. The case study must be evaluated and confirmed with actual cell from the entire result. This result shows only suggestion regarding to the question. Another reviewer noted identified formation conditions that appeared to make a major difference in cycle life and also optimized for total formation time. Lacking actual industrial experience in this area, such work could be very helpful in ensuring that the cells made in the program are of decent quality. Results are only applicable to one cathode chemistry, but methodology could be applied elsewhere. However, this work never seemed to go anywhere, so it's hard to value it much. One reviewer noted Gering has obtained interesting results that should be vetted in industry.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the lack of collaboration with globally viable battery producer limits potential applied utility of work. Another reviewer noted that only one was addressed for one issue. One reviewer commented this work does not seem to have been picked up and used by the rest of the program and the general feeling seems to be that it may not be right. If so, this is more likely a reflection of other issues with making and testing cells rather than the methodology per se. So maybe this reflects technical issues with the results rather than poor collaboration. Comments from another reviewer mentioned Gering has worked with ANL to some extent, but he should work more with industry.

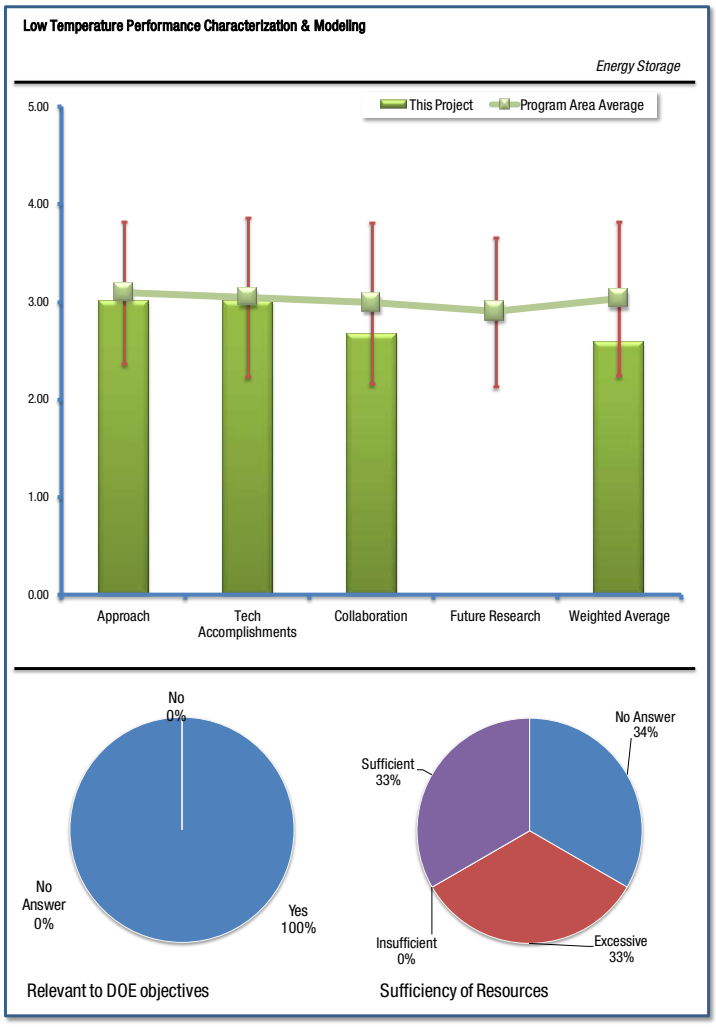
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated there was no specific material, system or etc mentioned as future work. There must be addressed as "need to check correlation between button cell and (at least) 18650 or laminate prismatic cell". Another reviewer commented no future work in this area seems planned. They think that once improvements in making cells are upgraded, that approaches such as this be revisited (Unless additional practical guidance can be obtained from industry). Three other reviewers noted this question does not apply as the project is completed.

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

A reviewer stated that once improvements in making cells are upgraded, that approaches such as this be revisited. Unless additional practical guidance can be obtained from industry (which may be possible), someone needs to be looking at formation for this and the other cell systems. Another reviewer commented that Gering had sufficient funding for this work.

Low Temperature Performance Characterization & Modeling: Andrew Jansen (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size
This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?
A reviewer stated the program was in support of the low temperature goal of the present year. However, the goal has changed and the project was brought to a close in September 2008.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
A reviewer stated the approach was solid in identifying the temperature limitations.

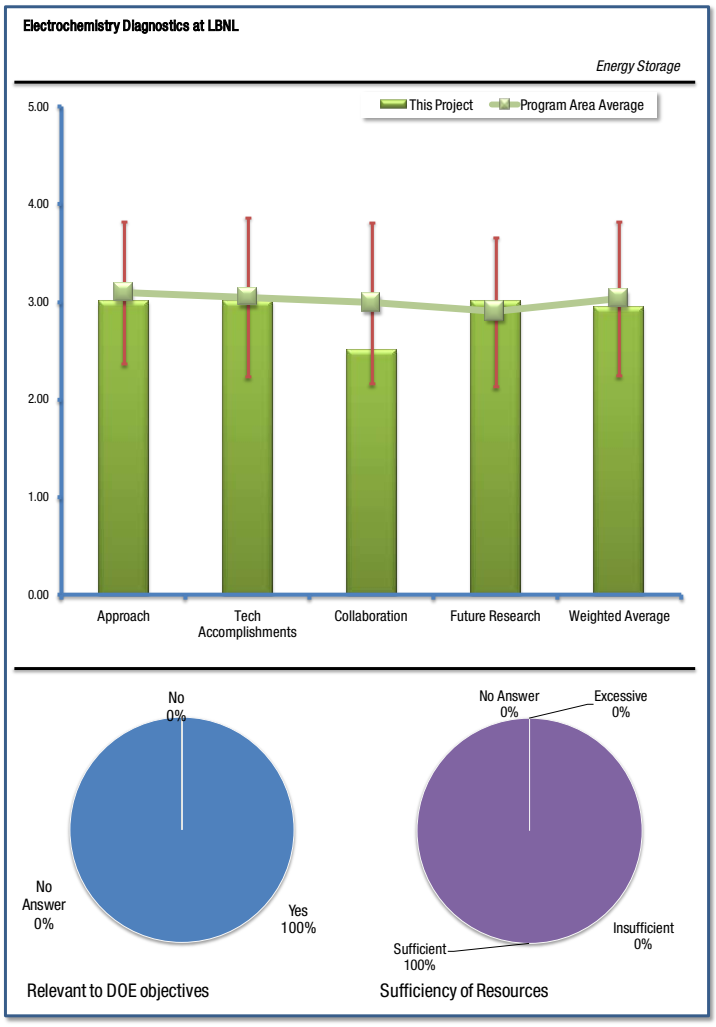
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated the progress was limited because new electrolytes were not found to be better than the standard electrolyte. This was an interesting result because the standard electrolyte has high capability.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated partnership with a globally viable battery producer would have been desirable and may have allowed for more tangible studies with more relevant electrodes/cells.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
Two reviewers agreed this question does not apply as the project is complete.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated partnership with a globally viable battery producer would have been desirable and may have allowed for reduced project cost and/or more tangible studies with a greater variety of more relevant electrodes/cells at the same project cost.

Electrochemistry Diagnostics at LBNL: Frank McLarnon (Lawrence Berkeley National Laboratory (LBNL)) - POSTER



Reviewer Sample Size
This project had a total of 2 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?
A reviewer stated that graphite is the most prevalent anode material understanding degradation and factors impacting degradation rate are important to cycle life and overall costs. Mechanisms for cycle life fade are more and more important as migration from HEV to PHEV and EV occurs - this work addresses understanding commercially viable materials. Another reviewer noted the research addressed objectives and barriers to match the requirement.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
A reviewer stated the study of impact of transition metals on anode and impact cycle life is right on target and focus on very relevant materials graphite, NCA and NMC is excellent. Another reviewer mentioned the approach of checking the material properties before and after cycle is good to know but this approach is similar to other researches. Need to address what and how the research will go to get stable cell performance based on the analysis.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated these are very solid results - fade of Gen 3 cathode cells however, no appreciable deposition of transition metals or electrode damage. There is further evidence of Mn poisoning of graphite.

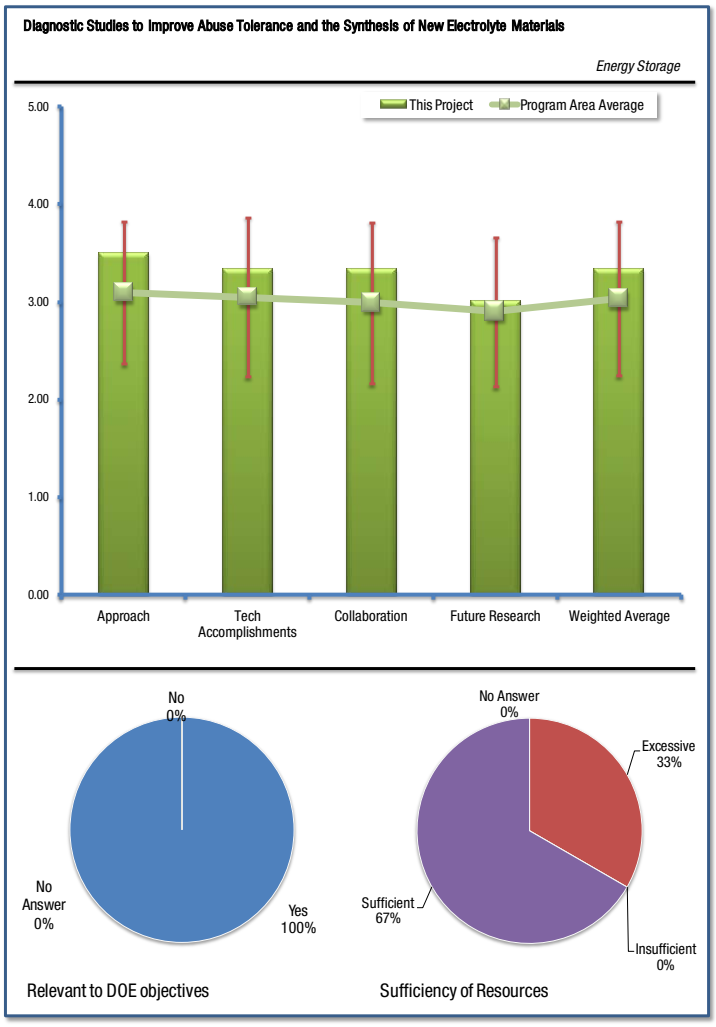
Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated very good National Lab coordination - seeking an industrial partner would be beneficial. Another reviewer added that other institutions are mentioned but there was a lack of information which part was done with other institutions.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated that continued efforts to understand SEI formation/stabilization has potential to really accelerate vehicle applications and dramatically improve performance of lithium ion batteries. For most relevance scale-up activities of promising materials should be done with U.S. manufacturing partner. Another reviewer noted the project needed to address how these activities will be connected to future target as cell improvement from material and chemical point of view.

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

There were no comments for this question from the reviewers.

Diagnostic Studies to Improve Abuse Tolerance and the Synthesis of New Electrolyte Materials: Xiao-Qing Yang (Brookhaven National Laboratory (BNL)) - POSTER



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the project is very relevant in order to have a fundamental understanding of the electrode processes. Another reviewer commented as part of the material development for high specific energy anodes and cathodes, it is important to have proper diagnostic techniques, either in-situ or ex-situ, that will help us understand the chemical changes, both surface and bulk, occurring in these materials, as is being carried out in this project. Globally speaking, the development of high specific energy Li-ion cells for PHEVs will contribute to their widespread use and reduce our petroleum consumption and demand. One reviewer mentioned that abuse tolerance and life are important items for vehicle usage.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated there are excellent approaches to understand key material properties. They are not sure how BNL got to work on electrolyte salts and additives. They look to BNL more for diagnostic work than for these results. Another reviewer noted the approach involves in-situ XRD and X-ray Absorption Spectroscopy to track the change (electronic states) in the transition metals from the cathode materials. This project is much similar to another project from the same researchers, except that this deals with the behavior of cathodes in conjunction with electrolytes and during thermal abuse. Is there any reason that these two can't be combined to make a more cohesive project?

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated there are very good results on key materials characteristics. These are solid clues into the behavior of important battery materials achievable thanks to the powerful technique BNL uses. They are less thrilled with the salt/additive results, except the results with the Li/LiCoO2 cells. Another reviewer added there are some useful data on the structural changes in the spinel-layered mixed cathodes, which may help design a mixed cathode. Also, there is additional structural information on the thermal stability of Gen and Gen 3 cathodes, which corroborate the precious observation (by several others) that Mn-rich layered compounds have superior thermal stability compared to Ni-rich or Co-rich analogues. Finally, some new electrolyte systems have been identified based on the boron-based anion receptors. One reviewer noted that the cathode material thermal stability result is quite reasonable. The expansion and usage of the method at different lab is also the right action and the result with electrolyte additive provides a good result.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated there is a great collaboration on this project. Another reviewer noted there is on-going collaboration with several other laboratories and battery companies. One reviewer mentioned the project collaborated good to reach the target and confirm the result. It is quite important to exchange the information and technologies between companies and/or institutions.

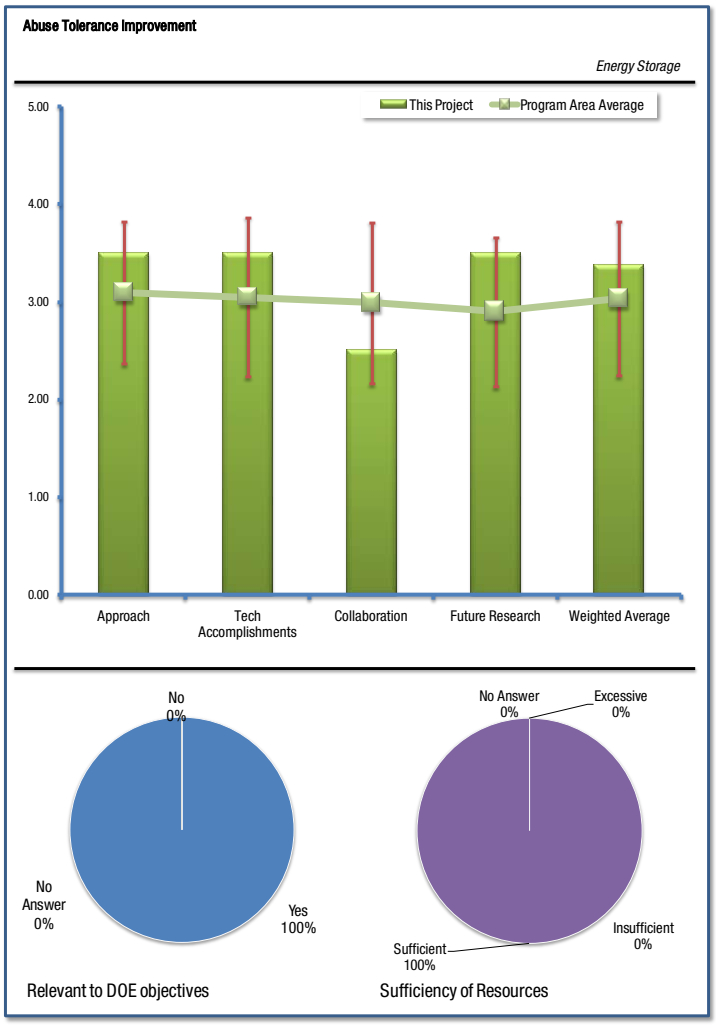
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated that BNL should diagnose as many cathode/anode materials as possible for fostering deeper understanding of these materials. They don't think the salt/electrolyte data looks appealing or unique enough for additional work to be continued. Another reviewer added the proposed future studies of continuing such diagnostics studies to understand the performance-limiting processes within the cathode structures and their thermal abuse characteristics and to develop new boron-based anion receptors for Li battery electrolytes is relevant to the overall DOE goals. One reviewer noted that most of the future work addressed are based on the past progress and expansion to the others.

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

A reviewer stated that resources may be slightly in excess, particularly if this project is combined with the other project on cathodes (consolidation).

Abuse Tolerance Improvement: Peter Roth (Sandia National Laboratory (SNL)) - POSTER



Reviewer Sample Size

This project had a total of 2 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that abuse tolerance is important in assuring a full application of Li batteries. Another reviewer noted this work is critical to the commercialization of automotive Li-ion batteries.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach is interesting in identifying some of the key abuse parameters. These technical barriers are not exclusive and might be integrated with those of mechanical nature.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the results are interesting and a good relation with the various cells. The general values of some of the conclusions/results may be beneficial to improve cell and material preparation. The use of the experimental results in simulation models would be of further value. Another reviewer mentioned that clearly Dr. Roth is an international leader in this field.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated there is no clear indication on collaborations. The collaboration with materials and cell modelers would be mutually beneficial.

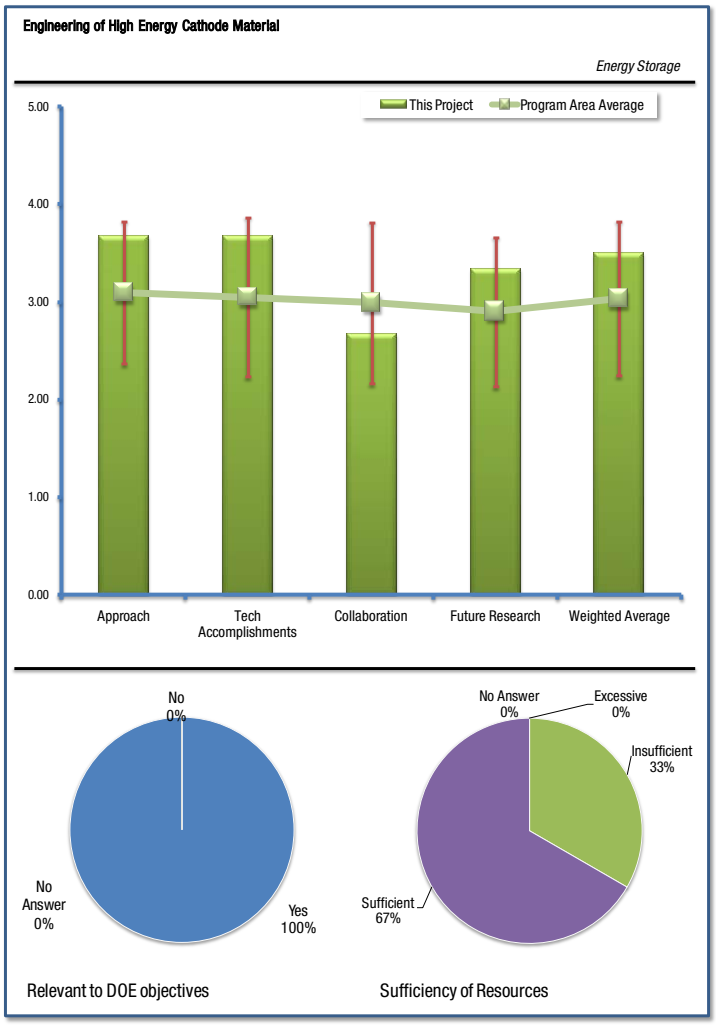
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the proposed future planning to PHEV system is acceptable in relation to the good results achieved and the expertise acquired on previous Li systems.

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

A reviewer stated the evaluation of adequacy is only partial because there is no clear perception of the number of systems/designs will be analyzed. Another reviewer added that while the funding is sufficient for Dr. Roth to do excellent work, just think what could be done if funding and manpower could be increased for this project.

Engineering of High Energy Cathode Material: Khalil Amine (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size
This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?
A reviewer stated these materials as presented offer very nice rate capability and capacity - both key objectives for vehicle applications. Also 0 cobalt compositions may have intrinsic materials cost benefits also a key need for automotive applications. Another reviewer noted the increased energy density and cheaper synthesis process will make the cost of the cathode material more affordable. One reviewer commented that Amine et al. are developing new materials to improve the energy density, e.g., for electrodes in lithium ion cells.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed?
Is the project well-designed, feasible, and integrated with other efforts?
A reviewer stated the approach is solid - although material sets are not that novel the carbonate precursor formation methods appears to enable morphology advantages and application to vehicle application performance testing is spot on. They think 18650 size evaluations for cycle life will be a key to establishing materials. Another reviewer mentioned the ANL designed continuous process will help with the objectives. One reviewer noted Amine et al. utilize an experimental approach which works well. However, they may be able to improve their success by utilizing modeling to optimize their preparation techniques.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated these are very promising results so far - next steps of surface modification and 18650 confirmation will be key. Another reviewer added the rate capability and first cycle loss may not be acceptable. One reviewer commented Amine et al. have had tremendous success in their work in the past and have continued to be successful.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated the collaboration with a large American cathode manufacturing company will help with the ultimate cost reduction. Another reviewer mentioned Amine et al. may benefit from collaboration with industry.

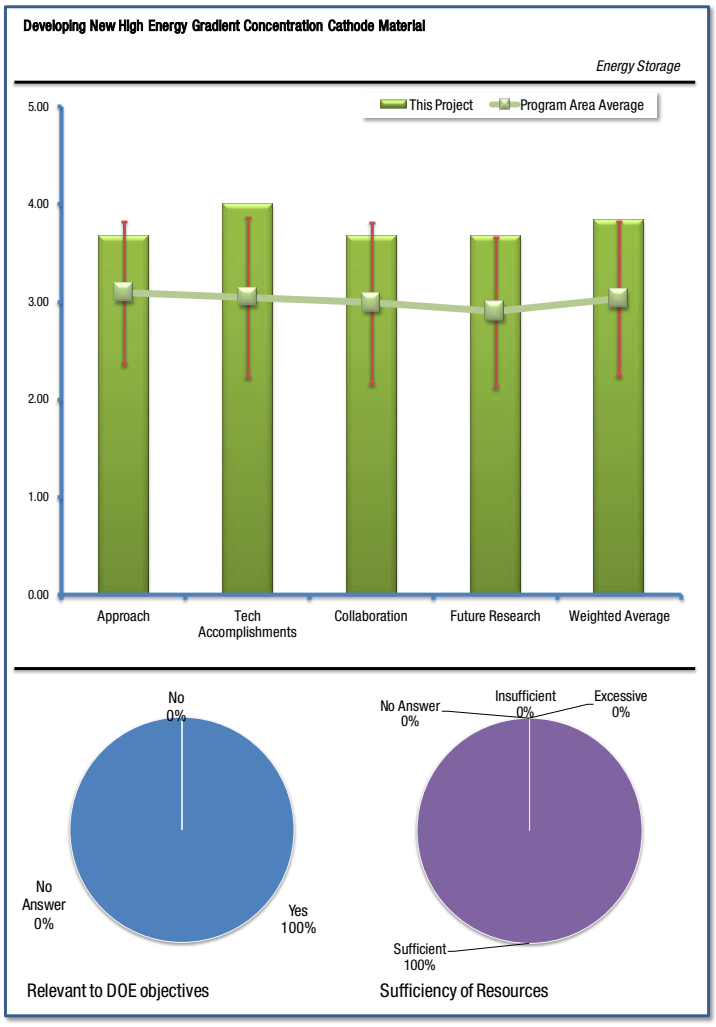
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the project is on the right track but they did not see 18650 size cycle life called out - coin cell data looks good but proof is in 18650s with each new material set. Another reviewer noted the program will end in

September 2009 and may not have enough time to improve the material. One reviewer commented Amine et al. have outstanding plans for the future that are well defined.

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

A reviewer stated Amine et al. should be funded at a higher level to help them produce even more useful material for lithium ion cells.

Developing New High Energy Gradient Concentration Cathode Material: Khalil Amine (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the project is a key part of identifying new high performance materials with 200 mAh/g or more. Higher capacity materials are essential to meet the future needs. Two reviewers noted the project is highly relevant. A higher performance cathode is critical for next generation Li ion batteries with good thermal stability.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated this is a very novel idea. They love the approach and are hoping that this approach opens up a lot of opportunities to engineer new materials with superior properties. The reviewer does have a concern about the cost of preparing such materials. Another reviewer noted the gradient concentration materials discovered by Professor Sun have great promise to solve the capacity limitations of layered materials. The approach so far has been material preparation oriented and now should be devoted to optimizing the composition and gradient characteristics for electrochemical performance such as rate capability and cyclability. A later stage should be to develop cost effective methods of preparation of the most promising materials. One reviewer mentioned this is a cleaver technique for making new cathode materials with higher voltage and mAh/g. The concept of coating one material with another is very innovative and clever. The resulting core-shell materials have unique performance characteristics.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated this is very nice work and excellent results and they are looking forward to seeing future results. Another reviewer commented the results have been outstanding to date on this class of materials. One reviewer noted the co-precipitation process actually works and can be translated into practice and small quantities of a high energy gradient concentration precursor and cathode material are available for evaluation/characterization. The material has gradient concentration with changing concentration of Ni, Mn and Co within each particle. The performance was demonstrated experimentally to have high capacity, good cycle life and excellent abuse tolerance.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the Hanyang University/ANL collaboration is very good and should be further developed. Another reviewer mentioned the work requires interacting with others on the ANL staff.

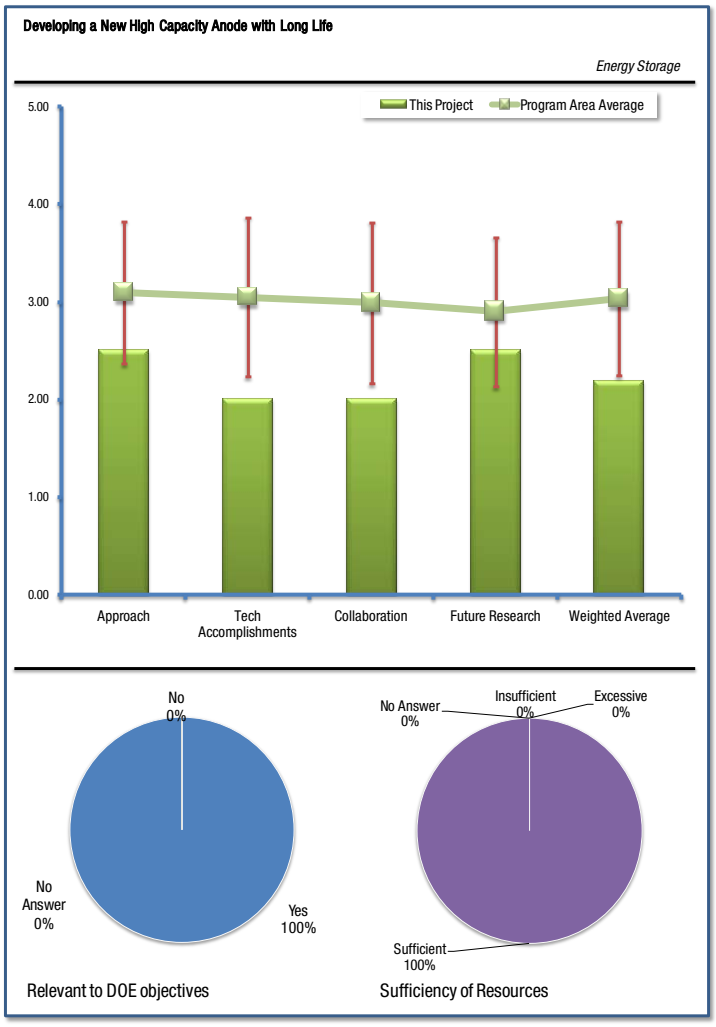
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the authors have a lot of experience to really exploit this technique for the synthesis and characterization of these next generation materials. Another reviewer added the barriers should be carefully assessed and systematically approached. Cell development should be pursued to make good assessments of these new materials. One reviewer commented that actually making sufficient amounts of the materials will confirm the initial work. Putting the material in real cells for testing is essential. Additional materials will be prepared and characterized, including ARC safety testing.

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

A reviewer stated the equipment and lab assistance is sufficient.

Developing a New High Capacity Anode with Long Life: Khalil Amine (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size

This project had a total of 2 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this project address the need to develop new anode materials with high specific energy for improving the specific energy of Li-ion batteries to make them viable for PHEVs, which will minimize our petroleum consumption and reduce emissions. Another reviewer added the project addresses the safety aspects and specific performances of anodes that will favor the reach of DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach of trying to improve the synthetic routes for TiO_2 to get sub-micron particle size looks reasonable. However, TiO_2 is not an attractive candidate due to its low capacity and high potential, such that the payoff isn't significant. Its advantages over lithium titanate anode, which is fairly mature, are not persuasive. Another reviewer noted the clear approach is based on an acceptable analysis of the technical barriers.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated there are useful results on the effects of additives on the particle agglomeration of TiO2. The data indicate a low capacity (200-250 mAh/g) even at moderate rates compared to a theoretical value of 330 mh/g – not particularly encouraging, especially with a high potential. Another reviewer mentioned the results are interesting but not yet allowing for a progress consistent with the planned objectives. More work is awaited on stability and performances verification.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated there is no external collaboration while another reviewer noted that collaborations are very limited, but sufficient for the ongoing work.

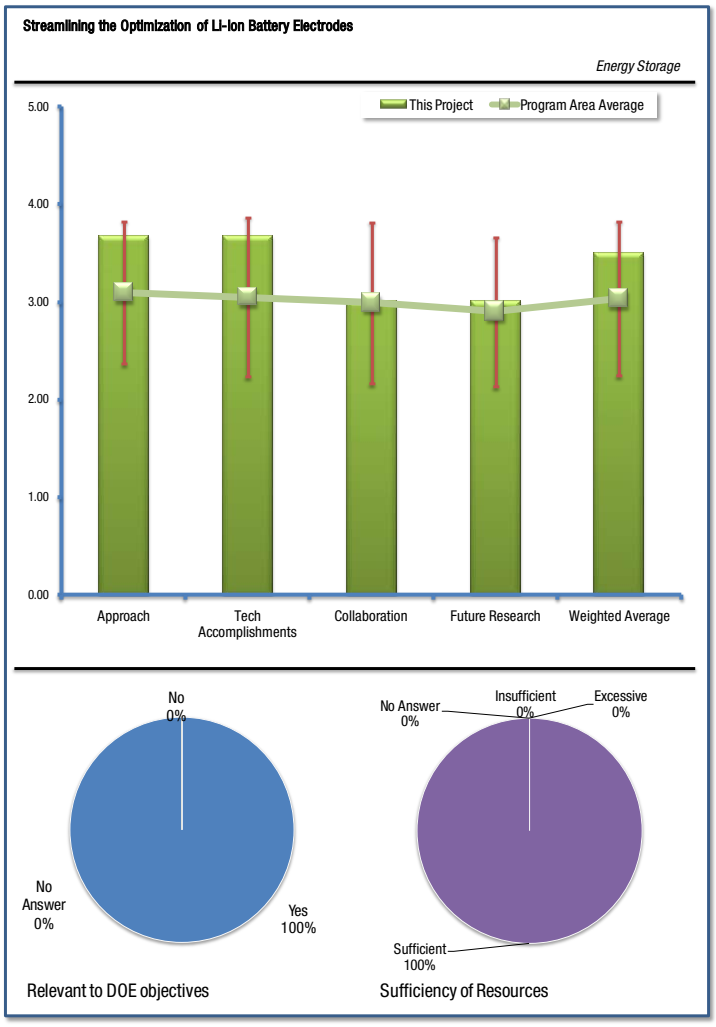
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the proposed studies of continuing to improve the synthesis reduce the irreversible loss, explore carbon coating look acceptable. Even if successful, however, these efforts will have not helped the DOE goals significantly (low pay off). Another reviewer added the future work is well defined but the focus on complete verification of project targets is not indicated.

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

A reviewer stated the resources are adequate while another reviewer mentioned the resources seem consistent with the planned activities.

Streamlining the Optimization of Li-Ion Battery Electrodes: Wenquan Lu (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the modeling and simulation of the battery performance based on the material properties and processing will reduce the long wait associated with the new materials. Another reviewer noted that electrode manufacturing and design is the key to meaningful evaluations of materials and setting direction for the program. One reviewer mentioned that Lu is trying to reduce the time necessary to produce an optimized electrode in a lithium ion cell.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the study of properties and characteristics of the material for electronic conductivities is a new approach. Another reviewer mentioned they were very impressed with the approach taken in trying to measure key electrode properties (such as electronic and ionic conductivity). One reviewer noted that Lu is working on understanding the conductivity of electrode materials and the aging process in these cells by carrying out EIS studies.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the electronic conductivity of various electrode material and information on aging of the electrodes helps with the understanding of the aging phenomena. Another reviewer commented that in a very short time, the PI has already demonstrated some useful learning's about electrode designs and conductivity. One reviewer added Lu has found that a particular combination of active material, conductive additive, and binder provide the lowest electrode impedance at the beginning of life and after cycling for a particular cathode. He has also made progress in determining the conductivity of various cathode powders.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the collaboration with cell modeler and using available S/W may add to the value of the development work. Another reviewer added there is an excellent linkage to Dees modeling and Jansen's new pilot line. It seems to the reviewer that this PI's work might benefit from consultation and/or collaboration with Prof. Sastry in Michigan, whose group has in the past done some great modeling work on electrode conductivity for the ATD/BATT programs. One reviewer noted Lu appears to be working with Dees at ANL, which is useful. It is not clear that he is working with others as he should be.

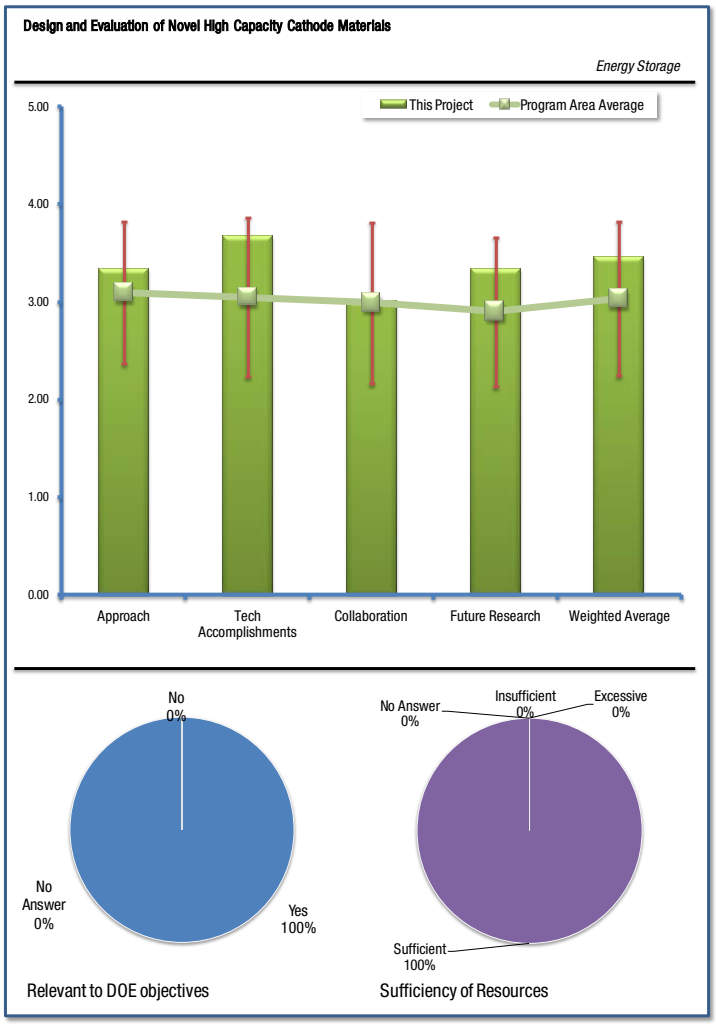
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated that continuation of the development work is promising. Another reviewer mentioned that good plans are in place. While studies that are planned to look at binder, carbon loadings, etc. may to a large extent be empirical; this is often how battery developers really get things done, even if they aren't very proud of it. One reviewer commented that Lu's plans for future work are reasonable expect for the need to develop the capability of predicting the outcome of his experimental plans. He should consider working more closely with Dees and others.

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

A reviewer stated the project seems to be very focused and working well with others. Another reviewer noted Lu has received sufficient funding.

Design and Evaluation of Novel High Capacity Cathode Materials: Michael Thackeray (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated there is a need for high energy (voltage & capacity) material desperately! Another reviewer noted this project will synthesize high energy cathode materials for PHEV applications and determine the physical and chemical properties of these new materials. One reviewer mentioned the objective of the research is matched to DOE's.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that most applications outside consumer electronics for high E/P applications require a rate between 1C & 5C. This needs to be taken this into account for rate capability assessment. Another reviewer commented the approach is to develop new avenues to prepare new cathode materials with 4 volts or higher to prepare new high energy battery systems. Develop procedures to use surplus lithium to load intercalation/alloy anodes. Evaluate the use of the stabilized lithium metal powder from FMC Corporation. One reviewer added as mentioned in approach slide, investigation and analysis of mechanism are important rather than optimization work.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the project demonstrated over 500 mAh/g in Li_5FeO_4 materials, and over 300 mAh/g in vanadium materials. These offer high capacity at reasonable cost. The work involved high Li_2O content and anti-fluorite structures. Another reviewer noted it seems a lot of work has been done to address and reach objectives.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

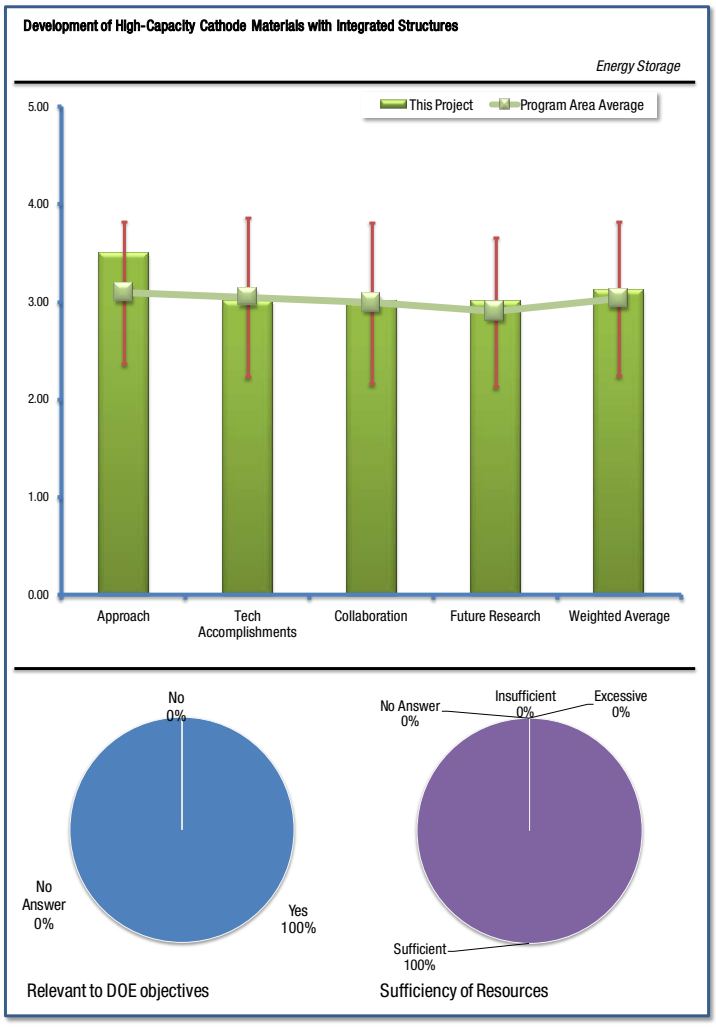
A reviewer stated that most of the work involves in-house equipment. Another reviewer noted that only one source was mentioned and could not find collaboration work in the presentation.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the project will evaluate properties of Li-rich anti-fluorite structures for their electrochemical and chemical as well as thermal stability in charged and discharged states. Determine structural properties by XRD, XAS and other spectroscopic methods. Extend studies to include manganese, nickel and cobalt. Another reviewer commented the future work addressed is based on the past result and reasonable to reach the target.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated that sufficient resources are available for the proposed work.

Development of High-Capacity Cathode Materials with Integrated Structures: Sun-Ho Kang (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size

This project had a total of 2 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated that high capacity and high voltage cathodes will contribute to an enhancement in the specific energy of Li-ion batteries, which makes them viable for PHEVs and reduce petroleum consumption and demand. Another reviewer noted this project addresses key barriers to enable broader implementation of lithium ion technology and therefore meet DOE objectives. Specifically, the project is improving energy density and overall cost including lifetime and safety.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated it's a good approach to combine spinel-layered; may not a single phase, but may have synergistic effect on rate and capacity. Another reviewer mentioned there is a good synergy leveraging other BATT program findings and developing method to address gaps. Cycling results at high voltage verify the success of this approach.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the structural features as well as discharge curves indicate integrated phases of spinel and layered phases. The capacities are approaching 250 mAh/g in some cases, which is quite interesting. Another reviewer comments the results are very nice so far, however, need to move from coin cell evaluation to larger cells, such as 18650 to really validate energy improvements and cycle life for these materials.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

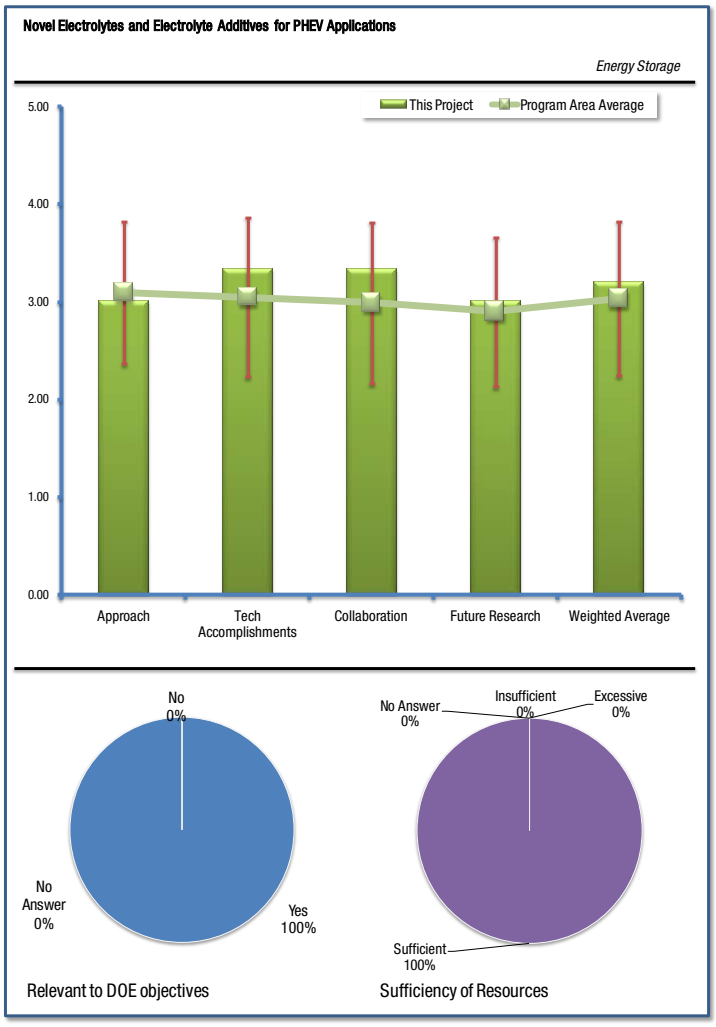
A reviewer states there is a good collaboration with ANL.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated it is worth pursuing the proposed studies to optimize the cathode materials further, study the effect of dopants and demonstrate their performance in full cells. Another reviewer noted there is a need to move from coin cell studies to larger cells with appropriate balance of electrolyte in order to continue to confirm progress and relevancy.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the resources are adequate for this project.

Novel Electrolytes and Electrolyte Additives for PHEV Applications: Daniel Abraham (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size
This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?
A reviewer stated the anode failure modes include the loss of lithium or SEI instability which may be reduced with the use of additives and/or new electrolytes. Another reviewer noted that new electrolytes could be an enabler for higher voltage cathodes and also maybe better cycle life. However, LOS seems very low. One reviewer mentioned Abraham is attempting to find an electrolyte additive to improve the performance capability of lithium ion cells with high voltage cathodes.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
A reviewer stated the use of new electrolyte and additives will help with the expected improvements. Another reviewer commented the strategy is not very clear, although the approach based on LUMO/HOMO calculations discussed by the presenter (not shown in poster) seem reasonable and is leading them to evaluate glycerol carbonate and some additives. However, in the reviewers view low temperature performance is likely to be very poor with the glycerol carbonate they are working on due to its high viscosity. However, the search for a new electrolyte is going to be very hard and they are not sure what advantage this group or approach has over anyone else. One reviewer noted that Abraham has not presented his literature survey that he probably conducted before selecting glycerol carbonates for further study. Also, it is not clear that he will be able to determine the effect of the additives based on cycling the anode/cathode pair he selected to 4.5 V. He should consider using a lower end of charge voltage or a different anode/cathode pair that would include a higher voltage cathode.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated the results show the additives may be helpful in improving the life of the batteries. Another reviewer noted as a new project, can't expect much at this time. Positive results with glycerol carbonate are very surprising in view of uncapped alcohol group. One reviewer mentioned that Abraham has obtained useful results and published them with Dees et al.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated that CSIRO will improve the probability of success. Another reviewer commented this exploratory work does not really need much coordination with other institutions. If they find anything, collaboration would become more important for follow-up work. Approaching others who are working in this area and asking to evaluate their materials under a non-analysis agreement might be worthwhile. One reviewer added Abraham is working closely

with Dees and publishing with him. This collaboration has generated useful results. It would be helpful if they could work with someone in industry.

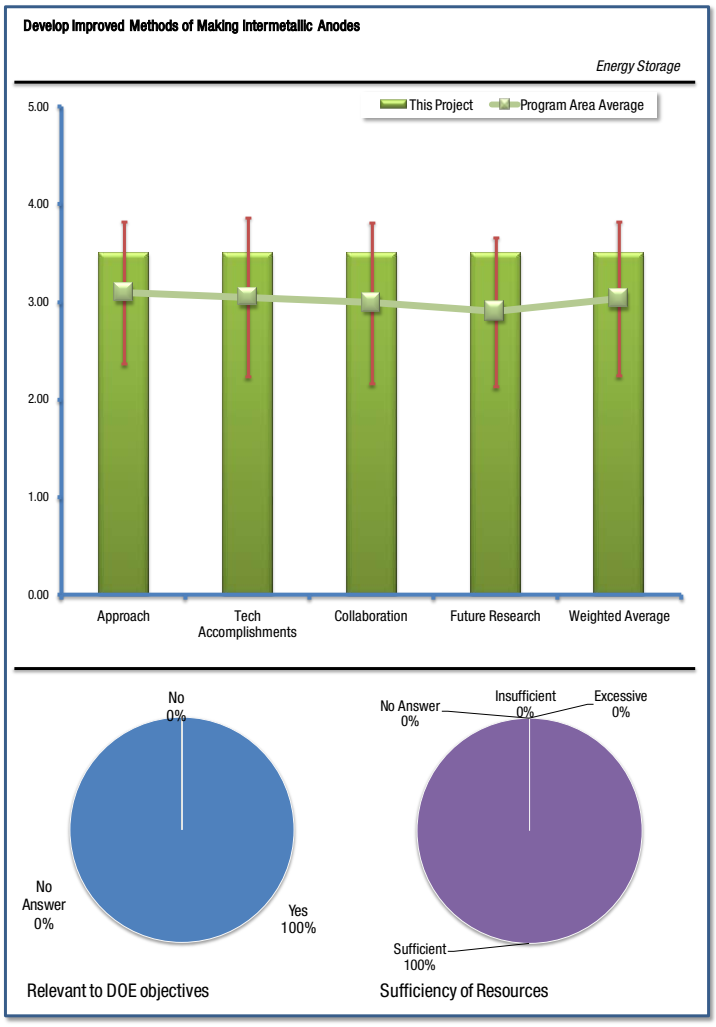
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the future research should include the graphite instability exploration with the PHEV application and make the graphite more stable. Another reviewer noted it seems OK, but again the likelihood of success seems pretty low. One reviewer commented Abraham's plans for the future are reasonable. However, it is not clear why he has chosen the ionic liquids that he is planning to study next year. He may want to reconsider this aspect of his future studies.

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

A reviewer stated they agree to fund this work only at a low level. Another reviewer mentioned Abraham's funding is sufficient for his project.

Develop Improved Methods of Making Intermetallic Anodes: Andrew Jansen (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size

This project had a total of 2 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the project is very relevant. A higher performance anode can significantly improve the current generation of Li ion batteries. Another reviewer noted that higher capacity than the present carbon anode materials is needed for the longer term.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the approach is a qualified good. They are quite skeptic about the success of most of the approaches pursued in the project thus far. They also believe the stability of these anodes will have to stem from the material itself, not from binders, additives. Many such approaches have already been reported without any major results. Nevertheless, for a long-term project as this one, they are ok with establishing baseline data like the ones the authors have obtained. Another reviewer mentioned the addition of elastic/inert binders to accommodate the large volume changes with alloy anodes is essential to their application in a practical cell. Another approach is the use if inert components in the alloy to control the particle size of the alloy element.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated given the long-term nature of the project, they think the authors were able to establish some good baseline data. Another reviewer commented that developed coating process to make electrodes with varying thickness of Cu_6Sn_5 to establish baseline. The accomplishments identified metals supplier to help in development of intermetallic alloys of varying particle size and morphology. The project evaluated the influence of conductive and resistive additives to electrode powder mix in an attempt to minimize copper migration. It expanded Argonne's Battery Design Model to assess the benefit of using intermetallic alloys in PHEV batteries. The project also obtained numerous samples of electrode binders for binder optimization study.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated there is very good collaboration with other workers. Another reviewer added that the project is mainly working with in-house experts.

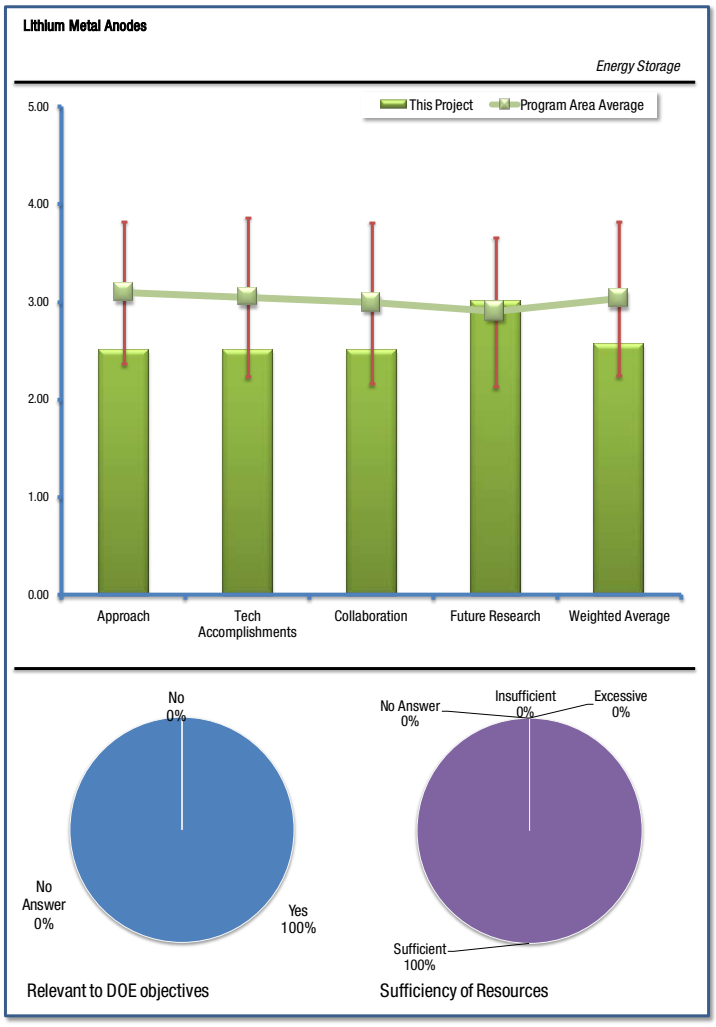
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they are very curious to see how the approach following Huggin's concepts pan out. The focus should be more on materials with new properties than working with different binders. Another reviewer noted the project will continue investigation of elastic binders for intermetallics. It will obtain and study vendor made samples of Cu_6Sn_5 samples made with varying particle size and substituted metal species in the $Li_xM_yCu_5Sn_5$ system, copper rich Cu_6Sn_5, and partial iron substitution of copper. Explore the subject of critical particle size based on Huggins work by making alloy casts of lithiated intermetallic alloys and evaluating their mechanical properties. Continue search for additives that promote copper retention at the particle level and electrode level. Initiate electrolyte additive study to enhance SEI formation for intermetallic electrodes.

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

A reviewer stated the resources are ok as is for the project.

Lithium Metal Anodes: Jack Vaughey (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size
This project had a total of 2 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?
A reviewer stated the use of Li metal anode will improve the specific energy of Li-ion batteries. Another reviewer noted the project is looking at solving a key problem of Li metal anode with a potential high impact on DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
A reviewer stated the technical barriers are clearly selected with an adequate approach. The combination of models and experimental work is valuable.

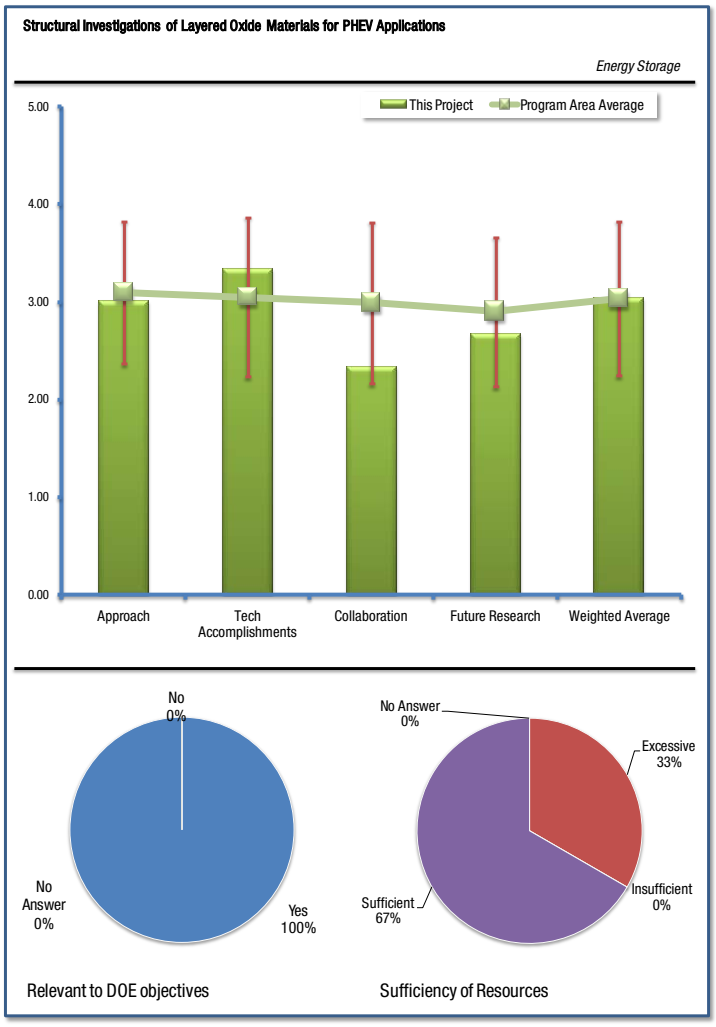
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated the Zintl metal coating shows some promise. Another reviewer mentioned there are very good results and potential good feedback for improving thermal stability.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated the collaboration is adequate for the needs.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the project is still focused on the main technical barriers of Li metal with adequate progress and future work based on effective results.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the resources seem consistent with the effort and the work planned.

Structural Investigations of Layered Oxide Materials for PHEV Applications: Daniel Abraham (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated the need for higher energy content electrode is observed in the automotive application. Another reviewer noted the project helps with understanding high energy cathodes important for meeting PHEV goals. One reviewer commented Abraham et al. are studying the fundamentals associate with oxides for lithium ion cells.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the high voltage layered compound will deliver higher energy content. The cost may be reduced with low-cost metals. Another reviewer mentioned that really good analytical techniques and use of Cr as a model element to probe the mechanism and structural changes occurring during discharge of the MnNi oxide. One reviewer noted Abraham et al. seem to be reinventing the wheel in this project. It is not clear what new information they have developed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the study of various cathode materials and success look promising. Another reviewer noted the project has accomplished a lot in a relatively short time (new program). Seem to have established some of the mechanistic details of some key materials already and providing valuable insights. One reviewer commented Abraham et al. have obtained interesting results, but again it is not clear what is new in their work. It would be helpful if they would review the literature as part of their work.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated the collaboration with universities will help. Another reviewer mentioned it seems to be mainly an ANL activity (they did not explore with the PI collaboration with the partners listed). They didn't see any linkage with modeling work either (Ceder), which would seem to be an important adjunct to such experimental studies. One reviewer noted Abraham et al. have listed collaborators, but it is not clear what these collaborators have contributed to this project or how they have used the results obtained in this project.

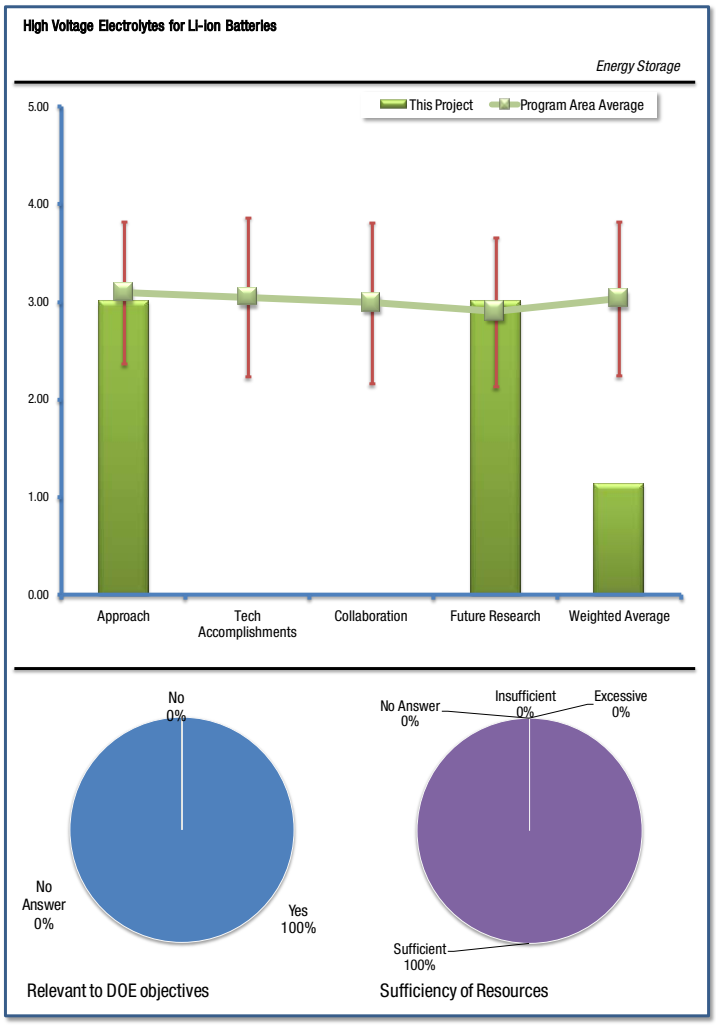
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the continuation of the development will lead to the energy and cost improvements. Another reviewer comments the plans seem to be aimed at answering important questions in key materials. If they understand this correctly, we still don't have a good explanation for the unusually high discharge capacity of ANL's material. The team will need to answer this question as the program gets going. The reviewer also wonders whether working with Clare Grey on NMR would also be helpful for this project, especially as some of the findings are that the materials are not always showing a well-ordered structure. NMR is well suited for studying the chemistry of disordered material. One reviewer mentioned Abraham et al. seem to be planning to do more work next year that will be repetitive in nature relative to what has already been published.

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

A reviewer stated they have a difficult task and are doing well with modest funding. The PI needs to make sure they leverage the program partners. Another reviewer added Abraham et al. should be encouraged to direct their efforts toward producing new materials for lithium ion cells.

High Voltage Electrolytes for Li-ion Batteries: Richard Jow (Army Research Laboratory) - POSTER



Reviewer Sample Size
This project had a total of 1 reviewer.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?
A reviewer stated the project will help develop high voltage electrolytes to accommodate the high voltage cathodes for HEV applications.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
A reviewer stated the approach explores asymmetric sulfone that has various functional groups for lower melting points and low viscosity, various functional groups containing un-saturated bonds. Explore non-sulfone based additives in combination with sulfone solvents for improved performance. Carry out quantum mechanical calculations based on HOMO/LUMO calculations.

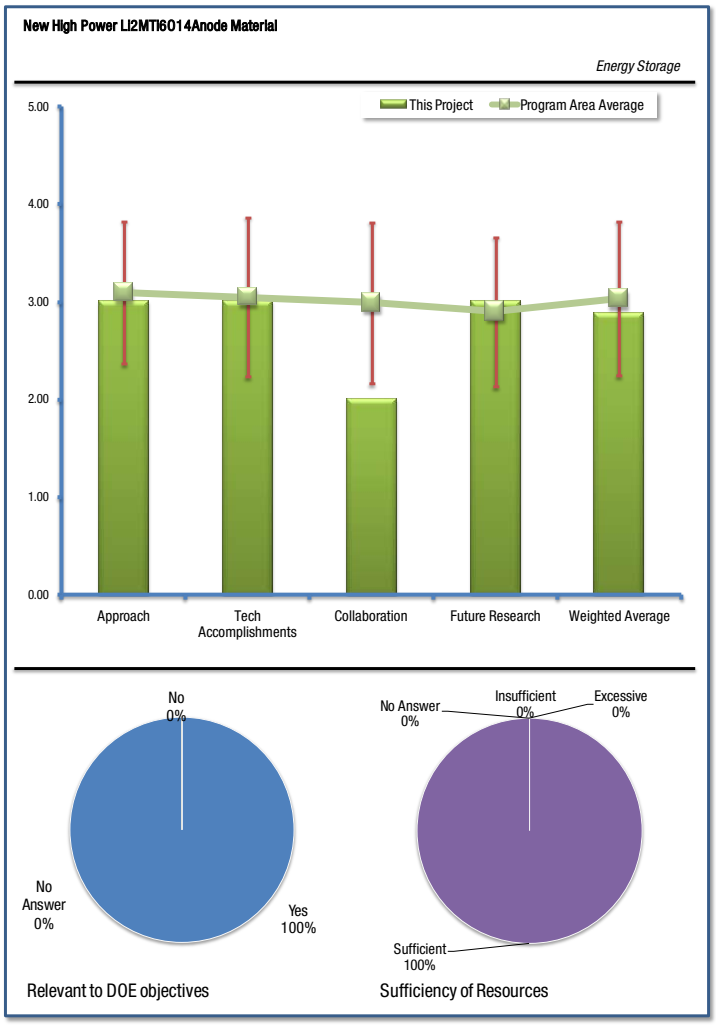
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated the high voltage electrolytes development has been focused on the development of anodically more stable sulfone based than currently used carbonate based solvent systems. Sulfone with different functional groups will be explored and synthesized as improved solvents and additives for Li-ion batteries. The formulated electrolytes containing developed sulfone based solvents in combination with other solvents will be evaluated with the high voltage cathodes in Li-ion cells.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated there is collaboration with Maryland for the calculations of HOMO/LUMO and the correlation coefficients between LUMO/reduction or HOMO.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the work to synthesize of the sulfones with new functional groups and the electrochemical and physicochemical characterizations of $LiPF_6$ in these solvents. Evaluate LiPF6 in conventional carbonate solvents and sulfone solvents with and without VC additives in cells containing high voltage cathodes.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the resources for this project seem sufficient for the work proposed.

New High Power $Li_2MTi_6O_{14}$ Anode Material: Khalil Amine (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size
This project had a total of 1 reviewer.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?
A reviewer stated the work on alternative anodes is supportive of the DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
A reviewer stated the approach is well defined with a clear view of the technical barriers to be analyzed and solved. The higher capacity of the new titanate integrated by the positive performances of the conventional titanate anode materials is a premium factor to be pursued in a clearly designed approach.

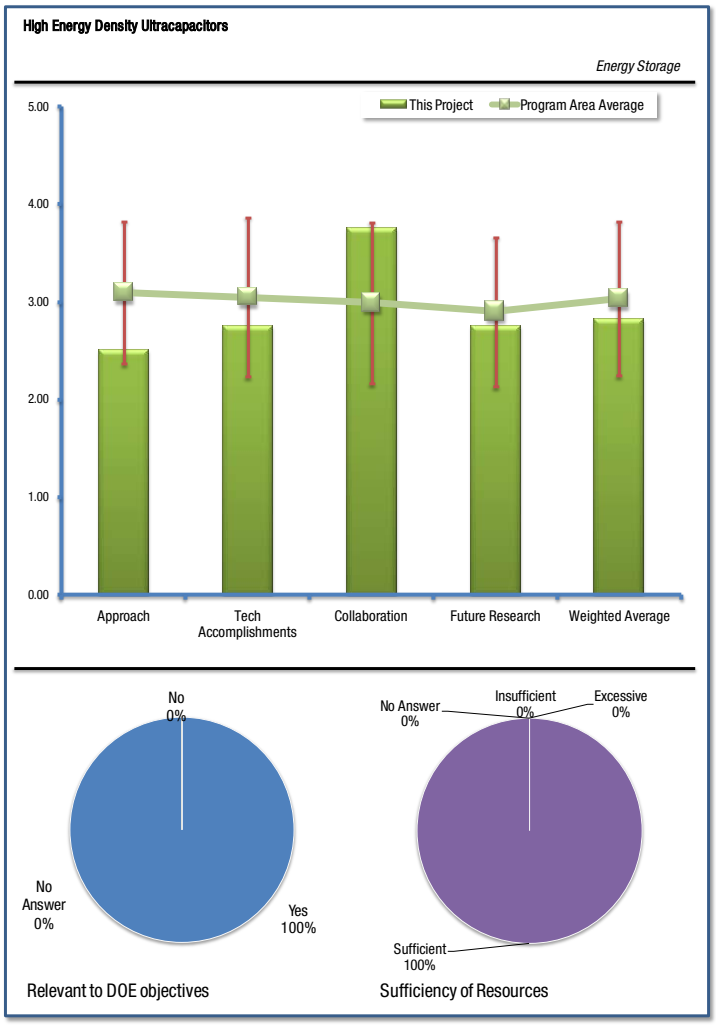
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated the results are very promising but needs further verification.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated the collaborations are very limited.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the future plan is good by combining process improvement and materials performance investigations.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the resources seem adequate, even if further work on complete cell realization and testing would be beneficial in accelerating the achievement of the results.

High Energy Density Ultracapacitors: Patricia Smith (Naval Surface Warfare Center) - POSTER



Reviewer Sample Size

This project had a total of 4 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated there is significant potential to improve Li-ion battery life in automotive applications using a coupled capacitor/battery energy storage system. This could both improve battery life during charge-sustaining operation and improve brake-energy recovery. Another reviewer noted the high energy ultracapacitors may be able to reduce the energy storage cost. One reviewer commented that while this technology does not have the energy to do PHEV or even HEV, super caps and especially their asymmetric ones, might find use in capturing the energy from regenerative braking. However, the increasing power capability of high rate Li-Ion cells is making this much less certain in their view. Comments from another reviewer mentioned Smith et al. are trying to produce high energy density ultracapacitors, which could be used in vehicles.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated the electrolyte and the electrodes investigations may lead to the optimum combinations to reduce the cost, self-discharge, and energy density limitations. Another reviewer mentioned this is a good approach to evaluating new materials. Seem to know what they are doing and how to look for signs of degradation in the cells. Seem to be an expert in their field, very knowledgeable. One reviewer noted Smith et al. appear to be working on a project that may have limited utility because of the possibly low cycle life.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the data with various carbons, electrolyte, and electrode material will lead to understanding of the limitations created by the components. Another reviewer commented that while, they are not very far along with the project, most of their main findings are pretty well-known in the industry. While they seem technically very astute, the reviewer is concerned they offer little in the way of true innovation as they are basically evaluating materials that others are making, and maybe that's all we are asking of them. One reviewer mentioned Smith et al. have accomplished little relative to what was known before they started this project.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated that collaboration with the innovative developers will help to improve the existing ultracapacitors. Another reviewer added the project appears to be linked in to a wide range of carbon sources. One reviewer noted Smith et al. are collaborating with a university worker and a company representative.

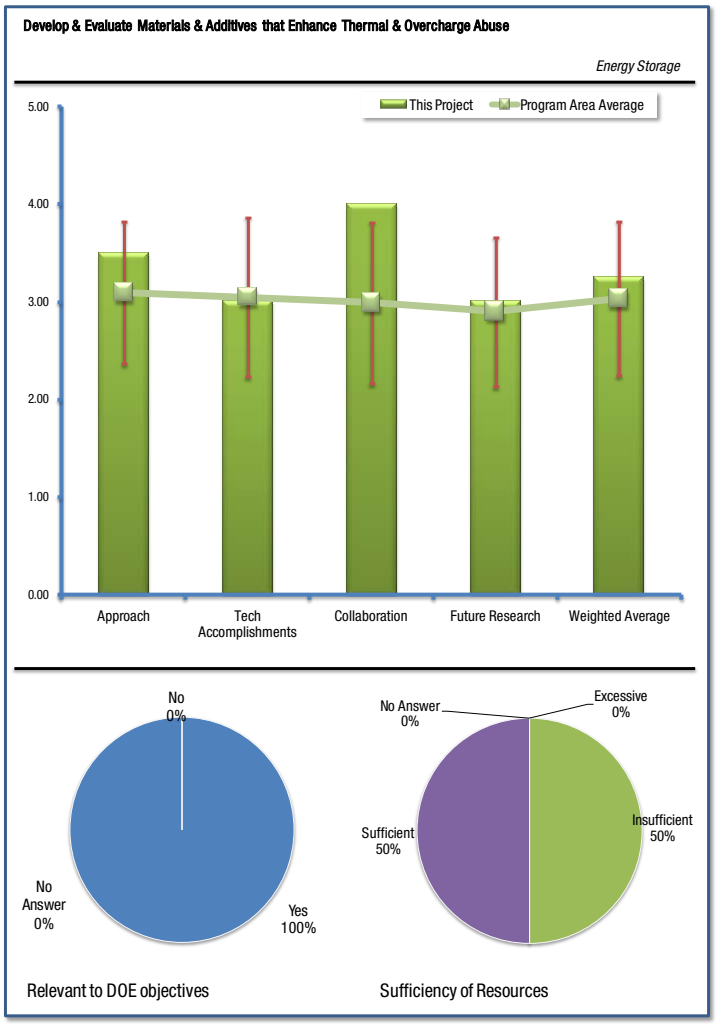
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the continuation of the development work will lead to improve the energy density of the ultracapacitors. Another reviewer mentioned if this work is aimed at evaluating where the technology can play in HEV/PHEV, they should do a very good job. They are concerned the project offers little in the way of true innovation as they are basically evaluating materials that others are making. The reviewer saw no technology plan to improve on current materials. If the DOE is expecting them to significantly advance the state of the art, then they fear this group will not succeed. One reviewer commented Smith et al. will probably not develop a device that will meet their projected energy and power densities that will have a useful cycle life for vehicle applications.

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

A reviewer stated the cost share by Nay provides the sufficient funding. Another reviewer noted Smith et al.'s funding is sufficient for this project.

Develop & Evaluate Materials & Additives that Enhance Thermal & Overcharge Abuse: Khalil Amine (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size

This project had a total of 2 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated this project supports the overall DOE objective of petroleum displacement. Another reviewer noted the project is directly related to improving abuse resistance of Li-Ion cells.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated they are not that convinced that the approaches pursued here will lead to any effective solutions to the problems addressed. The reviewer has seen these approaches followed for quite some time now but have not seen any real breakthroughs. Most of the approaches are variations on a theme and they are incremental with respect to benefits. The reviewer likes the idea of additives much better than coatings which are again band-aids. The shuttle concept is sexy on paper but has proven to be impractical in real systems. Besides, these systems often rely on low rate processes, which have no bearing on high-rate hybrid or PHEV systems. They however might be effective in EVs. This reviewer goes on to say they think the authors are stretched too thin. They are all over the map and I am not sure they can address all these issues in such a short period of time. Another reviewer noted the approach correlates the loss of oxygen from the charged cathode NCA and NMC, $LiMn_2O_4$, and $LiFePO_4$ the heat generated from the high rate discharge and oxidation of the electrolyte. Investigate the effect of surface area and morphology of cathodes on the safety of the cell. Determine the relationship between the surface area and morphology of the carbon and the heat from the SEI breakdown and quantify the role of the SEI breakdown by studding anodes that doesn't require SEI. Investigate the possible oxidation of the separator from the oxygen release.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated the authors have produced a lot of results but the only result considered significant is the stability of the resistance for cells using LiDFOB. Even that might not hold in longer-term storage studies. Most of the other results are not significant to me or too early to draw any reasonable conclusions. The reviewer has seen many such improvements disappear during long-term cycling or storage.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer states there are very good collaborations within the project.

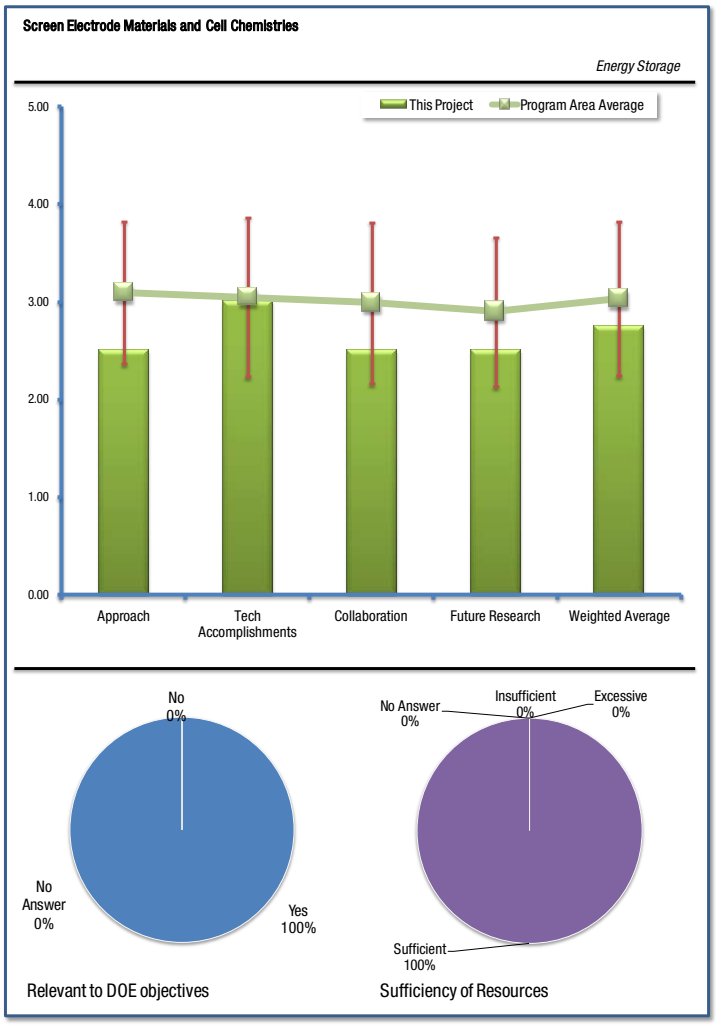
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated they would suggest focusing away from coatings and to some degree additives. It is easy to do a lot of work using such approaches but again the benefits have been incremental, if any. Some of the approaches proposed such as ALD is very attractive but is expensive and they often lead to lower power. May be authors can come up with an elegant and inexpensive way of achieving this objective. This reviewer would have loved to see more focused work. They are fighting too many fires within this project. Another reviewer mentioned the project will investigate the effect of more additives and surface coatings on the safety of lithium batteries. Exploring 3M's redox shuttles potential on preventing overcharge. Investigate the effect fluorinated carbonates, ionic liquids on the safety of lithium batteries. Investigate effect of and morphology of carbon.

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

A reviewer stated if we want the authors to pursue all the items they have listed, then the fund is not sufficient. Another reviewer noted the resources are reasonable but it is an ambitious program.

Screen Electrode Materials and Cell Chemistries: Wenquan Lu (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size
This project had a total of 2 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?
A reviewer stated the scientific and technological benchmarking is instrumental in supporting right choices for better reaching DOE objectives.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?
A reviewer stated the approach is good, without any specific original research activities, but clearly addressing key technical and economical barriers.

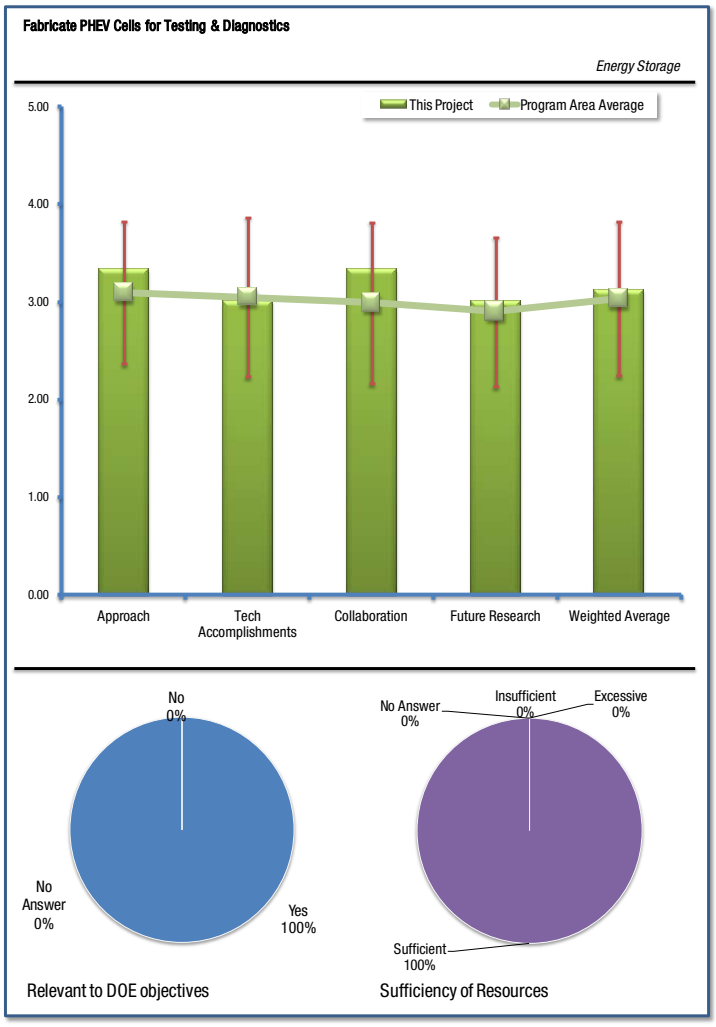
Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.
A reviewer stated the results are really good and easily repeatable thanks to the preparatory work in defining specific test procedures for material screening.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?
A reviewer stated there are no evident collaborations but probably there are not yet necessary at this stage.

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?
A reviewer stated the activities seem to be quite well in place with clear vision of the steps to continue the work. It is not completely clear the way the results are compared with those of the innovative materials under development in BATT.

Question 6: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
A reviewer stated the resources should be flexibly adapted to the yearly testing plan and evaluation/assessment work.

Fabricate PHEV Cells for Testing & Diagnostics: Andrew Jansen (Argonne National Laboratory (ANL)) - POSTER



Reviewer Sample Size

This project had a total of 3 reviewers.

Question 1: Does this project support the overall DOE objective of petroleum displacement? Why or why not?

A reviewer stated it is very critical to validate the performance of the PHEV batteries by first modeling and then actual cell testing. Another reviewer noted the plan to bring cell manufacturing in-house is critical if this program is ever to generate real cells for cycle life and lifetime assessments. Also, for the first time, they are starting to get down into the nuts and bolts of electrode manufacturing.

Question 2: What is your assessment of the approach to performing the work? To what degree are technical barriers addressed? Is the project well-designed, feasible, and integrated with other efforts?

A reviewer stated that making electrodes will require many experiments and coating equipments to optimize the process. There is not enough detail on the electrode manufacturing. Another reviewer mentioned they really liked the focus on basic design factors of the electrodes and linking them to models and performance. The cell line seems well thought out.

Question 3: Characterize your understanding of the technical accomplishments and progress toward overall project and DOE goals.

A reviewer stated that depending on the electrode and cell manufacturing vendors was not successful in the past. There is a need for an industry expert working at ANL for a successful outcome. Another reviewer commented the accomplishments already identified some useful constraints on electrode thickness and loading. It is still too early in the project to expect much else.

Question 4: What is your assessment of the level of collaboration and coordination with other institutions?

A reviewer stated there may be some lessons learned from the cell building operations at LBNL. Another reviewer noted they were very pleased to see good co-operation between the modeling work, fundamentals measurements on cells and formulation experts. Make sure they work with Sandia for best shared practices and try to tap in to "friendly" experts in the field who might be willing to impart helpful tips on cell manufacturing that are hard to find out any other way. (The reviewer knew this is hard to do.)

Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer stated the dry room operation will add the value to the success of the program. Another reviewer noted they think when this work gets going it could become a key link in moving ideas from the lab to real prototypes. The

reviewer liked their plan to use commercially made Gen2 cathode materials as a validation for this new electrode manufacturing line.

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

A reviewer stated they suspect that getting this line up and running will be fraught with many difficulties and is a major undertaking that is not fully appreciated. While the reviewer is somewhat heartened by plans to hire a process engineer, the prove-in of this line will likely be much longer and more expensive than expected. Thus, while the resources may be OK, this program step may need considerable patience to bring the production system on-line. Meeting the desired timeline for making good electrodes would be a miracle in this reviewer's opinion. Whoever has control over this facility needs to have authority to enforce a rigorous and disciplined usage (probably needs a thick skin as well). Management support is going to be the key in this area or pretty soon all you will have is a contaminated mess on your hands.