2. Energy Storage Technologies

Improving the batteries for electric drive vehicles, including hybrid electric (HEV) and plug-in electric (PEV) vehicles, is key to improving vehicles' economic, social, and environmental sustainability. In fact, transitioning to a light-duty fleet of HEVs and PEVs could reduce U.S. foreign oil dependence by 30-60% and greenhouse gas emissions by 30-45%, depending on the exact mix of technologies.

While a number of electric drive vehicles are available on the market, further improvements in batteries could make them more affordable and convenient to consumers. In addition to light-duty vehicles, some heavy-duty manufacturers are also pursuing hybridization of medium and heavy-duty vehicles to improve fuel economy and reduce idling.

The Vehicle Technologies Office (VTO) focuses on reducing the cost, volume, and weight of batteries, while simultaneously improving the vehicle batteries' performance (power, energy, and durability) and ability to tolerate abuse conditions. Reaching the Office's goals in these areas and commercializing advanced energy storage technologies will allow more people to purchase and use electric drive vehicles. It will also help the Department of Energy (DOE) meet the *EV Everywhere* Grand Challenge goal of making the United States become the first nation in the world to produce PEVs that are as affordable for the average American family as today's gasoline-powered vehicles within the next 10 years.

The VTO pursues three major areas of research in batteries:

- Exploratory Battery Materials Research: Addresses fundamental issues of materials and electrochemical interactions associated with lithium and beyond-lithium batteries. This research attempts to develop new and promising materials, use advanced material models to predict the modes in which batteries fail, and employ scientific diagnostic tools and techniques to gain insight into why materials and systems fail. Building on these findings, it works to develop ways to mitigate those failures.
- Applied Battery Research: Focuses on optimizing next generation, high-energy lithium ion cells that incorporate new battery materials. The activity emphasizes identifying, diagnosing, and mitigating issues that negatively impact the performance and life of cells using advanced materials.
- Advanced Battery Development, System Analysis, and Testing: Focuses on the development of robust battery cells and modules to significantly reduce battery cost, increase life, and improve performance. This research aims to ensure these systems meet specific goals for particular vehicle applications.

This research builds upon decades of work that the DOE has conducted in batteries and energy storage. Research supported by the VTO led to today's modern nickel metal hydride batteries, which nearly all first generation HEVs used. Similarly, the Office's research also helped develop the lithium-ion (Li-ion) battery technology used in the Chevrolet Volt, the first commercially available (PHEV). This technology is now being used in a variety of hybrid and PEVs coming on the market now and in the next few years, including the Ford Focus electric vehicle (EV), and Chevrolet Spark EV.

The major goals of the Batteries and Energy Storage subprogram are by 2022 to:

- Reduce the production cost of an EV battery to a quarter of its current cost
- Halve the size of an EV battery
- Halve the weight of an EV battery

Achieving these goals would result in:

- Lowering battery cost from $500/kWh to $125/kWh
- Increasing density from 100 Wh/kg to 250 Wh/kg, 200 Wh/l to 400 Wh/l, and 400 W/kg to 2000 W/kg

In August 2009, DOE announced the selection of 26 projects (totaling $1.5 billion) for expanding U.S. manufacturing capacity for advanced batteries and advanced battery components. These American Reinvestment and Recovery Act (ARRA)-funded projects support establishing a significant domestic capacity for batteries that will, in turn, help commercialize advanced electric drive vehicles. Twenty of those ARRA projects focus on developing manufacturing capacity for advanced batteries and battery components (including the production of lithium-ion cells and polymers), production of polymer separators and other components, and battery recycling. The six remaining projects focus on the creation of new battery facilities, or the upgrading of existing facilities, to enable researchers to test batteries, improve battery safety, and increase the throughput of specialized thermal testing.

Subprogram Feedback

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

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

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

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

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

Question 4: Other Comments.

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

Subprogram Overview Comments: David Howell (U.S. Department of Energy) – es000

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

Reviewer 1:

The reviewer noted an excellent overview of the DOE program directed at EV battery systems.

Reviewer 2:

The reviewer felt that the presentation covered the technical areas very well and provided measurable metrics toward the deliverables. It appeared that the DOE energy storage program was engaged very well with key industrial partners that were responsible for powertrain electrification. The focus areas clearly covered all key components, from battery materials to systems (packs and modules), including thermal management and performance modeling.

Reviewer 3:
The reviewer remarked that the overall battery program was well presented and clearly explained. The issues were highlighted and each sub-program's goals were laid out. The VTO's focus and status were clearly shown. This reviewer further noted that it was complementary to DOE Basic Energy Sciences (BES) and very realistic as to accomplishments and challenges.

Reviewer 4:
The reviewer stated yes and yes.

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

Reviewer 1:
The reviewer acknowledged that the cost target of $300 by 2015 seemed feasible and the cost roadmap seemed to sync very well with the progress in the technical roadmap. This reviewer added that the technical gap charts were clearly identified and a clear timeline was presented to identify the barriers.

Reviewer 2:
The reviewer stated yes, and that the portfolio was well balanced.

Reviewer 3:
The reviewer observed that the program addressed the major issues and proposed solutions that were viable. The challenge was to produce new battery systems with high performance and low cost. The program included a stretch in identifying new high performance systems and was beginning to address the manufacturing cost issues leading to a competitive EV.

Reviewer 4:
The reviewer said it was well presented, with a high level of emphasis on materials cost reduction. This reviewer added that there seemed to be a gap in novel coating processes for electrode manufacturing. Much of the overall cell cost could be addressed through new higher-throughput coating processes for Li-ion and other technologies.

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

Reviewer 1:
The reviewer would rank this sub-program very highly given a number of successes in the past year, both in terms of reducing the cost of battery cathode materials (with BASF) and developing a new synthesis method for addressing issues related to high-voltage cathodes.

Reviewer 2:
The reviewer asserted that the programs were focused to meet the identified needs.

Reviewer 3:
The reviewer simply said yes.

Reviewer 4:
The reviewer expressed that the VTO roadmap was well organized as explained by the presenter, and that this discussion was helpful over what was available online.

Question 4: Other Comments

Reviewer 1:

The reviewer explained that the program should be able to benefit from process and production advancements. This reviewer suggested considering how other industries had evolved and trying to accelerate the evolution of battery manufacturing in the United States. This reviewer emphatically noted operational excellence.

Reviewer 2:

The reviewer indicated that the Computer-Aided Engineering of Batteries (CAEBAT) program rightfully bridged the gap between different key areas of battery technology and had made good progress over the past year. This reviewer added that more efforts should be directed toward experimental validation.

Reviewer 3:

The reviewer highlighted that the lack of a U.S.-based Li-ion battery business was a drawback in developing new technology. Today, explained this reviewer, essentially all of the advanced systems were taken to China for implementation and cell production. This resulted in the loss of control of the technology on a worldwide basis.

Project Feedback

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

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
PEV and HEV Battery Cost Assessment	Brian Barnett (TIAX LLC)	2-9	2.86	2.29	2.29	2.67	2.48
† A High-Performance PHEV Battery Pack	Mohamed Alamgir (LG Chem, Michigan)	2-13	3.33	2.67	2.67	3.00	2.88
† JCI PHEV System Development-USABC	Avie Judes (Johnson Controls-Saft)	2-15	3.67	3.33	3.33	2.67	3.33
† Validation of Electrode Materials and Cell Chemistries	Wenquan Lu (Argonne National Laboratory)	2-17	3.33	3.33	3.33	3.00	3.29
Fabricate PHEV Cells for Testing & Diagnostics	Andrew Jansen (Argonne National Laboratory)	2-20	3.20	3.40	3.40	3.00	3.30
† Mitigating Performance Degradation of High-Energy Lithium-Ion Cells	Daniel Abraham (Argonne National Laboratory)	2-24	3.33	3.00	3.00	3.33	3.13
Novel Cathode Materials and Processing Methods	Michael Thackeray (Argonne National Laboratory)	2-27	3.80	4.00	4.00	3.20	3.85
High Capacity, High-voltage Cathode Materials for Lithium-ion Batteries	Arumugam Manthiram (University of Texas at Austin)	2-30	3.40	3.60	3.60	3.20	3.50
Design of High Performance, High Energy Cathode Materials	Marca Doeff (Lawrence Berkeley National Laboratory)	2-34	2.80	3.20	3.20	3.00	3.08
Development of High Energy Cathode Materials	Jason Zhang (Pacific Northwest National Laboratory)	2-38	3.00	3.40	3.40	3.00	3.25
Inexpensive, Nonfluorinated (or Partially Fluorinated) Anions for Lithium Salts and Ionic Liquids for Lithium Battery Electrolytes	Wesley Henderson (North Carolina State University)	2-41	3.50	3.25	3.25	3.25	3.31
Nanoscale Heterostructures and Thermoplastic Resin Binders: Novel Lithium-Ion Anodes	Prashant Kumta (University of Pittsburgh)	2-44	2.75	3.00	3.00	2.75	2.91
Metal-Based, High-Capacity Lithium-Ion Anodes	Stanley Whittingham (Binghampton University-SUNY)	2-47	3.50	3.50	3.50	3.25	3.47
Electrolytes - Advanced Electrolyte and Electrolyte Additives	Khalil Amine (Argonne National Laboratory)	2-50	3.50	3.25	3.25	3.25	3.31
Development of Electrolytes for Lithium-ion Batteries	Brett Lucht (University of Rhode Island)	2-53	3.33	4.00	4.00	3.00	3.71
Bifunctional Electrolytes for Lithium-ion Batteries	Daniel Scherson (Case Western Reserve University)	2-56	3.25	3.75	3.75	3.00	3.53
Novel and Optimized Materials Phases for High Energy Density Batteries	Jordi Cabana (Lawrence Berkeley National Laboratory)	2-59	3.40	3.20	3.20	3.00	3.23
Interfacial Processes - Advanced Diagnostics	Robert Kostecki (Lawrence Berkeley National Laboratory)	2-62	3.75	3.50	3.50	3.50	3.56
Development of Polymer Electrolytes for Advanced Lithium Batteries	Nitash Balsara (Lawrence Berkeley National Laboratory)	2-64	3.50	3.25	3.25	3.50	3.34

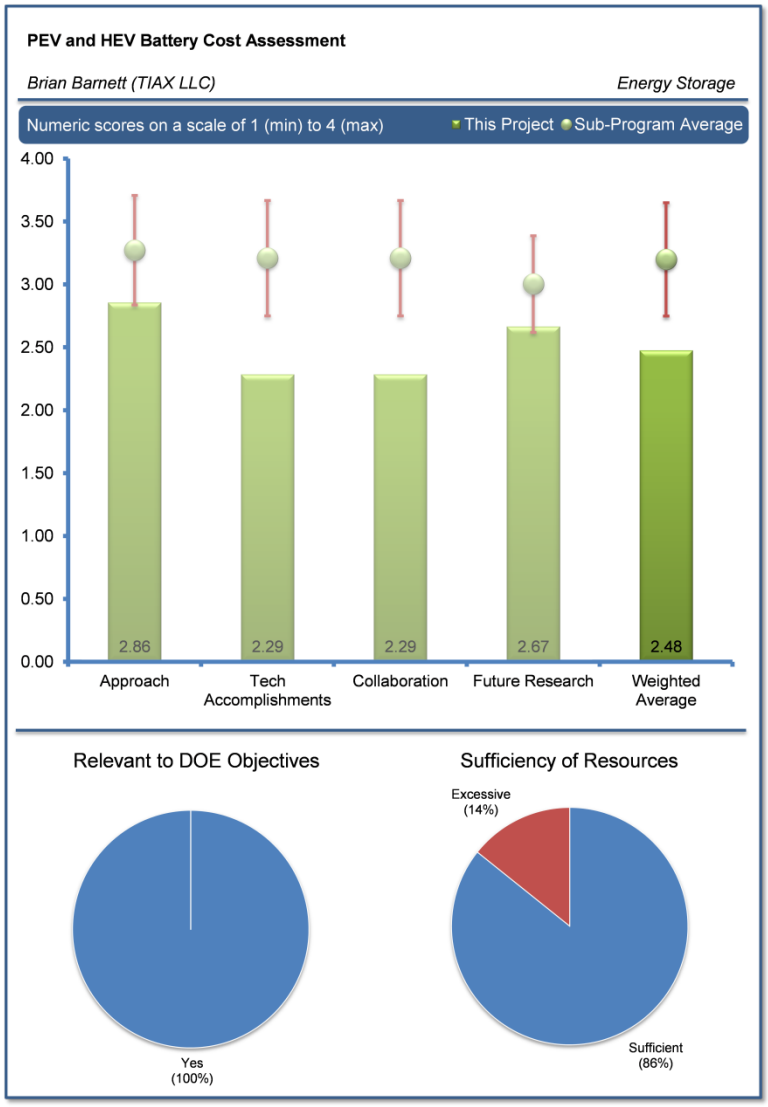
Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Interfacial and Bulk Properties and Stability	John Kerr (Lawrence Berkeley National Laboratory)	2-67	3.25	3.75	3.75	3.00	3.53
In-Situ Electron Microscopy of Electrical Energy Storage Materials	Ray Unocic (Oak Ridge National Laboratory)	2-70	3.60	3.20	3.20	3.20	3.30
Sulfone Liquids and Sulfate/Triflate Solids for High Voltage Electrolytes	Austen Angell (Arizona State University)	2-72	3.25	3.25	3.25	3.00	3.22
Carbon/Sulfur Nanocomposites and Additives for High-Energy Lithium Sulfur Batteries	Chengdu Liang (Oak Ridge National Laboratory)	2-74	3.20	2.80	2.80	3.00	2.93
Studies on High Voltage Lithium Rich MNC Composite Cathodes	Jagjit Nanda (Oak Ridge National Laboratory)	2-77	2.60	3.00	3.00	2.40	2.83
Progress of Computer-Aided Engineering of Batteries (CAEBAT)	Ahmad Pesaran (National Renewable Energy Laboratory)	2-80	3.57	3.71	3.71	3.29	3.63
† Development of High Energy Density Lithium-Sulfur Cells	Donghai Wang (Pennsylvania State University)	2-84	3.17	3.33	3.33	2.67	3.21
† Silicon Nanostructure-based Technology for Next Generation Energy Storage	Ionel Stefan (Amprius)	2-88	3.17	3.33	3.33	2.50	3.19
† Development of Large Format Lithium Ion Cells with Higher Energy Density	Erin O'Driscoll (Dow Kokam)	2-92	3.50	3.17	3.17	3.00	3.23
† Modular Process Equipment for Low Cost Manufacturing of High Capacity Prismatic Li-Ion Cell Alloy Anodes	Sergey Lopatin (Applied Materials)	2-96	3.33	3.83	3.83	2.83	3.58
† High-Voltage Solid Polymer Batteries for Electric Drive Vehicles	Hany Eitouni (Seeo)	2-100	2.67	2.67	2.67	2.67	2.67
† Innovative Cell Materials and Designs for 300 Mile Range EVs	Yimin Zhu (Nanosys)	2-104	3.33	3.50	3.50	3.50	3.46
† High Energy Novel Cathode / Alloy Automotive Cell	Jehwon Choi (3M)	2-107	3.50	3.33	3.33	3.33	3.38
† Utilization of UV or EB Curing Technology to Significantly Reduce Costs and VOCs in the Manufacture of Lithium-Ion Battery Electrodes	Gary Voelker (Miltec UV International)	2-111	4.00	4.00	4.00	4.00	4.00
† Significant Cost Improvement of Li-Ion Cells Through Non-NMP Electrode Coating, Direct Separator Coating, and Fast Formation Technologies	YK Son (Johnson Controls)	2-113	3.33	3.33	3.33	3.00	3.29
† Dry Process Electrode Fabrication	Mike Wixom (Navitas Systems)	2-115	3.00	2.67	2.67	2.33	2.71
† Stand-Alone Battery Thermal Management System	Brad Brodie (DENSO International America)	2-117	4.00	4.00	4.00	3.50	3.94
† Innovative Manufacturing and Materials for Low-Cost Lithium-Ion Batteries	Steve Carlson (Optodot Corporation)	2-119	4.00	4.00	4.00	3.50	3.94
† LEESS Battery Development	Kimberly McGrath (Maxwell)	2-121	3.00	3.33	3.33	3.33	3.25
† Lithium Source For High Performance Li-ion Cells	Keith Kepler (Farasis)	2-123	2.67	2.67	2.67	2.33	2.63
† Implantation, Activation, Characterization and Prevention/Mitigation of Internal Short Circuits in Lithium-Ion Cells	Suresh Sriramulu (TIAX)	2-125	2.83	1.40	1.40	2.25	1.86

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Novel Anodes Materials	Jack Vaughey (Argonne National Laboratory)	2-129	3.33	3.67	3.67	3.33	3.54
Development of Si-based High Capacity Anodes	Ji-Guang (Jason) Zhang (Pacific Northwest National Laboratory)	2-131	3.50	3.00	3.00	3.25	3.16
Atomic Layer Deposition for Stabilization of Amorphous Silicon Anodes	Chunmei Ban (National Renewable Energy Laboratory)	2-134	3.50	3.50	3.50	3.25	3.47
New Layered Nanolaminates for Use in Lithium Battery Anodes	Yury Gogotsi (Drexel University)	2-137	2.00	3.00	3.00	2.00	2.63
Synthesis and Characterization of Structured Si-Carbon Nanocomposite Anodes and Functional Polymer Binders	Donghai Wang (Pennsylvania State University)	2-140	3.50	3.25	3.25	3.50	3.34
Wiring up Silicon Nanoparticles for High Performance Lithium-ion Battery Anodes	Yi Cui (Stanford University)	2-142	3.75	3.25	3.25	2.75	3.31
Synthesis and Characterization of Silicon Clathrates for Anode Applications in Lithium-Ion Batteries	Kwai Chan (SwRI)	2-145	2.00	2.75	2.75	2.25	2.50
Addressing the Voltage Fade Issue with Lithium-Manganese-Rich Oxide Cathode Materials	Anthony Burrell (Argonne National Laboratory)	2-148	3.67	3.83	3.83	3.50	3.75
† Development of Industrially Viable Battery Electrode Coatings	Robert Tenent (National Renewable Energy Laboratory)	2-152	2.60	2.80	2.80	2.60	2.73
† Overcoming Processing Cost Barriers of High-Performance Lithium-Ion Battery Electrodes	David Wood (Oak Ridge National Laboratory)	2-155	2.80	3.40	3.40	2.80	3.18
† Roll-to-Roll Electrode Processing and Materials NDE for Advanced Lithium Secondary Batteries	David Wood (Oak Ridge National Laboratory)	2-158	3.20	3.20	3.20	2.80	3.15
† Process Development and Scale-up of Advanced Cathode Materials	Greg Krumdick (Argonne National Laboratory)	2-162	3.00	2.40	2.40	3.00	2.63
Process Development and Scale up of Advanced Electrolyte Materials	Greg Krumdick (Argonne National Laboratory)	2-165	3.50	2.75	2.75	2.75	2.94
Analysis of Electric Vehicle Battery Performance Targets	Jeremy Neubauer (National Renewable Energy Laboratory)	2-167	3.86	3.57	3.57	2.71	3.54
Promises and Challenges of Lithium- and Manganese-Rich Transition-Metal Layered-Oxide Cathodes	Kevin Gallagher (Argonne National Laboratory)	2-170	2.83	2.83	2.83	2.83	2.83
Composite Electrolytes to Stabilize Metallic Linium Anodes	Nancy Dudney (Oak Ridge National Laboratory)	2-174	3.75	3.75	3.75	3.50	3.72
In situ Solvothermal Synthesis of Novel High Capacity Cathodes	Patrick Looney (HRL Laboratories LLC/Brookhaven National Laboratory)	2-177	2.60	3.00	3.00	2.80	2.88
Lithium-Bearing Mixed Polyanion (LBMP) Glasses as Cathode Materials	Andrew Kercher (Lawrence Berkley National Laboratory)	2-180	2.40	2.60	2.60	2.40	2.53
† Cell Fabrication Facility: Current Research Activities in Electrode and Cell Prototyping	Bryant Polzin (Argonne National Laboratory)	2-183	3.20	3.00	3.00	2.80	3.03
† Linking Electrochemical Performance with Microstructural Evolution in Lithium Battery	Dean Miller (Argonne National Laboratory)	2-186	3.67	3.00	3.00	3.00	3.17

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
† Solid State NMR Studies and Local Structure of Voltage Fade Materials	John Vaughey (Argonne National Laboratory)	2-189	3.67	3.00	3.00	3.33	3.21
† Electrochemical Characterization of Voltage Fade in LMR-NMC cells	Daniel Abraham (Argonne National Laboratory)	2-192	3.33	3.33	3.33	2.67	3.25
† Examining Hysteresis in Lithium- and Manganese-Rich Composite Cathode Materials	Kevin Gallagher (Argonne National Laboratory)	2-195	3.25	3.00	3.00	3.00	3.06
† Arresting VF: Theory-Guided Synthetic Approaches to Cathodes	Christopher Johnson (Argonne National Laboratory)	2-198	3.50	3.00	3.00	3.50	3.19
† Impact of Surface Coatings on LMR-NMC Materials: Evaluation and Downselect	Ali Abouimrane (Argonne National Laboratory)	2-201	2.75	3.25	3.25	2.50	3.03
† Thermodynamic Investigations of Lithium- and Manganese-Rich Transition Metal Oxides	Wenquan Lu (Argonne National Laboratory)	2-204	3.50	2.75	2.75	3.25	3.00
† First-Principles Models of the Atomic Order and Properties of LMR-NMC Materials	Roy Benedek (Argonne National Laboratory)	2-207	3.50	2.50	2.50	3.50	2.88
† Addressing Voltage Fade: Synthesis and Characterization of Lithium- and Manganese-Rich Electrode Structures	Michael Thackeray (Argonne National Laboratory)	2-210	3.75	3.25	3.25	3.50	3.41
† Phase Relations and Voltage Fade Response in LMR-NMC Materials	Ira Bloom (Argonne National Laboratory)	2-213	4.00	3.25	3.25	3.00	3.41
† Impact of ALD Coating on Li/Mn-rich Cathode Materials	Shriram Santhanagopalan (National Renewable Energy Laboratory)	2-216	3.00	3.60	3.60	3.00	3.38
Overall Average			3.27	3.21	3.21	3.00	3.20

† denotes poster presentations

PEV and HEV Battery Cost Assessment: Brian Barnett (TIAX LLC) - es001



Reviewer Sample Size

A total of 7 reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that the approach to updating the existing PHEV cost model projections was very sound. The reviewer emphasized that some improvements in the presentation of the overall results were noted that may be a result of the approach. The reviewer outlined that the following comments reflect what those improvements could be: the addition of information such as the change in production yield because of the increase in the number of large format cells being produced, which it was stressed may also affect the production yield; clarifying how the manufacturing equipment cost information was used or incorporated into the cost model, showing graphically the different amounts of materials needed for the 25 million cells produced and, the total actual cost for that material for the different chemistries; and that nickel manganese cobalt oxide (NMC) should have been used as the example material rather than nickel cobalt aluminum oxide (NCA) because of the earlier mention of the NMC. The reviewer was not clear on the presenter's conclusion comment that there is greater variation based on cell designs and whether that applies to cylindrical or prismatic cell designs or both.

Reviewer 2:

The reviewer indicated that the analysis was sound; it was narrow, however, focusing on one type of cell design.

Reviewer 3:

The reviewer asserted that the inclusion of Japan and Korea exchange rate influence effects provided good insight. The reviewer felt it would be useful to expand this relative effect consideration to also include the People's Republic of China (PRC) exchange rate influences and to go even further to look at not just the direct impact to the United States, but also the effect between Japan, Korea, and PRC.

Reviewer 4:

The reviewer pointed out that this is only a paper study without a validation of results. The sensitivity analysis is very useful in predicting the range and variation of cost estimations.

Reviewer 5:

The reviewer identified a need to state assumptions such as cell type used in modeling. Even though the difference between prismatic pouch cell and cylindrical cell was presented in 2012, the reviewer said that it was worthwhile to have a comparison slide, given the perceived labor and capital equipment cost associated with pouch cells.

Reviewer 6:

The reviewer stated that the project seems to be logically structured, but its limitation to consider only a vertically-integrated manufacturing process chain could be too much of a simplification. The reviewer also noted that there is no obvious evidence presented of how the project is integrated with other program efforts.

Reviewer 7:

The reviewer thought that the scenarios giving sensitivity analyses of different parameters (changes to loading, changes to cathode and anode chemistry, etc.) represent a sound approach and help target areas of future battery development for cost reduction. The reviewer, however, was not sure why the manufacturing layout and costs in the model are still largely based on wound/cylindrical cells. Production PHEV applications (General Motors [GM] Volt, Honda Accord PHEV, Toyota Prius Plug-in) are using stacked or folded and laminated cells, which is a very different manufacturing process with different costs and different manufacturing throughput. The reviewer was also not sure that freezing the balance of plant design is valid considering the differences in heat rejection between different cell geometries and the differences in cell size between cylindrical and stacked or folded and laminated cell geometries.

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

Reviewer 1:

The reviewer asserted that significant progress was made in updating the PHEV Cost Model to provide better cost projections. The presentation provided enough information to show a very systematic approach to capture the most recent production and material cost information from the various stakeholders (material and cell manufacturers in particular).

Reviewer 2:

The reviewer summarized that the activity was to revise the model using recent information. This activity wholly accomplished this goal and no additional model featuring was considered.

Reviewer 3:

The reviewer reported that the DOE accepted cost model was used for the new inputs. The new input shows the sensitivity of the material and equipment cost.

Reviewer 4:

The reviewer affirmed that the presenter's conclusions on materials dominating the cost and breakdown of the materials cost were in agreement with the previous model developed by Ralph Brodd, but TIAX's conclusions were actionable and showed one path to reduce the cost per kilowatt-hour ($/kWh).

Reviewer 5:

The reviewer criticized that the presentation does not include identified goals, nor does the project directly address any technology or cost goals. The project aims at providing an updated cost assessment, necessary for guiding further program decision-making. The reviewer explained that one of the findings feeding into the cost assessment is an increase in throughput in manufacturing operations. Together with costs, this higher throughput is used in the cost assessment. No indication is given on how increased throughput may affect the quality of the semi-product and how this, in turn, may affect costs. The reviewer added that a relevant cost factor, namely recycling, is not considered.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noticed that the presenter stated that material and cell manufacturers were consulted, but the reviewer reported that none were highlighted. The reviewer felt that it would have been good to highlight that major material and cell manufacturers from China, the United States, and/or Korea, were consulted for this information to add real value to the numbers presented.

Reviewer 2:
It appeared to the reviewer that the Principal Investigator (PI) received significant cooperation from the supply base, as well as peer review.

Reviewer 3:
The reviewer reported that it is not very clear who the collaborators are. The reviewer surmised that the material suppliers and equipment suppliers may be collaborators.

Reviewer 4:
The reviewer simply stated that the status of collaborations were unknown.

Reviewer 5:
The reviewer asserted that to achieve its goals, the project must necessarily have interacted with a number of stakeholders; however, no evidence of such interaction was presented.

Reviewer 6:
The reviewer would have liked to see better coordination between the development of Argonne National Laboratory (ANL) BatPaC Model and the TIAX Cost Model. The reviewer felt that there appeared to be considerable overlap between inputs, outputs, and targeted end users of these two models.

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

Reviewer 1:
The reviewer reported that there was no need or plan for future research.

Reviewer 2:
The reviewer pointed out that the presenter provided no identification of topics for further research within the project; however, the last slide presented recommendations to guide further work at program level.

Reviewer 3:
The reviewer stated that no clear future plans for this project were presented.

Reviewer 4:
The reviewer said that no future work was planned at this time.

Reviewer 5:
The reviewer could not rate this element since future research was not discussed.

Reviewer 6:
The reviewer indicated that future research plans were unknown, but expected.

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

Reviewer 1:
The reviewer stated that the project has helped to identify that there has been significant progress in development of manufacturing processes that drive cell costs down and that DOE's involvement has played a valuable role in that progress. Consequently, the reviewer added, continued DOE involvement and initiatives will keep that progress moving at a faster rate.

Reviewer 2:
The reviewer explained that the model provides insight into those design features in cells with greatest sensitivity to input costs, and those design outputs with greatest sensitivity to design requirements. The reviewer noted that this permits the DOE to evaluate other research projects for the rationality of their claims and research objectives.

Reviewer 3:
The reviewer agreed that the project indirectly supports DOE’s overall goal by providing program-level guidance for achieving this DOE objective.

Reviewer 4:
The reviewer indicated that the DOE cost goals are dependent on the reliable cost models; however, the DOE assumptions are not validated here.

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

Reviewer 1:
The reviewer stated that the resources seemed sufficient for the project.

Reviewer 2:
The reviewer commented that there were no issues.

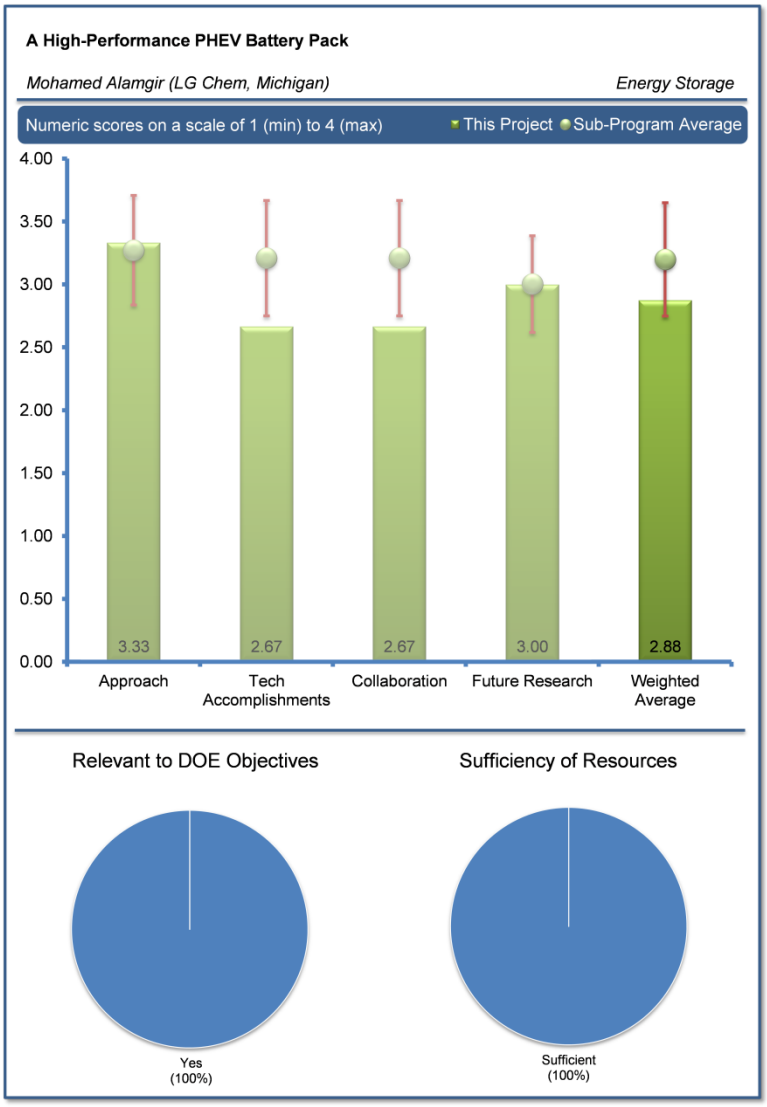
Reviewer 3:
The reviewer indicated that the level of resources was unknown.

Reviewer 4:
The reviewer remarked that no information on resources was available; however, that TIAX is a capable organization for this type of study.

Reviewer 5:
The reviewer remarked that no cost was provided in the presentation.

Reviewer 6:
The reviewer expressed that it was difficult to answer the question, as no project milestones were identified.

A High-Performance PHEV Battery Pack: Mohamed Alamgir (LG Chem, Michigan) - es002



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the approach is good and that the program goal is to lower the cost close to a $3,400 target. The reviewer concluded by asking for clarification on what the current cost is.

Reviewer 2:

The reviewer explained that the project's approach addressed the need to develop a cell that was able to meet the PHEV 40- mile program performance and cost goals. The reviewer indicated that the technical barriers to achieve these goals included: specific energy and power; cycle and calendar life; and affordability. The reviewer reported that the barriers were being addressed by studying high capacity, manganese-rich cathode materials from several vendors and by developing a refrigerant-to-fin indirect cooling system.

Reviewer 3:

The reviewer highlighted that the researchers did not address the electrolyte stability with the 5V cathode.

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

Reviewer 1:

The reviewer summarized that the future work included surface modified cathodes; however, the reviewer asked if this meant that a different coating other than the one used now would be needed. The reviewer asked what the reasons for the new electrolyte composition and additives were.

Reviewer 2:

The reviewer explained that the project is near completion and according to the Quad Chart (Slide 6), only 21% of the efforts remains to be completed in the next eight months. The reviewer mentioned that $2 million was allocated to the project for fiscal year (FY) 2012. The reviewer stated that, with respect to the manganese cathode investigation, there appeared to be minor accomplishments made. The reviewer criticized that several of the Accomplish/Results slides were duplicative of the previous (2012) presentation; these included Slides 12, 13, 15, 17, and 18. The reviewer observed, however, that the data on Slides 10, 14, and 16 were updated. The reviewer also acknowledged that there was new work reported on an improved separator (Slide 19); but that was not mentioned in the Approach, which gave the reviewer the impression that it may have been the offspring of another project. The reviewer also pointed out that the results from the manganese cathode surface coating study (Slide 22) were new and promising. The reviewer also reported

that it was noted in the 2012 presentation that efforts would be directed to improving power and life would include investigating different electrolyte compositions; however, there were no results reported in this area. It appeared to the reviewer that much of the efforts this year were directed toward the cooling system with results reported in Slides 27 and 28.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer acknowledged the good collaboration between LG Chem and the National Laboratories (e.g., Idaho National Laboratory [INL], Sandia National Laboratories [SNL], and National Renewable Energy Laboratory [NREL]).

Reviewer 2:
The reviewer voiced that collaboration with other institutions are good. The reviewer suggested that the researchers should try to test the Envia Systems battery if possible.

Reviewer 3:
The reviewer stated that no collaboration was mentioned.

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

Reviewer 1:
The reviewer summarized that future work includes surface modified cathodes; however the reviewer asked if this meant that a different coating other than what is used now would be needed. The reviewer asked what the reasons for the new electrolyte composition and additives were.

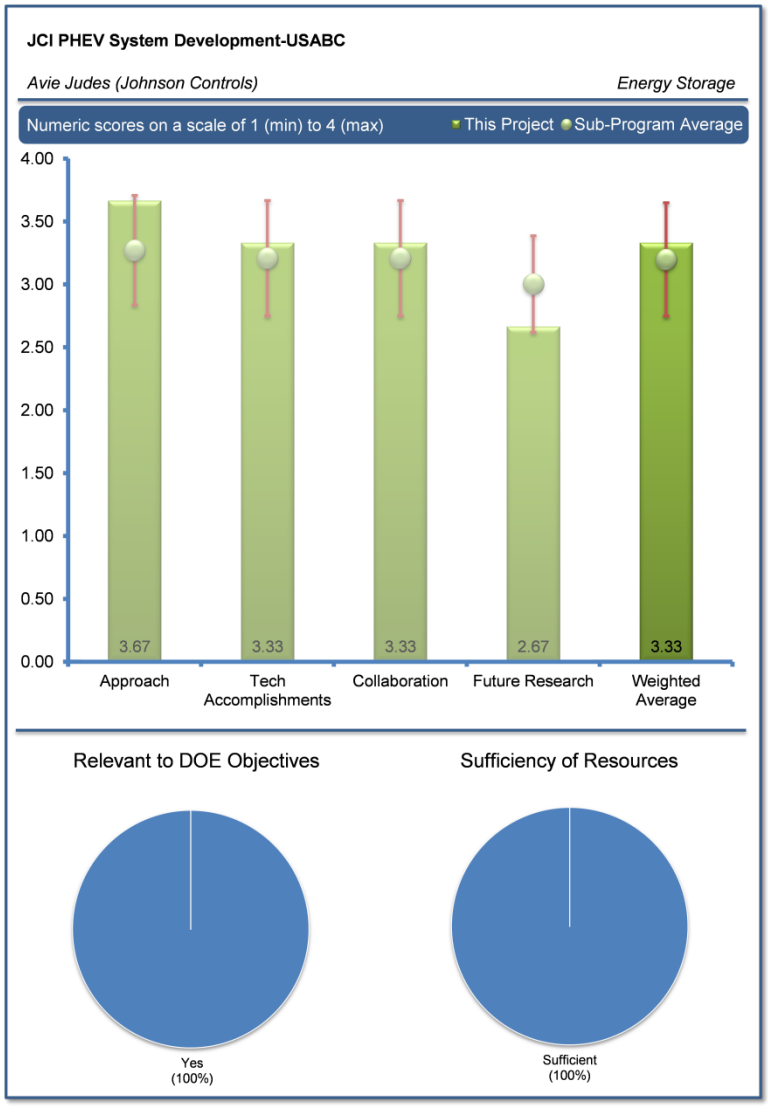
Reviewer 2:
The reviewer pointed out that it was noted in the presentation that future efforts in the use of new electrolyte compositions or additives would be pursued; however, there was no mention of this in the Approach slides.

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

Reviewer 1:
The reviewer agreed that the project supports DOE objectives of petroleum displacement by seeking to develop a cell/battery that will meet the PHEV 40-mile program goals.

Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
No comments were received in response to this question.

JCI PHEV System Development-USABC: Avie Judes (Johnson Controls) - es005



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the approach is good. However, the reviewer indicated that the water-based binder and perform coating trials were not clearly defined.

Reviewer 2:

The reviewer summarized that the program is investigating higher energy electrode materials to meet the program energy density goals. The materials include blended cathode materials, cathodes of high nickel content in the nickel, manganese, cobalt (NMC) material. The reviewer agreed that lowering the cobalt content of NMC is expected to decrease material cost which supports another program objective. The reviewer pointed out that the program is undergoing an electrode processing and design optimization effort. The reviewer also mentioned that, although not expressed implicitly in the slides, the dry powder compounding process should result in a more affordable cell because it reduces the amount of solvents required.

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

Reviewer 1:

The reviewer asked the researchers why the 11% energy density increase showed the same power as the baseline, and requested an explanation of the potential reasons for this. The reviewer also pointed out that the high Ni NMC (A) had higher specific capacity, but asked for how many cycles.

Reviewer 2:

The reviewer described that this program was initiated in April 2012 and is reported to be 45% complete; however, the presenter noted that $1.9 million (35%) was spent out of the $5.5 million allocated for the program total. The reviewer agreed that the program has demonstrated good technical accomplishments. The reviewer noted that cycling test data of cells under the last United States Advanced Battery Consortium (USABC) PHEV program were shown. The reviewer also felt that excellent cycle life has been demonstrated to date. Cycling of cells developed in this new program was also reported and two high content NMC cathode materials showed higher specific capacities that the baseline. The reviewer also mentioned that data were also presented on the efforts to extend the useable state-of-charge window and to optimize the electrode processing. Although no specifics were given regarding the optimization of cell connections and insulation, the reviewer mentioned that it was noted in bullet format on Slide 20.

Reviewer 3:
The reviewer stated that no details on the specific capacity (mAh/g), number of cycles, or actual storage time were provided, so it was difficult to assess the project's progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer felt that the collaborations were good.

Reviewer 2:
The reviewer thought that there was good collaboration with national laboratories regarding electrical and thermal testing of cells; however, the reviewer criticized that no collaboration was shown with the laboratories experienced in cathode/anode material development.

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

Reviewer 1:
The reviewer agreed that the proposed efforts were justified and relevant to the success of the program.

Reviewer 2:
The reviewer stated that the proposed future work indicated completion of several tasks. The reviewer emphasized that it was good to put a timeline and section criteria for all.

Reviewer 3:
The reviewer commented that it was difficult to assess future work due to a lack of details on the accomplishments.

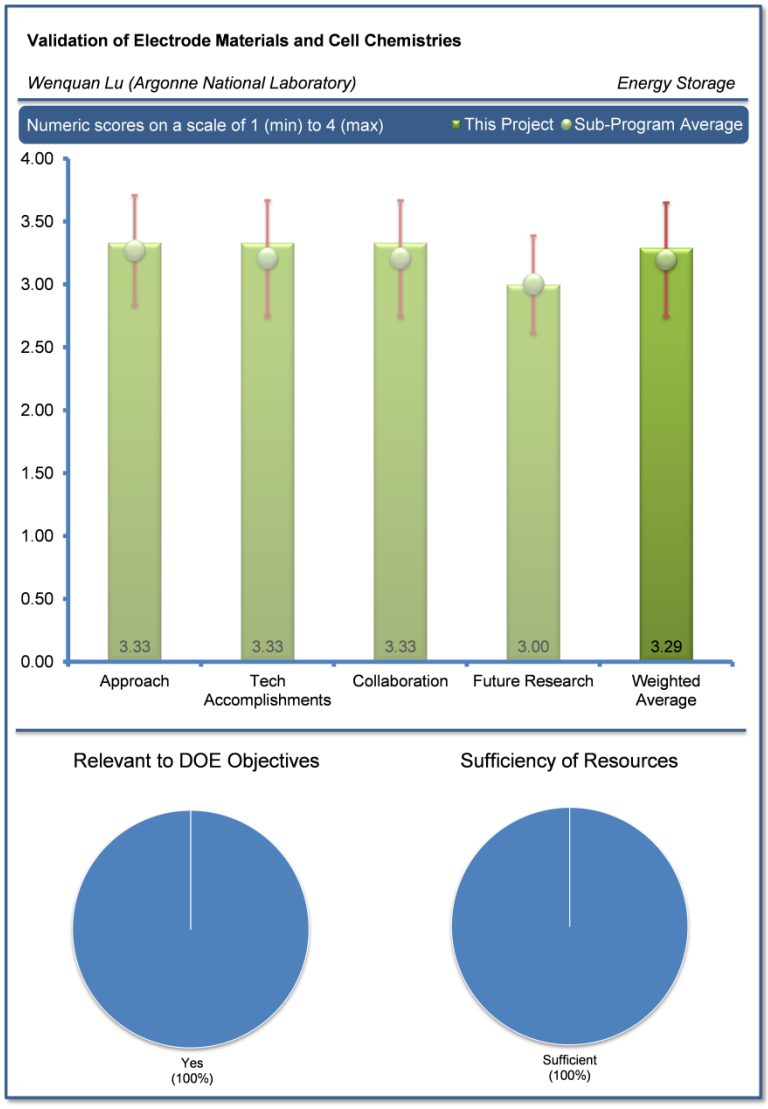
Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer agreed that the program's objectives are clearly in line with DOE objectives of petroleum displacement, including seeking to develop Li-ion PHEV systems for 20- and 40-mile all-electric range applications. The reviewer mentioned the following specific goals: improvement to the low temperature performance of cells; increased volumetric energy density (goal of 350 Wh/L), affordability ($250/kWh), and safety.

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

Reviewer 1:
The reviewer commented that no funding information was provided.

Validation of Electrode Materials and Cell Chemistries: Wenquan Lu (Argonne National Laboratory) - es028



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

The reviewer confirmed that the project approach is substantially focused on the barriers. The reviewer highlighted that the aqueous binder work can have important implications on cost.

Reviewer 2:

The reviewer explained that the approach adopted here for the electrochemical assessment was quite comprehensive and is usually used for evaluating battery materials. The reviewer noted that several experimental variables had been examined e.g., type of binder, electrolyte, voltage regime, electrolyte additive, etc. The reviewer observed that even though these studies added value by themselves, it was not clear if all the material characterization presented was being coordinated/consolidated through this task (i.e., does this represent the Cell Fabrication facility), or if this was in addition to what had been done by several other individual PIs in their tasks. In any event, the reviewer thought this task/approach was justified if it looked at commercial, low-cost materials, or materials from external sources or from the ANL scale-up only. Also, the reviewer added that these studies would be justified if these assessment studies would use design parameters (such as electrode loadings, test conditions) that were consistent with the industry; for example, results with thinner electrodes (and excess electrolytes) and half-cell tests resulted in misleading conclusions.

Reviewer 3:

The reviewer explained that lithium and manganese rich-NMC (LMR-NMC) and silicon are both relevant for PHEVs and hopefully EV, but the key success would be if they worked together. The reviewer felt that it would have been really outstanding if the PI would have done a systematic study to address the barriers associated with this high energy redox couple.

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

Reviewer 1:

The reviewer agreed that the use of styrene butadiene copolymer (SBR) aqueous binders was an excellent idea. The reviewer stated that more work should be done with conventional binders so that aqueous binders can be compared with a large database.

Reviewer 2:

The reviewer acknowledged that good progress has been made in terms of understanding the behavior of LMR-NMC cathode and silicon composite anode in different electrolytes. Furthermore, the reviewer noted that several studies were successfully carried out with various high energy cathodes, silicon and carbon anodes, electrolytes, additives, etc. However, the reviewer criticized that the results were not significant. The reviewer asked whether these materials (electrolytes additives, redox shuttles) are new, or being adopted from other on-going tasks. The reviewer offered that, based on these results, for instance, reviewers cannot judge if a particular material has attained the technology maturation for it to be picked up by the industry. The reviewer also reported that some of the cycling tests on the LMR-NMC cathode were performed over a wider voltage range, while the other tests were carried out over a narrow voltage range (only to 4.55 V). Overall, the reviewer felt that the amount of progress is impressive, but stated that the relevance of these results in the context of the overall DOE Applied Battery Research program was still not quite clear.

Reviewer 3:

The reviewer described that the first part of the work relates to the voltage fade (VF) aspects of LMR-NMC, which is already being studied by a number of Argonne PIs. The reviewer criticized that this does not add too much to current understanding, or at least should be clubbed into that project. The reviewer also suggested that Si anode and aqueous binder work should be encouraged.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer pointed out that, as expected from the nature of the project, there are several contributors and collaborators to provide electrode, electrolyte and other materials.

Reviewer 2:

The reviewer reported that the list of collaborators was substantial. The reviewer thought it was interesting to see that several of them were from the industry.

Reviewer 3:

The reviewer observed that the PI had a whole laundry list of collaborators and industrial partners. The reviewer suggested that it may help to know who the critical contributors are.

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

Reviewer 1:

The reviewer thought that the proposed future research to continue the assessment of materials coming out of the Material Engineering and Research Facility (MERF) and from other sources to build materials performance database is logical and useful. Also, the reviewer indicated that the planned studies on the lithium-excess layered-layered composite materials and Si anode were quite relevant, as these are the focus of the DOE Applied Battery Research program.

Reviewer 2:

The reviewer agreed that, as mentioned by the authors, the scale-up by the MERF should be emphasized.

Reviewer 3:

The reviewer suggested that the PI should work on full cell chemistry as much as possible trying various binder chemistry and compositions.

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

Reviewer 1:
The reviewer agreed that yes this project is very relevant and important since a variety of samples from different companies can finally be analyzed under the same set of conditions.

Reviewer 2:
The reviewer explained that with several advanced materials of cathodes, anodes and electrolytes being developed in the DOE Applied Battery Research program, as well as elsewhere, it is essential to have their performance independently assessed against the PHEV performance targets in standard test vehicles and environment. The reviewer indicated that the objective of this project is to conduct independent screening tests using standardized test procedures to: streamline the Li-Ion electrode optimization process; enhance the understanding of these advanced materials; and select promising advanced materials and cell couples for an internal cell build and further testing. The reviewer thought this project would thus serve as a bridge between the material development and the scale-up/cell fabrication activities within the DOE Applied Battery Research program. The reviewer remarked that a successful verification will thus lead to an infusion of the high-energy materials in PHEV cells and batteries.

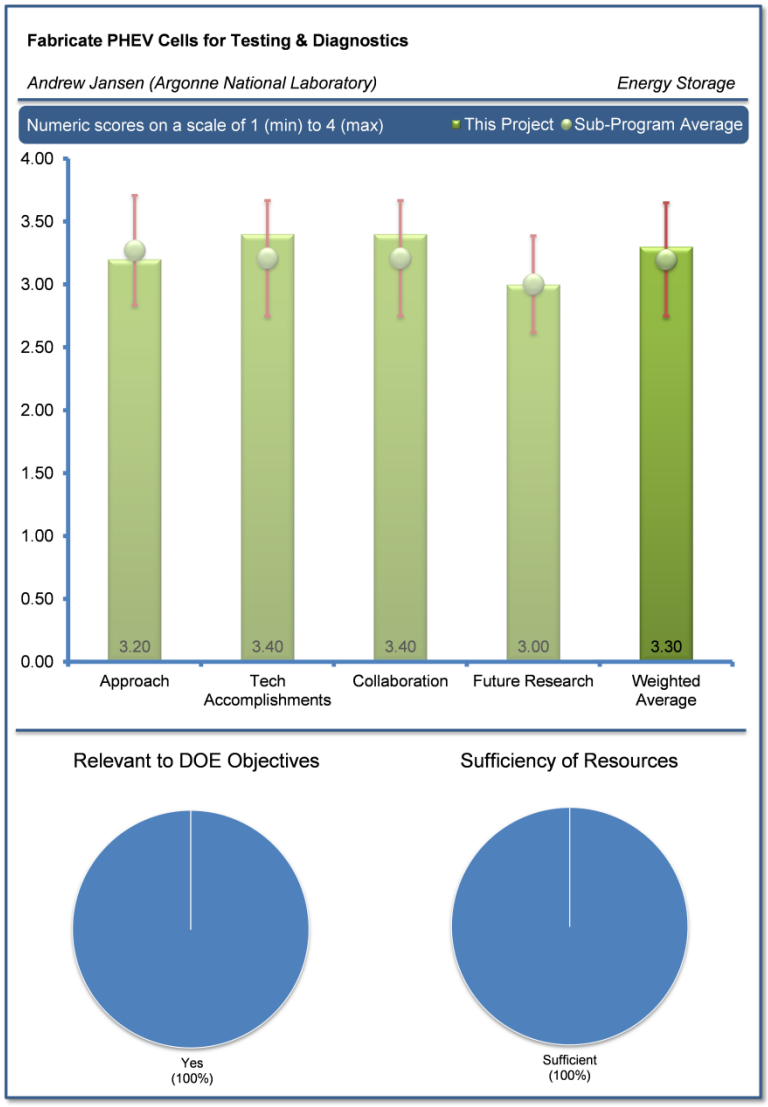
Reviewer 3:
The reviewer summarized that the research and development (R&D) area is related to the development of high energy density batteries.

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

Reviewer 1:
The reviewer thought that the budget of $550,000 looked adequate for the scope of the work.

Reviewer 2:
The reviewer simply stated that the resources were covered well.

Fabricate PHEV Cells for Testing & Diagnostics: Andrew Jansen (Argonne National Laboratory) - es030



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that a very clear, straightforward presentation on the high level objective, goals, and approaches to providing a flexible cell demonstration platform was provided. The reviewer also commented that the approach was a useful objective that appears to have been carried out. The reviewer felt that there could be some more discussion regarding the specific objectives and goals that will be generated, with the ability to produce cells from materials provided by suppliers.

Reviewer 2:

The reviewer was unclear on the real value of this project for overcoming key barriers. The reviewer acknowledged that having cell making capabilities was clearly beneficial, and could lead to acceleration of new learning, but the reviewer asked how that was different from what, for example, was offered by TIAX where a full functioning line was in place and available for use. The reviewer also expressed concerns about the reliability and know-how that is necessary to operate cell making equipment. The reviewer explained that this took many years for leading cell makers, so it was hard to imagine getting through this step faster. The reviewer suggested that, perhaps collaborating with cell makers in a more engaged way would be helpful.

Reviewer 3:

The reviewer was not clear how this project was integrated with numerous other DOE Applied Battery Research programs on LMR-NMC. The reviewer asked how materials graduated from bench to Cell Fabrication Facility evaluation, and what decisions or improvements followed from Cell Fabrication Facility results.

Reviewer 4:

Many aspects of the program show considerable progress and merit the rating on the approach; however, the reviewer had some concerns about the approach to cell building and data presentation. The reviewer was concerned about the scarcity of statistical data in presentations, and elaborated that it is a standard practice in the battery industry to include the error bars (determined from multiple cell measurements) on the data points to indicate the reliability of the conclusions drawn from the data. The reviewer highlighted that if the populations of two measurements overlap sufficiently, it is not statistically accurate to claim that one measurement is better than another. In these cases, the reviewer added that it then becomes a good practice to do a thorough statistical analysis of any comparison made under these circumstances. The reviewer acknowledged that the workers may be aware of this, and may be using the appropriate

analysis, but in the absence of any statistical data it was not obvious that this is the case to the reviewer. The reviewer also expressed that the approach used is limited by using only a few formulations of electrode materials, without any attention to the possibility that the range of formulation is far from the optimum. The reviewer again stressed that the standard practice of the industry is to vary the formulation for trial materials to observe the sensitivity of the material to the formulation. In fact, the reviewer observed that after some early trial formulations, it seems that a single formulation has been adopted. The reviewer remarked that the effect of graphite as an electrochemically active component of the positive electrode was noted, but the result on the formulation was not discussed. The reviewer warned that this can be a very serious result, since all previous formulations are based on at least equal amounts of graphite and carbon black. The reviewer pointed out that if the new formulations contain no graphite, then previous conclusions may still not be valid. Finally, the reviewer thought that it would be very useful to get some discussion and advice from the industrial partners, because it is in everyone's interest to obtain the maximum benefit from this program.

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

Reviewer 1:

The reviewer pointed out that the technical accomplishments were dominated by getting the entire facility up and running. The reviewer agreed that this should contribute substantially to the materials program at ANL. The reviewer suggested that attention should now be directed to making the best electrodes with a reasonable effort as possible to give the best results to materials developers. The reviewer would like to see greater efficiency in processing, so that several runs per week, including formulation and processing variations, can be carried out. This would require several coating runs as well as calendaring, slitting, and cell manufacturing. The reviewer noted that the runs do not need to create large coating areas, but should be sufficient to produce statistically significant cell numbers.

Reviewer 2:

The reviewer commented that the data generated in a variety of systems was interesting and it appeared the work and progress has been good. A somewhat more comprehensive overview of what the specific testing would be, and why it would be helpful, should have been included in the presentation rather than just listing a variety of different experiments and conclusions.

Reviewer 3:

The reviewer reported that the cell fabrication lab is fully-functioning and that various projects are under way to learn from larger cells compared to coin cells. The reviewer highlighted that the fundamental question, which was not answered in the report, is how much new learning is really happening due to larger cells and the use of commercial equipment compared to what was already known from coin cell tests.

Reviewer 4:

The reviewer reported that this is a lot of progress. The reviewer, however, added that the starting point was not defined, but clearly reflects work that began prior to the October 2012 restructuring.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer felt that collaborations are good within the laboratory and with external customers, but as previously noted, thought that it would be valuable to have more input from industrial partners to improve throughput and emphasize statistical experiments as well as formulation improvements.

Reviewer 2:

The reviewer mentioned that it appears that an open and extensive collaboration plan was pursued, with good result.

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

Reviewer 1:
The reviewer suggested that some thought should be put in to considering the larger intent of the capability. The reviewer asked whether it was available for the purpose of evaluating materials developments provided by a number of contributing companies, or if it had been developed to provide a platform for independent development (i.e., performance improvement) of specific systems. The reviewer concluded that it appeared to have elements of both, so it was just a question about the mission.

Reviewer 2:
The reviewer explained that there are plenty of research directions that will be explored. The reviewer suggested that perhaps more effort on optimizing and streamlining fabrication equipment and process would also be valuable. This approach may reduce variability and improve the quality of the data.

Reviewer 3:
The reviewer criticized that the project had a very broad scope and relatively little in terms of quantitative goals or go/no-go decisions that would narrow scope or permit higher priority directions to be accelerated. The reviewer asked for a description of what the decision making process was.

Reviewer 4:
The reviewer reported that the authors stated that there was no definitive Si anode material available, but that the 3M work in this area may be close to providing a commercial solution. The reviewer suggested attempting to work with materials from and to seek advice from 3M, as their materials become available.

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

Reviewer 1:
The reviewer affirmed that this facility is critical to DOE programs in materials and has great relevance to determining progress in these programs. The reviewer emphasized that it will be necessary to have high reliability cells produced by the facility and to be able to substantiate the degree of improvement in experimental materials.

Reviewer 2:
The reviewer explained that a cell platform above the level of coin cell, but below the level of commercial cell, is quite useful for the evaluation of new materials and may be in limited supply. The reviewer remarked that the facility can provide solid benchmarking within a known demonstration platform, which can be quite useful. The reviewer suggested that carefully addressing the question of the type of work that will be employed on the platform is worth some more consideration.

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

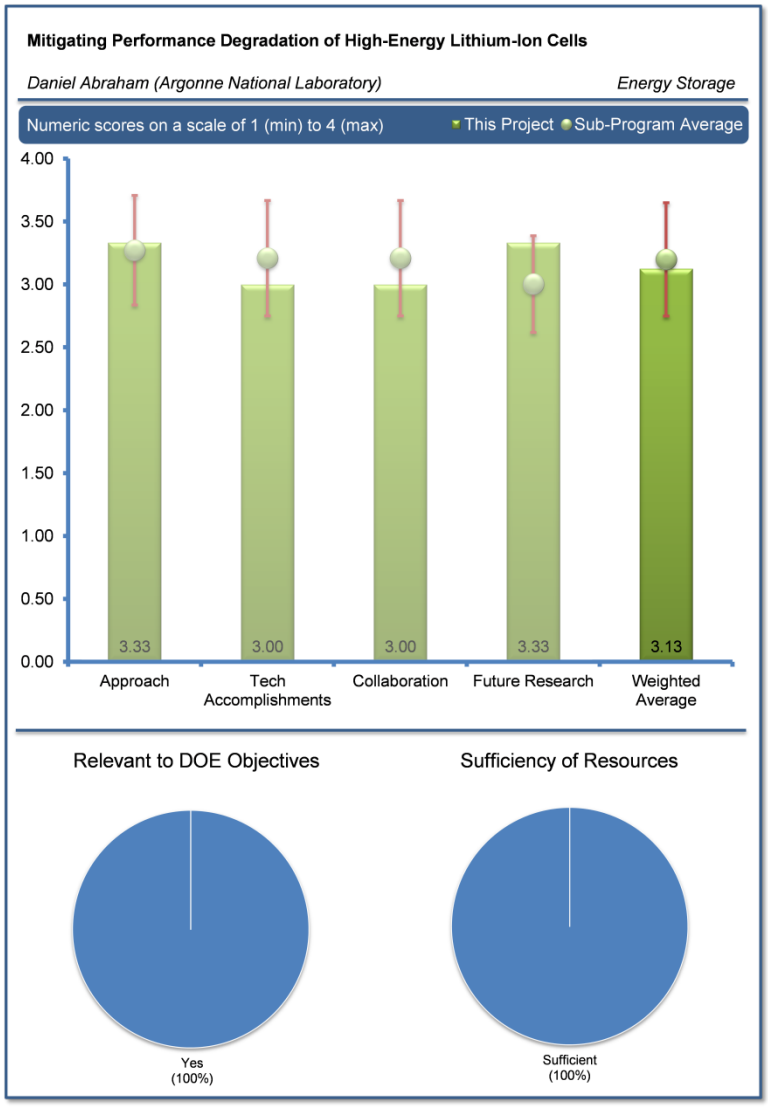
Reviewer 1:
The reviewer felt that the resources seem adequate to the challenges faced by this group.

Reviewer 2:
The reviewer commented that the project appears to be appropriately manned. The reviewer asserted that this was not an easy area, so it was thought that a good deal of progress had been made by the team.

Reviewer 3:
The reviewer indicated that it was difficult to tell from review information where the budget is in terms of CapEx and labor and alignment of spending with time line. The reviewer stated that it would be interesting to know what the limiting resource is (test

channels), and what results additional resources would produce. Overall, the reviewer felt that this seemed to be a pretty productive and well-organized team.

Mitigating Performance Degradation of High-Energy Lithium-Ion Cells: Daniel Abraham (Argonne National Laboratory) - es032



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that the work is nicely focused on the technical barriers. The reviewer also pointed out the very interesting information about the impedance rise on aging and the use of additives to mitigate this problem.

Reviewer 2:

The reviewer expressed that a relevant approach has been used to study the reason for capacity fade in LMR-NMC chemistry. The reviewer described that the PI has used several techniques, such as secondary ion mass spectrometry (SIMS), x-ray photoelectron spectroscopy (XPS) and electrochemical studies, to evaluate cell level performance degradation and correlate this to changes at the electrode and materials level.

Reviewer 3:

The reviewer explained that the approach is fairly standard, i.e., to make test cells (coin, pouch or half cells) with the selected electrode couples, study the interfacial properties through electrochemistry and harvest the electrodes after cycling, for various ex-situ analytical techniques. Interestingly, the reviewer observed, in addition to being a diagnostics project, that this project also examined several experimental variables such as cathode coatings, electrolyte additives, and electrode composition (conductive diluent, binder, etc.). The reviewer noted that the approach being adopted here addresses the technical barriers of Li-ion batteries, i.e., limited cycle life and performance degradation (e.g., energy loss in lithium-rich NMC cathode materials) during cycling. It is important, according to the reviewer, to understand these performance-limiting processes for designing new materials to overcome these limiting processes. The reviewer highlighted that more emphasis was placed on EIS measurements, which are not as informative on the material properties or the interfacial changes. Instead, the reviewer suggested that this project should focus more on ex-situ analysis to augment the on-going in-situ studies elsewhere to gain a better handle on the material properties and interfacial layers. As with some of the other projects, there seems to be considerable overlap with the other projects in diagnostics (e.g., at ANL's diagnostic facility and at Brookhaven National Laboratory [BNL]), which if avoided and if such diagnostics-related projected were better coordinated, would be helpful to the overall VTO.

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

Reviewer 1:
The reviewer highlighted that the technical accomplishments were outstanding considering that the project started only a few months ago.

Reviewer 2:
The reviewer acknowledged that reasonably good progress has been accomplished in terms of understanding the performance limitations of the LMR-NMC cathode. In particular, the reviewer pointed out that it was shown that lower charge voltages are preferable to extend the cycle life and that a surface coating (alumina) would help in the capacity retention during cycling; however both these findings are known to the battery community. The reviewer emphasized that the more interesting results are with the use of electrolyte additives (LiDFOB, HFIP, etc.), which need to augment the surface studies on the harvested electrodes (apart from tacking the EIS). For example, the reviewer suggested that evaluating the effect of such an additive (or any such experimental variable) on the manganese dissolution (and presence of anode) would be useful. The reviewer agreed that the overall progress, though moderate, was oriented towards meeting the project and DOE program goals.

Reviewer 3:
The reviewer asserted that the presenter had delivered quite a bit of message. The reviewer thought it was good to see conclusive evidence that manganese, nickel, and cobalt are deposited on anode (graphite) after long-term cycling of LMR-NMC. The reviewer indicated that the other important aspect is the choice of carbon that needs to be used for high-voltage composition. The reviewer was impressed by the technical detail, rigor, and the clear conclusion. The reviewer concluded by asking whether the PI could do a careful analysis of manganese dissolution (possibly at anode) under cell abuse condition both calendar and cycle life, preferably at 55-60°C.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer reported that there are several useful collaborators in this effort, mainly from universities and national laboratories.

Reviewer 2:
The reviewer remarked that it seems that the team is well-coordinated. The reviewer suggested that it could be very important to also find an industrial partner.

Reviewer 3:
The reviewer acknowledged that there was a pretty good team here that was also receiving help from other national laboratory colleagues when needed for addressing/mitigating issues.

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

Reviewer 1:
The reviewer pointed out that future plans included performing similar studies with the LMR-NMC cathode materials under various experimental cognitions, with 5V manganese spinel oxide, and the silicon-carbon anodes. The reviewer reinforced that clearly the industry needed to understand a lot on these next-generation materials, in terms of their structural and interfacial stability, and that the proposed studies were quite relevant and well-aligned with these objectives.

Reviewer 2:
The reviewer reinforced that the experiments with water-based binders should be strongly encouraged because that type of work may have important implications on cost.

Reviewer 3:
The reviewer observed that the PI and team's work seemed to be heavily dependent on the ongoing DOE focus on the current Li-ion chemistry, which the reviewer surmised was probably the current mandate. The reviewer suggested, however, that the researchers should also use these tools to study other interesting chemistries such as Si and other high capacity multivalent cathodes.

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

Reviewer 1:
The reviewer agreed that the project supports the overall DOE strategy of petroleum displacement by focusing on very practical issues such as cycle life and abuse tolerance.

Reviewer 2:
The reviewer agreed that the work directly relates to high energy density batteries for electric vehicles.

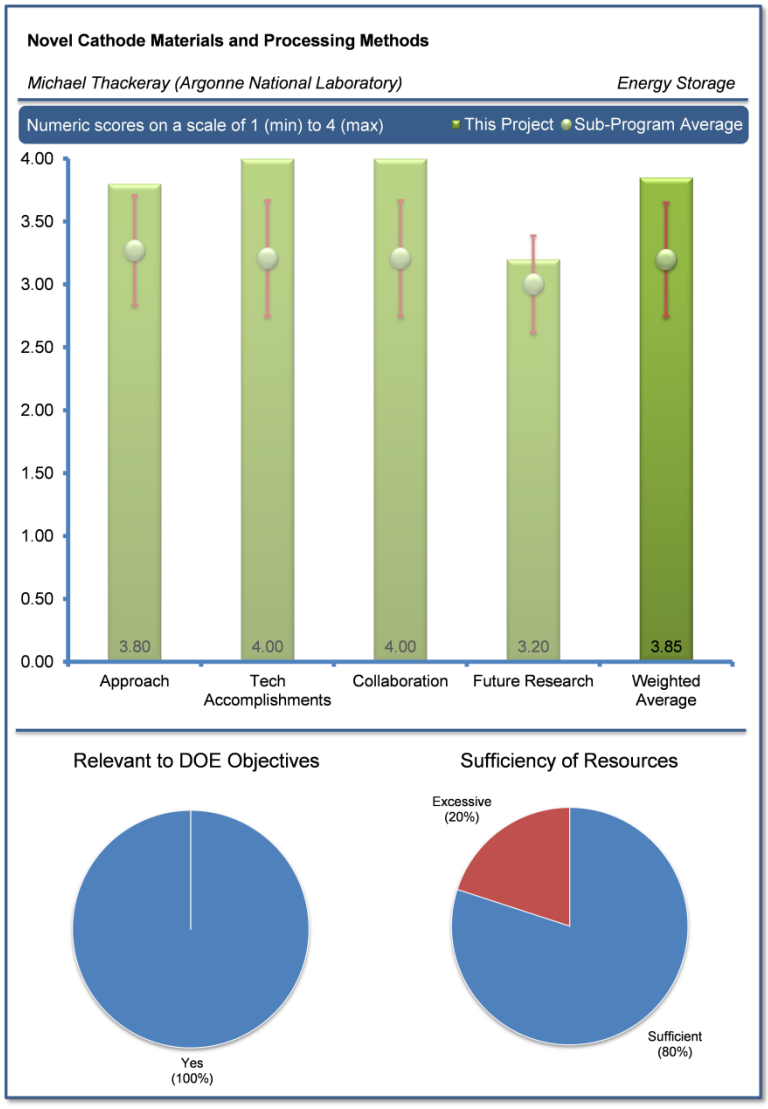
Reviewer 3:
The reviewer reported that the current and advanced Li-ion battery, especially the high energy (high voltage) cathode materials being developed for PHEVs and EVs do not quite meet the requirements in terms of calendar life and cycle life. In addition to the significant changes in the structure and microstructure of the materials, the reviewer commented that there are considerable changes at the interfaces with the electrolyte, more so with the use of high-voltage cathode and high capacity anodes (silicon-composites). It is essential to understand these changes at the system level, as a function of electrolyte composition, additives, electrode compositions, etc., which this project has been addressing. As a result, the reviewer thought this project is thus well-aligned with the goals and objective of DOE's VTO.

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

Reviewer 1:
The reviewer commented that the budget of $450,000 per year looks reasonable for the scope of the project.

Reviewer 2:
The reviewer stated that the resources were adequate.

Novel Cathode Materials and Processing Methods: Michael Thackeray (Argonne National Laboratory) - es049



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer reported that the approach was innovative and appeared to have good potential for optimized performance of structurally integrated electrode structures. The reviewer explained that sonochemical coatings were used to coat oxides in order to protect underlying metal oxide particles from the electrolyte. The reviewer also mentioned that first-principle modeling was planned to be used to aid the design of bulk and surface cathode structures and to understand electrochemical properties.

Reviewer 2:

The reviewer simply stated that the approach was good.

Reviewer 3:

The reviewer confirmed that the approach was sound and focused on the technical barriers. The reviewer observed that objectives are to design high capacity, high power, and low-cost cathodes for PHEVs and EVs. To accomplish this, the reviewer observed that the PI proposes to improve the composition of the manganese-based cathode, explore new processing routes for advanced electrodes, and use atomic-scale modeling to guide the identification and design of the new cathode materials.

Reviewer 4:

The reviewer observed fundamental, hypothesis-driven work to understand stabilization and structural formation in layered-layered material. The reviewer agreed that this was essential to fixing problems and felt that the researchers have made good use of theory/simulation to strengthen their understanding.

Reviewer 5:

The reviewer suggested that the 5V layered composite approach to achieve high energy should also be compared to other high-voltage cathodes such titanium (Ti)-substituted NMC.

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

Reviewer 1:

The reviewer reported that excellent progress was made in understanding the VF issue.

Reviewer 2:
The reviewer simply stated that the project accomplishments seemed to be good.

Reviewer 3:
The reviewer noted that the VF phenomenon for the cathode materials was studied. The reviewer explained that structural issues and the cycling limitations of layered-layered composite structures were studied with state-of-art X-ray absorption spectroscopy (XAS) and X-ray diffraction (XRD) techniques. The reviewer also described that several stabilized oxides were successfully tried to be deposited on the electrode particles and that first-principle modeling was used to simulate the manganese dissolution and coatings.

Reviewer 4:
The reviewer explained that this is the first reporting period for this effort (25% complete). The reviewer thought the PI has demonstrated excellent progress toward meeting the program goals. The reviewer highlighted that a considerable amount of effort had been made in the area of manganese cathode development and understanding the nature of degradation upon cell cycling was demonstrated. The reviewer also noted the excellent publications, patents, and presentations that resulted from this effort.

Reviewer 5:
The reviewer expressed that all milestones are ongoing, so it is difficult to measure progress. The reviewer added that, certainly, there is increased knowledge and understanding, but the researchers are not necessarily at the point of the project to demonstrate improvements from the increased knowledge.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer expressed that the research team appears to be a very strong team with both the academic and industry partners. The reviewer suggested that the involvement of battery and/or components producers will help the potential transition of the technology to be developed. It was unclear to the reviewer if the industry partners have been involved in the evaluation and characterization of the cathode fabrication process.

Reviewer 2:
The reviewer simply stated that the project was well-coordinated.

Reviewer 3:
The reviewer confirmed that excellent collaboration has occurred in this program. There is involvement with scientists and laboratories that bring good value to the effort.

Reviewer 4:
The reviewer concluded that the collaboration to better understand and solve the VF in layered-layered materials is well-coordinated and well-communicated. The reviewer explained that this project provides concepts to all researchers from which they can build their experiments.

Reviewer 5:
The reviewer noted there was excellent collaboration to solve the VF issue.

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

Reviewer 1:
The reviewer described that the team seemed to be focused on the important issues of stabilization for both the surface and bulk structures of composite electrode materials using Li_2MnO_3 and other precursors. The reviewer also mentioned that the processing route with sonication to prepare the electrodes will be continued in the future work.

Reviewer 2:
The reviewer asserted that the proposed future work was justified and the accomplishments to date suggested that this approach would succeed. The effort was well-planned and thought out.

Reviewer 3:
The reviewer warned that, at some point, the researchers needed to set targets for improvements. But the reviewer agreed that this was good fundamental work and the learnings can be leveraged to many others.

Reviewer 4:
The reviewer suggested that efforts to stabilize both surface and bulk structures of composite electrode materials using Li_2MnO_3 and other precursors for layered oxide versus spinels should be compared to explain the possible future aspects for each of them.

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

Reviewer 1:
The reviewer reported that development of reliable high capacity positive electrode materials with high performance was a critical element for battery advancement and is relevant to the DOE effort of reducing petroleum consumption.

Reviewer 2:
The reviewer agreed that the program's objectives were clearly in line with DOE petroleum displacement objectives, in that it sought to design high capacity, high-power, and low-cost cathodes for PHEVs and EVs.

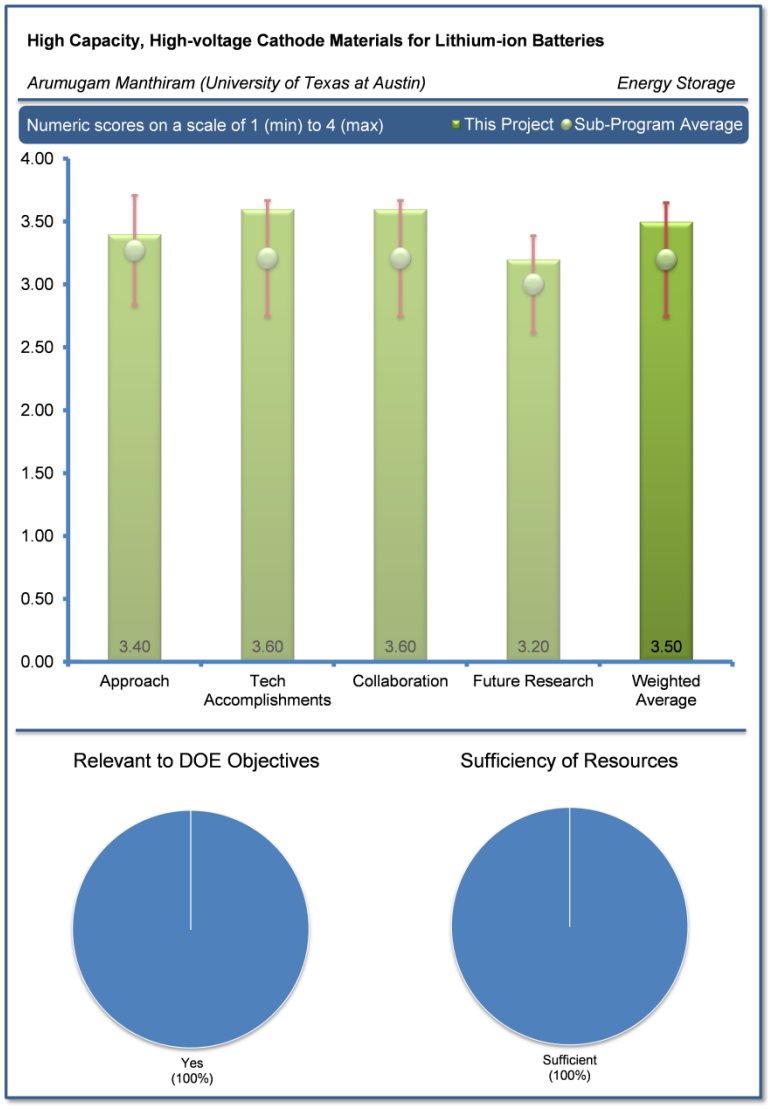
Reviewer 3:
The reviewer explained that high energy density batteries are required to enable widespread adoption of battery electric vehicles (BEV). The reviewer explained that layered-layered cathode material is one of few options available to meet the desired targets; thus this project provides the fundamental knowledge required to solve the remaining problems for this material.

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

Reviewer 1:
The reviewer claimed that the project resources and funding available seemed to be sufficient for the work

Reviewer 2:
The reviewer felt that the resources were sufficient to achieve the stated goals of the program.

High Capacity, High-voltage Cathode Materials for Lithium-ion Batteries: Arumugam Manthiram (University of Texas at Austin) - es051



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer remarked that the approach was innovative and that an understanding of the factors controlling the electrochemical performance of the cathodes materials was established to help developing the cathodes. The reviewer felt the surface control appeared to have potential for improving electrochemical performance. It was unclear whether the electrolyte employed in the electrochemical investigation is stable to the developed cathodes and it was suggested to run more charge/discharge cycles with the experimental cell and characterize the capacity decay for polyanion cathodes.

Reviewer 2:

The reviewer simply stated that the approach was good.

Reviewer 3:

The reviewer explained that the program was focused on the technical barriers of cost, cycle life, and energy/power density by developing a fundamental understanding of the factors that control the electrochemical performance of high-voltage spinel and polyanion cathodes. Once this understanding is obtained, the reviewer stated that new cathode materials would be developed. The reviewer felt that this was a good approach towards meeting the need for higher energy density batteries that have good cycle life.

Reviewer 4:

The reviewer was very glad to see supported work on alternative cathode materials and acknowledged that the researchers were exploring a rich variety of materials using a richer variety of synthesis techniques. The reviewer pointed out that these were seed projects to show a proof-of-concept, each of which could then become its own research project. The reviewer suggested that the work could benefit from some calculations/predictions of theoretical energy densities to help focus (although this may not be possible). Also, the reviewer cautioned that the charge capacities for some of these materials were too low, although the discharge looked okay due to the presence of the lithium metal. It was not so clear to this reviewer that this was a kinetic effect. The reviewer asked the researchers what evidence the project team had that all of the lithium incorporated during synthesis was actually in the structure. The reviewer also asked if these materials were phase pure.

Reviewer 5:
The reviewer suggested that the polyanion cathodes that were presented might not be competitive with other high-voltage cathodes on an energy density (Wh/L) or specific energy (Wh/kg) basis, so the reviewer asked the researchers to please compare the energy density of the polyanion cathodes with the other high-voltage cathodes.

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

Reviewer 1:
The reviewer explained that this work encompasses a large number of materials and methods of preparation and has shown good progress on evaluation of many compositions. The reviewer asked whether there is a timeline for prioritizing or ruling out some of the approaches. The reviewer affirmed that the researchers were certainly contributing to the fundamental understanding of these materials; however, this person felt that it was hard to judge the progress towards performance goals since the targets were not quantitative.

Reviewer 2:
The reviewer noted that extensive data, correlating structure, composition and performance was gathered; however it was not clear to this person if the annealing effect at 700°C versus 900°C can solely account for the cation ordering. The reviewer pointed out that manganese spinel is very prone to oxygen non-stoichiometry and noted that Tarascon showed that the oxygen stoichiometry of $LiMn_2O_4$ spinel can be tuned by annealing at different temperatures.

Reviewer 3:
The reviewer summarized that the factors that influenced the high-voltage spinel cathodes were studied and revealed that particle morphology and surface facets plays a dominant role for their electrochemical properties. The reviewer reported that several polyanion cathodes were synthesized; however, it seemed that the low temperature performance of polyanion cathodes continued to be one of the challenges for potential applications in batteries.

Reviewer 4:
The reviewer explained that a good comparison of several preparation procedures for the synthesis of materials and their cycling behavior was presented. The reviewer asked if the researchers could explain the fact that the truncated Poly 2 shows poor rate capability despite a highly disordered structure and that Poly 2 traditional 900°C is better than 700°C.

Reviewer 5:
The reviewer mentioned that this was the first reporting period for this effort (25% complete) and that the program showed good to fair progress meeting the program objectives. The reviewer stated that the researchers observed that the morphology of the cathode particle plays a dominant role compared to other factors like cation ordering on the electrochemical properties. Some of the observations the researchers pointed to during the discussion, however, have been reported by others. The reviewer also noted that three polymorphs of $LiVOPO_4$ were synthesized. The reviewer felt that over the time period, this represented good progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer acknowledged that the research team appears to have had some good collaboration with high-voltage cathode and electrolytes developers.

Reviewer 2:
The reviewer simply stated that the project is well-coordinated.

Reviewer 3:
The reviewer confirmed that excellent collaboration has occurred in this program. The reviewer highlighted that the group is working with scientists at the University of Rhode Island, Pacific Northwest National Laboratories (PNNL), Hydro-Quebec, Oak Ridge National Laboratory (ORNL) and DuPont. The reviewer felt that these collaborations should bring value to the effort.

Reviewer 4:
The reviewer expressed that the presenter clearly understood the need for diverse collaborators, from academic to national laboratory to industry, and remarked that it was good to see all of these partners collaborating on the project.

Reviewer 5:
The reviewer was glad to see the collaboration with electrolytes group, to enable the use of these high-voltage spinels

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

Reviewer 1:
The reviewer simply stated the future research plans used a good approach.

Reviewer 2:
The reviewer explained that the research seemed to be focused on further optimizing the synthesis conditions for polyanion cathodes and developing an understanding of the factors that affect 5V spinel cathodes electrochemical properties. The reviewer cautioned that while the capacity and rate capability as well as cost are the focus of the future work, some progress on capacity decay understanding and prevention may be needed.

Reviewer 3:
The reviewer observed that the PI proposed to continue on their efforts to develop an understanding of the factors that influence the electrochemical performance of high-voltage cathodes. The reviewer stated that the researchers will continue to explore novel synthesis techniques and that the plans are good and are addressing the technical barriers.

Reviewer 4:
The reviewer recommended that the researchers use energy density (Wh/L) and specific energy (Wh/kg) as a guide in their exploration of other polyanion cathodes to see if these are competitive with other high energy density cathodes.

Reviewer 5:
The reviewer suggested that decision points need to be incorporated into the project to help with prioritization going forward. The reviewer asked if there were energy densities high enough given the operating potentials and specific capacities of some of these materials. The reviewer also asked if the researchers could utilize learnings from these first materials and apply them to similar structures with higher voltages and/or capacities.

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

Reviewer 1:
The reviewer summarized that this project addressed the improvement of a key material for increasing tap density, cycle life, energy, and power that were suited for batteries was aligned with goals to reduce dependence on petroleum.

Reviewer 2:
The reviewer confirmed that the program's objectives were clearly in line with DOE objectives of petroleum displacement. The program's targets are long cycle life and high-voltage (4.7V) cathode materials.

Reviewer 3:

The reviewer explained that high energy density materials are required for vehicle electrification and widespread adoption of BEVs, yet there are few cathode materials in development right now. The reviewer remarked that this project is one of few that reaches out to new chemistries.

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

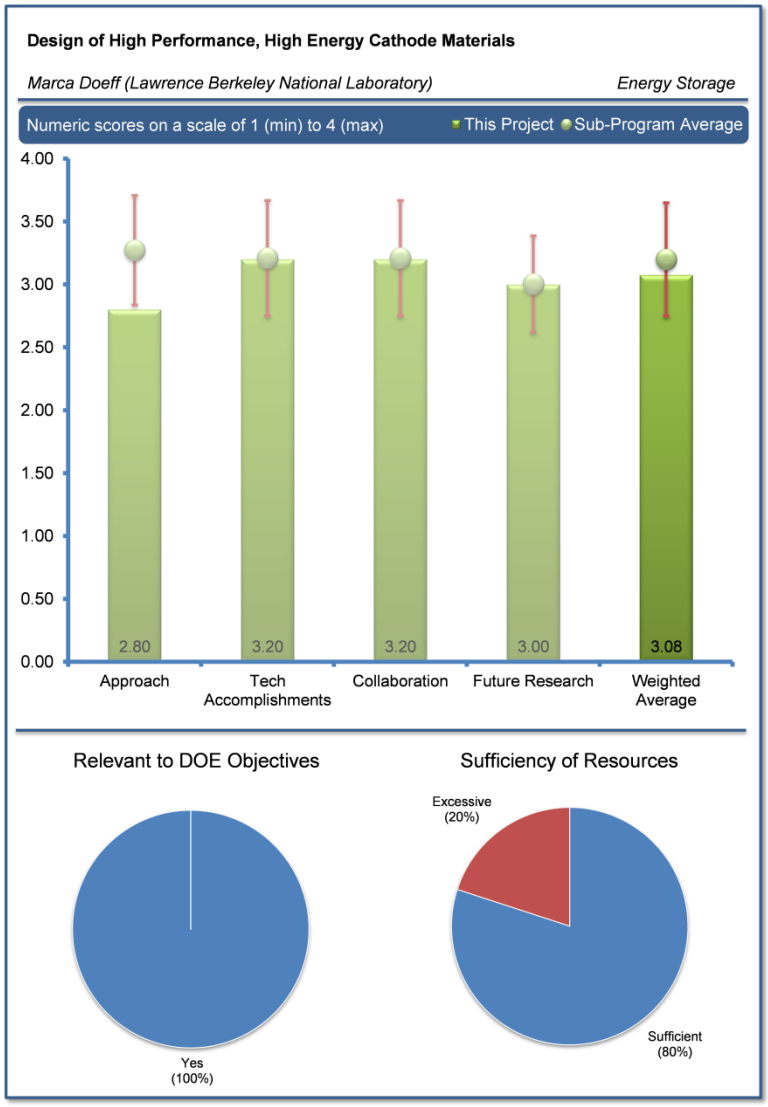
Reviewer 1:

The reviewer commented that the funding available for this project appeared to be sufficient for the work.

Reviewer 2:

The reviewer felt that the resources were sufficient to achieve the stated goals of the program.

Design of High Performance, High Energy Cathode Materials: Marca Doeff (Lawrence Berkeley National Laboratory) - es052



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer expressed that the lithium nickel manganese oxide cathode electrode coating with spray pyrolysis method seemed to be interesting, but the reviewer voiced that very limited characterization data on the composite materials was presented. The partial substitution of cobalt with Ti appeared to the reviewer to be effective in increasing NMC cathode capacity, and noted a desire to see further study to reduce the capacity decay. It was unclear to the reviewer if the partial Ti-substitution would benefit to electrode/electrolyte interface stability.

Reviewer 2:

The reviewer felt that the approach seemed to be reasonable.

Reviewer 3:

The reviewer explained that the program was developing high energy, affordable cathode materials to address the technology barriers of energy density, cost, and cycle life. The reviewer expanded that the developed cathode will be a material that is a partial Ti-substitution of the NMC materials. The reviewer also noted that the investigators will also explore spray pyrolysis, and related techniques, to produce coated and composite high-voltage materials. The reviewer concluded by summarizing that the presenter's reasoning and the methods were clearly explained and are reasonable.

Reviewer 4:

The reviewer offered that it was good to see systematic studies on effect of composition and method of synthesis; noting further that the results were quite intriguing. However, the reviewer asked if the researchers are really getting the most out of the data. The reviewer was unable to clearly delineate the effects of synthesis versus composition (e.g., Slide 10-11). The reviewer suggested that the researchers should consider alternative ways to view the results visualization/data mining tools are available, as it is very difficult to compare when multiple variables are being considered. In addition, the reviewer suggested that researchers should look for effects on other properties, such as rate, cycle life as well as interactions, when multiple variables are changed at once.

The reviewer asserted that Ti-substitution is well-documented in the literature, and asked what was being done differently in the presented approach. The reviewer asked if the researchers have tried any of these processes/compositions at a larger scale, and if so, whether the benefits were still observed.

Reviewer 5:
The reviewer stated that the researchers had developed a good alternative approach to the high-voltage composite-layered cathode that possibly would not have a VF issue.

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

Reviewer 1:
The reviewer reported that this project demonstrated considerable progress this year. The reviewer highlighted that Ti-substitution in NMC materials was shown to enhance cell capacity, which the reviewer thought was a possible route to higher energy density cells if thermal stability and cycle life can be maintained.

Reviewer 2:
The reviewer exclaimed that this work encompasses a tremendous number of experiments/results which clearly showed that the research team is highly productive. The reviewer suggested that the researchers should use visualization software to ensure you maximize the return on the data you have.

Reviewer 3:
The reviewer highlighted that there was good progress on the understanding and synthesis of Ti substituted NMC, but suggested that the researchers needed to show more cycle life than 20 cycles.

Reviewer 4:
The reviewer described that the partial Ti-substitution for cobalt in NMCs seems to increase its capacity, but the capacity decay remains to be a challenge. The impact of partial Ti-substitution on discharge/charge rate of the cathodes was not provided in the presentation, so the reviewer supposed that this may be included in the future investigation. The reviewer mentioned that the characterization of the cathodes prepared with the spray pyrolysis method was not provided, suggesting that this approach may bring some breakthrough in preventing the voltage and capacity decay.

Reviewer 5:
The reviewer stated that the technical accomplishments showed a certain level of improvement, but criticized that the accomplishments were not very significant.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer indicated that the research team appeared to have had good ongoing collaborations with other National Laboratories and universities by working together to attack the technical barriers.

Reviewer 2:
The reviewer noted that there was good collaboration as a team member.

Reviewer 3:
The reviewer pointed out that good collaboration existed between the PI and other scientists at Lawrence Berkley National Laboratory (LBNL) and at the Stanford Synchrotron Radiation Laboratory.

Reviewer 4:
The reviewer suggested that the researchers try to get some breadth in their collaborations outside of LBNL. The reviewer thought this might bring in additional insights into understanding all the good data the researchers had.

Reviewer 5:
The reviewer asserted that the researchers need to coordinate/collaborate with groups working on the high-voltage electrolytes to enable the use of these Ti-substituted NMC at high voltages.

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

Reviewer 1:
The reviewer described that the future plans were to continue the spray pyrolysis work on the composite electrode and evaluate and characterize the Ti-substituted NMCs. The reviewer noted that the experiments and computational effort towards understanding the origin of the first cycle efficiency improvement is interesting and is included in the future work plan. Overall, the reviewer remarked that the plans seemed to be sound, but suggested that an extension for the evaluation study to a wider temperature range may be useful to further see the effectiveness of Ti-substitution.

Reviewer 2:
The reviewer summarized that work would continue on the Ti-substituted NMCs, but the spray pyrolysis effort will be reduced. The reviewer felt that this was appropriate considering the results thus far.

Reviewer 3:
The reviewer emphasized that the researchers have shown good focus on the best performing materials. The reviewer asked if a thorough literature/patent search has been done on Ti-doped layered oxides. The reviewer cautioned the researchers to be careful to not re-invent the wheel here. The reviewer concluded by asking whether the researchers felt that some work on electrolyte evaluation on these new compositions should be done.

Reviewer 4:
The reviewer agreed with the presenter's emphasis on Ti-substituted NMC, but suggested that the project team might also want to explore Ti-substituted NCA since it has less first cycle irreversible loss than NMC and is denser, albeit less safe, than NMC.

Reviewer 5:
The reviewer asked what systems Ti-substituted NMCs served as a good model for as offered in the presentation. The reviewer pointed out that even though there is an improvement with Ti-substitution in the beginning, it starts to degrade, so the reviewer asserted that the reasons were not clear. The reviewer opined that the following presenter statement was unclear: it is possible that once this understanding is achieved that other routes could lead to higher capacities and better cycling in NMCs without the need for Ti-substitution.

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

Reviewer 1:
The reviewer liked this project a lot, as it strived to get the most out of materials that were already in the marketplace. The reviewer remarked that, with the issues around layered-layered NMC and 5V LNMO, running NMC out to higher voltages was an attractive way to improve energy densities to enable vehicle electrification. The reviewer remarked that if elemental substitution could allow acceptable cycle life at higher voltages, that this was definitely something that should be looked at.

Reviewer 2:
The reviewer described that the project was developing high energy and high performance cathode materials that cost less for advanced batteries and that this was aligned with DOE objectives to reduce dependence on petroleum.

Reviewer 3:
The reviewer explained that the effort is directed toward identifying high energy density cathode materials that have a long cycle life; thus the objectives were clearly in line with DOE objectives of petroleum displacement.

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

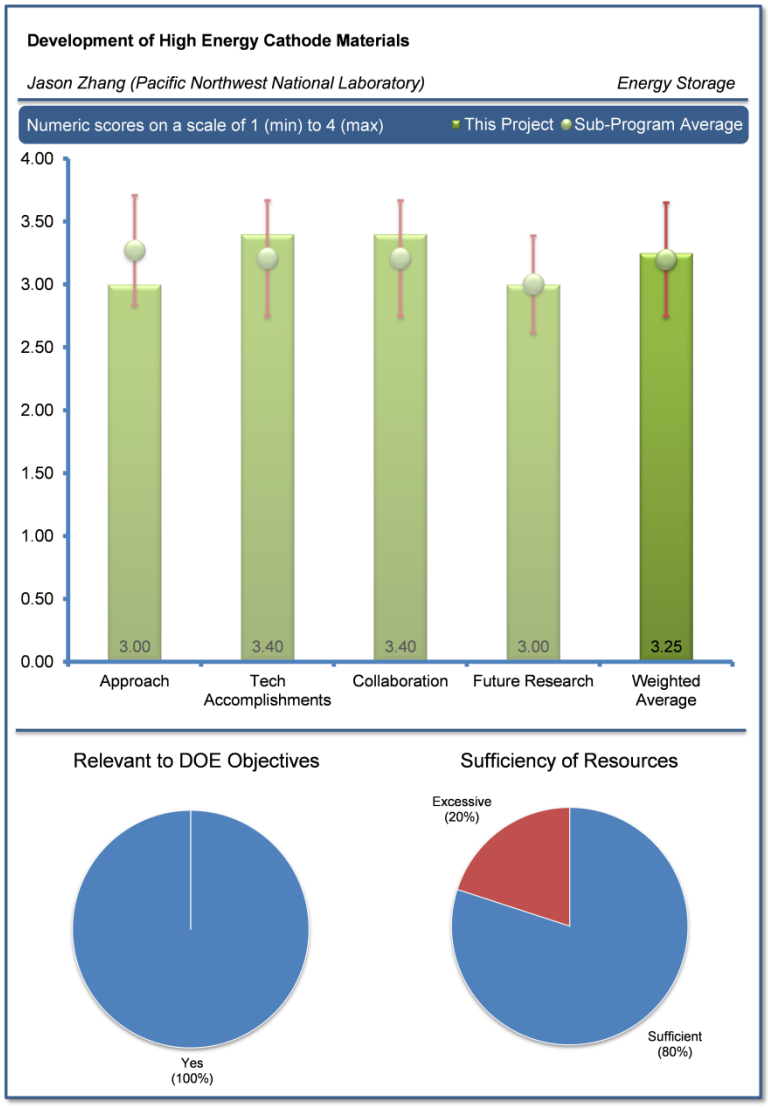
Reviewer 1:

The reviewer stated that the funding and resources available for this project appeared to be sufficient to conduct the research work.

Reviewer 2:

The reviewer indicated that the resources were sufficient to achieve the stated goals of the program.

Development of High Energy Cathode Materials: Jason Zhang (Pacific Northwest National Laboratory) - es056



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that the technical approach towards tuning contents of disordered phase/lattice Mn^{3+} in high energy spinel cathodes by controlling the cooling rate and element substitution appeared to be effective. Understanding on high-voltage spinel has been applied in layered composites. The approach of using electrolyte additives and/or surface treatment may help to reduce the resistance change and capacity drop but the reviewer was not sure if it could help to reduce the voltage decay problems for layered compounds. The approach has not been differentiated from the prior research efforts on LMR-NMC layered compounds in terms of coating and additives.

Reviewer 2:

The reviewer said that the approach was good.

Reviewer 3:

The reviewer observed that the program was addressing the technology barriers toward achieving an affordable, high energy density, long cycle life lithium ion battery. This will be accomplished by systematically investigating high-voltage spinels. The reviewer added that the investigators will improve the performance of lithium-rich, manganese-rich materials.

Reviewer 4:

The reviewer stated that this work provides excellent fundamental understanding of the HV spinel chemistry and asked if it was generally applicable. Some results seemed inconsistent with Professor Manthiram's results with regard to the effect of ordering in the material (C-rate results). In addition, the reviewer added that the project team's attention to the effect of the high voltage on the inactive materials is very valuable and is too often ignored.

The results for the electrolyte additive on VF should be presented using the Argonne protocol. The reviewer believed that the project team said that these results were in progress, so it would be good to get some comparison against the baseline. It was hard to tell with the data presented, if there was a kinetic component or not.

The project team's work on the effect of the cell casings at high voltage was noteworthy. Certainly, for researchers this was an important finding that needed to be communicated. The reviewer asked if anything was learned here that would be applicable for larger cell formats, how 18650 cells might need to change, and if there would be any issues with laminate/prismatic cells.

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

Reviewer 1:
The reviewer commented that the high-voltage spinel cathode was systematically investigated and that the obtained information was applied trying to accelerate layered composites development. Electrolyte additives had been identified for potential improvement of Li-rich, Mn-rich layered composite cathodes. The method for cooling rate control was claimed to be used in preparing LMR-NMC cathodes, but corresponding comparison data was not provided.

Reviewer 2:
This reviewer asked what more than previously published $LiNi_{0.45}Cr_{0.05}Mn_{1.5}O_4$ composition was learned and if Cr was environmentally acceptable.

Reviewer 3:
The reviewer observed that the program demonstrated considerable progress this year. The investigators systematically investigated high-voltage spinel cathodes for Li-ion batteries and a new electrolyte additive was identified to mitigate the continuous side reaction on the electrode/electrolyte interface at high voltages.

Reviewer 4:
This reviewer noted that the researchers were making progress, but that the objectives were not quantitative. In addition, the researchers do not give a perspective on the electrolyte additives. The reviewer asked if it was necessary to test hundreds of additives to get one that worked, and if the one presented was novel or suggested from the literature.

Reviewer 5:
This reviewer felt that there was good data on correlating the performance of the high V spinel with oxygen stoichiometry. The reviewer suggested that the project team might want to cite the work by Tarascon on the effect of oxygen stoichiometry on spinel's performance. The project team's data on Li_2MnO_3 was also significant. It showed that Li_2MnO_3 transformed structurally when fully delithiated and may not be effective in stabilizing the Li Mn rich composite cathode.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that excellent collaboration exists in this program. The PI is collaborating with The State University of New York (SUNY) Binghamton, Argonne, Brookhaven, Hydro-Quebec, U.S. Army Research Lab and University of Rhode Island.

Reviewer 2:
This reviewer observed that the project had good collaboration with industry, academia, and national laboratories. The reviewer would like to make sure there was more collaboration than just supply of materials. The reviewer thought that this was a very strong team for which interactions would drive the project faster.

Reviewer 3:
The reviewer indicated that the research team appeared to have had collaborations with industry, universities, and national laboratories. However, it was unclear what roles of those collaborators played for the research.

Reviewer 4:
This reviewer said that the project needed to collaborate with other groups working on the voltage sag issue in the Lithium Manganese Rich (LMR) cathode.

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

Reviewer 1:
The reviewer thought that understanding the voltage decay mechanism appeared to be a good plan. Future plans also included continuing the electrolyte additives development, investigating electrode/electrolyte interface, and direct synthesis of the stable cathode structures. It is suggested the PNNL team work more closely with the Argonne research team to use the information that Argonne team has learned on LMR-NMR. It appears the Argonne team claimed that additives and coating will not help to reduce the voltage decay.

Reviewer 2:
The reviewer felt that the future work proposed is good. The investigators will continue to understand the capacity degradation and voltage fading mechanism of Li and Mn rich cathode materials. They will then move on to electrolyte additive development.

Reviewer 3:
This reviewer asked what the specific plans for the capacity degradation and voltage fading mechanism of Li-Mn-rich layered composite cathode was.

Reviewer 4:
The reviewer noted that there are no decision points in the future plans. Clearly, the future work builds on what has already been done, but the reviewer asked how the project team would prioritize in the future.

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

Reviewer 1:
This reviewer noted that the development of high energy cathode materials is the key to improving battery energy density for potential EV/ HEV applications and that it is aligned with DOE goals to reduce dependence on petroleum.

Reviewer 2:
The reviewer observed that the program's objectives were clearly in line with DOE objectives of petroleum displacement. It seeks to design high capacity, high-power and low-cost cathodes

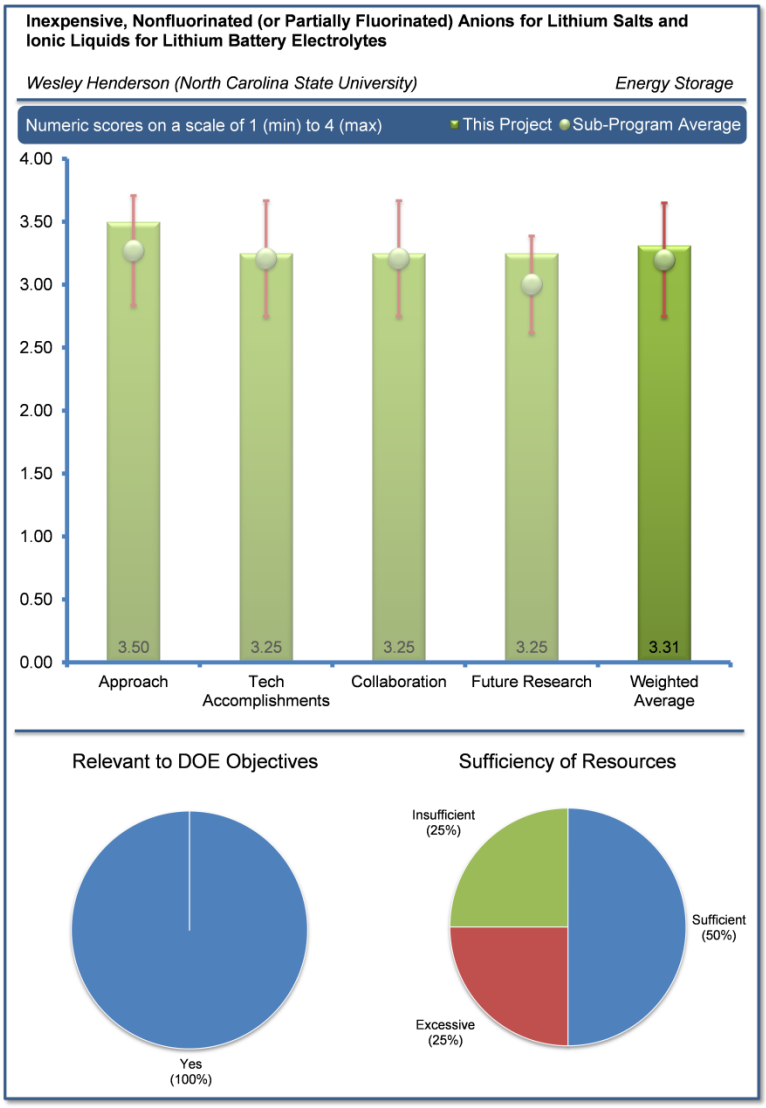
Reviewer 3:
The reviewer felt that solving the remaining problems with the layered-layered material will ensure a good high energy cathode material for vehicle electrification. This is essential to widespread adoption of BEVs.

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

Reviewer 1:
The reviewer thought that the funding and sources available for this project appeared to be sufficient to conduct the proposed study.

Reviewer 2:
This reviewer stated that the resources were sufficient to achieve the stated goals of the program.

Inexpensive, Nonfluorinated (or Partially Fluorinated) Anions for Lithium Salts and Ionic Liquids for Lithium Battery Electrolytes: Wesley Henderson (North Carolina State University) - es057



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer summarized that the project is directed at developing new electrolyte systems with additives leading to lower cost and higher performance. The reviewer exclaimed that the availability of Drs. M. Armand and Smart are significant additions to the strength and scope of the project. The reviewer remarked that success in this area is essential to significantly improve battery storage capability in advanced battery systems.

Reviewer 2:

The reviewer applauded that the researchers had a terrific approach to the design of better electrolyte diagnostics and to understanding why solvents behave as solvents do.

Reviewer 3:

The reviewer felt that the approach was fine.

Reviewer 4:

The reviewer felt that the approach to determine the properties of battery electrolytes was very good. The reviewer, however, criticized that the approach to evaluating newly discovered electrolytes, including concentrated electrolytes, has not had a very practical outlook. The reviewer believed that a more serious consideration of cost perspectives, as well as performance in actual cells, should have been more prominent in the approach.

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

Reviewer 1:

The reviewer highlighted that excellent progress was made in identifying new electrolytes. As a base, the project established the base of present $LiBF_4$, LiDFOB and LiBOB with cyclic carbonates used in present electrolytes and compared to the properties in ester gamma buteryl lactone and GVL. The reviewer also reported that a new electrolyte based on LiTDI was identified and full characterization is underway. Also, new electrolytes based on LiTFSI-EC mixtures with high concentrations of lithium salt showed good promise in the reviewer's opinion.

Reviewer 2:
The reviewer explained that the technical accomplishments were good, as a number of new electrolyte types as well as the studies of more concentrated electrolytes as replacement for $LiPF_6$ have shown promise. However, the reviewer reported that, no indication of cell performance was presented.

Reviewer 3:
The reviewer asserted that the researchers have served the community well by creating phase diagrams and publishing valuable information about solvation numbers.

Reviewer 4:
The reviewer stated that ionic liquids have to be reconsidered for Li-ion batteries.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer acknowledged the excellent collaboration with Oleg Borodin. The reviewer indicated that lots of all the right people were involved.

Reviewer 2:
The reviewer summarized that the collaborations included: O. Borodin for quantum chemical calculations and molecular dynamics simulations; Bryant Polzin (ANL) for graphite anodes and cathodes used in testing LiTDI electrolytes; Marshall Smart for testing guidance and concentrated electrolyte guidance; Vincent Battaglia provided cathodes for testing; Steve Greenbaum (NYU) for NMR measurements; and Daniel Abraham for special electrolytes.

Reviewer 3:
The reviewer commented that the absence of cell testing was one of the points lacking in the approach and results. The reviewer felt that this could have been accomplished in collaborative studies, and recommends that this be included in any future plans.

Reviewer 4:
The reviewer asked who in the team was testing and expressed interests for the ionic liquid-based battery.

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

Reviewer 1:
The reviewer indicated that the future research would determine the properties of these electrolytes.

Reviewer 2:
The reviewer stated that this project was one of the few efforts the reviewer was aware of where researchers were using state-of-the-art technologies to predict how to make better electrolytes.

Reviewer 3:
The reviewer noted that no proposed future plans were presented.

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

Reviewer 1:
The reviewer stated that new high-performance electrolytes with good voltage range were essential for success in developing high performance Li-ion systems with superior energy storage capability.

Reviewer 2:
The reviewer simply stated that better electrolytes were the core to improved batteries.

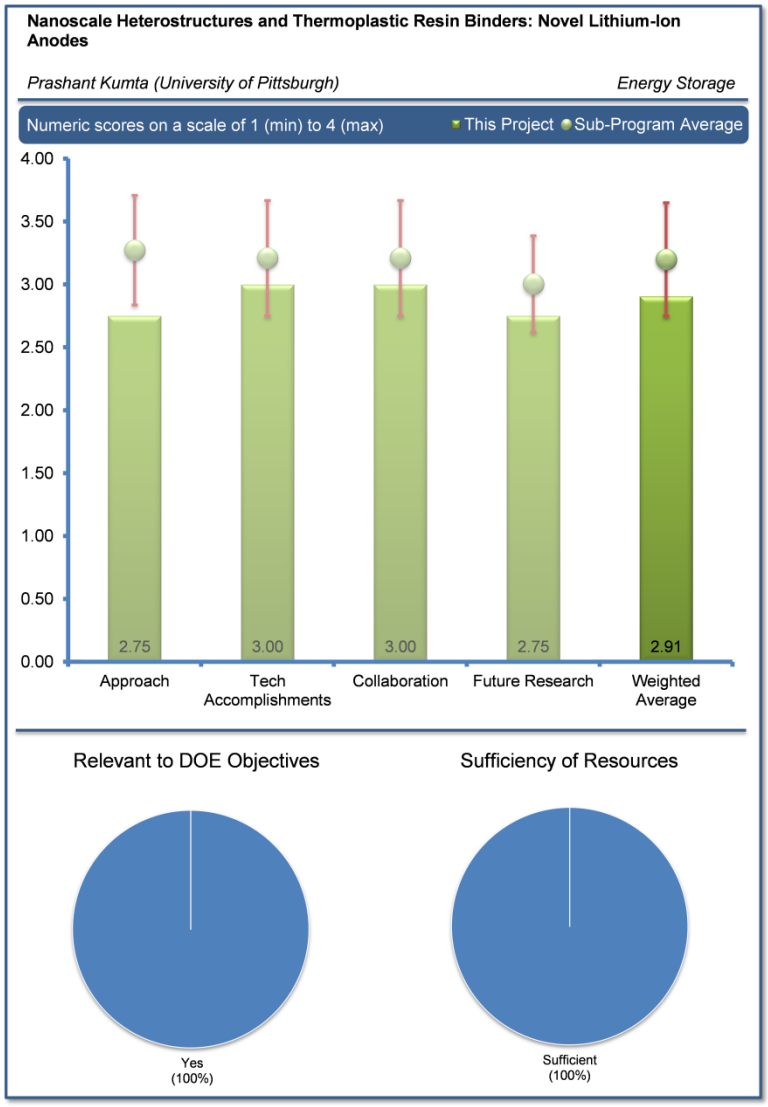
Reviewer 3:
The reviewer explained that the relevance to DOE's goals would have been greatly assisted by more cell data.

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

Reviewer 1:
The reviewer felt that the resources were adequate, but suggested that additional funding would accelerate new developments in this critical technology area.

Reviewer 2:
The reviewer suggested that the PI should develop some expertise in cell testing as well as the required equipment.

Nanoscale Heterostructures and Thermoplastic Resin Binders: Novel Lithium-Ion Anodes: Prashant Kumta (University of Pittsburgh) - es061



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer described that this project has brought some interesting methods of preparation of silicon-based materials. The reviewer thought that many of the results were promising, but to date, none has solved all of the problems of Si. The best results, according to this reviewer, would appear to be with Si carbon composite with improved binder. The reviewer appreciated the listing of columbic efficiency as well as first cycle irreversible loss, loading and reversible capacity with the curves. The reviewer suggested that it would be desirable if all alloy field workers would adopt this practice. While some may argue that the composites do not give extremely high capacity, the reviewer felt that the order of 800-1000 mAh/g is sufficient to make a big improvement in the anode. The reviewer explained that this would enable the anode coating thickness to be reduced by a factor of two, which would result in considerably higher cell energy density. The reviewer also thought it was intriguing that chemical vapor deposition of Si gives good performance when done properly.

Reviewer 2:

The reviewer summarized that this program is attempting to address the technical barriers by identifying new alternative nanostructured anode materials that will provide higher gravimetric and volumetric energy density. To accomplish this, the reviewer explained that microcrystalline, nano-crystalline, nanoparticle and amorphous silicon-based anode materials will be investigated. The reviewer thought that this approach could improve the specific capacity, and hence available energy, of a Li-ion battery. The reviewer also mentioned that the program will identify new elastomeric thermoplastic binders that may prevent delamination.

Reviewer 3:

The reviewer said that while this appeared to be a very complete approach to the development of a Si-based anode via multiple pathways, the reviewer wanted to know if these were really practical. The reviewer acknowledged that these may be, but would like to see this question addressed. The reviewer went on to ask whether carbon nanotube composites were cost-effective. The reviewer also asked if the deposition of the interface control additive via ion/e-beam deposition was scalable and economical. The reviewer asked whether the researchers could make higher loadings/thicker films. The reviewer did like the high-energy milling approach with etching to get pure silicon, and suggested that this may be more practical. The reviewer asked whether the researchers had specific

ideas on how to improve the first cycle efficiency. The reviewer felt that the more holistic approach to the development of a silicon/binder system was beneficial.

Reviewer 4:

The reviewer indicated that the researcher needed to clearly state the impact of the amorphous versus nanocrystalline Si approaches and that researcher needed to show how the various synthesis approaches would be down-selected.

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

Reviewer 1:

The reviewer described that this project had seen steady progress and uncovered several methods of creating stabilized silicon which could give good cycling and high columbic efficiency. Many of these methods appeared to this reviewer to be scalable and capable of low-cost production. The reviewer asserted that the use of reasonable loadings for the electrodes was important, as it leads more quickly to decision making regarding the various preparation methods.

Reviewer 2:

The reviewer pointed out that good progress had been achieved. The reviewer mentioned that several milestones were met during 2012, including: an improved cycling stability using an interface control agent for carbon nanotubes (CNT)/SI heterostructures; and the development of a scalable method for making hollow Si nanostructures that display high capacity.

Reviewer 3:

The reviewer observed that there has been a lot of work on this project, and that the project's overall goals are to explore a variety of approaches to the development of silicon anodes. The reviewer thought it would have been helpful to have a simple, clear table listing all of the approaches and the resulting performances. The reviewer asked whether fair comparisons are being made. The reviewer asked whether there is a clear winner in the approaches. The reviewer asked when/where will the project start to focus down on the most promising approaches. The reviewer also reported that the high-strength binder is interesting and suggested that post-mortem work should be done to validate if it really is high-strength, or not. The reviewer suggested that there may be chemical reasons why improved performance was observed.

Reviewer 4:

The reviewer cautioned that all of the presenter's good performance data was based on very low Si loading. The reviewer recommended that the researcher needed to demonstrate good cycle life at a loading level that was practical for high energy Li-ion cells to be relevant.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer voiced that it was good to see the involvement of Ford Motor Company and national laboratories in collaboration with the PI. The reviewer highlighted that customers can have a great impact on program direction.

Reviewer 2:

The reviewer noted that the program has good collaboration with other scientists and engineers. Specifically, the reviewer mentioned that the PI is collaborating with two members at his university (University of Pittsburgh) as well as Ford Motor Company, the National Energy Technology Laboratory (NETL), and LBNL.

Reviewer 3:

The reviewer suggested that this work might benefit from broader collaboration. The reviewer agreed that the researchers have some unique skills in the synthesis area; however this person thought that working closer with others might help focus the project on the most promising outcomes. The reviewer added that simply providing samples to another institution may not be enough collaboration.

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

Reviewer 1:
The reviewer stated that the proposed future research was justified on data obtained this year and was well-reasoned.

Reviewer 2:
The reviewer was happy to see the testing of full cells planned for the coming FY. The reviewer pointed out that in some cases, cycling is surprisingly improved in the presence of a cathode material, but in other cases it is worsened; the only way to find out the reasons is to try various cathodes with the test anode materials. The reviewer hoped that the alloy group will develop a protocol for full cell testing so that the results are comparable between workers.

Reviewer 3:
The reviewer thought it was fine to start a program on trying many different approaches; however the next step needs to focus down on a couple approaches. The reviewer remarked that the researchers talk about low cost a lot, but asked where the process economics are to back up this claim.

Reviewer 4:
The reviewer recommended that the researcher needs to demonstrate that he can achieve good cycle life at higher loading levels of greater than 5 mAh/cm^2.

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

Reviewer 1:
The reviewer observed that this work was clearly relevant to DOE objectives. The reviewer explained that the possible energy density gain was substantial and the material cost was low. The reviewer emphasized that workers must be careful to maintain low processing costs in addition.

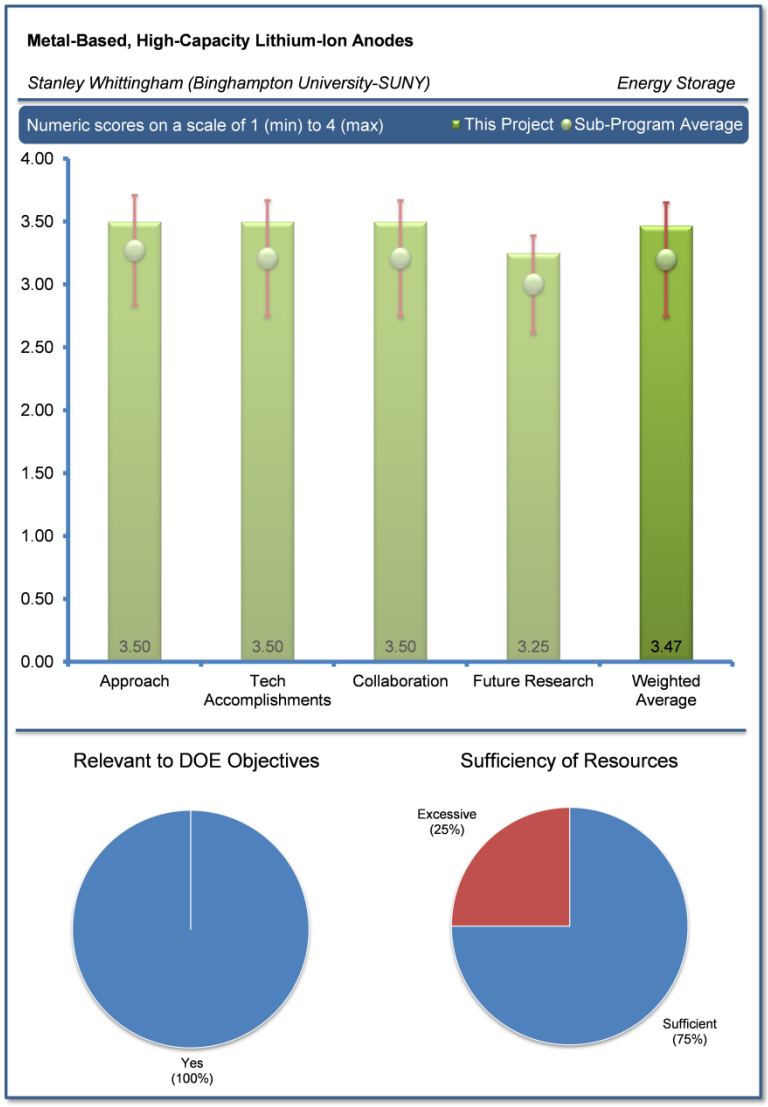
Reviewer 2:
The reviewer agreed that the program's objectives were clearly in line with DOE petroleum displacement objectives. The reviewer explained that the project sought to address the low specific energy and poor cycle life of present batteries and the high cost of the raw materials.

Reviewer 3:
The reviewer affirmed that the development of high energy anode and cathode materials is required for widespread adoption of BEVs. The reviewer confirmed that this project can provide approaches to successful high energy anode materials.

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

Reviewer 1:
The reviewer felt that the funding required was sufficient to complete the objectives.

Metal-Based, High-Capacity Lithium-Ion Anodes: Stanley Whittingham (Binghamton University-SUNY) - es063



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer indicated that this was a well thought out project and that Dr. Whittingham continued to convey the reasoning behind the proposed work in a logical, clear manner. The reviewer summarized that the project sought to increase the volumetric capacity of the anode by a factor of two and to increase the gravimetric capacity of the anode to over 500 Ah/kg. To do this, the PI placed an emphasis on low-cost materials such as tin and silicon, both of which were wise choices, according to the reviewer. The reviewer noted that the investigators recognized that the side reactions with the nano-tin may be a problem and were taking steps to prevent this. The reviewer also offered that safety was being addressed and that the researchers were exploring methods to minimize dendritic growth of lithium during charge.

Reviewer 2:

The reviewer agreed that work on both silicon and silicon alternatives were important to achieve target energy densities to enable practical BEVs, and the researchers demonstrated a variety of techniques to prepare potential materials. The reviewer thought this should mitigate the risk that nothing will work. The reviewer highlighted that it was good to see the go/no-go decisions on each approach to focus down the project. The reviewer particularly liked the emphasis on cost reduction through low-cost starting materials or processing. The reviewer, however, questioned the premise that Si (or Si alternatives) would be safer than carbon-based materials. The reviewer explained that while there was ample evidence to show that carbon/graphite was not good for safety, the project team asked whether there were any large format data on batteries to quantify a safety improvement with Si or tin; or of it was only hypothesized.

Reviewer 3:

The reviewer stated that the Sn_2Fe approach is promising.

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

Reviewer 1:

The reviewer pointed out that this project was initiated in January 2011 and is 50% complete. The reviewer felt that excellent progress had been made toward achieving the goals. The reviewer commented that the limitation to the electrochemical behavior of

mechanochemical Sn has been determined and the electrochemistry of a new nano-silicon material was determined. The reviewer also mentioned that the reaction mechanism of the nano-Sn-Fe-C system was also determined. The reviewer remarked that this continued progress indicates that the project should be able to demonstrate continued progress in the future.

Reviewer 2:
The reviewer stated that Sn_2Fe showed better performance than SnCoC.

Reviewer 3:
The reviewer confirmed that good progress was demonstrated versus the project milestones. The reviewer indicated that the presentation may have been misunderstood, but it looked like some of the best performance (e.g., high capacity, stable cycle life, and good rate) was demonstrated by the SMOG material. The reviewer observed that the 2013 slide is the same as 2012, and asked why more work has not been done on this approach, especially since it looked encouraging.

Reviewer 4:
The reviewer explained that for a given cathode, a summary table comparing the Wh/L, Wh/kg, first cycle irreversibility and volume change of nano-Sn_2Fe versus nano-Si would have been very useful.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer expressed that outstanding collaboration and coordination was occurring in this project. The reviewer highlighted that Dr. Whittingham is collaborating with several national laboratories, the New York Battery and Energy Storage Technology Consortium, as well as a local company (Primet Precision Materials).

Reviewer 2:
The reviewer indicated that it was nice to see involvement with a small company (Primet Precision Materials).

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

Reviewer 1:
The reviewer stated that the future work proposed was very good and includes optimizing the synthesis methods (both mechanochemical and solvothermal) of the promising nano-Sn_2Fe material.

Reviewer 2:
The reviewer asked if the researcher had go/no go targets/timelines for the next year; explaining that this was an excellent approach to focus the project which the reviewer hoped would continue. The reviewer suggested that development of nano-silicon from low-cost Al-Si alloy should be emphasized because it looked promising, and would enable a robust supply chain.

Reviewer 3:
The reviewer indicated that the researcher needed to propose more specifics on how the project team planned to reduce first cycle irreversibility in nano-Si.

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

Reviewer 1:
The reviewer stated that the program's objectives were clearly in line with DOE objectives of petroleum displacement. The reviewer explained that increasing the volumetric capacity of the anode by a factor of two would increase the cell energy density by up to 50%, which would lower the cost of tomorrow's batteries.

Reviewer 2:

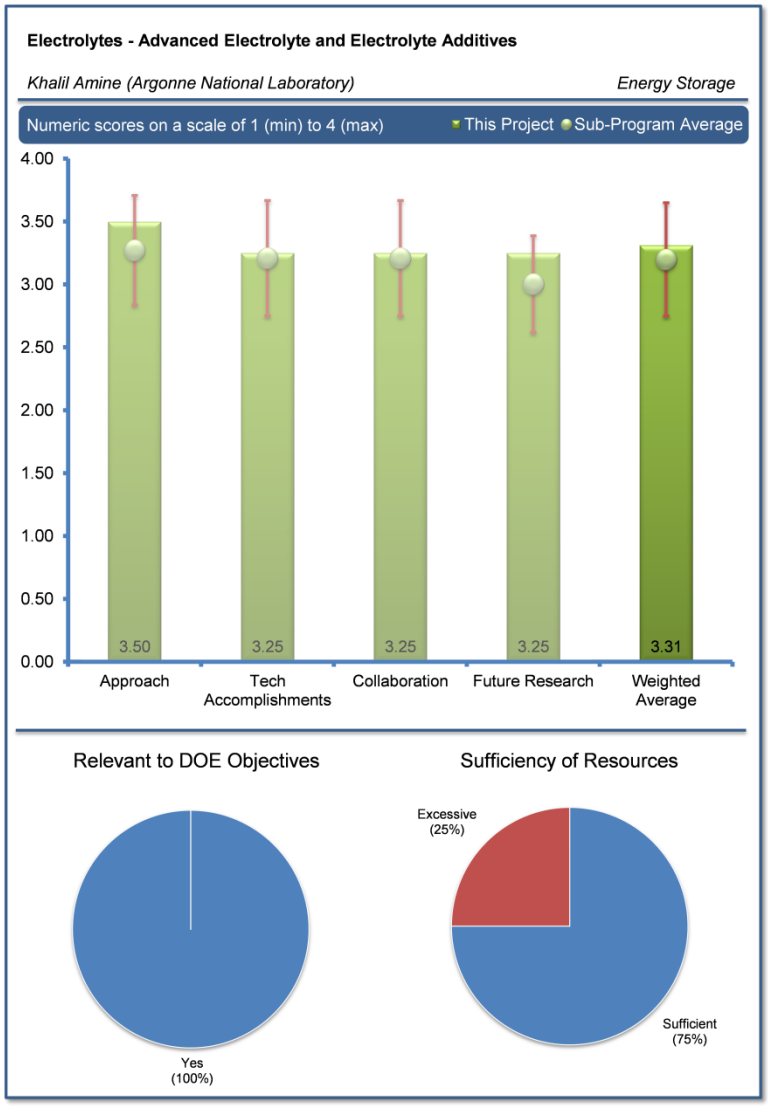
The reviewer explained that the development of both high energy density cathodes and anodes was required for development and subsequent adoption of BEVs in the United States. The reviewer pointed out that despite much effort, silicon anodes were not ready; this project takes a multi-pronged approach to materials and processes and can focus down on which provide target performance and which can be made practically and economically.

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

Reviewer 1:

The reviewer felt the resources were sufficient to perform the stated work in a timely fashion

Electrolytes - Advanced Electrolyte and Electrolyte Additives: Khalil Amine (Argonne National Laboratory) - es066



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer applauded the excellent approach and terrific collaborations.

Reviewer 2:

The reviewer agreed that the approach was good.

Reviewer 3:

The reviewer agreed that the approach was good, but felt that it could be improved with more attention to the properties of the additives after exposure to the cell environment, particularly after cycling. Also, the reviewer felt that in the case of MA, that it appeared that a good additive had been identified for 55°C cycling in the chosen cell, but no other comparisons were made so that the effects on room temperature and low-temperature cycling were not known. Also, the reviewer pointed out the effect on the abuse tolerance barrier was not determined. It was not clear to the reviewer what cell type was used for testing and how reproducible the tests were. The reviewer cautioned that this was very important for additive testing where the effects may be small under certain conditions. In this reviewer's experience, the performance of the standard electrolyte was surprisingly poor in the case of graphite NMC cell cycling tests at 55°C, which brings into question the test accuracy. The reviewer suggested that, for high-voltage electrolytes, the use of abuse testing might be of considerable importance.

Reviewer 4:

The reviewer stated that the researchers hypothesized that additives that polymerize at greater than 2 volts made better solid/electrolyte interface/interphase (SEI) films. However, the reviewer saw no special justification for this assumption.

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

Reviewer 1:

The reviewer indicated that it was encouraging that additives were identified for improved SEI formation, and that fluorinated solvents were identified for high-voltage cells since the last year. The reviewer would like to see more comprehensive testing in both of these areas.

Reviewer 2:
The reviewer pointed out that the researchers' calculations served as screens, but the reviewer's sense was that finding species that were reduced at +1 or +2 volts above lithium was not a very difficult task. The reviewer did not see what sort of failure mechanism the project team had; that is, the reviewer wanted to know how SEI properties related to improved performance. Overall, the reviewer summarized that the improvement was fair.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer acknowledged excellent collaborations with leaders in the field.

Reviewer 2:
The reviewer simply stated that the collaborations were adequate.

Reviewer 3:
The reviewer claimed the PIs do not indicate how collaborations occurred in the program, although it was noted that there were collaborators.

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

Reviewer 1:
In addition to the stated work on SEI formers and redox materials, the reviewer would like to see the high-voltage work continued, as this was needed for spinel materials as well as lithium rich materials. The reviewer would also like to see a larger group of tests be conducted on new, and existing, materials.

Reviewer 2:
The reviewer reinforced that new electrolytes are essential to the continued improvement of Li-ion battery performance. The reviewer described that the search has included a quantum mechanical screening of new electrolytes and the composition of the SEI film formation. The reviewer explained that once the film formation on the anode is understood, new electrolytes can be identified by quantum mechanical calculations, which will expedite the development of new electrolytes.

Reviewer 3:
The reviewer indicated that the future plans included improved modeling of decomposition reaction pathways leading to SEI formation, but asked that the researchers explain the improved modeling.

Reviewer 4:
The reviewer would have appreciated seeing a greater effort in understanding how and why the additives worked.

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

Reviewer 1:
The reviewer affirmed that electrolyte solvents are a major barrier to further progress in Li-ion batteries.

Reviewer 2:
The reviewer voiced that electrolyte development is core to the program.

Reviewer 3:
The reviewer commented that improved Li-ion battery performance is essential to the success of the battery power electric vehicles; longer range and lower cost are essentials.

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

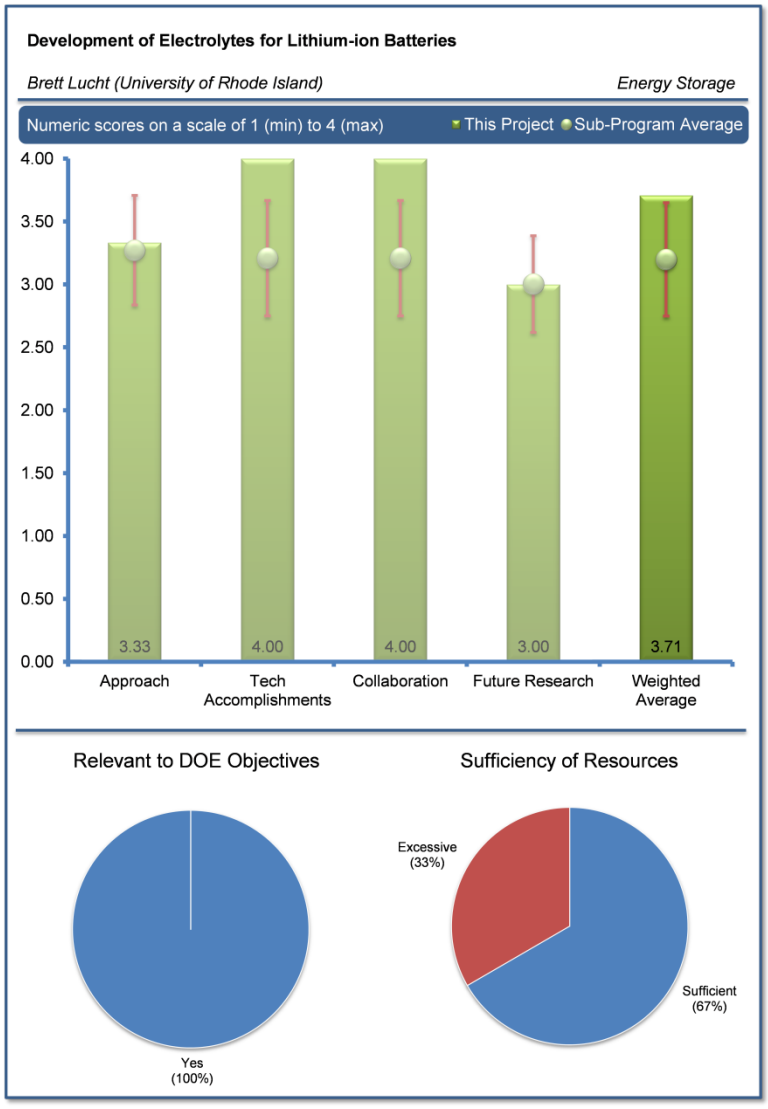
Reviewer 1:

The reviewer explained that the PI is a careful worker, and one of few that have industrial experience. This reviewer agreed that sufficient resources are available to carry out the proposed work, but thought additional resources would speed the work and offer the opportunity to expand exploration so suggested that DOE may want to consider increasing the funding on this project. The reviewer highlights that the new Envia Systems battery system uses the new Si anode developed in the researcher's laboratory.

Reviewer 2:

The reviewer reported that the resources were extensive (but not excessive) for the task; thus, expectations should be especially high for this project.

Development of Electrolytes for Lithium-ion Batteries: Brett Lucht (University of Rhode Island) - es067



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

The reviewer explained that the approach is very well-focused on the cycle life barrier, although the abuse barrier and calendar life barrier are not discussed. The reviewer acknowledged that it is difficult to address the calendar life barrier in a program of this magnitude and time, but noted that the accelerated aging test was found to be quite useful. The reviewer was happy to see cycling at different rates and temperatures to get a better feel for the efficacy of the additives and electrolyte composition.

Reviewer 2:

The reviewer noted that the work is a continuation of the work to develop new high performance electrolytes for Li-ion batteries based on $LiPF_6$/methyl butyrate-based (MB) electrolytes.

Reviewer 3:

The reviewer stated that standard approaches to get improved performance, with some calculations to help along, were being used. The reviewer also mentioned that studying electrode surfaces after use is good.

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

Reviewer 1:

The reviewer acknowledged that the program had some successes in the past year; in particular, the additive to the standard electrolyte for high-voltage cells showed considerable promise. The reviewer suggested that the evaluation of accelerated aging along with impedance and XPS studies would be valuable to apply to this situation. The reviewer also emphasized that the lowering of manganese transfer from cathode to anode is an important finding.

Reviewer 2:

The reviewer reported that an understanding of the role of electrolytes in capacity fade and cycling efficiency has been developed. The reviewer explained that new electrolyte formulations to decrease capacity fade and improve operating efficiency have been identified. The reviewer also mentioned that a new electrolyte to improve cycling and lower capacity fade has been designed/identified and proven.

Reviewer 3:
The reviewer commented that Lewis base additives improved performance, but asked whether this depended on how much water has leaked in. In real cells, maybe very little water leaks in, so the reviewer was not convinced one way or another whether this is important. The reviewer pointed out that LiFOP gives films with high impedance, so the performance is not very good. The reviewer criticized that insufficient effort to decide whether changes in SEI should be good or bad, rather than just being different. The reviewer also noted that the thickness changes were only semi-quantitative. The reviewer agreed that building half-cells out of used full cells is a good thing to do, but was not novel. The reviewer was unsure what new was learned in the program, other than testing some new materials. The reviewer also reported that delamination was observed in some cases, but it was not clear whether the electrolyte was responsible. In general, the reviewer did not feel that much new was learned.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer highlighted that the collaborations are well-handled by the PI, as the laboratory is set up for electrolyte property studies, it was necessary to find groups willing to do timely cell construction and evaluation.

Reviewer 2:
The reviewer summarized that the collaborations are comprised of leaders in the field including: D. Abraham (ANL); M. Smart [National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL)]; V. Battaglia (LBNL); J. Kerr (LBNL); A. Garsuch (BASF); F. Puglia (Yardney); and the LBL Spinel Focus Group.

Reviewer 3:
The reviewer affirmed that all the right people and organizations were on-board.

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

Reviewer 1:
The reviewer commented that the future work proposed was on a solid basis and it was hoped that the new additive, and others developed, would prove generally useful.

Reviewer 2:
The reviewer summarized that the future work includes: developing an understanding of the role of electrolyte when cycling at higher temperature; additives for film formation; new electrolytes for Si anodes; and a mechanistic understanding of limiting reactions of electrolytes in Li-ion batteries. The reviewer also noted that the plans include synthesizing and characterizing new electrolyte combinations to reduce capacity fade on cycling.

Reviewer 3:
The reviewer did not have the sense that there was a novel future direction in mind.

Reviewer 4:
The reviewer asked what kind of improved cathode film forming additives for graphite/ $LiNi_{0.5}Mn_{1.5}O_4$ cells to improve cycling performance at 55°C would be developed.

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

Reviewer 1:
The reviewer explained that the work was very relevant, as the high-voltage cathode is definitely limited by available electrolytes.

Reviewer 2:

The reviewer commented that the need for longer cycle life and higher performance electrolytes in high performance anode and cathode systems is essential to meet the requirements for use of Li-ion batteries in transportation.

Reviewer 3:

The reviewer expressed that improved electrolytes are a core to the program.

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

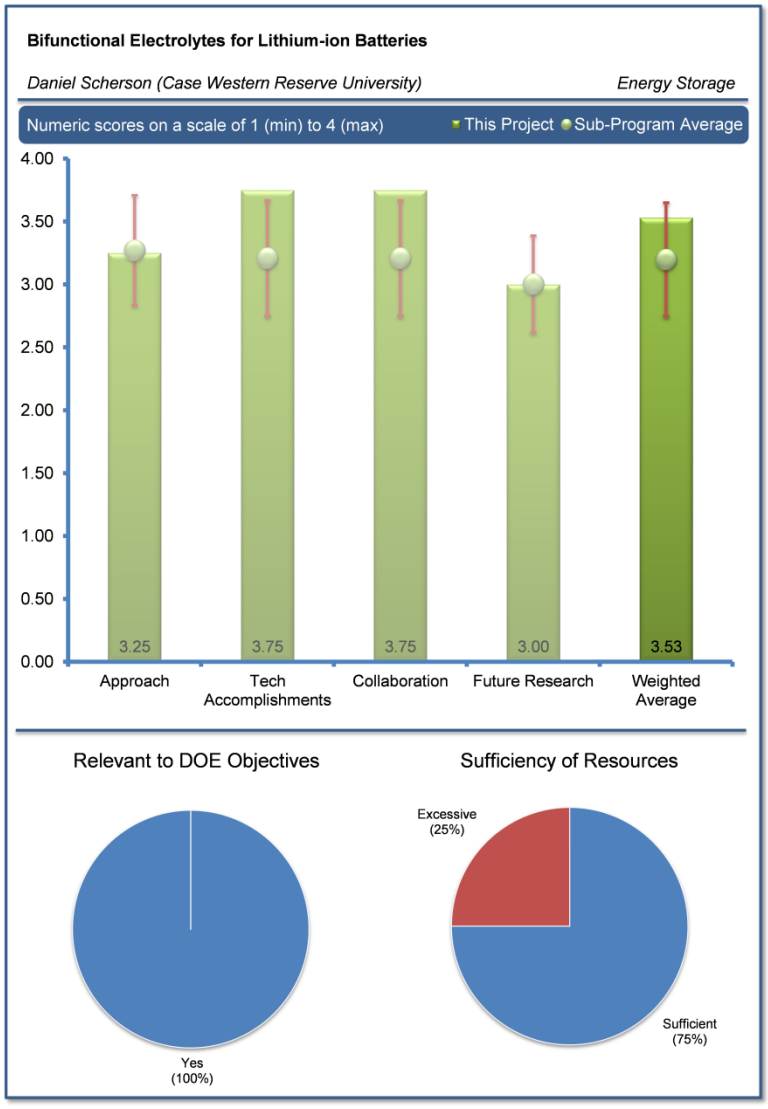
Reviewer 1:

The reviewer agreed that, with the good collaborations in place, the resources were seen as sufficient.

Reviewer 2:

The reviewer confirmed that the funding was the right order of magnitude for the proposed work.

Bifunctional Electrolytes for Lithium-ion Batteries: Daniel Scherson (Case Western Reserve University) - es068



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer explained that the approach was to identify and develop new fire retardant Li-ion based electrolytes based on boron and phosphorus. Specifically the project developed structure functionality to guide the development of new flame retardant electrolyte ions (FRION) electrolytes with increased abuse tolerance and then identify and develop new low-cost high performance electrolytes for Li-ion batteries.

Reviewer 2:

The reviewer described that the approach focused on developing novel lithium salts containing flame retardant functional groups, such as with boron and phosphorus moieties, to impart additional flame retardant properties to the electrolytes and thus make the Li-ion cells intrinsically safer. The reviewer explained that the approach is to design and synthesize such FRIONS and assess their compatibility with Li-ion anodes using both electrochemical and in-situ spectroscopic techniques. This understanding, according to the reviewer, will lead to further refining the salts to achieve the desired stability as well as abuse tolerance. The reviewer agreed that the approach looks interesting and felt that it can lead to new safer salts for Li-ion cells. However, the reviewer cautioned that, probably guided by solubility and/or compatibility restrictions, these FRIONS are being used in fairly low proportions (1%), such that the FRIONS may not have any noticeable impact on flame retardancy (or safety). The reviewer surmised that low solubility may be one limiting factor, as was also highlighted by another reviewer (and not answered satisfactorily). The reviewer thought that even with much higher proportions, some of the known flame retardant additives have not prevented thermal runaway in some of the abuse tests. On the other hand, the reviewer pointed out that these salts, in such low proportions, may have more significant effect on the interfacial properties of the electrodes, like LiBOB, vinylene carbonate (VC), etc.

Reviewer 3:

The reviewer explained that the project's scope was to design, synthesize, and characterize flame-resistant salts, which was a very ambitious idea. Incorporating flame retardant chemical groups to anions in lithium salts was also a good idea. The reviewer added that the researchers were aware of how trace impurities were very important. The reviewer noted that a lot of work has preceded this project's research into resistance to burning, and asked whether the project would result in new results.

Reviewer 4:
The reviewer simply stated that the approach was good.

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

Reviewer 1:
The reviewer observed that several flame retardant electrolyte ions (FRIONS) based on boron and phosphorous compounds had been developed and characterized.

Reviewer 2:
The reviewer indicated that good progress has been made in the design, synthesis and evaluation of a couple of FRION salts; specifically, two new salts, lithium [$B(DPC)_2$], lithium [B(DPC)(oxalato)], and several LiCRBR salts were synthesized from inexpensive, commercially-available materials and were characterized using a wide array of spectroscopic techniques. The reviewer explained that these salts have been demonstrated to have high thermal stability and also good electro-chemical compatibility, when added to the conventional electrolytes. Further in order to understand the compatibility with battery electrolytes, the reviewer recounted that an in-situ spectro-electrochemical cell has been designed and constructed for performing in-situ Attenuated Total Reflectance (ATR)- Fourier Transform Infrared Spectroscopy (FTIR) measurements of highly reactive systems. Finally, the reviewer reported that gram-quantities of these samples have been sent to DOE laboratories (ANL and LBNL) for their assessment. Overall the reviewer felt that the progress was good, but suggested that the non-flammability of the electrolyte solutions containing only 1-2% of the flame retardant salt is questionable.

Reviewer 3:
The reviewer observed that new materials were synthesized, building the flame resistance into the salt. The reviewer thought that this was a very neat idea, but cautioned that lots of phosphorous compounds have been tried before, and asked the researchers if there were any reasons to expect different results here. The reviewer also liked the spectroscopy work.

Reviewer 4:
The reviewer indicated that not much improvement was observed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer asserted that collaborating with organizations that are experts in flammability is critical.

Reviewer 2:
The reviewer noted that the flammability of the new electrolytes were tested by Dr. Morgan at Dayton University and that Novolyte (a U.S.-based electrolyte developer), LBNL, and ANL carried out cell testing of the new electrolytes.

Reviewer 3:
The reviewer reported that there are several useful collaborations with industry and universities. Additionally, collaborations with the DOE laboratories have recently begun for the material assessment.

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

Reviewer 1:
The reviewer commented that the future plans continue to build a knowledge base of new electrolytes with abuse tolerance and excellent performance in battery operation.

Reviewer 2:
The reviewer felt that the researchers have identified the right path forward.

Reviewer 3:
The reviewer summarized that future studies involve continuing efforts to design, synthesize and characterize new FRIONs and similar safety-enhancing bi-functional materials, and utilize in-situ ATR-FTIR to understand the reactions between the FRION salts and the lithium anode in conventional battery electrolytes, with and without these new salts.

Reviewer 4:
The reviewer remarked that the PI must explain what kind of new approach for design, synthesis, purification, and full characterization of FRIONs and other safety enhancing bi-functional materials will be used.

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

Reviewer 1:
The reviewer reinforced that Li-ion batteries must have greater resistance to their tendency to erupt in fire. As a result, new electrolytes must be available for the next generation of higher performance vehicle batteries. The reviewer explained that this project offers excellent promise and is directed by experienced investigators. The reviewer noted that the early work has already identified several promising electrolyte compositions.

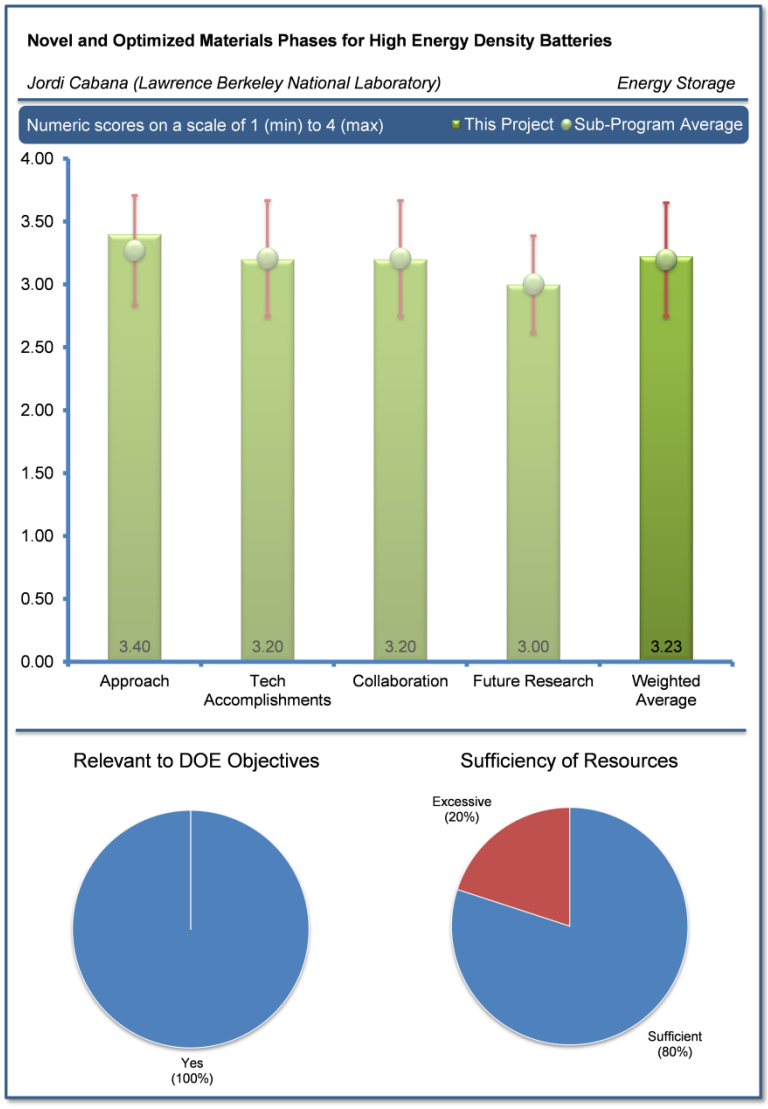
Reviewer 2:
The reviewer explained that Li-ion cells are not tolerant to electrical, thermal, or mechanical abuse, which may lead to thermal runaway. Various mitigation strategies are adopted such as battery management with cell-voltage controls, thermal management with active cooling, and mechanical containment systems for anti-intrusion. In lieu of these extraneous measures, it is better to have an inherently safe Li-ion battery less prone to thermal runaway. The reviewer pointed out that non-flammable electrolytes are being sought in various forms with ionic liquids or with the addition of a flame retardant additive. The present project is developing bi-functional electrolytes, where the flame retardant component is embedded into the electrolytes (as salt). As a result, the reviewer reported that the improvement in safety, as being addressed here, is crucial to the widespread use of Li-ion batteries for PHEVs and EVs.

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

Reviewer 1:
The reviewer stated that the budget of $200,000 per year was consistent with the scope of the project.

Reviewer 2:
The reviewer commented that the resources were adequate for the present proposed work, but suggested that the funding should be expanded to assure success in this important area. The reviewer highlighted that higher capacity was the driving force of previous electrolyte development, but flammability would be essential to enhance the success for future applications.

Novel and Optimized Materials Phases for High Energy Density Batteries: Jordi Cabana (Lawrence Berkeley National Laboratory) - es070



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer said that the researchers used a good mix of materials synthesis and characterization to determine the electrochemical properties related to ordering in $LiNiMnO_4$.

Reviewer 2:

The reviewer noted that the researchers used a good approach in correlating the performance with structure/composition and working with a modeling group, such as Cedar, to explore new high energy materials.

Reviewer 3:

The reviewer summarized that the project was directed towards: understanding the correlation between the $LiNi_{1/2}Mn_{3/2}O_4$ structural properties and electrochemical performance; and synthesizing new Li-M-O-F materials for increased cell voltage and capacity. The reviewer added that this approach may also increase cell safety; for example, fluorine substitution of the $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ material showed improved thermal stability (Kim, 2005).

Reviewer 4:

The reviewer reported that the researchers used good hypotheses and well-designed experiments in this project. The reviewer thought that the work on LMOF compositions builds upon a lot of literature on fluorine substituted materials and may yield novel materials with improved stability. The reviewer highlighted that there is also good fundamental knowledge coming from innovative ways to look at the electrochemistry of the LNMO material. Overall, the reviewer indicated that this project is an excellent blend of synthesis, evaluation, and characterization work.

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

Reviewer 1:

The reviewer explained that the program demonstrated fair progress this past year. The reviewer detailed that the investigators completed the crystal and chemical characterization of $LiNi_{0.5}Mn_{1.5}O_4$ and that good information was obtained in the annealing study about a material that the PI describes as having a rich crystal-chemistry. The correlation between electrochemical performance and the

increasing disorder driven by an extended solid region was also shown. The Li-M-O-F cathode search for materials with substantial amounts of F was initiated.

Reviewer 2:

The reviewer affirmed that the work on correlating structure with electrochemistry is very interesting, and certainly builds the knowledge base. It appears other goals are on target, but the reviewer wished they were more quantitative.

Reviewer 3:

The reviewer mentioned that the work showed a stronger relation between ordering and performance than Mn^{3+} concentration, as well as a determination of the surface chemical/oxidation and effect of fluorine.

Reviewer 4:

The reviewer noted that the manganese-based spinels are known for its oxygen non-stoichiometry, and that when annealing under different atmospheres, one also needs to correlate the oxygen non-stoichiometry in the spinel with the manganese and nickel oxidation states.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the PI is demonstrating good collaboration with other groups that can enhance the investigation, including members within the Batteries for Advanced Transportation Technologies (BATT) program as well as from groups in Spain and France. Additionally, the reviewer stated the presenter noted efforts on partnering with Drs. Wang and Looney at BNL to screen the phase diagrams using in-situ synchrotron XRD.

Reviewer 2:

The reviewer asserted that the project includes a nice group of collaborators. The reviewer particularly liked the spinel focus group, suggesting that this should serve as a model for other technology/chemistry areas.

Reviewer 3:

The reviewer simply stated that the researchers were working with others in BATT and other groups.

Reviewer 4:

The reviewer indicated that the researchers are working with high-voltage spinel, and identified a need to collaborate with researchers working on high-voltage electrolytes.

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

Reviewer 1:

The reviewer explained that the PI's planned future work is a logical extension of the work conducted this year. The reviewer asserted that the plans are sound with efforts shifting attention from understanding the $LiNi_{1/2}Mn_{3/2}O_4$ material's bulk effects to obtaining an in-depth understanding of the surface-electrolyte reactions. The reviewer also mentioned the PI will continue to explore Li-M-O-F in collaboration with the BATT computational teams. The reviewer asserted that prior computational studies by others have been highly successful in accelerating the material discovery and design process, so there is every reason to believe that this method will help here too.

Reviewer 2:

The reviewer asked the researchers to please add some decision points to their future work and whether there are certain targets the researchers want the LMOF work to reach. The reviewer also asked how the researchers will know if they are, or are not, successful.

Reviewer 3:
The reviewer agreed that the approach of focusing on surface effects is appropriate for continuation of project results to date.

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

Reviewer 1:
The reviewer agreed that this project is relevant as it seeks to understand the correlation between the cathode material chemistry and structural properties with electrode performance. The reviewer asserted that such information is critical if DOE is to meet the battery energy density, cost, and cycle life goals.

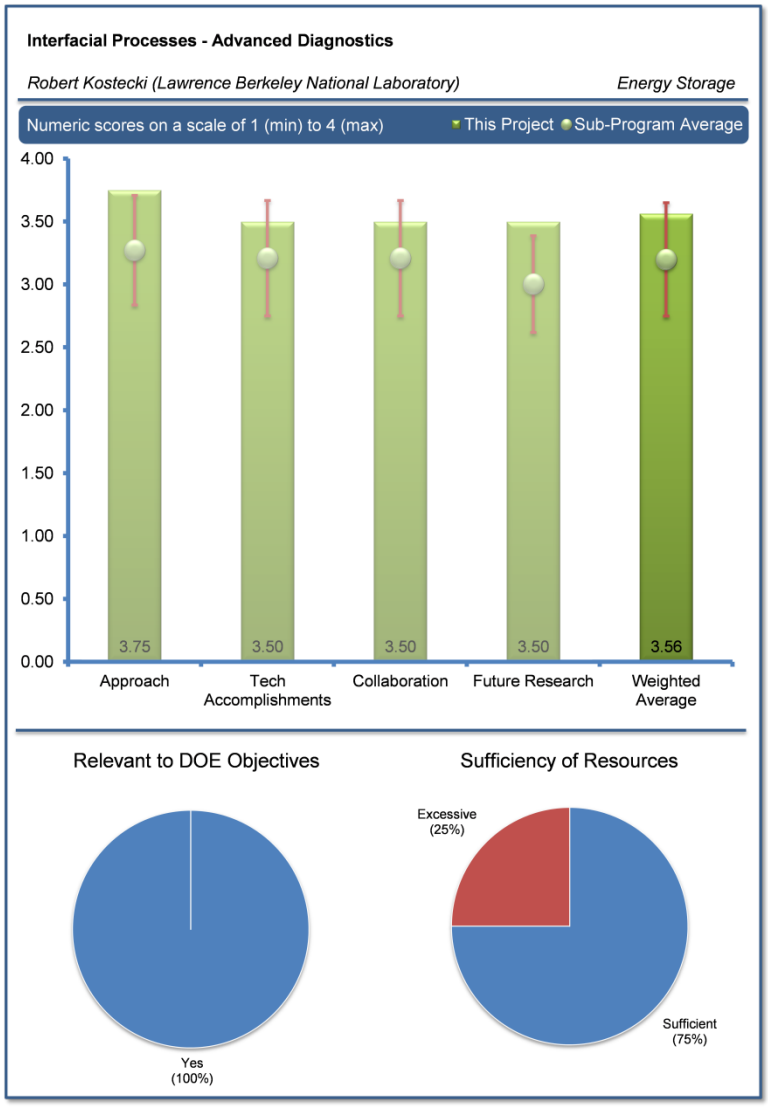
Reviewer 2:
The reviewer commented that high energy density materials are required for vehicle electrification and widespread adoption of BEVs, yet that there are few cathode materials in development right now. The reviewer explained that this project is one of few that reaches out to new chemistries with the LMOF work. In addition, the reviewer noted that the high-voltage material is a good candidate with remaining challenges addressed by this project.

Reviewer 3:
The reviewer stated that the project contributes to the understanding of advanced cathodes for EVs.

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

Reviewer 1:
The reviewer explained that the FY 2013 budget was $450,000, which should be sufficient to complete the planned effort.

Interfacial Processes - Advanced Diagnostics: Robert Kostecki (Lawrence Berkeley National Laboratory) - es085



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed use of in-situ and ex-situ Raman, Fluorescence, FTIR, and electrochemical cell charge-discharge operations to characterize $LiNi_{0.5}Mn_{1.5}O_4$ single crystals.

Reviewer 2:

The reviewer agreed that the approach is excellent.

Reviewer 3:

The reviewer expressed that the project showed excellent work developing in-situ methods to look at SEI formation, which is a critical issue with current organic electrolytes.

Reviewer 4:

The reviewer described that there was good use of in-situ and ex-situ spectroscopy techniques to understand the SEI on high-voltage cathodes.

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

Reviewer 1:

The reviewer mentioned that the project developed new experimental techniques and methodologies to improve Li-ion performance. The reviewer also reported that the project determined that insoluble electrolyte decomposition products accumulate and form electronic and ionic barriers in cathodes which contribute to lowering cell performance. The reviewer also summarized the project finding that manganese and nickel dissolution were identified and the products migrating to the anode interfere with its normal operation. Finally, the reviewer reported that insoluble electrolyte decomposition products form resistive barriers and interfere with normal electrode operation and give rise to an impedance increase in the cell.

Reviewer 2:

The reviewer commented that significant progress has been achieved in identifying organic compounds and M-O vibrational states on the cathode surfaces.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer indicated that collaborations with the BATT Task Groups and industrial partners were in place to improve Li-ion cell performance and understanding.

Reviewer 2:
The reviewer noted that extensive collaborations with a number of groups were mentioned.

Reviewer 3:
The reviewer would have liked to see collaboration with groups working on high-voltage electrolytes so that the project team can leverage the insight on the SEI from this effort to design high-voltage electrolytes.

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

Reviewer 1:
The reviewer described that the approach will apply the novel experimental tools developed in the first stage to develop improved Li-ion cell performance.

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

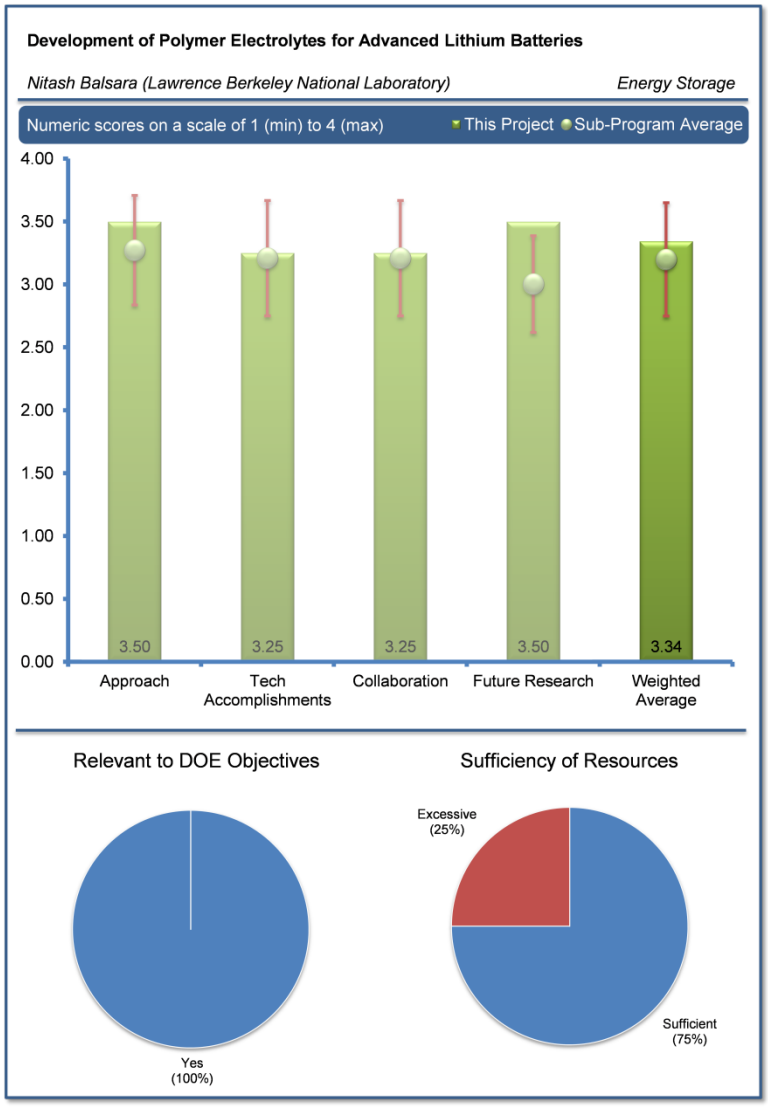
Reviewer 1:
The reviewer explained that a basic understanding of the chemistry and materials is essential in the design and development of improved cell performance.

Reviewer 2:
The reviewer agreed that the project contributed to an understanding of advanced cathodes for EVs.

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

Reviewer 1:
The reviewer felt that the project resources were adequate.

Development of Polymer Electrolytes for Advanced Lithium Batteries: Nitash Balsara (Lawrence Berkeley National Laboratory) - es088



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer acknowledged that this is an unquestionably difficult project as the requirement is for continuous electron and ion paths within the electrodes and continuous ion paths in the separator. The reviewer explained that the use of block copolymers only provides continuous ion paths within the electrodes, and then only if the conductive block is continuous with sufficient area of contact throughout to provide adequate ion conductivity. The electron network must be provided by a sufficient amount of electron conductive material. The reviewer noted that the authors have made such structures, but it was not clear to the reviewer that enough studies have been done using blocking and ion conductive electrodes to measure the capability of both paths in a systematic way.

Reviewer 2:

The reviewer summarized that the project involved developing a new process for: the preparation of nanoporous polymer separators; evaluating the effect of nanostructured electrolytes on dendrite formation; and developing a binder with anion and electronic conductivity.

Reviewer 3:

The reviewer noted that specific barriers were identified, but criticized that the presentation was weak on quantitative data at the full cell level. Generally the reviewer felt the project was well-focused and that the overall approach in different areas was good with work being done by different students, with the PI providing general direction and serving as the representative to the BATT program.

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

Reviewer 1:

The reviewer summarized that the project's accomplishments included: developing a process for preparation of self-assembled separators based on block copolymers; developing a cost-effective process for making nanoporous separator films; developing a binder that conducts ions and electrons; developing an iron phosphate - lithium metal cell with a polymer electrolyte; and developing a new concept for Li-S cells based on solid polymer electrolyte with ORNL.

Reviewer 2:
The reviewer agreed that the developments were good and indicated that most barriers appeared to have been overcome. The reviewer also noted that different work areas were represented by different students working for the PI on different projects, which resulted in a less than optimum integration.

Reviewer 3:
The reviewer offered that the block networked electrode still needs systematic work. Very little full cell data was reported, so it was not clear to the reviewer what the usefulness of the electron/ion conductive polymer blends will be. It was also not clear to the reviewer what effect the new separator material will have on safety or what is the cost saving potential. The reviewer asserted that these are important next steps, but the project seems to be ending without addressing them. The reviewer suggested that collaboration with a separator company would have been valuable in this respect and the reviewer recommended discussion within DOE to address this issue; otherwise, the work will probably not receive a fair test.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated there was more than adequate and relevant collaboration.

Reviewer 2:
The reviewer simply noted the collaboration with Vince Battaglia (LBNL VT program) and Nancy Dudney (ORNL).

Reviewer 3:
The reviewer explained that the collaboration with a spin-off company was fine for the block copolymer work, but criticized that there was a lack of collaboration in the other areas of separator development and redox polymer work.

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

Reviewer 1:
It seemed to the reviewer that the Li-S work was important for the future and the reviewer was happy to see the collaboration with ORNL which seemed to be a leader in this area. The reviewer, however, felt that it would be important to set up some collaboration with interested industrial partners in this area.

Reviewer 2:
The reviewer noted that the present project is ending, and the new program with BATT is focused on developing an all solid-state Li-S cell.

Reviewer 3:
The reviewer mentioned that the plans for work on Li-S system are of interest. However, the reviewer cautioned that there have already been many workers in this area, and asked what was new in this project.

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

Reviewer 1:
The reviewer affirmed that this work is highly relevant to future high energy advanced batteries, as it supports a future all electric economy with important technology for the transportation sector.

Reviewer 2:
The reviewer stated that the project was in line with DOE objectives.

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

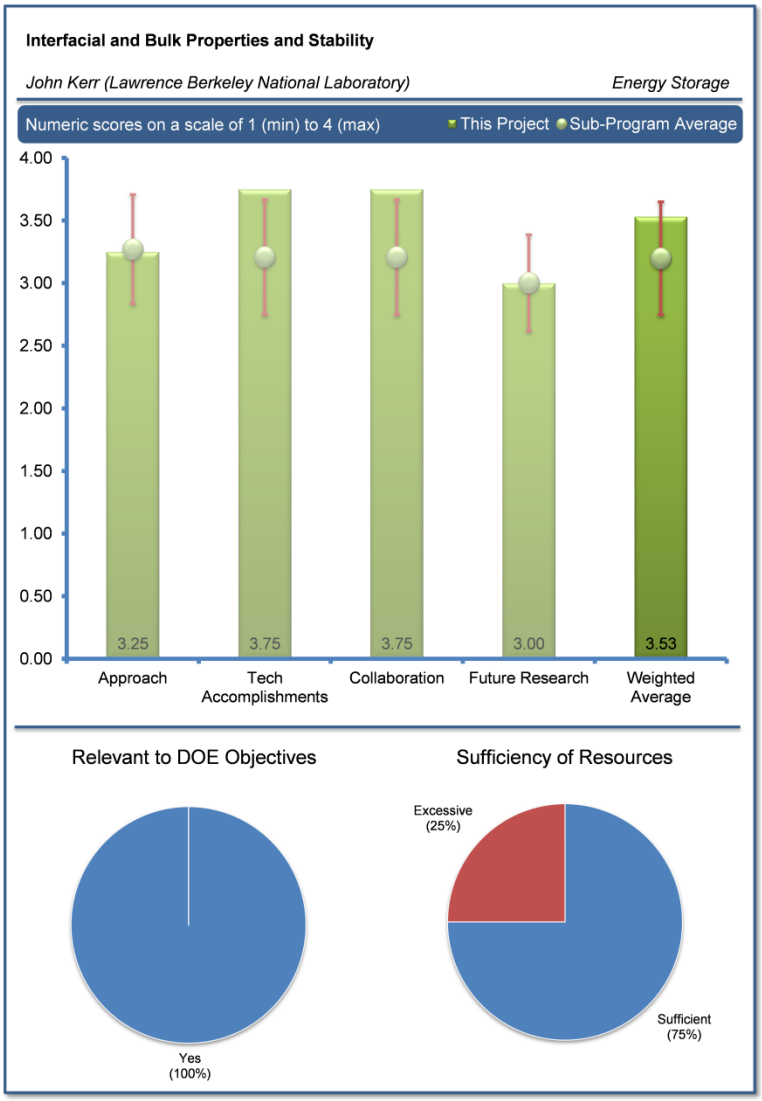
Reviewer 1:

The reviewer felt that sufficient resources were available for the project at this stage.

Reviewer 2:

The reviewer observed that this program was nearly complete and it appeared to have made good use of its resources on a number of different technical topics.

Interfacial and Bulk Properties and Stability: John Kerr (Lawrence Berkeley National Laboratory) - es089



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer simply stated that the approach was good.

Reviewer 2:

The reviewer observed that single ion conductors yield greater coulombic capacity (Ah) and eliminate concentration polarization from cell operation.

Reviewer 3:

The reviewer suggested that integration of some results to the cell level, either by modeling or tests of prototype cell builds with testing, would make results more appreciated by others. The reviewer also suggested that time line charts of progress on specific quantitative goals chosen by the BATT team would also be helpful.

Reviewer 4:

The reviewer expressed that it would be difficult for this polymer electrolyte project to succeed. The reviewer added that the approach to date has shown definite progress, but high interfacial impedance has been a definite stumbling block. At this point, the reviewer cautioned that it does not seem to be known which interfaces are the largest contributors to impedance, and the reviewer would like to see some work directed to this area. The reviewer suggested that the project may be to the point of needing surface active agents as interfacial intermediates.

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

Reviewer 1:

The reviewer highlighted that the project has come a long way and has now shown the feasibility of single ion conducting (SIC) electrolytes with actual battery materials. The reviewer explained that this has required substantial innovative chemical work to adapt a commercial polymer to yield a single ion conductor. The reviewer voiced that considerable work needs to be done to make a practical device, not to mention a competitive one, with existing electrolytes. It was not clear to the reviewer that the solvent additives may weaken the polymer structure to the extent that lithium dendrites may occur and result in battery shorting. It was somewhat disturbing to the reviewer that ether additives have a higher lithium impedance than carbonates. The reviewer suggested that perhaps tetraethylene glycol dimethyl ether was not the best choice for ether additive, since it may have more OH groups than cyclic ethers and yield a higher impedance.

Reviewer 2:
The reviewer commented that the project established that single ion conductors give higher performance in Li-ion cells and that cells with a single solid-state electrolyte single ion conductor give good performance.

Reviewer 3:
The reviewer simply noted that the technical accomplishments are good for the work performed.

Reviewer 4:
The reviewer had difficulty in determining from the presentation exactly what the key quantitative goals were and what the progress towards them was. Also, the reviewer felt it was difficult to tell on numerous collaborators where the responsibility lies, with the BATT or collaborative teams.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that it seemed that there were a number of good collaborations in the project. The reviewer offered that it is important that as many people in the polymer field share the information to advance the field as a whole as it requires a lot of innovation to complete a practical cell.

Reviewer 2:
The reviewer listed the collaborations included: JPL, ABR, Los Alamos National Laboratory (LANL), Energy Research, and PHI Inc. The reviewer also noted the parallel work to the Office of Fuel Cell Technologies as well as Grant Smith (University of Utah), LANL, PHI Inc., Energy Frontier Research Center, and Center for Electrocatalysis, Transport Phenomena, and Materials.

Reviewer 3:
The reviewer commented that numerous relevant collaborative activities were noted and appreciated.

Reviewer 4:
The reviewer simply stated that there was good collaboration.

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

Reviewer 1:
The reviewer confirmed that the need for work on reducing interfacial impedance is clearly evident; however, it was not clear what the approach would be.

Reviewer 2:
The reviewer indicated that future plans will continue on the present direction with synthesis of polyelectrolyte materials, characterization of new materials developed in the project including lithium metal anodes, composite cathodes, and determination of the composition of the SEI.

Reviewer 3:
The reviewer indicated that the proposed future work is a very logical extension of the current work towards achieving the overall goals. The reviewer mentioned that the PI noted that the project will conclude this year and asked if someone else in BATT will take over this work.

Reviewer 4:
The reviewer expressed that the continuation of TFSI and fluoroalkylsulfonate LiMDFB anions attached to both polyether and polysulfone backbones with a range of equivalent weights was okay, but cautioned that a strategy for decreasing the interfacial resistance was missing.

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

Reviewer 1:
The reviewer agreed that this work was clearly relevant to DOE goals; a lithium metal battery could greatly enhance energy density if it has a high current efficiency on the negative electrode.

Reviewer 2:
The reviewer commented that a new single ion conductor electrolyte will significantly improve Li-ion cell performance.

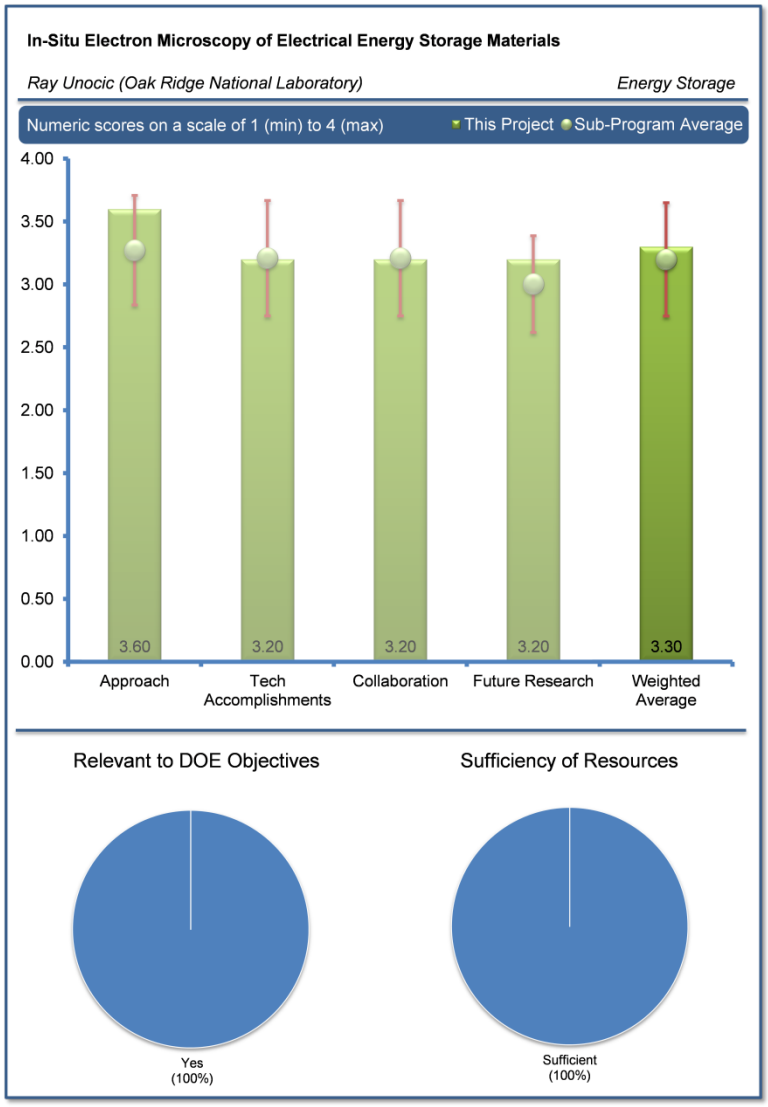
Reviewer 3:
The reviewer acknowledged that this work supported the overall use of EVs to displace petroleum use with all electric transportation technology.

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

Reviewer 1:
The reviewer simply stated that the resources were adequate.

Reviewer 2:
The reviewer indicated that adequate resources were devoted to this project and the single ion conductor technology option.

In-Situ Electron Microscopy of Electrical Energy Storage Materials: Ray Unocic (Oak Ridge National Laboratory) - es095



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer summarized that the work describes another detailed in-situ technique that can be accomplished in real-time. The detailed structural information possible is very good according to the reviewer. For some specialized problems like SEI growth, the reviewer questioned whether the PI was actually measuring representative SEI growth since the spatial development of the SEI was not at all typical of other findings. The reviewer asked whether it was possible that the method of measurement perturbed the situation to change the in-situ nature of the observations.

Reviewer 2:

The reviewer summarized that the project is developing a means to study the effects of nanostructured materials relating to performance and capacity loss on cycling, electrode degradation mechanisms, and safety. The reviewer also described that an in-situ liquid electrochemical cell using scanning transmission electron microscopy spectroscopy was developed to study the SEI layer on anodes. The project also accomplished a chemical analysis using Electron Energy Loss Spectroscopy (EELS) to study electrode surface changes on cycling of electrode structures.

Reviewer 3:

The reviewer mentioned that the project is developing in-situ techniques to evaluate SEI formation which is critical with current organic electrolytes.

Reviewer 4:

The reviewer highlighted that in-situ transmission electron microscopy is a very useful tool for understanding the SEI growth mechanism on electrode material particles. However, the reviewer cautioned that this approach might miss the interaction with other components of the electrode such as the carbon additive that can contribute to the SEI growth mechanism.

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

Reviewer 1:

The reviewer commented that so far, a small set of results have been obtained, but acknowledged that the main advance has been in development of the technique itself, which appears to have made considerable progress.

Reviewer 2:
The reviewer indicated that the researchers developed the experimental tools for in-situ liquid cell microscopy technique and demonstrated the ability to conduct in-situ chemical analysis with Energy Dispersive X-ray Spectroscopy (EDS)-EELS.

Reviewer 3:
The reviewer pointed out that the manganese dissolution mechanism will be challenging.

Reviewer 4:
The reviewer confirmed that the developed technique was able to observe growth, but noted that it was less sensitive to composition than others in program.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed that collaborations were in place with the University of Texas at Austin, ANL, ORNL, and the GM Global Research and Development Center.

Reviewer 2:
The reviewer explained that now that the technique is well along towards development it would be useful to collaborate with structural and preparative material scientists to see what the technique can disclose about their materials and structures.

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

Reviewer 1:
The reviewer explained that the future research will continue studies with different electrolytes, capacity fading on cycling, and dendrite growth mechanisms.

Reviewer 2:
The reviewer observed that each of the future plan projects would benefit from including collaboration with a material scientist with expertise in the particular area.

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

Reviewer 1:
The reviewer agreed that the work was relevant in offering a method to help solve battery problems.

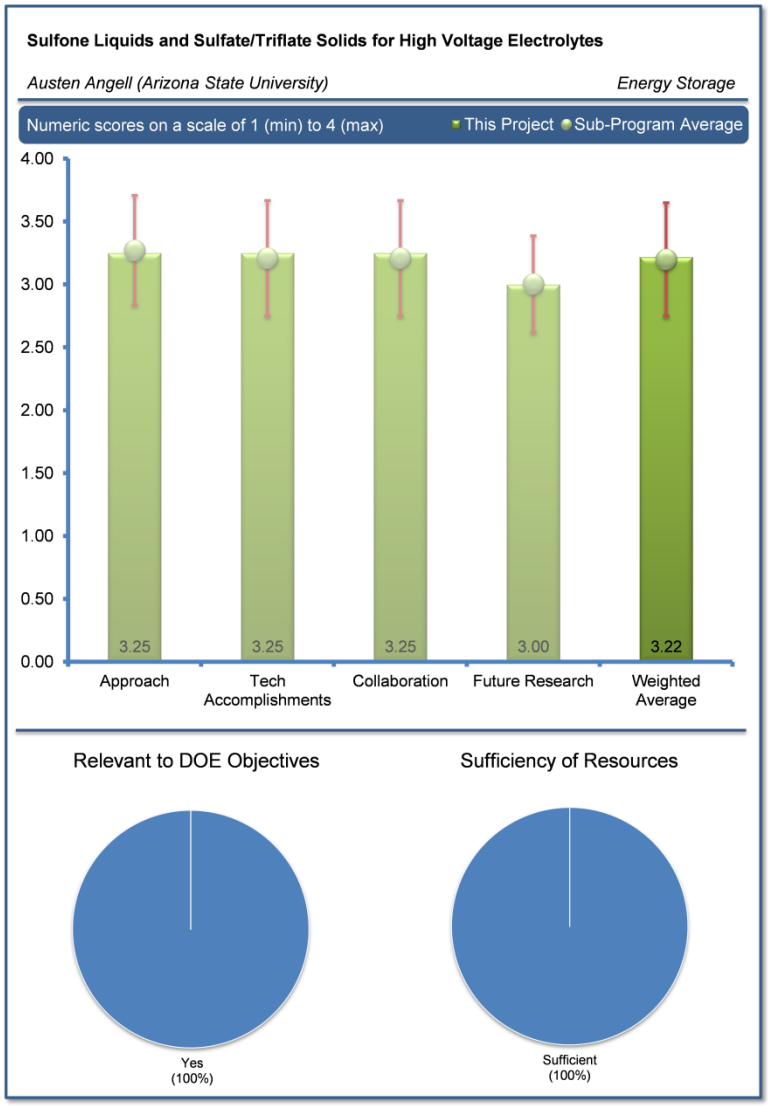
Reviewer 2:
The reviewer indicated that understanding the degradation mechanisms of Li-ion cathodes will lead to improved high performance materials.

Reviewer 3:
The reviewer commented that the project contributed to the understanding of advanced cathodes for EVs.

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

Reviewer 1:
The reviewer felt that sufficient resources were available for proposed work.

Sulfone Liquids and Sulfate/Triflate Solids for High Voltage Electrolytes: Austen Angell (Arizona State University) - es100



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer observed several different investigations of improved electrolyte concepts applicable to lithium and sodium ion batteries. This reviewer also identified potential utility as high voltage electrolytes. The reviewer reported that each project was done by a different student. This reviewer concluded that demonstration at the cell level in full cells still had to be done.

Reviewer 2:

The reviewer noted development of new electrolytes based on ionic liquids composed of sulfone, superionic glasses, conducting polymers, and ceramics.

Reviewer 3:

The reviewer stated that the approach has been somewhat scattered over the past couple of years, but hopefully the new emphasis on polymer electrolytes will now receive more concentrated effort.

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

Reviewer 1:

The reviewer indicated that the sulfone electrolytes have not been found to be satisfactory and a new approach is needed. The polymer electrolyte work is certainly a new approach and some progress has been made.

Reviewer 2:

The reviewer reported new materials with: solid electrolyte conductivity similar to that of most liquid electrolytes, electrolytes that do not dissolve manganese and nickel from the cathode, single species conductivity, and new sodium ion conductors.

Reviewer 3:

The reviewer indicated good progress in that several alternatives have been developed. These alternatives compare favorably with Japanese work on solid state crystalline electrolytes. This reviewer also noted work on sodium electrolytes.

Reviewer 4:

The reviewer would like to know how to make the electrolyte dense.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that existing collaborations appear to be more than adequate.

Reviewer 2:
The reviewer reported project partnering with Utah, LBL, University of Rhode Island, and PNNL.

Reviewer 3:
The reviewer suggested that the PI collaborate with some battery makers and testers to accelerate the evaluation of ideas. This could have saved a lot of time in the sulfone work.

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

Reviewer 1:
The reviewer noted that plans for future work are reasonable.

Reviewer 2:
The reviewer stated that this project is ending. Existing plans are adequate except for the need for full cell testing of new concepts.

Reviewer 3:
The reviewer felt that it is not clear from the presentation what the proposed future research will entail.

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

Reviewer 1:
The reviewer felt that new electrolytes are definitely relevant to DOE goals.

Reviewer 2:
The reviewer noted that new electrolytes are required to meet the future goals for cell performance.

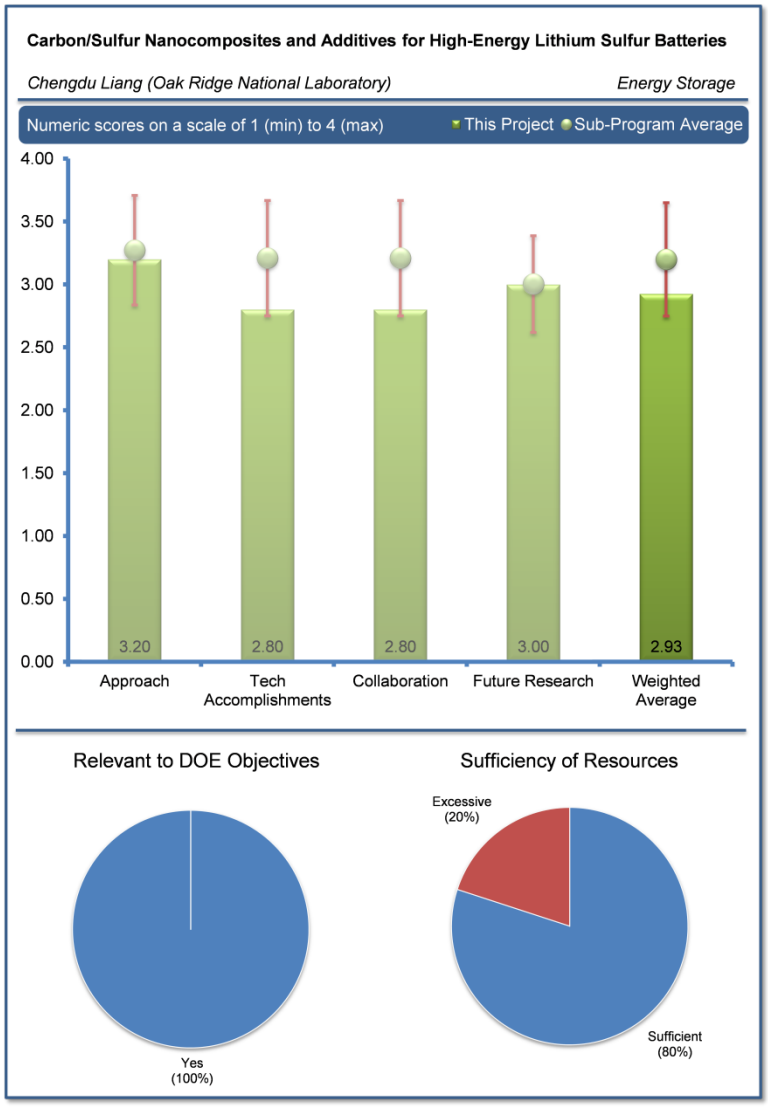
Reviewer 3:
The reviewer reported that this project is very relevant to the development of high energy batteries needed in the transportation sector for all electric vehicles with long range and high levels of market penetration.

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

Reviewer 1:
The reviewer stated that funding is in the right order of magnitude.

Reviewer 2:
The reviewer indicated that program resources are more than adequate to support this level of work.

Carbon/Sulfur Nanocomposites and Additives for High-Energy Lithium Sulfur Batteries: Chengdu Liang (Oak Ridge National Laboratory) - es105



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that this work has developed very well. From the unsuccessful attempts to make liquid electrolyte lithium sulfur cells with adequate cycling, the work has moved in the direction of finding a suitable solid electrolyte having good compatibility with the sulfur cathode, and an improved cell was constructed. The reviewer reported that the positive electrode still had serious deficiencies so an improved polysulfide material was developed that has shown positive results.

Reviewer 2:

The reviewer indicated the approach to include improving the conductivity of the sulfur electrode using mesoporous carbons, block the polysulfide shuttle to extend cycle life, and develop new high performance electrode structures leading to an all solid state battery system.

Reviewer 3:

The reviewer stated that the approach is good.

Reviewer 4:

The reviewer reported the approach is developing Li-S battery chemistry and investigating critical polysulfide issues.

Reviewer 5:

The reviewer noted that the solid state electrolyte is a good approach to mitigate soluble polysulfide issue but room temperature (RT)/low temperature performance is a concern for solid state electrolyte.

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

Reviewer 1:

The reviewer stated that the technical accomplishments were very good as an interesting new lithium/solid electrolyte/ complex polysulfide cell has been discovered.

Reviewer 2:
The reviewer summarized accomplishments such as developing all solid state cells with good cycle life and high rate performance and new solid state electrolytes with good conductivity.

Reviewer 3:
The reviewer asked how to further improve the Li_3PS_4 ionic conductivity and also enable it to work at room temperature.

Reviewer 4:
The reviewer felt the project made very good progress toward electrode optimization and understanding of polysulfide mechanisms.

Reviewer 5:
The reviewer stated that long-term stability of the solid state electrolyte versus Li still remains unclear. Li_2S-P_2S_5 system was explored in the 1980's and did not have long-term stability with metallic Li.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that work was carried out primarily at Oak Ridge with little outside collaboration.

Reviewer 2:
The reviewer stated good collaboration.

Reviewer 3:
The reviewer indicated collaboration mostly within ORNL.

Reviewer 4:
The reviewer felt that it would be helpful to go outside of ORNL to add to collaborations and get some additional input into the possibilities of this new system.

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

Reviewer 1:
The reviewer stated that the PI has presented an excellent program for future research. The reviewer observed encouraging work with mixed cathodes in addition to those listed as at least in the case of TiS_2-S mixtures, very good cycling with high capacity has been found (A. Garsuch et al, Abstract 160 221st ECS Meeting, 2012). There are other very good mixed conductors such as MoS_2 which could be considered.

Reviewer 2:
The reviewer stated that the proposed program is on the right path for continued progress to develop a commercial Li-S battery.

Reviewer 3:
The reviewer noted future work to develop new sulfur-rich compounds with ionic conductivity greater than 10^{-5} S/cm. Explore solid electrolytes of high ionic conductivity and low interfacial resistance.

Reviewer 4:
The reviewer stated that no future work was proposed to improve RT and low temperature performance, and to validate long-term stability versus Li.

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

Reviewer 1:
The reviewer noted the project was highly relevant to improved energy density and specific energy.

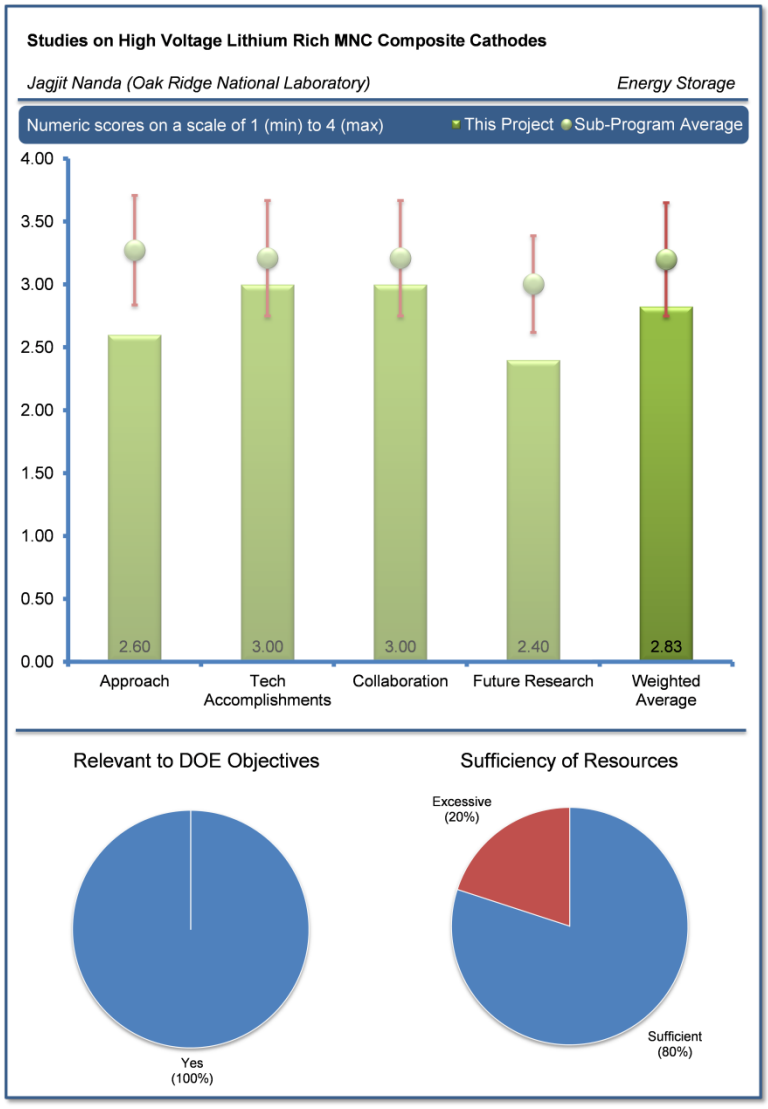
Reviewer 2:
The reviewer stated that new high-performance, all solid state lithium-sulfur batteries could replace the Li-Ion cells in future designs.

Reviewer 3:
The reviewer commented that the project contributes to the understanding of advanced batteries for EVs.

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

Reviewer 1:
The reviewer indicated sufficient resources for the proposed work.

Studies on High Voltage Lithium Rich MNC Composite Cathodes: Jagjit Nanda (Oak Ridge National Laboratory) - es106



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the PI's approach to achieving good electrode performance is sound and justified (Slides 5-7). Cell limitations are clearly explained and a mitigation strategy is provided.

Reviewer 2:

The reviewer reported that the project addresses a number of approaches to better understanding performance limitations in layered-layered materials, and a means to mitigate. Multiple approaches reduce risk of failure. The researchers use good hypotheses to guide experiments, and understand the need for good characterization methods.

Reviewer 3:

The reviewer noted that the coating on particles [e.g., atomic layer deposition (ALD) coated on $LiCoO_2$] was shown by many groups to reduce reactivity and improve performance at high voltages. It was not clear how any coating on electrode (versus particles) can reduce reactivity, given that the majority of the high voltage electrode is still in contact with liquid electrolyte.

Reviewer 4:

The reviewer stated that there is a wide mix of approaches to address performance issues. The reviewer commented that the project does not give the impression of a fundamental understanding; it is more Edisonian.

Reviewer 5:

The reviewer stated that the approach is good, but this approach has been already performed by Y.S. Park in Kangwon National University, Korea. The reviewer would like to know what the new approach is.

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

Reviewer 1:

The reviewer noted that the program's progress since the last merit review has been very good. The EIS studies and materials characterization of the LMR-NMC materials and electrode has been completed. The reviewer reported that the interfacial stability of

the electrode by Lipon coating has been demonstrated and full cell studies of the material coupled with A-12 graphite are in progress. It is noted that the results of these investigations are being documented in the form of a journal article to the J. Mater. Chem.A.

Reviewer 2:
The reviewer investigated a number of systems and demonstrated some improvement in performance with LiPON coating.

Reviewer 3:
The reviewer indicated that there are not specific quantitative milestones or targets for this project and there would be some benefit to defining these. Nevertheless, the researchers are doing a lot of work and providing fundamental understanding for next experiments.

Reviewer 4:
The reviewer asked were the results based on single cell or multiple cells for each coating level. It was difficult to understand how few nm of coating on the electrode had such a big improvement on cycle life. The reviewer stated that the bulk of the electrode was still in contact with liquid electrolyte at 4.9V, which should result in electrolyte decomposition [and possibly carbon black (CB) decomposition] on long-term cycling, especially at slow rates such as C/10. So, it was surprising that the project team was able to obtain such good cycling data.

Reviewer 5:
The reviewer stated that the technical accomplishments are similar to other work. Thicker and thinner coatings have similar capacity retention on extended cycling at 60ºC, but thicker coating degrades faster at room temperature. The reviewer would like to know if the PI can explain this behavior.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated good teamwork.

Reviewer 2:
The reviewer noted that good collaboration appears to exist in the program. The PI is partnering with excellent scientists within the national laboratories as well as partnering with industry.

Reviewer 3:
The reviewer noted that the researchers appear to work well with the entire team working on VF, and are incorporating the Argonne protocol for determination of VF. Collaboration with Daniel Abraham on the characterization is a key strength.

Reviewer 4:
The reviewer indicated a few collaborators.

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

Reviewer 1:
The reviewer indicated that the proposed work is clearly justified. Efforts will continue to stabilize the LMR-NMC phase without compromising capacity. This will include testing of materials that are synthesized by their collaborators.

Reviewer 2:
The reviewer reported that there was no follow-up work on the LiPON coated electrode, given the demonstrated good cycle life. The project needs to demonstrate good cycle life performance using LiPON coated electrode in full cells. The reviewer asked can the LiPON coating on the electrode be scaled up for manufacturing.

Reviewer 3:
The reviewer suggested providing more quantitative targets with decision points.

Reviewer 4:
The reviewer asked how the continued work on the capacity fade analysis at a full cell level for high voltage LMR-NMC cathodes will help the degradation.

Reviewer 5:
The reviewer said a mix of things, lacking focus.

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

Reviewer 1:
The reviewer asserted that this project supports the DOE objective of petroleum displacement. Undertaking advanced materials research in the area of high capacity electrode materials for lithium ion batteries will help DOE accomplish the technical target goals for the EV and 40 mile PHEV.

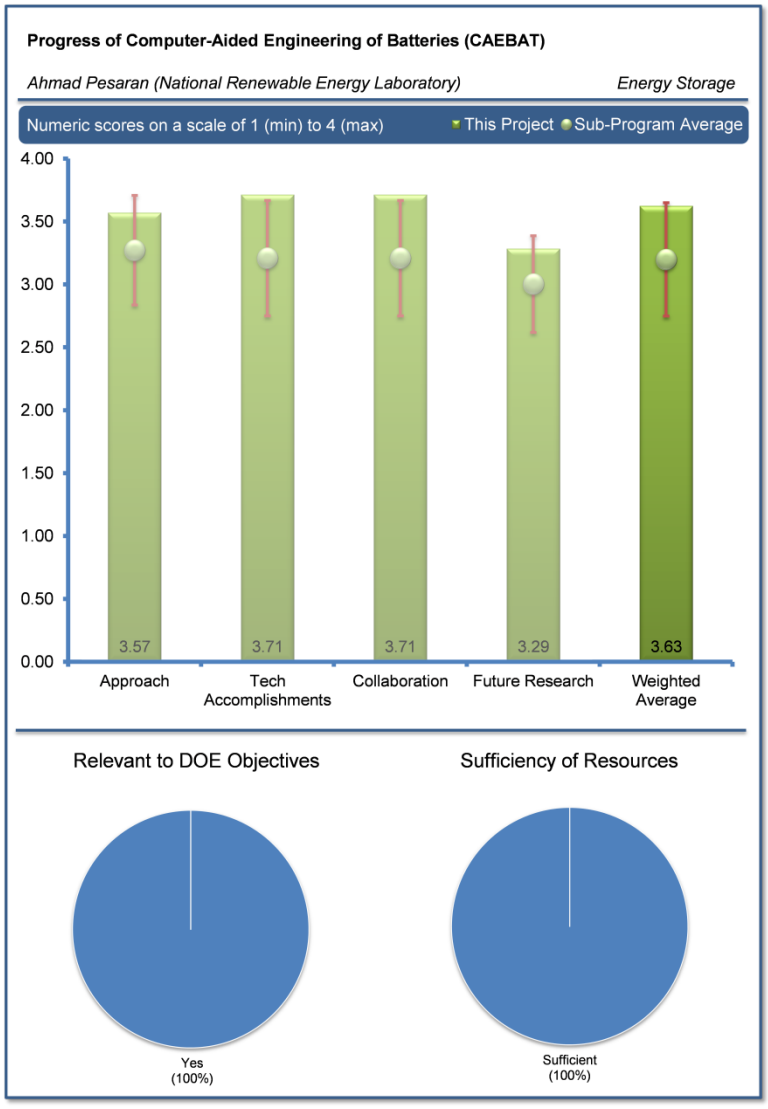
Reviewer 2:
The reviewer stated that the layered-layered material has the potential to enable high energy density cells necessary for widespread adoption of BEVs in the United States. This project directly addresses some of the remaining issues in the development and commercialization of this material.

Reviewer 3:
The reviewer noted that the project contributes to understanding of advanced batteries for EVs.

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

Reviewer 1:
The reviewer noted that the program appears to have the necessary resources to complete the milestones on schedule.

Progress of Computer-Aided Engineering of Batteries (CAEBAT): Ahmad Pesaran (National Renewable Energy Laboratory) - es117



Reviewer Sample Size

A total of 7 reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the approach was excellent with very clear objectives; project start/stop dates, go/no go decision points and milestones. Multi-path development of Computer-Aided Engineering of Batteries (CAEBAT) tools has allowed for development of three modeling tool versions that are or will soon be commercially available. The reviewer indicated that this will allow customers to customize the model for their system and keep modeling development cost at a minimum.

Reviewer 2:

The reviewer reported outstanding results based on strong collaboration with other institutions and in particular with industry.

Reviewer 3:

The reviewer indicated that CAE models are critically necessary for automotive battery pack design, particularly for automotive manufacturers and Tier 1 suppliers. The closed/proprietary nature of the models under development limits their usefulness by researchers outside of the three project teams or for technology evaluation and cost analysis by federal regulatory agencies. The reviewer stated that it is not clear to what extent software will be made available outside of the specific collaborations.

Reviewer 4:

The reviewer reported that this is a well-structured, highly ambitious project with a considerable added value when successful. One necessary condition for its success is an effective coordination of activities within and between the three sub-projects with guarantees of timely and appropriate cross-fertilization. The reviewer noted that based on the evidence presented this seems to be the case, but it will remain one of the main challenges.

Reviewer 5:

The reviewer stated that the goals are very challenging in setting up the joint development work among the industry OEMs, DOE labs, and software companies.

Reviewer 6:

The reviewer commented this was a novel initiative and well structured. Some activities appear to be potentially redundant.

Reviewer 7:
The reviewer noted that it is useful to have an integrated model from materials to pack level. But it is not clear if this will really shorten the battery design cycle since validation testing takes time and difficult to shorten the validation testing time.

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

Reviewer 1:
The reviewer indicated excellent progress if one considers that not much work has been done in this area previously. The very comprehensive approach taken by the authors is ambitious and very good.

Reviewer 2:
The reviewer stated that NREL transferred their deliverables to the industry partners, which is a big accomplishment. Also, all three industry partners have released their codes. The reviewer commented that ORNL is also doing their part efficiently.

Reviewer 3:
The reviewer referenced comment in previous question on redundancy. The reviewer stated that progress has been excellent, and commercial products are being delivered. One of the software packages is considered a de-facto industry standard.

Reviewer 4:
The reviewer commented that technical progress reported over the last year is substantial. There seem to be good chances for reaching the project goal of delivering a tool that will allow shortening design time through the developed models and the interfaces between them. The reviewer questioned how the final product will be able to provide output and guidance on cost and safety.

Reviewer 5:
The reviewer stated that the project is on schedule to meet the initial goals despite stating that the project is only 40% complete. Big concern may be what the validated portion of the project objectives means. The reviewer reported that beta versions of the software have been released or will be released this year for commercial use.

Reviewer 6:
The reviewer suggested providing an example of how CAEBAT has shortened the battery design cycle since its initiation in 2010.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer indicated that the authors have done a great job in this area. The collaboration with industrial partners seems very important and in this project it appears that it has been a priority.

Reviewer 2:
The reviewer stated the project was a model for multi-level industry-government-academia collaboration.

Reviewer 3:
The reviewer stated that multiple real world end-user collaborators and interaction opportunities allowed this project to make excellent progress.

Reviewer 4:
The reviewer indicated that the list of collaborators was quite impressive. The division of the collaborators into three teams makes sense from a standpoint of project management.

Reviewer 5:
The reviewer stated that the necessary internal coordination seems quite okay. No evidence is presented on Slide 27 on interaction with non-project participants.

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

Reviewer 1:
The reviewer felt that the authors are going in the right direction. The combination that goes from electrode level to cell and pack level research is very comprehensive and can give important information about thermal management, aging, cycle life, etc.

Reviewer 2:
The reviewer indicated that barriers are defined by both users and creators. Both have a forum whereby their issues may be addressed. Open s/w architecture facilitates flexible response to technological barriers. The reviewer recommended that design iteration throughput improvement be demonstrated, when compared to conventional, stratified analysis design software.

Reviewer 3:
The reviewer noted looking forward to seeing the results of future validation work.

Reviewer 4:
The reviewer reported that one key concern was the validation of the model and the inclusion of an aging and abuse modeling capability. This and several other areas are addressed in the proposed future work and the multi-collaborator approach will be followed again.

Reviewer 5:
The reviewer reported that the new solicitation will continue to develop the models which will accelerate the development process.

Reviewer 6:
The reviewer stated that the information provided on future work in Slide 28 is both logical and purpose-oriented. In addition to the research work, internal project coordination should also remain at high level in the future and probably will require even more effort in view of the 60% work remaining for the 1.5 years until project closure.

Reviewer 7:
The reviewer commented that instead of focusing on shortening the battery design cycle, it will have more impact to model degradation at the materials and cell level over the PHEV or BEV temperature range. This might shorten the testing time. In addition the modeling results from the materials and cell aging can feed into the modeling design at the module and pack level, in order to mitigate the aging impact.

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

Reviewer 1:
The reviewer reported that the ability of both battery suppliers and vehicle manufacturers to quickly identify the potential capabilities of various batteries under different usage scenarios is critical to helping OEM senior management to make the appropriate decisions on the development of an electrified vehicle powertrain. This project provides multiple tools to facilitate those decisions and reduces the need for additional in-house modeling activities and the associated costs.

Reviewer 2:
The reviewer asserted that the project supports the overall strategy of DOE of petroleum displacement by focusing on very practical problems such as cycle life and abuse tolerance that go all the way from one single electrode to a cell, and finally to a battery pack.

Reviewer 3:
The reviewer noted that the software programs can be used to facilitate the development of optimum cell-system combinations.

Reviewer 4:
The reviewer suggested that the objectives need to be achievable.

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

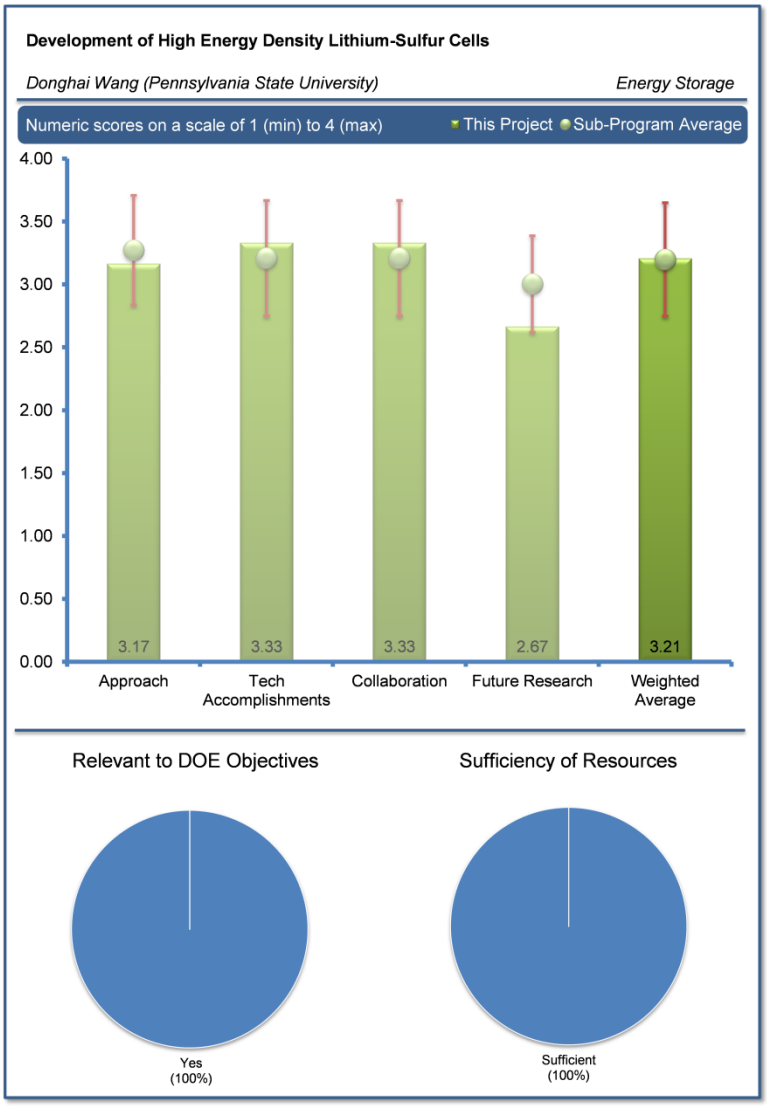
Reviewer 1:
The reviewer indicated that this is a very interesting model of sharing the cost of a project with contractors. If the authors come up with additional or very important practical implications such as improving the life of the battery or if the authors manage to develop a simplified thermal management for a battery pack, the project team should consider the need for additional funding.

Reviewer 2:
The reviewer stated that the resources are in agreement with the project needs.

Reviewer 3:
The reviewer commented no issues.

Reviewer 4:
The reviewer offered that one sub-project led by GM is much larger in resources that the other two. It is unclear how this impacts the overall project structure and whether it may bias the final outcome of the project.

Development of High Energy Density Lithium-Sulfur Cells: Donghai Wang (Pennsylvania State University) - es125



Reviewer Sample Size

A total of 6 reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the goal of this project at Penn State University (PSU) is to develop a full lithium-sulfur battery system for high energy density, efficiency, and good cycle life. The project has so far taken baseline measurements on lithium-ion (nickel-manganese-cobalt, or NMC cathode) cells, with the lab also concurrently developing a lithium-sulfur (Li-S) cathode material. The reviewer indicated that it has scaled up production of this material to 50 g batches. The thermal safety of many of the Li-S cell components has been characterized. Partners in this project have been developing two different anode materials and an electrolyte. The reviewer summarized that the idea is for each respective partner to create their best material, and for the project member to bring these together into cells down the line. Initial complete cells will be 1 Ah in capacity, with the goal of achieving 4 Ah-sized cells. Though these components have been brought together in full cells that have been tested, the most challenging part of the experiment lies ahead.

Reviewer 2:

The reviewer reported an excellent approach to addressing the key material issues associated with the Li-S cell. The approached was greatly enhanced by the collaboration team that was assembled. The reviewer felt this allowed the teams to use their expertise on specific aspects of the cell rather than trying to handle all of the issues.

Reviewer 3:

The reviewer stated that the work structure was good. The study was particularly good in defining the tasks to be achieved, and in translating metrics to the material, and then maintaining a constant scaling method to the test vehicles, so that material performance could be tracked, and translated to a meaningful cell metric. The reviewer recommended more generous use of the baseline cell performance, for data tracking and comparison.

Reviewer 4:

The reviewer stated that the approach was focused and had a well-paced plan and progress.

Reviewer 5:

The reviewer commented that the approach does not include the ionic barrier on Li anode. The barrier is necessary to improve the cycle life and self-discharge.

Reviewer 6:

The reviewer noted that the polymer electrolyte for S cathode has been tried previously, and is not sure what is new here.

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

Reviewer 1:

The reviewer reported that the vast majority of the work shown is new since the 2012 AMR. The project aspires to make complete Li-S cells, and has already made early versions of this coupling, as well as the baseline NMC cells. The reviewer noted that it should be made clear in cycle life measurements going forward what depth of discharge was used for the tests in the PSU lab; INL should be measuring cells according to their standard protocols. The reviewer stated that component materials of the first batch of Li-S cells (anode, cathode, electrolyte) have been made and tested for their individual properties, such as cycling stability and thermal stability. In addition to the composite lithium-based anode that was in its original plans, this year the PSU team also investigated a silicon anode. The reviewer also indicated in progress since last year, the team has tested four generations of sulfur-carbon cathode materials that were developed for their sulfur-trapping properties and charging rate performance. New electrolytes from both ANL and PSU have been tested, and the capacity retention versus cycle number has greatly increased since the single electrolyte for which the team shared data last year (presumably the baseline electrolyte was $LiPF_6$). The reviewer reported that self-discharge of Li-S cells with PSU's novel electrolyte was greatly improved over that with a baseline electrolyte. The PSU team has also tested silicon/sulfur full cells (not 1 Ah pouch cells yet, probably coin cells), which so far have been successfully cycled (albeit with a short cycle life, with a great loss of capacity over only 40 cycles). The reviewer stated that the project team has analyzed the reason for the capacity loss and ascribed the cause to sulfur loss from the cathode. The project team also reported on some additional technical challenges the team needs to investigate further in the reviewer-only slides. The team has moved its milestones forward a few months and is thus accomplishing the phases of research earlier than it stated it would in its 2012 presentation.

Reviewer 2:

The reviewer stated that the progress is very good and should meet the project objectives on time. The cycling life, however, is still not where it needs to be. Additionally, the temperature performance while excellent the high temperature needs significant work to meet the cold temperature performance that is needed. The reviewer noted that more effort should be directed at this issue.

Reviewer 3:

The reviewer reported some minor issues in the method of presentation of data (e.g., no control/baseline clearly indicated on Slide 10). The reviewer commented please ensure the date presentations are self-supporting and unambiguous. Once this issue was cleared, all results were obvious, and supported the claims of progress. The reviewer suggested to please be more explicit on test procedures applied, when presenting data and results (e.g., cycling conditions used on Slide 12). The reviewer would like to clarify whether the same lab performed testing on both materials, for example.

Reviewer 4:

The reviewer stated that although progress has been made in self-discharge reduction, greater emphasis and focus on this would be desirable as the current capability in the best case seems to be show-stopping.

Reviewer 5:

The reviewer noted that the self-discharge was more than 72% per month; it should be about 2-3%/month at 40°C.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer indicated that the PSU group is collaborating with ANL on electrolyte development and testing, which is being done concurrently. It is also working with EC Power and Johnson Controls (JCI) on two different anode materials designs, and both of these companies are also working with PSU on overall cell design and testing. The reviewer stated that PSU also worked with ANL, JCI, and EC Power to set strong project baselines. Idaho National Lab is doing testing of its baseline cells.

Reviewer 2:
The reviewer noted that the project allowed the different collaborators to make full use of their technical strengths and this allowed the project to move forward.

Reviewer 3:
The reviewer felt that this is a strong team. Excellent collaboration exists. The reviewer recommended that the activities of each partner be more clearly called out on the slides (example Slide 12 – reviewers see who provided the materials, but not who made the cells and who tested them).

Reviewer 4:
The reviewer indicated a well-balanced team of partner capabilities.

Reviewer 5:
The reviewer felt it is not clear if the collaborators are proving the anode protection to eliminate anode reaction with Li polysulfides.

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

Reviewer 1:
The reviewer stated that the PSU team seems to be pursuing the logical pathways to overcome the performance issues it has seen with the electrolyte and electrode materials. In the reviewer-only slides, the project team noted some particular challenges they are facing with their novel materials now that the team has begun to assemble these into cells. The reviewer indicated that the project team specifically noted the following: Self-discharge for high-loading electrodes has been difficult to curtail, and the team will need to investigate electrolytes that can prevent polysulfide diffusion and the polysulfide shuttle; and silicon-based anodes show significant voltage fading when paired with the sulfur cathodes. The team needs to find a way to counteract this fading or else focus on the composite lithium-based anode; hitting the energy density goal of 600 Wh/L will require increasing the stable capacity and cathode loading, which the team needs to work towards by optimizing the electrolyte, cathode composition, and coating techniques. The reviewer summarized that plans do build on their past progress and are generally focused on overcoming barriers.

Reviewer 2:
The reviewer acknowledged almost having given a score of 2. The investigators have correctly identified the most significant barriers to their research, but were very general in the approach to be taken in addressing these barriers. The reviewer felt given the challenges faced by this electrochemical system, the description provided by the PI may have been appropriate.

Reviewer 3:
The reviewer stated that there is a need for improved low temperature performance. It is not clear if work will continue on both anodes or there will be a downselect somewhere.

Reviewer 4:
The reviewer stated that the Si anode may provide better life and performance.

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

Reviewer 1:
The reviewer stated that developing a lithium-sulfur battery that has a very high energy density and that can be manufactured as a viable automotive product in a cost-effective fashion would go a long way towards helping to bring down the cost of PEVs. A battery that would make a PEV a cost-competitive purchase against a conventional internal combustion engine (ICE) vehicle absolutely supports the DOE objective of petroleum displacement.

Reviewer 2:
The reviewer noted that this project seeks to increase the energy density of the high voltage (HV) battery systems that will be the near term vehicle propulsion systems.

Reviewer 3:
The reviewer indicated that the Li-S system may offer a closer solution to beyond lithium-ion than its counterparts. It is essential that alternative approaches to resolving rapid capacity fade and fundamental cell design be investigated.

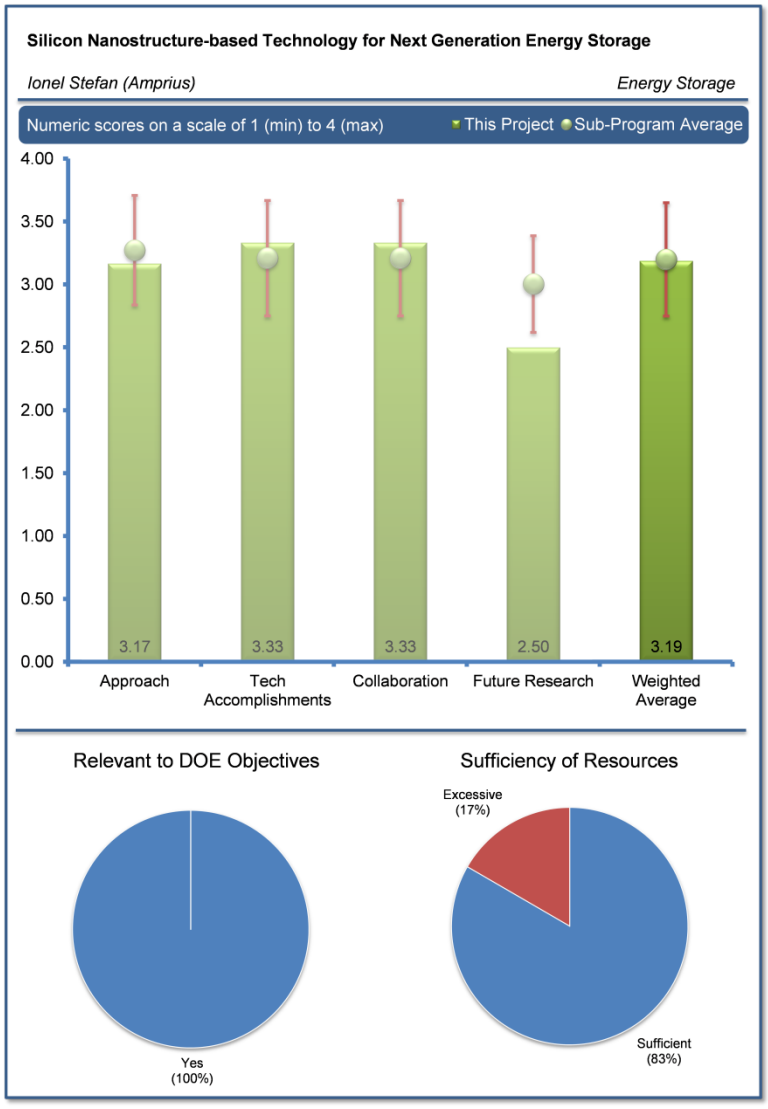
Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented that the project appears to have made significant progress since AMR 2012 on the funding the project has received.

Reviewer 2:
The reviewer stated that the resources are adequate for this project.

Reviewer 3:
The reviewer noted that the collaboration within the team appears to be sufficient, to support the activities called out in the project. There is appreciable risk in this project, with respect to electrolyte development. More fundamental science may need to be driven by the project, in order to achieve its goals.

Silicon Nanostructure-based Technology for Next Generation Energy Storage: Ionel Stefan (Amprius) - es126



Reviewer Sample Size

A total of 6 reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that Amprius' approach to this work is to establish baseline measurements of its silicon nanowire anode structure (which has a unique property in that the Si nanowires are attached to the current collector metallurgically as opposed to through chemical characteristics) with commercial cathode materials such as nickel cobalt manganese (NCM) and nickel cobalt aluminum (NCA). It is making full cells with its anode materials and cathodes being developed in partnership with BASF and Yardney.

The reviewer indicated that the performance targets in the project objective have relaxed a little since 2012. Last year the target figures were greater than 900 Wh/L energy density, greater than 400 Wh/kg at1,000 cycles, and in 2013 they were listed as greater than 680 Wh/L energy density, greater than 330 Wh/kg at 300-1,000 cycles. The reviewer reported that the energy density objectives grew more specific, at NCM 523 (523 is a particular NCM chemistry) or lithium cobalt oxide (LCO) cathode and balance of cell components exceeding 250 Wh/kg. But the PI mentioned during the poster session that Amprius had to change the direction of its research last year due to problems with the scale-up of its anode materials.

Reviewer 2:

The reviewer noted that the boundaries and goals of the project were well defined. The investigation pathway design supports those goals and boundary definitions.

Reviewer 3:

The reviewer stated that the overall approach is sound and has clearly stated objectives that outline most of the main technical barriers of the objectives; the development and demonstration of a silicon anode that replaces the carbon anode to improve energy density, while maintaining life and performance. The reviewer articulated a main concern, that there is no reference to how the mechanical stability of the system is or will be addressed. This is a critical characteristic for this system. Also there is no clear reference to how temperature performance will be addressed. Finally the reviewer indicated that since neither of these issues is identified as barriers, the concern is that solutions will come about that do not support these issues.

Reviewer 4:

The reviewer commented that insight into challenges or practical feasibility of deposition process is missing.

Reviewer 5:
The reviewer stated that the approach can be improved by selecting higher energy cathode material, e.g., layered-layered compound and limiting the anode specific capacity to match the cathode to meet 1,000 cycles.

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

Reviewer 1:
The reviewer reviewed that Amprius has matched its silicon anodes to NCA cathodes in cells made in its laboratory and seen an improvement in cycle life. It has tried various formulations of electrolytes with additives that have had a strong effect on the cycle life of its cells. The reviewer reported it has created a cell that has achieved a cycle life of around 800 to 900 cycles before the performance diminishes to 80% of the initial charging voltage (cycles are at 80% depth of discharge). The PI mentioned that Amprius' research took a 90-degree turn over the past year due to a problem with scale-up of its materials. The reviewer noted that its plans clearly changed, as in 2012 the team had planned to have an anode with a 1,000-cycle life, which is a goal that they have had to relax.

However, even if the research did not develop in the originally intended direction over the past year, the team has much to show for its efforts such as: improved anode design to enable longer silicon cycle life; improved stability of the Solid Electrolyte Interface (SEI) that forms on the surface of the silicon electrode; identified additives that extend silicon cycle life; qualified NCM cathode materials to be integrated into the baseline cells; and designed, built and delivered 18 baseline cells matching graphite anodes with NCM cathodes. The reviewer reported that the full cells that Amprius is now testing show considerable loss in capacity, with capacity decreasing to 80% before 250 cycles with most additives tested. So there is greater understanding of these materials as a result of the work done over the past year, even though the cells are far from ready for prime time.

Reviewer 2:
The reviewer stated that the technical progress demonstrating improvements over the baseline appear to be excellent. Based on the data presented the cell performance improved significantly since the initial start of the program. The reviewer felt it would have been clearer if there was a NCA/Carbon Anode cell cycled the same as the three silicon anode full cells shown on Slide 10. The assumption was that the worse cell shown performed better than the baseline cell. Electrolyte formulations also show excellent improvements.

Reviewer 3:
The reviewer commented that some of the data was confusing, as to convincing that improvements were indeed made. During the poster session discussion it became clear that many of the issues pertained to cell build quality. A good baseline has been established and results are encouraging.

Reviewer 4:
The reviewer indicated that the cycle life goal of 1,000 cycles with higher energy cathodes for vehicle uses not reached. The self-discharge should be less than 1 % per month at room temperature.

Reviewer 5:
The reviewer felt there were insufficient details provided to be able to assess the progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that Amprius is collaborating with BASF, Yardney, and Nissan. It is working with BASF in optimizing cathode material. Yardney collaborates in optimizing cathode material, working on the cell fabrication and manufacturing. The reviewer indicated that Nissan is doing cell design. The efforts seem to be coming together well so far, and it will be interesting to see how the collaboration develops in the coming year.

Reviewer 2:
The reviewer stated that excellent collaboration with key partners (with the appropriate expertise) has and should help keep this project on focus. Support or collaboration with an electrolyte specialist may have been a good fit, but Amprius appears to be doing this work in-house.

Reviewer 3:
The reviewer noted that BASF and Yardney are good partners for high energy cell development.

Reviewer 4:
The reviewer indicated that the collaboration appears strong. The reviewer recommended more specific callouts on each slide, indicating sources of material and test results. It was not clear for example where Nissan had contributed.

Reviewer 5:
The reviewer stated that actual specific contributions and necessity of involvement given the stated roles of all partners is unclear.

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

Reviewer 1:
The reviewer stated that Amprius has work to do in its anode composition and properties, and in the uniformity and yield of its anode processes. It also has to work on electrochemistry issues (matching its anode with cathode material, electrolyte). It seems like there are many aspects of the cells using Amprius' anodes that need to be worked on, so the focus on overcoming barriers is broad (as opposed to a sharp focus on barriers). The reviewer detailed future work. Anode material efforts include optimizing size, structure, surface, and composition of the silicon nanowires to increase cycle life and volumetric charge capacity, as well as improving anode uniformity and production yield (this is a new research direction since 2012). Electrochemistry efforts include new electrolyte formulations for silicon SEI and high voltage cathode; formation and cycling protocol; and anode/cathode matching. Cathode development efforts include coating formulation development and validation for high loading and high energy density cathodes; and electrolyte compatibility validation. Cell design and testing efforts include iterating cell design for best energy density and safety performance. This reviewer indicated that in the reviewer-only slides, Amprius said that it had recently identified an alternative manufacturing path that preliminary results suggest will improve silicon uniformity, reduce anode- and cell-level swell, extend cycle life, and facilitate production scale-up.

Reviewer 2:
The reviewer reported that the future work states that the project team will optimize the silicon anode for cycle life and volumetric charge capacity, but temperature performance and mechanical stability are not mentioned. Neither is the temperature performance addressed for the other cell components. The reviewer commented that if the anode work is in its infancy and is not addressing the temperature issue in this project, the electrolyte and cathode efforts (which should be more advanced) should be addressing the low temperature performance issue in future work.

Reviewer 3:
The reviewer noted that the proposed cost of the Si active material is still very high. The targets should be greater than 300 Wh/kg and $100/kWh at the cell level.

Reviewer 4:
The reviewer reported that insufficient details provided on results, thus difficult to assess the future work needed.

Reviewer 5:
The reviewer noted that the activities look good, but the PI should indicate what specific barriers are to be addressed by each area of investigation. Without this focus the approach appears to be scattershot/speculative. The reviewer provided as an example, Slide 18

indicates different cell designs. The reviewer inquired which is representative of the baseline, and what has been demonstrated. It is not clear what the gap to goals is, and how to close those gaps.

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

Reviewer 1:
The reviewer stated that Amprius aims to reduce the size and weight of the lithium-ion battery anode through its Si nanowire anode technology. Reducing the weight and volume of lithium-ion battery technology that can be cost-effectively used in plug-in electric vehicles will help to make these vehicles attractive compared to conventional ICE vehicles, which would aid in the DOE objective of petroleum displacement.

Reviewer 2:
The reviewer noted that the silicon's high anode energy density fully supports the DOE objectives by allowing for a decrease in the cost/mile to the general public to own and operate an EV.

Reviewer 3:
The reviewer stated that the cell design should appreciably improve cell energy density, and it is hopeful demonstrate good performance and cost reduction, all of which are essential to the adoption of BEV's, and therefore reduction in petroleum consumption by light-duty motor vehicles.

Reviewer 4:
The reviewer stated that Si anode replacing graphite is important for high energy density and lower cost.

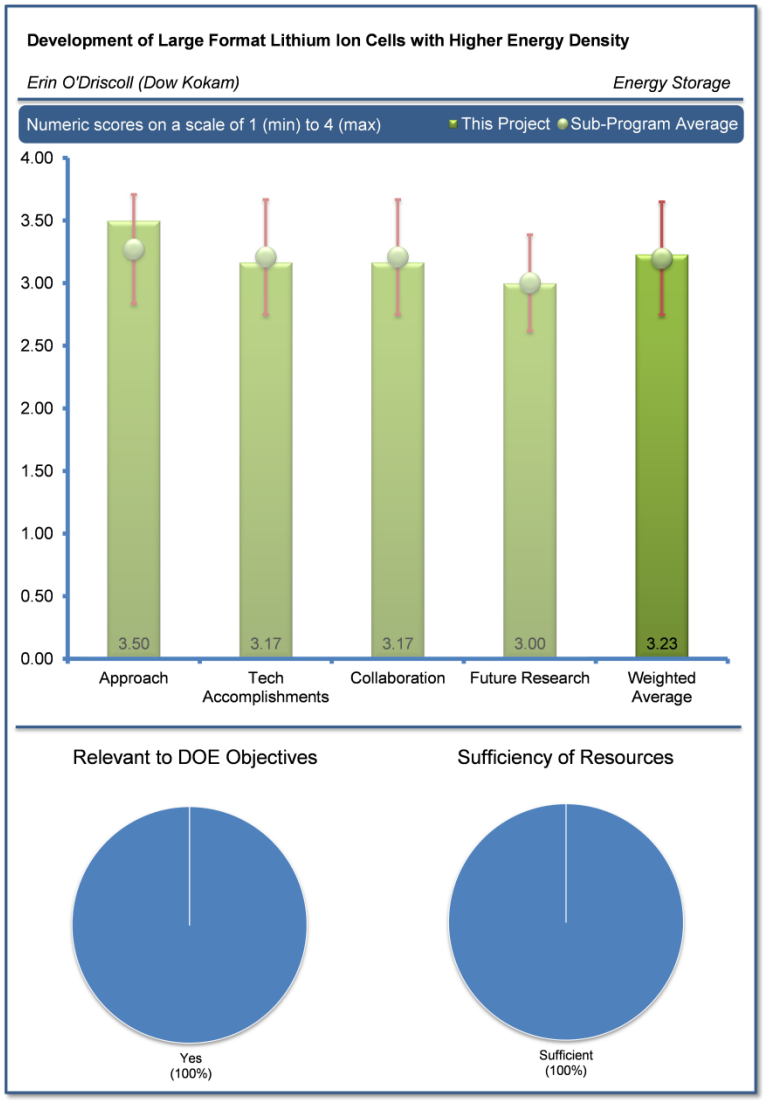
Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer noted that there seems to be sufficient resources in terms of both funding and partnerships to reach the stated milestones in the next 1.5 years.

Reviewer 2:
The reviewer stated that the resources are adequate for this project.

Reviewer 3:
The reviewer indicated that the rate of progress suggests that the work group is sufficiently staffed.

Development of Large Format Lithium Ion Cells with Higher Energy Density: Erin O'Driscoll (Dow Kokam) - es127



Reviewer Sample Size

A total of 6 reviewers evaluated this project.

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

Reviewer 1:

The reviewer reported that Dr. Wu explained that Dow Kokam's approach to developing large-format lithium-ion cells with higher energy density is to approach it in two ways: by exploring cathode materials that are high-voltage, and both anode and cathode materials that are high-capacity. The project team has begun this project by obtaining baseline measurements on a cell with an NMC cathode and graphite anode. The team's baseline cells have excellent cycle life, with 87% capacity at 2,785 cycles. The reviewer stated that Dow Kokam now has a high-capacity anode, and it is developing a high-voltage cathode which still has issues (gas-generation during a cycle life test, though the cathode has apparently achieved 5V during cycling tests). It is also exploring high-capacity cathode materials, working with its partner Wildcat Discovery Technologies which is identifying the most promising materials that can optimize the desired cathode properties. The reviewer indicated that work seems to be at the stage of pursuing promising leads as of May 2013.

Reviewer 2:

The reviewer stated that the objectives and goals are clearly stated and the approach to reach those objectives and goals is outlined well. The approach as outlined allows for easier tracking of the progress.

Reviewer 3:

The reviewer indicated not being aware of a DOE target goal of 500Wh/L for a cell. The project phases were well selected and well defined. The sequence of work was reasonable, given the scope of work and the project and technical goals.

Reviewer 4:

The reviewer stated that the selection of higher than graphite specific capacity and higher than NMC cathode is critical to reach 300 Wh/kg, 600 Wh/L for vehicle applications.

Reviewer 5:

The reviewer commented being unclear on what is the project team's performance goal is 370 Wh/L or greater than 500 Wh/L.

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

Reviewer 1:
The reviewer reported that Dow Kokam has delivered baseline cells (NMC-graphite) to ANL for testing. It has also characterized high-capacity, silicon anodes and high-voltage cathodes that it will prepare to test in smaller-format (2 Ah) cells in the coming year. The reviewer stated that this measures up against a goal of developing a large-format lithium-ion cell with energy density greater than 500 Wh/L. The team reported that its high-voltage cathode material has demonstrated an energy density of 340 Wh/L in 64X95-mm format full cells with graphite anode, which still falls short of the goal. The reviewer indicated that the high-capacity cathode materials are considered the much more experimental thrust of their project. This part of the project is contingent on the progress that project partner Wildcat Discovery Technologies is able to make in discovering suitable materials. The reviewer commented that Dr. Wu noted that because there had been a fire in Dow Kokam's cell testing facilities early on in the project, Dow Kokam had been granted a six-month extension to their project, and thus progress would lag as a result.

Reviewer 2:
The reviewer noted that the program has the right teams working on the appropriate sections of the project. Cathode and electrolyte work is progressing well based on data presented. The reviewer indicated that the anode progress is not as well defined but, what little data is presented appears to be promising.

Reviewer 3:
The reviewer stated that the cathode development progress is encouraging. Issues are well defined, although the success of high voltage cathode (HVC) is a concern. The reviewer reported that multiple pathways to achieving the goals have been defined. What also lacks is the scalability effects of moving from the 2Ah cell to the large format cell design, and how that is to be inferred onto the goal chart. The reviewer noted that data was lacking in this presentation.

Reviewer 4:
The reviewer stated that the energy density is only 370 Wh/L with continued gassing.

Reviewer 5:
The reviewer indicated slow progress, only demonstrating 340 Wh/L using the high V cathode, and no cycle life data.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer reported that Dow Kokam is collaborating with Wildcat Discovery Technologies to identify high-capacity cathode materials, which is the heart of its experimental work here. Its other collaborations are with Oak Ridge National Lab for some materials characterization and failure mode analysis, and with a lab at the University of Missouri, Kansas City, for some analytical support.

Reviewer 2:
The reviewer noted that all areas of responsibility are clearly defined, with close collaboration between groups.

Reviewer 3:
The reviewer indicated that the right teams are working on the right sections. It is not clear however how project team members are interacting with each other to progress the overall project effort. This could result in an anode that is not fully compatible with the selected HCC/electrolyte couple.

Reviewer 4:
The reviewer commented that the contribution of Wild Cat on selection of the appropriate high specific capacity anode and cathode is not very clear because they are not material suppliers and their selection is not optimized for energy and gassing.

Reviewer 5:
The reviewer asked if there was any duplication of effort with other government funded high energy Li-ion cell.

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

Reviewer 1:
The reviewer stated that the steps proposed for the coming year seem logical, with plans to make 2-Ah format cells with the high-capacity anode, and then taking steps to make other cells that combine the high-capacity anode with the high-voltage cathode. High-voltage electrolytes need to be tested as well. The reviewer reported that once some promising candidates for the high-capacity cathode material are identified and synthesized, these will be tested with the high-capacity anode in a cell. This full cell can then be measured to see how closely it achieves the goal of a higher-energy-density cell to achieve 500 Wh/L.

Reviewer 2:
The reviewer noted that the development pathway is well defined, although specific barriers could have been better defined/listed in the presentation, and specific sub-tasks to close gaps listed.

Reviewer 3:
The reviewer stated that the proposed future work is very good, but more focus is needed on the Si anode development. It is not clear that the difficulties of working with a Si anode are fully realized.

Reviewer 4:
The reviewer stated that the high-capacity anode (HCA) should be either Si, SiO_2, or Si/C composite, and high-capacity cathode (HCC) should be layered-layered or better capacity. Further, the reviewer observed that the High voltage cathode (HVC) needs a new electrolyte, and the development tasks are not very clear.

Reviewer 5:
The reviewer felt more specifics were needed on how the project team will down-select between HVC and HCC.

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

Reviewer 1:
The reviewer reported that a higher-energy-density, large-format lithium-ion cell suitable for automotive use would help to bring down the usage of costly materials (and their weight) in a battery for a plug-in electric vehicle. A less-expensive PEV battery would help to make these cars more cost-competitive with conventional ICE vehicles, which could help to lead to increased sales of PEVs. These PEVs would likely displace petroleum-consuming vehicles on the road.

Reviewer 2:
The reviewer stated that the increase in battery energy density is needed to make EVs an acceptable alternative to the gasoline powered vehicle. The objective of this project is to reach the DOE goals needed to offer that alternative.

Reviewer 3:
The reviewer noted that this project specifically targets the goals of improved energy density and low cost in large format cells, necessary to achieve longer term EV goals.

Reviewer 4:
The reviewer provided that Dow Kokam may be an automotive supplier with 300 Wh/kg and low cost cell or system supplier.

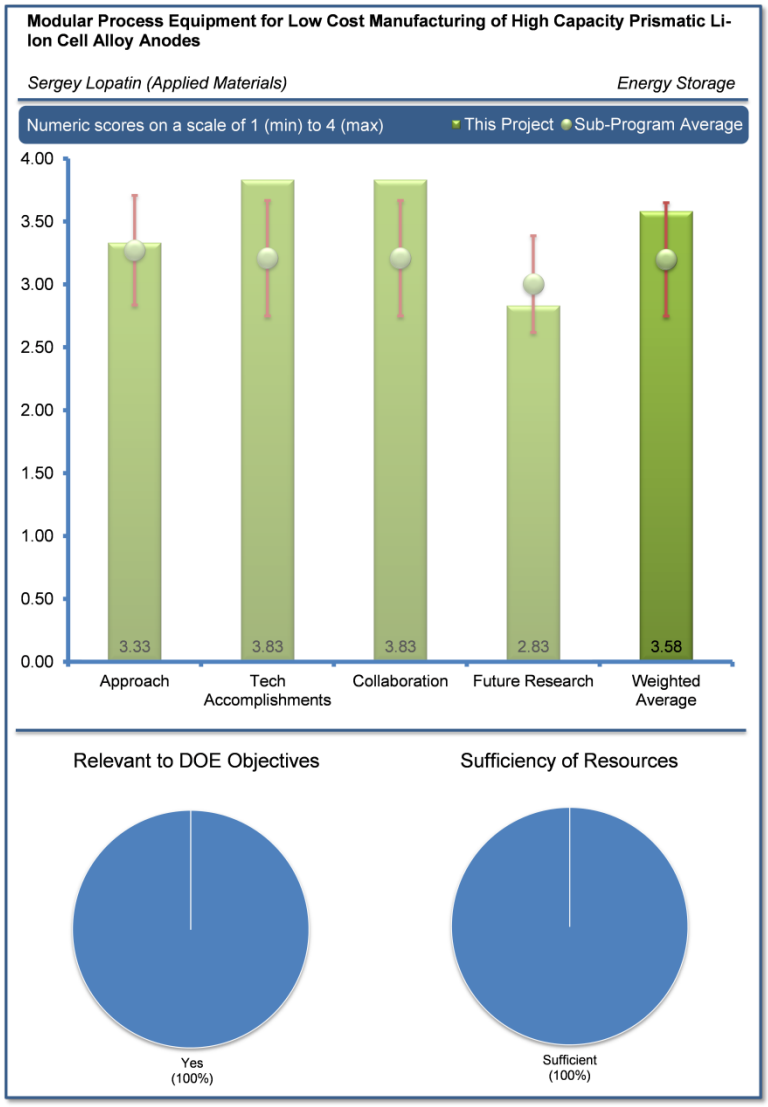
Question 6: Resources: how sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer reported that the project appears to be proceeding well on the funding that it has received so far.

Reviewer 2:
The reviewer indicated that resources are sufficient.

Reviewer 3:
The reviewer indicated no issues seen with respect to resource usage.

Modular Process Equipment for Low Cost Manufacturing of High Capacity Prismatic Li-Ion Cell Alloy Anodes: Sergey Lopatin (Applied Materials) - es128



Reviewer Sample Size

A total of 6 reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the goal of this project is to develop a high-capacity alloy material for an anode for a lithium-ion cell which has reduced cost (both per square meter and per Wh) and which also displays higher performance as a next-generation 3D (3-dimensional) anode. The alloy material CuSnFe (copper-tin-iron) has a higher capacity (mAh/g) than current copper (Cu) functioning as a current collector can achieve. The reviewer noted that the function of the Fe (iron) in the anode material is to reduce the grain size, which would mean that the anode can achieve a greater surface area. This in turn will facilitate a faster charge and increased capacity of the electrode. The reviewer summarized that the group is developing a high-volume manufacturing (HVM) prototype module for developing anodes in a continuous roll-to-roll process at low cost. The project entails using this module to test progressively next-generation materials with the high-rate deposition process. The reviewer noted several baseline cells of 30 mAh capacity with a standard graphite coating on the anode current collector have been made and tested, and then other cells have been made with CuSn (copper-tin) on the anode (not yet with the Fe portion of the ultimate alloy). There are interim cycle life tests for these cells. The reviewer reported that the Cu metal current collector has been characterized by structural analysis, and then the final 3D anode has also been characterized after the graphite coating (baseline).

Reviewer 2:

The reviewer states that the approach is sound based on the stated intent of the project. The project appears to be very ambitious as the material is being developed in parallel with the manufacturing process for that material. While ambitious, this approach helps identify any potential manufacturing pitfalls early, and reduces the possibility of development of a product that is extremely difficult to manufacture. The reviewer felt this approach also makes collaboration with a cell manufacturer and others more important.

Reviewer 3:

The reviewer indicated a comprehensive structured approach.

Reviewer 4:

The reviewer stated that the 3D electrodes with the cost goals of meeting $150/kWh at the system level is a very challenging requirement for the automotive application and Applied Materials may have the know-how.

Reviewer 5:
The reviewer remarked on the excellent and interesting work and progress technically. The plan to demonstrate a commercially viable production process, economic feasibility, and mechanical robustness is unclear.

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

Reviewer 1:
The reviewer stated that it looks like the development of the module for processing the anode development took up a large part of the first year of the project. That must be why the project is at the halfway point and just the cells (made of NMC333, a variety of nickel-manganese-cobalt cathode material, with a copper-graphite anode) and some interim alloy (CuSn) anode cells have been made so far for baseline characterization. The reviewer reported that the baseline and interim alloy cells have been run through cycle life tests and characterized. The completion and testing of these cells represent the main fruit of the work done over the past year, as in 2012 the bulk of the results were characterizations of the microstructure of the material. The reviewer indicated that the Applied Materials team has also developed its materials processing equipment in order to be able to electrodeposit a 3D porous structure for a copper current collector and a 3D CuSnFe alloy anode coating. It uses water-based processing. The reviewer stated that the projected cell lifetime was estimated at ~800 cycles for 3D CuSnFe/graphite anode interim cells at 80% capacity retention at C/3 discharge rate.

Reviewer 2:
The reviewer noted significant progress was made on both key project fronts—material development and manufacturing process development, and data to support that progress was provided. Improvements in anode energy density towards stated goals for the anode material development effort were demonstrated for both of the primary material selections. The reviewer stated that the development of the process to manufacture these materials was also demonstrated and was evident by the consistent cell performance provided, which indicated good process control.

Reviewer 3:
The reviewer indicated the cycle life of 3D electrodes is very impressive.

Reviewer 4:
The reviewer felt it was not clear as to what the baseline cell was and it was therefore difficult to gage progress versus current state-of-the art. Technical accomplishments in process design and electrode design were otherwise excellent.

Reviewer 5:
The reviewer noted good technical progress and technical demonstration towards some DOE goals. Demonstration of feasibility or practicality towards automotive application is not apparent.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer summarized that the Applied Materials group is collaborating with a researcher at LBNL for matching the anode and cathode for cell balancing, conductive binder, and electrolyte additive evaluation. It is also collaborating with a researcher at ORNL for materials characterization and degradation analysis using advanced spectroscopic techniques (micro-Raman mapping, X-ray characterization, etc.). There are also three industrial partners in this effort: FMC Lithium, Navitas Systems (formerly A123 Systems), and the Nissan Technical Center. FMC Lithium is providing stabilized lithium metal powders and coating on anode structures for pre-lithiation. Navitas Systems is evaluating the Applied Materials electrodes using testing equipment for half coin cell, full coin cell, and full scale 63450 prismatic cell geometries. Finally, the Nissan Technical Center (North America) has a researcher who is conducting cell performance measurements and final cell validation to USABC requirements.

Reviewer 2:
The reviewer commented that the project provided clearly defined areas of responsibility that took full advantage of the expertise of each of the multiple collaborators.

Reviewer 3:
The reviewer noted a solid team, with clearly defined responsibilities.

Reviewer 4:
The reviewer indicated excellent collaboration and balanced nature of partners.

Reviewer 5:
The reviewer stated that Nissan and A123 provide the automotive requirements.

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

Reviewer 1:
The reviewer summarized the plan for 2013, which was to continue demonstrating the baseline cell process with 3D Cu/graphite with thicker graphite and at higher charge/discharge rates, to submit 18 prismatic cells for DOE independent testing, to optimize the high-loading CuSnFe/graphite electrode when developing the interim cell further, to complete a cycling test in full-cell assembly, to have an interim cell sent for characterization and analysis at LBNL and ORNL to measure grain size, porosity, and other parameters. A reviewer-only slide lists a number of the technical risks and how the team intends to mitigate them. The reviewer concluded that the key technical risks have to do with improving the process for forming the electrodes.

Reviewer 2:
The reviewer stated that the future work planned for 2013 fits in with the project goals and timing. The assumption is that the Manufacturing Economics work will address the cost of incorporating new equipment to manufacture the material(s), but it is not clearly stated. The reviewer felt it is not clear that the mechanical stability of the system is being addressed or when is will be evaluated. The mechanical stability of this material may be a critical issue and should be addressed.

Reviewer 3:
The reviewer noted that lessons learned from baseline were not clearly defined, as to how they would impact future phases. The Phase elements have enough independence to continue with this risk in mind.

Reviewer 4:
The reviewer stated that the coating width to meet the cost goals is needed for the success of the coating equipment.

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

Reviewer 1:
The reviewer offered that improving the capacity of lithium-ion cell anodes can help to improve the energy density of batteries made of these cells and used for plug-in electric vehicles. Improving the energy density of PEV batteries and delivering this at low cost will help to make PEVs an attractive alternative to conventional ICE vehicles. The reviewer indicated that if more consumers purchase PEVs instead of ICE vehicles, this will certainly lead to petroleum displacement.

Reviewer 2:
The reviewer stated that this project has very strong relevance for the DOE goals of reducing the use of petroleum products to power vehicles.

Reviewer 3:
The reviewer noted that this unique manufacturing approach delivers a unique anode, which could facilitate appreciably higher performing EV cells. Cost remains a question at this point, but should be part of the final deliverable.

Reviewer 4:
The reviewer responded yes, the project could provide fundamental advancement in basic Li-ion battery capability if technology was shown to be feasible and practical.

Reviewer 5:
The reviewer indicated that the equipment manufactured by Applied Materials will reduce the manufacturing cost of anodes.

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

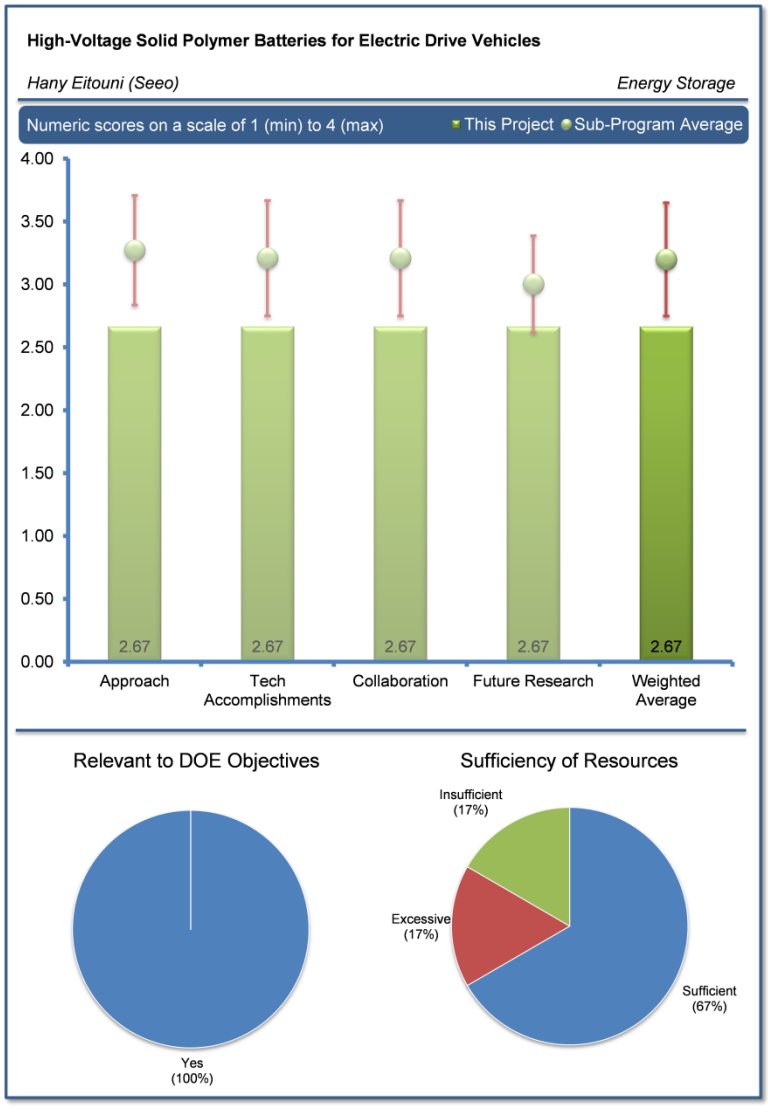
Reviewer 1:
The reviewer reported that the resources may or may not be sufficient, but Applied Materials should show more forward movement if the project were to request additional funding.

Reviewer 2:
The reviewer indicated that the appropriate resources are in place.

Reviewer 3:
The reviewer stated no issues with resources.

Reviewer 4:
The reviewer stated that the capital equipment is cost shared with DOE and future customers.

High-Voltage Solid Polymer Batteries for Electric Drive Vehicles: Hany Eitouni (Seeo) - es129



Reviewer Sample Size

A total of 6 reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that project has captured the barriers and approaches the solution from two different directions to increase chances of success. Both approaches should yield a product that could be used to support the development of a polymer battery that meets the performance requirements. The reviewer voiced that there is some concern that the low temperature performance issue does not appear to have sufficient focus. Also it is not clearly stated when the project will decide which approach will be focused on for the final deliverable.

Reviewer 2:

The reviewer summarized that the project has a very intriguing approach for developing a high-voltage solid polymer battery which entails exploiting the fact that solid polymer electrolytes do not flow and therefore cannot mix. Instead of having to use only one electrolyte throughout the entire cell which would therefore have to withstand the higher potential difference (above 4.2 V), Seeo can instead continue to use the DryLyte solid electrolyte that it has already developed in the dry solid separator section, and then it can develop a new solid electrolyte within its cathode (a catholyte). The reviewer stated that the thinking is that the new catholyte will not need to be stable at the total voltage of the cell, but just at a "high enough" voltage to be stable within the cathode while still enabling the cell to perform at a high-voltage level in concert with the electrolyte. Having two different electrolytes layered this way appears to be a creative and potentially robust solution to the problem of achieving a high-voltage lithium-ion cell, which depends on having an electrolyte that will not be flammable at the high voltage. The reviewer concluded that the focus of this work is on developing this catholyte material, and the Seeo team is taking two different approaches to accomplish this. This is a very creative, highly risky project with no guarantee that there will be a suitable material found at the end of the investigations.

Reviewer 3:

The reviewer indicated there was concern in meeting cycling goals. Focus was a little vague in how the specific performance targets were to be achieved. For example, the reviewer would like to know what tasks are targeted to tackle which specific goals.

Reviewer 4:

The reviewer stated that minimal insight into required temperature of operation and/or related limitations is missing.

Reviewer 5:
The reviewer noted that the solid state electrolyte conductivity is not acceptable at 25°C. Hence the cell operation is at higher temperature. This may not be acceptable for automotive application. The right approach should be a significant increase in the room temperature conductivity.

Reviewer 6:
The reviewer indicated uncertainty as to what is the uniqueness of the Seeo polymer electrolyte versus previous polymer electrolyte efforts

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

Reviewer 1:
The reviewer stated that at the 2012 AMR, the Seeo team had no experimental results to report from this project. Therefore, all results reported at the 2013 AMR represent work done over the past year. The reviewer reported that the Seeo team is taking two approaches to developing its solid polymer cell system, with its main approach consisting of using its high-voltage-stable polymer (or catholyte) as a binder for its cathode. The second approach is to coat the cathode material particles with organic and ceramic coatings and then to use the same solid electrolyte throughout the cell, as with its current solid polymer cell design. This is considered more of a fail-safe approach if the first approach does not prove to be workable. The reviewer reported that Seeo is evaluating different salts to mix in with its polymer electrolyte and evaluating the stability of the salts by looking at corrosion on the electrode. So far, its primary approach of using the two different electrolytes is yielding promising results, with high-voltage polymers showing promise when matched to cathodes over the baseline polymer electrolyte. The reviewer stated that the team's work with coating cathode particles and them embedding them all within a single polymer electrolyte throughout the cell is at an earlier stage of investigation, but the team has verified that the particles are forming the organic coating as intended.

Reviewer 2:
The reviewer noted that it appears that the goals for phase one have been achieved, although it was difficult to identify what specific changes were being driven by which specific objectives.

Reviewer 3:
The reviewer said progress was noted on both approaches. The progress on the catholyte polymer approach appeared to be strong and was a bit clearer than the particle coating approach. The message on the graph showing particle adherence for the second approach was not very clear.

Reviewer 4:
The reviewer noted that the ceramic and conductive coating on the cathode particle will improve the internal resistance at room temperature.

Reviewer 5:
The reviewer indicated very little performance data (cycle life, rate capability at various temperatures, stability), and difficult to assess progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that the IREQ has very deep knowledge of their Li metal polymer batteries and Li dendrite issues.

Reviewer 2:
The reviewer indicated that Seeo is collaborating with the Institut de Recherche d'Hydro-Québec (IREQ) and two commercial suppliers of high-voltage cathode materials. IREQ is developing Li foil anodes for the cells being investigated. IREQ is also assessing

the manufacturing costs for high-capacity anodes and is leading safety, abuse and performance testing for final cells in this study. The reviewer said that Seeo also noted it has commitment from its investors for the full duration of the project.

Reviewer 3:

The reviewer reported that the work performed so far shows little if any collaboration with identified partner. The overall program does have work that appears to have more collaboration later on near project end.

Reviewer 4:

The reviewer indicated little engagement with primary partner to date. Other partners were not identified.

Reviewer 5:

The reviewer noted there was insufficient collaboration.

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

Reviewer 1:

The reviewer indicated that the next steps seem very clear and seem to be the logical continuation of the work done thus far. The reviewer elaborated that the next step are to validate cathode, polymer and salt combinations in small-area full-cells. Investigate techniques for stabilization of cathode, salt and polymer composites. Develop block copolymers based on candidate materials and tune mechanical and electrochemical properties to minimize interfacial resistance with Seeo anolyte. Develop, test and evaluate scale-up methods for high-voltage catholyte block copolymers. Deliver interim cells made of these materials to DOE for characterization. The reviewer noted that in the reviewer-only slides, Seeo listed several issues that have been identified with the polymers being used, and approaches that the project team will take to mitigate them.

Reviewer 2:

The reviewer noted that while the future plans build on past progress, plans do not address some of the potential areas of concern such as low temperature performance improvement. Also, the reviewer commented that there is no clear go/no-go decision on which approach will be used.

Reviewer 3:

The reviewer indicated a lack of definition on barriers. This must be more clearly identified.

Reviewer 4:

The reviewer reported that there was no plan to address the critical issues of polymer electrolyte, i.e., long-term stability and RT/low temperature rate capability.

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

Reviewer 1:

The reviewer noted that high-voltage lithium-ion cells (which may be based on solid polymer technology) will be needed in order to maximize the energy density of the batteries to be used in PEVs. These will both decrease the weight of the battery and the amount of materials needed to manufacture the battery. The reviewer commented that if this can be done in a cost-effective manufacturing process, such developments will go a long way towards reducing the cost of PEVs relative to conventional ICE vehicles. Customers will be more likely to purchase and drive competitively-priced PEVs, and a greater number of these vehicles reaching the road would definitely displace petroleum.

Reviewer 2:

The reviewer stated that the project is relevant as improved battery energy density, with no negative impact on safety is critical to reaching the DOE energy goals.

Reviewer 3:

The reviewer commented that if the technology can demonstrate the performance goals set forth in Slide 1, it does meet the objectives of DOE.

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

Reviewer 1:

The reviewer indicated that Seeo appears to be making very solid progress thus far with the resources received. Seeo noted that it has commitment from its investors for the duration of this project.

Reviewer 2:

The reviewer indicated that resources are sufficient for this project.

Reviewer 3:

The reviewer noted that fundamental cell development is underway. There is also fundamental material research required, and the science required in these endeavors may overwhelm the deliverables timeline.

Innovative Cell Materials and Designs for 300 Mile Range EVs: Yimin Zhu (Nanosys) - es130

Reviewer Sample Size

A total of 6 reviewers evaluated this project.

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

Reviewer 1:

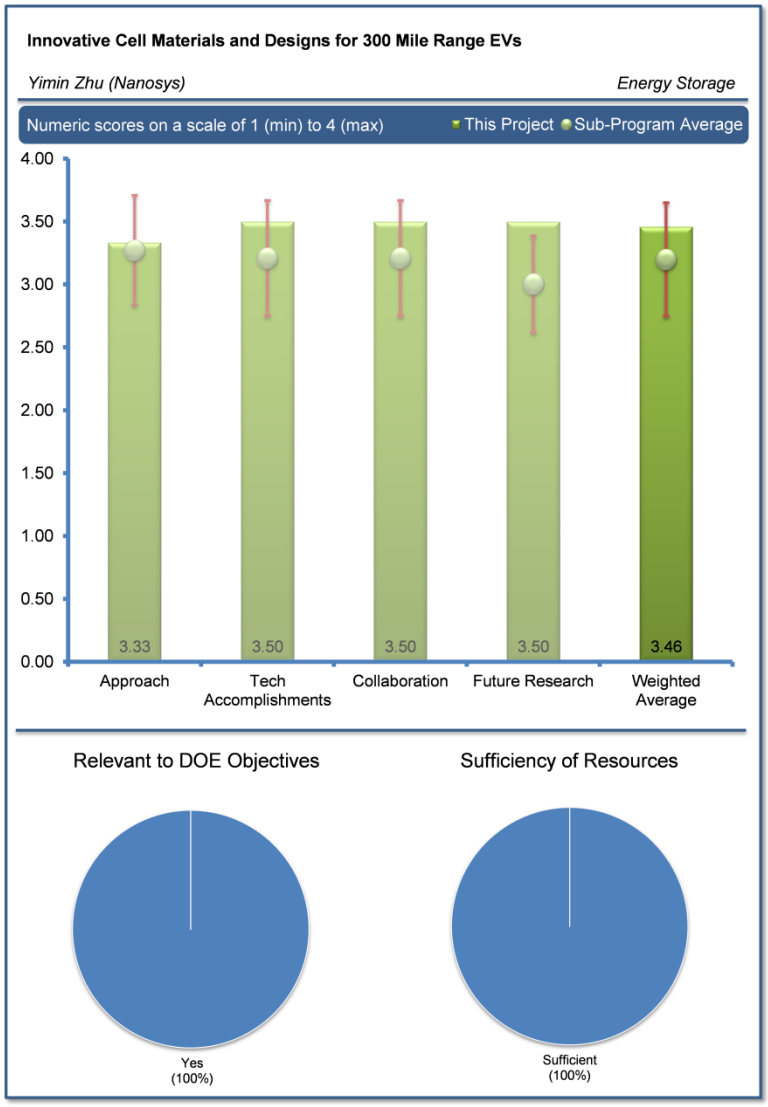
The reviewer reported a solid approach to materials selection and optimization.

Reviewer 2:

The reviewer stated that the objectives of the project are clearly stated. The barriers are identified and the methods to address each of the barriers using specific cell component goals are spelled out.

Reviewer 3:

The reviewer noted that the focus is on improving the specific capacity of anode and cathode material. The Si nanowire carbon composite has better chance of success with Mn rich cathode material. The calculations for 300 mile EV are not included. The reviewer felt that the targets for the EV should be better than 350 Wh/kg, 800 Wh/L, and $100/kWh at the cell level. Nanosys is a material supplier and should target the cost of the anode to meet $100/kWh at the cell level.



Reviewer 4:

The reviewer stated that the overall goal of this project is to develop battery materials that support a high-energy battery. Nanosys has a composite anode material consisting of silicon nanowires which use graphite powder as a substrate for the nanowire growth. Nanosys calls this material SiNANOde, which is a nanowire with a lower surface area/volume ratio, and thus less side-reaction with the electrolyte and a better cycle life. The reviewer commented that it claims that this mix of its silicon nanowires and graphite is a cost-effective way of increasing the capacity of the anode over the standard graphite, and that it can control this capacity in its manufacturing process. Nanosys is currently able to manufacture at a scale of several kilograms per batch (and overall can make several tons a month). It is therefore partly along the way of addressing the issue of materials scale-up.

The reviewer indicated that Nanosys' goals for the battery components are as follows: For the anode, develop a 700~1600 mAh/g Si anode (SiNANOdeTM) toward greater than 800 cycles; for the cathode, develop a 260 mAh/g cathode (Mn-rich) toward greater than 800 cycles; and for the cell, develop unique cell combining SiNANOde with greater than 250 mAh/g cathode to eventually achieve 350 Wh/kg and 800 Wh/L, resulting in less than 150 /kWh (cell).

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

Reviewer 1:
The reviewer reported that the project appears to track well against goals. The predominant issue remains cyclability for the high specific capacity anode materials. The reviewer recommended the use of a baseline data in more of the data presentations.

Reviewer 2:
The reviewer stated that the project accomplishments are on track to meet specific project performance goals. Project indicates that there is some concern about the electrolyte progress and may need to start considering the low temperature performance of the electrolyte in addition to its HV stability.

Reviewer 3:
The reviewer noted that a 600-800 mAh/g anode may be good enough for an appropriate cathode material.

Reviewer 4:
The reviewer stated that during the past year, the Nanosys team has completed a baseline SiNANOde cycle life demonstration, improved the specific capacity of its SiNANOde anode material to within its target range of 700~1600 mAh/g, improved the cycle life of its anode material at the desired composition to 510 cycles at 83% of capacity at 0.3C discharge rate, scaled up its anode manufacturing process to the level of several kilograms per batch, and claims to have optimized its cathode composition. The reviewer commented that Nanosys has delivered 18 cells with high energy density at the end of November 2012, on track with its project milestones. For the cathode, it claims that a manganese-rich (Mn-rich) cathode with a high capacity of greater than 250 mAh/g will be needed, and that it is screening these cathodes. However, the material is not identified. The reviewer indicated that Nanosys also states that a high-voltage electrolyte is being developed, but no further details are given.

Reviewer 5:
The reviewer indicated that some specifics (Wh/L, Wh/kg, rates) were not provided for evaluation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that collaboration with key material suppliers and a major user and cell builder supports this project very well.

Reviewer 2:
The reviewer noted that Nanosys is collaborating with LG Chem, as its test batteries are being made on LG Chem's production line. Nanosys also notes that it is collaborating with Dow Kokam on this project, though the specific nature of this collaboration is not revealed. The reviewer stated that the company also lists several other collaborations outside of the VTO-funded research, which is nice but not relevant to this review.

Reviewer 3:
The reviewer indicated good collaboration, although it was not clear what deliverables are provided by each collaborator for each piece of work.

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

Reviewer 1:
The reviewer commented that future work is closely aligned with the remaining gaps within the project.

Reviewer 2:

The reviewer stated that future work revolves around the key objectives of the project and the objectives are in line with the barriers that need to be overcome. The reviewer again reminded that temperature [low temperature (LT) in particular] needs to be included in future work.

Reviewer 3:

The reviewer reported that Nanosys researchers plan to focus on achieving high energy density and enhanced cycle life. More specifically, researchers will aim for cycle life enhancement for the 700~1000 mAh/g anode that it began to test in the past year. The project team plans pilot-scale manufacturing quantities of SiNANOde product, along with cost-sensitivity modeling. The reviewer reported that the team will optimize the SiNANOde and appropriate binders, and develop electrolyte additives (for the unnamed electrolyte) to improve cycle life. Following these steps, project team aims to improve the anode material further, to achieve a capacity of 1,600 mAh/g anode. The team also is targeting improved battery discharge rate performance and high electrode loading. The reviewer indicated that the third thrust is optimization of cathode composition and cell components. The team aims to minimize inactive components in the cell, address cathode electrode activation during cell formation cycles, evaluate the compatibility of the developed electrolyte, improve the cell design to achieve high energy density and long cycle life, and integrate the new binder and electrolyte and cell formation/testing protocol.

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

Reviewer 1:

The reviewer indicated the increase in the energy density of the battery cell cells at good cost are needed to make this technology competitive with the gasoline vehicle. This project has an excellent chance of meeting the DOE targets designed to reach that goal.

Reviewer 2:

The reviewer stated that the project represents advanced Li-ion EV cell technology. It is consistent with the technology required to meet EV battery goals, necessary for widespread EV adoption. There is a concern that this work carries appreciable redundancy with other programs of its kind co-funded by the DOE.

Reviewer 3:

The reviewer reported that creating high-capacity batteries that could have energy density high enough to reduce the size of the batteries significantly could lead to cost-competitive PEVs. Nanosys states that its explicit goal is to create materials that could support a cell that would be the foundation for a battery to go into a 300-mile-range PEV. The reviewer felt that if PEVs become as affordable and convenient as conventional ICE vehicles, then a greater number of consumers may purchase them and therefore begin to displace the ICE vehicles on the road, and therefore also the petroleum consumed by the ICE vehicles.

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

Reviewer 1:

The reviewer indicated that the funding appears to be sufficient.

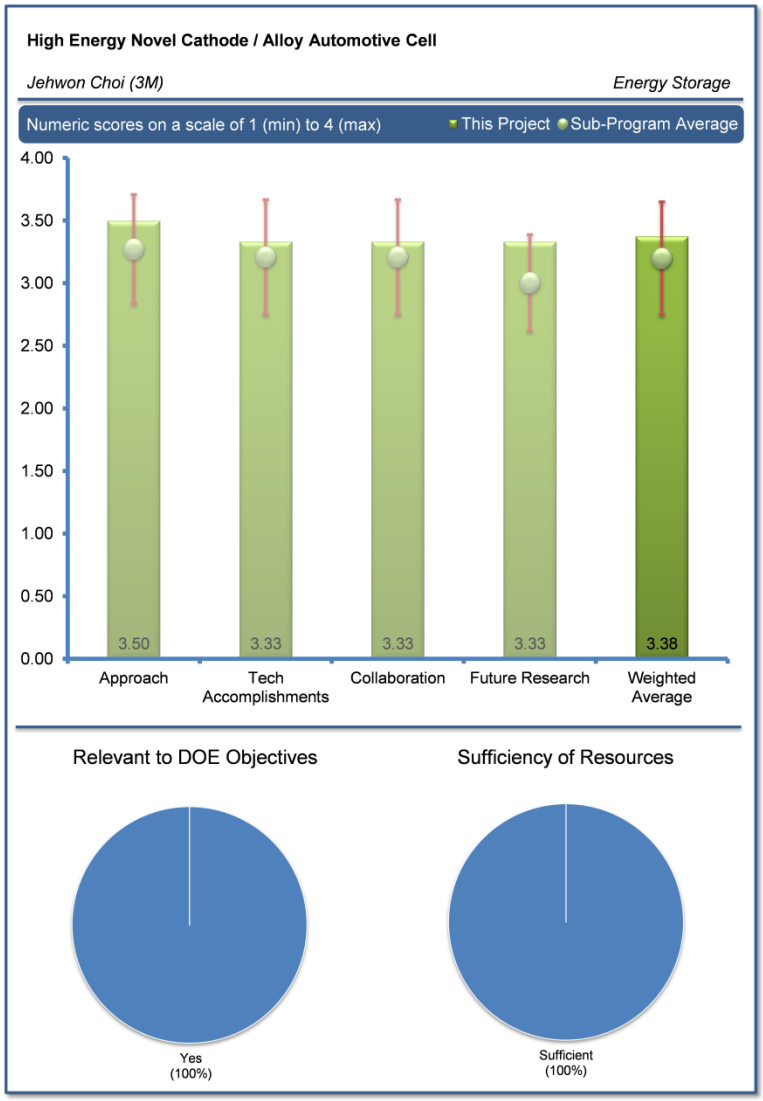
Reviewer 2:

The reviewer stated that resources were adequate.

Reviewer 3:

The reviewer reported that no issues were observed.

High Energy Novel Cathode / Alloy Automotive Cell: Jehwon Choi (3M Company) - es131



Reviewer Sample Size

A total of 6 reviewers evaluated this project.

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

Reviewer 1:

The reviewer noted that the approach was clear; the key barriers were identified; realistic targets were clearly established; and the concept was presented in a technically sound and clear format.

Reviewer 2:

The reviewer reported a focused and well-defined plan and approach.

Reviewer 3:

The reviewer stated that the improvement in the energy and reduction in cost are the right approach for the automotive systems.

Reviewer 4:

The reviewer summarized that the project objectives are to develop a high-performance battery cell for electrical vehicle with high energy density and low cost by integrating advanced chemistries. Desired features include at least 40% (1.4X base Wh/L) increase in energy density compared to baseline cell performance (NMC111 and Graphite), 35% increase in energy for advanced high voltage cathode, 70% increase in volumetric capacity for alloy anode, at least 25% lower cost per unit energy at cell level for a comparative integrated advanced materials cell to a baseline materials one. The reviewer noted that the 3M team has pursued a core-shell structure for its NMC cathode material, with a core that has a composition skewing towards nickel (Ni, increasing the capacity) and a shell that has more manganese (Mn, which should improve cycle life). The idea is that combining these two properties within a cathode material would lead to a stable high-energy cell. It has presented data on a half-cell that shows stability over a number of cycles. The reviewer reported that the anode research focuses on developing an alloy with a proprietary structure that uses silicon as its basic active material (as opposed to the commonly used graphite). The alloy particles are less than 20 nm across, mixed in with graphite, conductive carbon, and binder to form the anode. The reviewer summarized that the idea is to reduce electrode expansion over the course of charge/discharge cycles, as this expansion and contraction has been shown to lead to cracks in the material which contribute to the degradation of the electrode. The reviewer reported that the team is matching its high-energy cathode and anode materials and putting them into a cell. The team has tested these cells with a couple of different electrolytes to identify effective electrolytes. An unidentified electrolyte has increased the cycle life by 50%, though the cycle life needs further improvement to be able to reach 800 cycles above 80% of initial charge.

Reviewer 5:

The reviewer stated the project is well designed and managed, but the performance improvements are modest, when compared to EV battery objectives.

Reviewer 6:
The reviewer indicated good approaches but also should include the high voltage layered composite cathode materials as part of the cathode energy factor comparison.

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

Reviewer 1:
The reviewer noted that overall cell energy improvement was demonstrated, and cyclability issues identified. The 40% increase in energy density is modest.

Reviewer 2:
The reviewer noted good progress demonstrating performance in relevant 18650 cell form factor.

Reviewer 3:
The reviewer indicated thus far, the 3M team claims to have demonstrated materials development with a viable high-energy NMC cathode. It has shown a stable voltage curve and an improved cycle life when the cathode and anode are combined with an electrolyte in an 18650 cell. The reviewer commented that in the latest phase of this project (during 2012 and the first part of 2013) the cell energy showed ~40% improvement over that of a baseline NMC/graphite cell coupling. Also, an experimental electrolyte is helping a cell to extend its cycle life by 50% before its capacity is reduced to 80% of the initial charge level (do not know the depth of discharge in these measurements, though). The reviewer stated that the 3M team characterized its anode technology as almost commercialized and currently being tested in cells. It claimed that the cathode material was undergoing limited sampling with partners.

Reviewer 4:
The reviewer indicated that the energy and life improvements validate 3M's approach.

Reviewer 5:
The reviewer stated that the data presented clearly showed significant technical progress toward the project target goals. The cathode work demonstrated a significant improvement over current production NMC 111 as stated. Electrolyte work contributed to improved cycle life for the 3M anode and NMC 111 - when cycled to 60% beginning of life (BOL) capacity. However, at 80% BOL capacity the performance of the electrolytes is the same. The reviewer noted that this supports the need for continued electrolyte work. Not clear on the value of the thin and thick cell design data set, unless, the point is being made that a big hurdle left is scaling the cell design format up to an EV cell Ah capacity. Si electrode expansion work was well documented excellent and appeared to meet the project target goal.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated this was a tight project, but with solid peer review processes.

Reviewer 2:
The reviewer reported that the 3M team is collaborating with researchers at Dalhousie University in terms of technical discussion for most of lithium-ion battery-related areas. Project team has also consulted with ANL experts on battery testing procedures, specifically protocols for EVs. The reviewer recommended that the partners who are doing sampling of these materials/cells should provide feedback.

Reviewer 3:
The reviewer noted that while most of the experimental and development work was done by the sponsoring organization, much consulting was involved to keep the project moving. Ideally, it would have been good to have a cell manufacturer as a collaborator to build a larger cell format for use as a test vehicle.

Reviewer 4:
The reviewer stated that Jeff Dahn's group will help with the final goals.

Reviewer 5:
The reviewer expressed the need to collaborate with groups working on high voltage electrolytes to enable the use of high voltage HE NMC.

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

Reviewer 1:
The reviewer reported that the proposed future work is to refine the performance of the cells so that they approach readiness for commercialization.

The reviewer detailed future research. First, improve cycle life, including improve Si alloy design; improve composite (Si alloy/Graphite) design; and optimize high energy NMC design.

Second, increased 18650 testing, including develop improved electrolytes – 3M recognizes than an entirely new electrolyte system may be needed to achieve a cycle life where capacity is retained at a level of 90% even after 800 charge/discharge cycles; develop and test 18650 designs under range of conditions; and initiate EV protocol testing.

Reviewer 2:
The reviewer indicated that most issues identified in the project summary sheet that need to be addressed are addressed in the proposed future work. This included evaluating the cells under different conditions. The reviewer stated that the assumption is that those conditions include low and high temperature testing. While the project only called for 18650 cell format builds, incorporating the material into a larger cell format would have been a good future goal. This view is only being expressed because of the slide showing the performance of a thin versus thick cell design.

Reviewer 3:
The reviewer reported that alternatives to potential outcomes are considered. Next steps are logically planned out.

Reviewer 4:
The reviewer felt that some minimal (at least) investigation of relative abuse tolerance would be useful.

Reviewer 5:
The reviewer said that some future work should be devoted to reducing the first cycle loss in the HE NMC.

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

Reviewer 1:
The reviewer indicated that this work is very relevant as it drives toward a viable and significant increase in energy density for current battery technology, while offering a significant cost reduction. Overcoming these barriers is essential to meeting the DOE objectives for petroleum displacement

Reviewer 2:
The reviewer stated that while the goals of a 40% energy improvement are modest, the material development approach and demonstration is solid, and the kind of approach essential in advancing the state of the art.

Reviewer 3:

The reviewer noted that an improved cell that is high-energy could lead to a viable long-range and lightweight battery pack for a PEV. If PEVs can be made with batteries that use less material, then the cost of the battery will be reduced. The reviewer indicated that a more affordable battery will make PEVs more affordable to consumers, and it will increase the likelihood that they will purchase a PEV. The more PEVs on the road, the fewer vehicle miles traveled on petroleum. Thus, this research does support petroleum displacement.

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

Reviewer 1:

The reviewer stated that the resources appear to be sufficient to support the work that 3M is pursuing in this project.

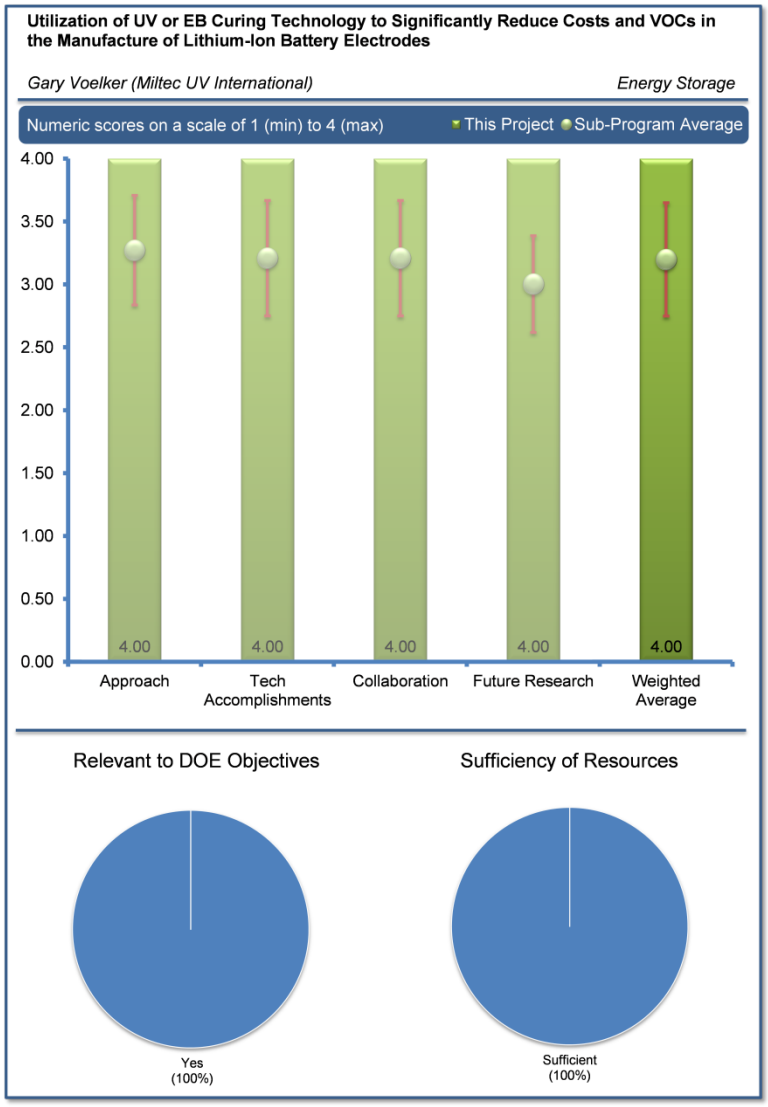
Reviewer 2:

The reviewer indicated that existing funds for this project are sufficient.

Reviewer 3:

The reviewer commented no issues.

Utilization of UV or EB Curing Technology to Significantly Reduce Costs and VOCs in the Manufacture of Lithium-Ion Battery Electrodes: Gary Voelker (Miltec UV International) - es132



Reviewer Sample Size

A total of 2 reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that new electrode coating process will reduce capital, space and operating costs while minimizing solvent recovery and cell assembly costs.

Reviewer 2:

The reviewer reported that the project goals are very ambitious, and the authors have demonstrated great progress.

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

Reviewer 1:

The reviewer noted that technical accomplishments for this work are very good. The project is 50% completed and the authors are demonstrated a very good cathode performance using UV curable binder. The reviewer concluded that it will be of great interest how a full cell performs when both electrodes contain an UV curable binder.

Reviewer 2:

The reviewer stated that electrode materials were produced and assembled into NCM cathode and /Timcal C-45 anode using polysiloxane based UV curable binder and assembled in coin cells for testing. The reviewer reported over 2,000 cycles to 60% capacity in test cells, cells have good high rate performance, cells with $LiFePO_4$ produced and cycled as cells with silicon anodes, cells have good high rate and cycle life. Prototype coater designed and constructed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported close collaboration with ORNL personnel in developing the overall process.

Reviewer 2:

The reviewer stated that the collaboration with other institutions is very good. The sharing of some of the cost by a company such as Miltec is very encouraging.

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

Reviewer 1:
The reviewer stated that future work will likely include producing electrode structures for assembly into prototype vehicle cells for confirmation of the new electrode coating process.

Reviewer 2:
The reviewer reported that the proposed future research is pointing in the right direction. A full cell testing where both electrodes use curable binder can have very important implications in cell manufacturing. Probably, in the future, additional work should be done with different cathode chemistries.

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

Reviewer 1:
The reviewer indicated that the ability to use new binder opens up new avenues for material choices. New electrode process does not use regulated solvents in its operation.

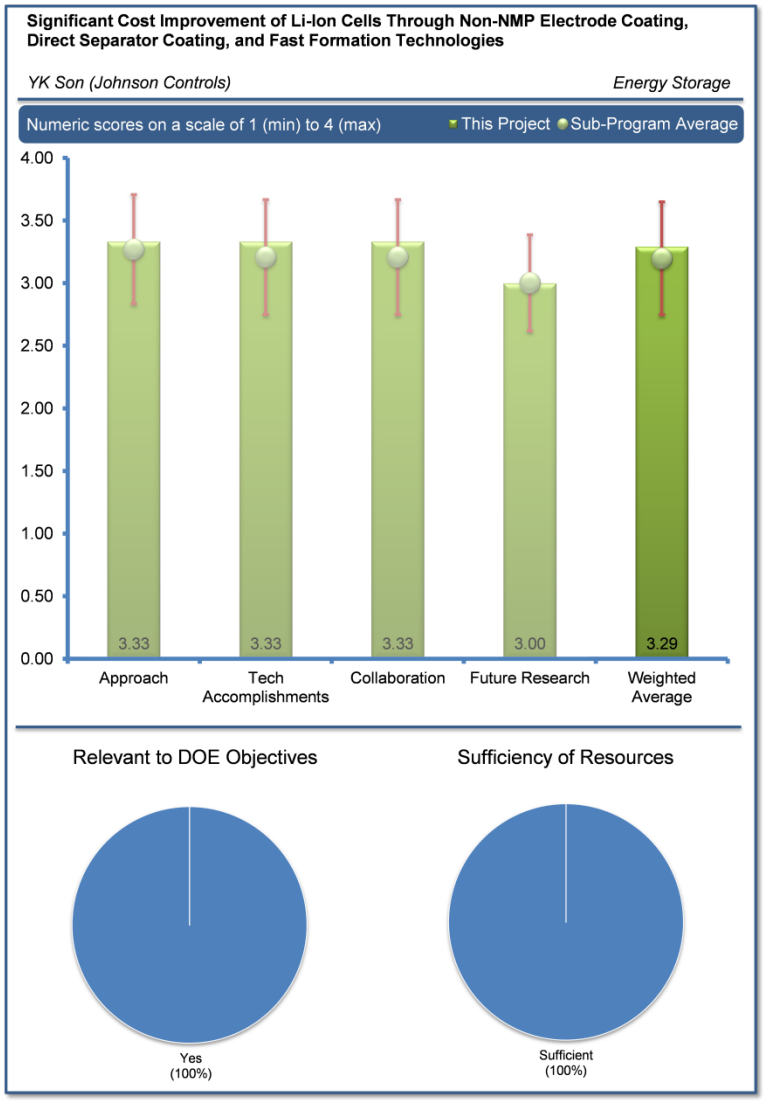
Reviewer 2:
The reviewer said yes, it is supporting the overall strategy of DOE of petroleum displacement by focusing in a very practical problem that can lower the cost of electrode manufacture tremendously.

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

Reviewer 1:
The reviewer stated if the authors managed to demonstrate in a full cell, and at least with one cathode chemistry, that their approach is feasible and can lower the cost of electrode manufacture, the project team should receive additional resources.

Reviewer 2:
The reviewer indicated that the resources are used efficiently and effectively.

Significant Cost Improvement of Li-Ion Cells Through Non-NMP Electrode Coating, Direct Separator Coating, and Fast Formation Technologies: YK Son (Johnson Controls) - es133



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the main barrier that the PI is addressing is the public's acceptance of electrified vehicles. To meet this challenge, the battery must be cost effective. The reviewer reported that Johnson Controls' approach to lowering cost by greater than 50% is to make significant improvements in the Li ion manufacturing process by developing a non-NMP electrode coating process and a direct coated separator. This is a good approach and if successful has a very high chance of lowering battery costs. The reviewer criticized that no specifics or a pathway on how to accomplish this was provided.

Reviewer 2:

The reviewer reported good and sensible approaches to reduce Li-ion cells cost.

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

Reviewer 1:

The reviewer indicated that lamination shows most promising results compared to others.

Reviewer 2:

The reviewer noted that good progress has been made this past year. The baseline 3Ah and 15Ah pouch cells and coin cells were completed. The reviewer stated that experiments were conducted on cells using dry-coated and water-based electrodes. The dry coating process did not meet the performance specs and it is unclear if the water-based electrodes will meet the cost objective (greater than 50%). The reviewer reported that efforts were directed to develop direct coated separator technologies. Lamination was shown to yield the most promising results. A fast formation process investigation was also undertaken.

Reviewer 3:

The reviewer noted that progress seemed slow since the project inception in 2011. The reviewer commented that they did not have sufficient data to evaluate the progress on shortened formation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer reported that very good partnerships have been formed under this program. Johnson Controls is collaborating with Entek Membranes, Maxwell Technologies, and University of Wisconsin.

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

Reviewer 1:
The reviewer stated that the plan seems to be clear.

Reviewer 2:
The reviewer reported that the future plans outlined during this review are justified. Future plans build on the challenges confronting the technology improvements and the results to date.

Reviewer 3:
The reviewer indicated good proposals but need more progress.

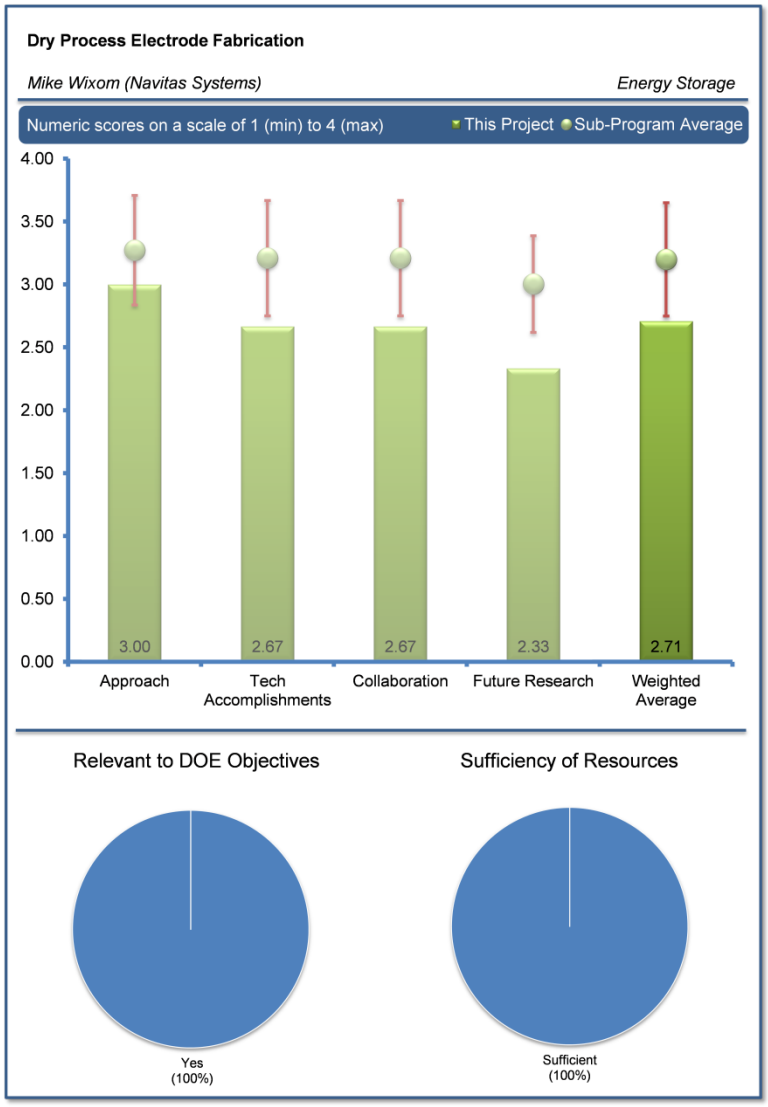
Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that this project, as outlined, is highly relevant because it supports the DOE objective of petroleum displacement. To accomplish petroleum displacement, there must be a viable battery option and the public will not accept a battery option unless it is cost effective and the performance is good.

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

Reviewer 1:
The reviewer noted that this program appears to have the necessary resources to complete the tasks successfully. The total project funding includes $3.6 million (from DOE) and $3.67 million from Johnson Controls and the sub-recipients.

Dry Process Electrode Fabrication: Mike Wixom (Navitas Systems) - es134



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the program seeks to: identify a binder system for a solvent-free anode fabrication that is stable over 500 cycles to full state of charge; and produce a free standing dry process cathode that retains 50% capacity at the 1C rate. It is not clear how the investigators plan to accomplish this because no information was provided.

Reviewer 2:

The reviewer indicated that the use of solvent-less binder and extrusion is generally effective to thicker and dry electrode fabrication but the process and electrode adhesion/cohesion could be vastly improved over what is achieved. The reviewer stated that the process overcomes use of hazardous solvents in the coating process but the approach is questionable in terms of speed of fabrication as compared to the coating process. Therefore the relative cost savings is questionable on scaling up this process that also requires lamination part.

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

Reviewer 1:

The reviewer felt that the accomplishments this year appears to be fair. It would have been helpful to the evaluation process if the PI had clearly identified the accomplishments on the slides.

Reviewer 2:

The reviewer suggested explaining the strength of these dry coatings.

Reviewer 3:

The reviewer felt that given the time line of the project, the technical accomplishment/progress is not adequate. The cathode adhesion/cohesion, loading level, and porosity are far from optimum level for decent rate and cycle life. The reviewer stated that the choice of electrode thickness at greater than 100 micron to make any impact on energy not good enough and will not achieve higher loading for metal oxide cathodes. The reviewer remarked it is not clear whether the choice of current collector is metal grid or foil. The reviewer indicated that this will influence process speed and the quality of the electrodes vastly. The data presentation is very poor and deceptive without any controls for comparison.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said only fair, at best, collaboration exists in this program.

Reviewer 2:
The reviewer reported the need for clarification on why one collaborator was dropped. The reviewer would like to know if it is a business decision mandated from the acquisition of parent company. The reviewer also asked was the initial collaboration with Maxwell aimed at battery/ capacitor hybrid to achieve HE+HP system. The reviewer indicated that need for some quantification on what level of consulting with Zn-air industry going on and how is appropriate for Li-ion electrodes.

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

Reviewer 1:
The reviewer reported that future efforts appear to be routine. This includes reducing the electrode thickness, blending high energy density cathodes, fabricating cells, etc.

Reviewer 2:
The reviewer stated that the proposed reduction in electrode thickness is counter to what the initial strategy of 2X loading. The reviewer also explained that processing aids and/or pore formers add to cost and speed. The reviewer suggested that overall the project needs a better milestone definitions and quantifications for the statements.

Reviewer 3:
The reviewer queried how there was reduction in the electrode thickness.

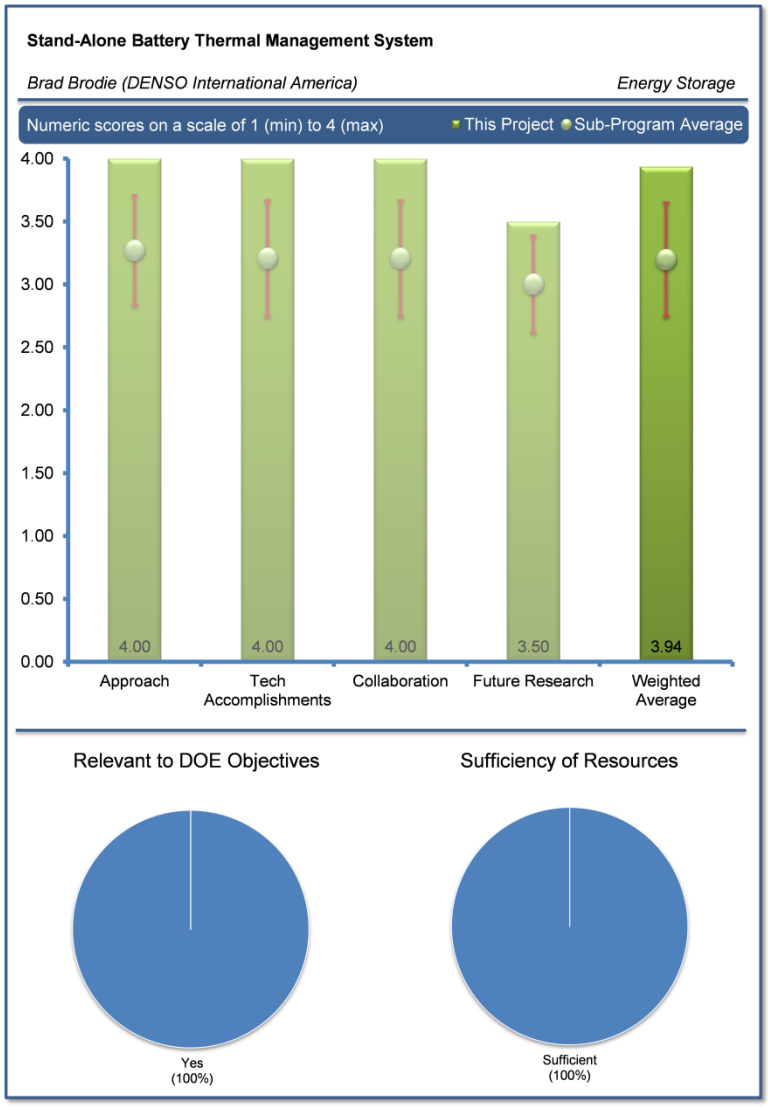
Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that this project is highly relevant and supports DOE objectives of petroleum displacement. In order to convince the American public to drive an EV an affordable battery is necessary. The reviewer highlighted that the focus of this project is to identify a low-cost method of processing electrodes.

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

Reviewer 1:
The reviewer reported that the funding for this 3-year effort appears to be sufficient. The DOE share is approximately $3 million and the contractor's share is $1 million.

Stand-Alone Battery Thermal Management System: Brad Brodie (DENSO International America) - es135



Reviewer Sample Size

A total of 2 reviewers evaluated this project.

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

Reviewer 1:

The reviewer summarized that a comprehensive model of the total battery system has been developed and it can be configured to match any battery system.

Reviewer 2:

The reviewer stated that the authors have managed to simulate the drive profile current and voltage response. It will be of great interest to do something similar with different battery chemistries to understand the limitations of the computer program.

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

Reviewer 1:

The reviewer stated that the accomplishments have been very good. In the future the project team should indicate with additional details which are the assumptions the team has to introduce in their model and how those assumptions may change based on the different cathode chemistries, for example.

Reviewer 2:

The reviewer reported that the work was accomplished in good time. Designs include a combination of liquid and vapor heat control systems in order to provide reliable control of battery operations.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported good collaborations with Chrysler and PNNL were held to assure that sound principles were used, and that they corresponded to vehicle needs.

Reviewer 2:

The reviewer stated that it seems that the collaboration with other institutions has been good. The project team should interact even more strongly with Chrysler.

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

Reviewer 1:
The reviewer indicated that future work will validate the model and apply it to real systems in bench testing.

Reviewer 2:
The reviewer felt that the authors may find that their model is not applicable for every cathode and anode chemistry. That should be clearly stated. The approach of comparing all results and choosing the one that meets the project objective appears reasonable and practical.

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

Reviewer 1:
The reviewer noted that thermal management is essential for long life of the battery system. The model has the capability to meet the standards of the proposal.

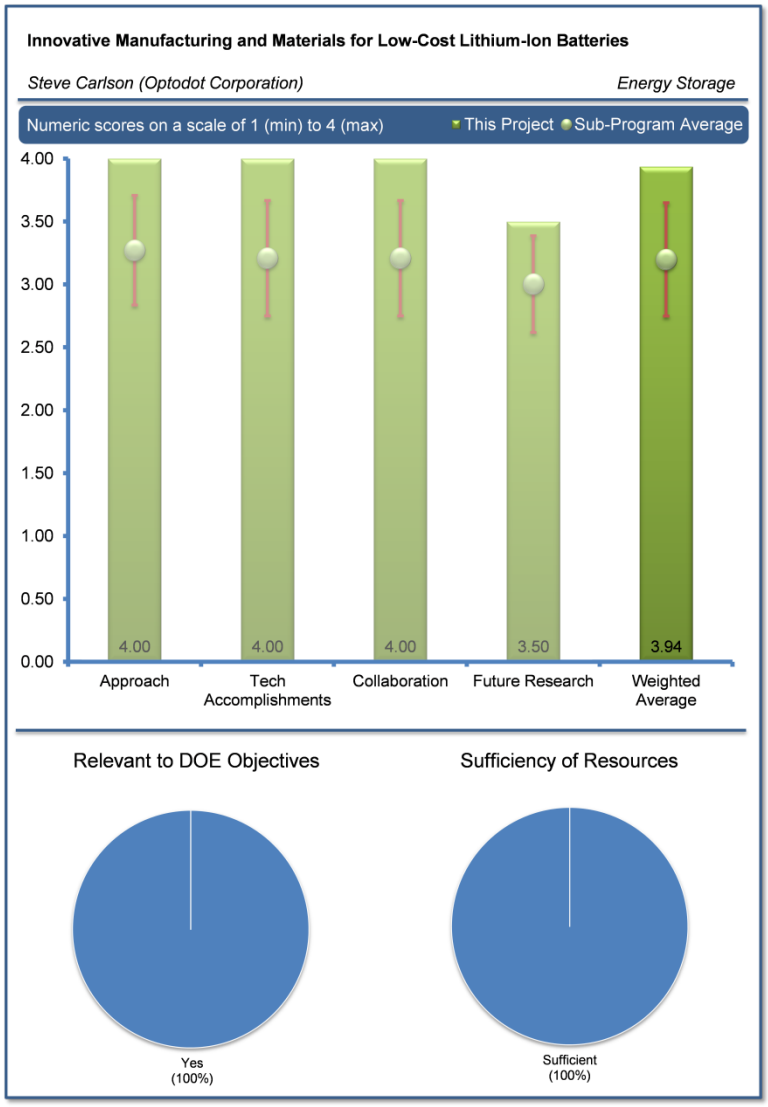
Reviewer 2:
The reviewer said yes, it is supporting the overall DOE strategy of petroleum displacement by focusing on a 20% cost reduction at the battery pack level; that saving is critical and very important.

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

Reviewer 1:
The reviewer reported that the project already has a cost sharing from DENSO and that is very good. If the authors manage to prove an overall 20% cost reduction of the battery pack, the project team should ask for additional support.

Reviewer 2:
The reviewer stated that the necessary resources were available to carry out the project.

Innovative Manufacturing and Materials for Low-Cost Lithium-Ion Batteries: Steve Carlson (Optodot Corporation) - es136



Reviewer Sample Size

A total of 2 reviewers evaluated this project.

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

Reviewer 1:

The reviewer thought that this was another interesting presentation where the lowering of the cost of a battery is the main topic. The reviewer felt that the authors have demonstrated great progress under a very ambitious goal of cost reduction.

Reviewer 2:

The reviewer listed the goals were to reduce the cost, weight and volume of cell inactive components by 20-40% while developing a new electrode assembly process.

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

Reviewer 1:

The reviewer reported that the authors developed a thick ceramic separator with a very narrow pore size distribution. It would be of great interest to the reviewer to know how this separator reacts with the different cathode chemistries.

Reviewer 2:

The reviewer listed accomplishments as having developed ceramic separator with narrow pore size distribution and thickness. The reviewer also relayed that ANL cost model predicted process could reduce electrode cost by 20%.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer thought that it was very important to have industrial partners such as Madico and Dow Kokam.

Reviewer 2:

The reviewer listed that the project was working with Madico for manufacturing processes (mixing and coating), Dow Kokam for electrode coating, Rhode Island University for cell cycling tests, and Ashland for polymer binder selections.

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

Reviewer 1:
The reviewer felt that the future work was well directed, and anticipated that the scale-up of some of the improvements that the authors describe is going to be critical.

Reviewer 2:
The reviewer reported that the future work would consist of: optimizing and scale-up of anode, cathode and current collector designs for improved process efficiency, incorporating improved electrolyte into cell process, assessing the cost of cells using improved manufacturing processes, and delivering cells for testing to confirm advantages of new process.

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

Reviewer 1:
The reviewer felt that this project did support the DOE goals because cost reduction is one of the most important variables to consider when the goal is petroleum displacement, and the authors are well coordinated towards that goal.

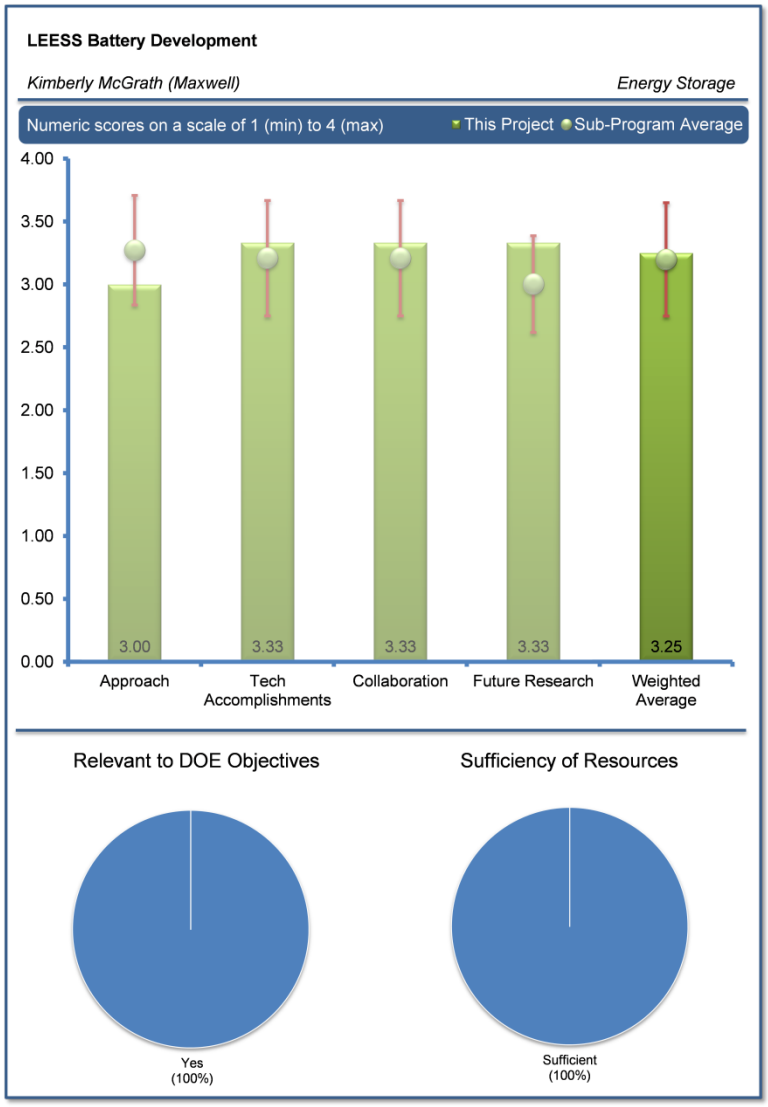
Reviewer 2:
The reviewer predicted that new more efficient electrode fabrication leading to lower cell costs would be needed for future EVs.

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

Reviewer 1:
The reviewer found there to be an efficient use of resources.

Reviewer 2:
The reviewer reported that the project already has a cost sharing from Optodot. If the authors managed to prove an overall cost reduction the authors should ask for additional support.

LEESS Battery Development: Kimberly McGrath (Maxwell) - es139



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

The reviewer thought the project utilized a good approach with specific targets.

Reviewer 2:

The reviewer reported that the program is scheduled to end March 2014. The overall approach taken thus far has been generally good and continues to be so. Efforts are focused on the systems level as well as improved materials. However, the reviewer noted that the specifics on why a certain type of material was selected for investigation or a design was chosen was not conveyed.

Reviewer 3:

The reviewer related that there were not many pursuing the Li-ion-based capacitors other than Maxwell in United States. However, the reviewer said that it remains to be seen at the system level whether this hybrid approach is better than lithium iron phosphate (LFP) based high power battery systems.

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

Reviewer 1:

The reviewer found the project to be very well organized and the target, goals, and timeline to be very well addressed.

Reviewer 2:

The reviewer reported that good progress had been achieved to date. Significant weight and size reduction of the modules were projected based on partial scale prototype modules. The reviewer relayed that although data was provided on the conductivity of the improved electrolyte, no data on cell cycling (coin cells or small laboratory cells) at the low temperatures were provided.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer understood that good collaboration existed between Maxwell Technologies, Porous Power Technologies, the University of Rhode Island, and the national laboratories.

Reviewer 2:

The reviewer thought there was good collaboration and that it was appropriate in terms of fundamental work versus product related functions; the reviewer listed all of the collaborators: Porous Power, University of Rhode Island., INL, NREL, and Sandia National Laboratories (SNL).

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

Reviewer 1:

The reviewer felt that the proposed future work was a logical extension of the completed efforts to date. Gen-3 cells will be fabricated utilizing the best materials identified to date. The reviewer related that, once built, the module will be fabricated and sent to the national laboratories for performance, heat modeling and abuse testing.

Reviewer 2:

The reviewer concluded that testing at the national laboratories was critical to the project.

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

Reviewer 1:

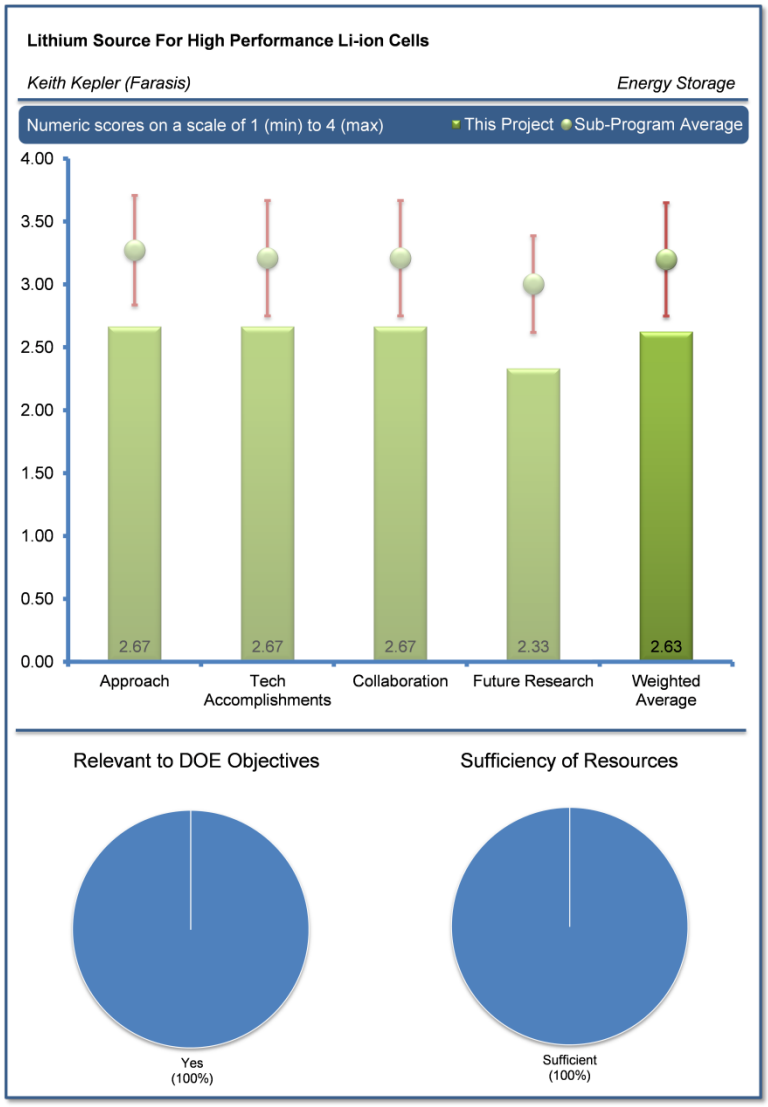
The reviewer felt that the program was relevant and supported the DOE objective of petroleum displacement. It seeks to provide an affordable energy storage device and to improve its performance. The reviewer reported that the goals were clearly defined; $920 project goal assuming a production of 100,000 units per year.

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

Reviewer 1:

The resources appeared to the reviewer to be appropriate for the level of effort.

Lithium Source For High Performance Li-ion Cells: Keith Kepler (Farasis) - es140



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

The reviewer felt that the project had a good approach.

Reviewer 2:

The reviewer thought that this alternative approach by use of lithiated Fe/V oxide as Li source is good, but warned that the difficulty of extracting Li from the proposed structure, synthesis and the stability of the lithiated lithium iron oxide (LFO) etc., could all limit the practical use, and therefore add little to the energy improvement at the full cell level.

Reviewer 3:

The reviewer reported that the effort seeks to develop an affordable, safe, low-cost, lithium ion battery by developing high capacity cathode materials that are low cost. The materials under consideration are pre-lithiated and enable the charging of the anode. It would enable the use of partially charged cathode materials. The reviewer concluded that this was a logical approach, and could succeed.

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

Reviewer 1:

The reviewer stated that this program was completed, and that good progress was achieved last year. The LFO degradation process was characterized by Raman spectroscopy, the material utilization was increased to greater than 850 mAh/g, and the synthesis procedure was scaled to 1 kg batch sizes.

Reviewer 2:

The reviewer was not clear on capacity data and stability, and noted that in Slide 21 the capacity data for LiV_3O_8, should be explained.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer saw an indication of collaboration with Argonne National Laboratory, but it was unclear what form this took.

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

Reviewer 1:
The reviewer reported that the program has concluded. The primary investigator PI did note the need for future optimization of LFO for capacity and stability, as well as evaluation of manufacturing methods and impact on cell variation and performance.

Reviewer 2:
The reviewer confirmed that the project has been completed, but would really like to see the impact at the cell level before any future funding related to this effort is put into effect.

Reviewer 3:
The reviewer would have liked to see a discussion of the current issues and an explanation of how these issues will be addressed for future optimization.

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

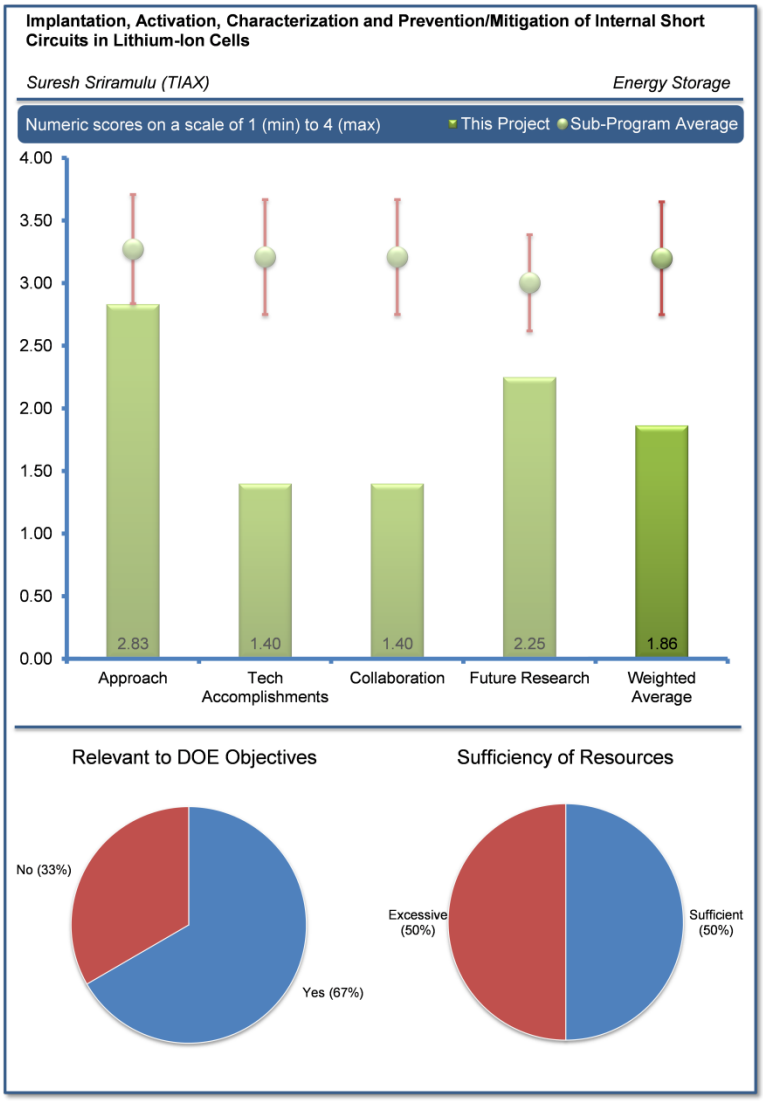
Reviewer 1:
The reviewer thought that this project was relevant and supported the DOE objective of petroleum displacement. The effort undertook to identify new electrode materials that would allow a high energy density, affordable, safe, lithium ion battery to be developed.

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

Reviewer 1:
The reviewer felt that resources were sufficient. The project has concluded.

Reviewer 2:
The reviewer stated that no details were provided.

Implantation, Activation, Characterization and Prevention/Mitigation of Internal Short Circuits in Lithium-Ion Cells: Suresh Sriramulu (TIAX LLC) - es142



Reviewer Sample Size

A total of 6 reviewers evaluated this project.

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

Reviewer 1:

The reviewer found that there was excellent control study of the safety impact of nail penetration on Li-ion cells with different chemistries.

Reviewer 2:

The reviewer reported that the purpose of TIAX's research was to investigate the standard nail penetration test used to assess the safety of Li-ion cells. The test entails driving a metallic nail through a charged Li-ion cell at a prescribed speed, and if no smoke or flame appeared after this abuse, the cell was deemed to have passed the test. However, the reviewer noted that the connection of the test to actual failures of the cell in the field was tenuous, and the TIAX team sought to evaluate the nail penetration test and see whether it is a valid gauge of a cell's safety.

The reviewer went on to inform that TIAX built a test chamber which controls the relevant parameters for the nail penetration test, which is not standardized among manufacturers. It also was equipped for acquiring sensitive voltage, temperature, and pressure data, as well as high-speed photography for capturing visual results. The reviewer relayed that the team also conducted computer simulations to disentangle the mechanisms behind the phenomena that they observed experimentally.

The reviewer concluded that TIAX was doing a great service to the battery field by questioning and systematically assessing this common test.

Reviewer 3:

The reviewer thought that from one perspective, the purpose of the project appeared to be to invalidate in general the utility of nail penetration tests on actual cells and the use of differential scanning calorimetry (DSC) measurements in the study of relative thermal stability of individual electrode materials. Other than this, the project purpose appeared to the reviewer to be unclear.

The reviewer further offered that this project appeared to illustrate response of Lithium Cobalt Oxide (LCO), Nickel Cobalt Manganese (NCM), and Nickel Cobalt Aluminum (NCA) cells in nail penetration tests which would be unexpected based on related DSC results, implying that the differential scanning calorimetry (DSC) and/or nail penetration tests were not useful. However, the reviewer reported that no details or background regarding internal cell construction, separator, nail penetration, etc., or the possible impact of these on response were offered or implied.

Reviewer 4:
The reviewer stated that there was no information on the program cost or timing-- information that was critical to fully understanding the approach. The approach as outlined was not followed. The reviewer concluded that no clear objective, no clear test plan, and no results were shown that supported the ambiguous objective of this project.

Reviewer 5:
The reviewer felt that while the approach described should help to characterize the test, the test results failed to indicate that in fact the nail penetration test had been characterized.

Reviewer 6:
The reviewer said that the cause of one cell out of 10 million cells was not discussed in detail and supporting information.

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

Reviewer 1:
The reviewer thought that it made sense to discard the typical nail penetration test to simulate the internal short.

Reviewer 2:
The reviewer observed excellent results dispelling the misconception of materials DSC data's correlation with safety performance in an actual cell.

Reviewer 3:
The reviewer relayed that TIAX compared commercial 18650 cells with two common chemistries. The cathode materials were harvested from the cells and then rebuilt into coin cells, with DSC measurements done to characterize the thermal stability of the materials. The superior thermal stability characteristics of NCM at higher temperatures have led to the conventional wisdom that NCM cells would be safer (in thermal terms) than LCO cells. However, the reviewer noted that the TIAX team showed that a commercial LCO cell withstood a mild temperature rise upon the nail penetration, while the supposedly safer commercial NCM cell experienced violent thermal runaway under the same circumstances.

TIAX's tests have established some important results, which the reviewer listed as: state of charge (SOC) of the battery strongly influences the nail penetration test outcome, with higher SOCs corresponding to a higher degree of destruction of the battery by flames; local temperature measurements showed that any temperature rise due to the nail penetration does not correlate with any explosions (violent thermal runaway); computer simulations used to simulate the phenomena arising from the nail penetration experiment showed that what is observed is not consistent with internal short circuits; cathode DSC measurements (used to measure thermal stability) do not predict cell safety, which is instead based on complex interactions between heat release, heat transfer and cell design.

Reviewer 4:
The reviewer felt that the apparent, but not clearly stated, objective of the project was to evaluate multiple test variables (which were clearly identified) that could be used in a nail penetration test and to show the effectiveness (or non-effectiveness) of the test in stimulating an internal short.

The reviewer revealed that no data was presented that showed any of the work related to those variables. Rather, the results provided was mostly on cell material performance, rather than the test method itself, which was the actual objective of the project. The reviewer heard comments made about the handbuilt chamber being well built, but no data was provided to support that claim.

The reviewer noted a lack of detail presented, and would have liked to see nail speed control capability; tip diameter, nail material, etc. in the presentation. About how the test was performed little data was presented; other than that, cell SOC matters, which has been well-documented for years.

Reviewer 5:
The reviewer felt that there was little evidence of anything novel generated within this project, and held that most information was already known by the industry.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed good internal collaboration between the engineers and scientists.

Reviewer 2:
The reviewer reported that no other collaborators were noted.

Reviewer 3:
The reviewer cited no significant evidence of any collaboration.

Reviewer 4:
The reviewer assumed there was no collaboration, as there were no details provided.

Reviewer 5:
The reviewer confirmed that there was no information on the collaboration.

Reviewer 6:
The reviewer wanted to note that the poor rating corresponds to the fact that this project showed little collaboration with partners. Because this project was about questioning a common test of battery safety, this was not product-oriented research that would likely make money for a company in industry, and it is not likely to yield the kind of breakthrough result that would reward an academic laboratory with tenure and grant money. The reviewer found that this project did yield results that provided a service to the battery industry. The reviewer did not think the experiment could have been done any better through collaboration, so disagreed with the poor rating.

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

Reviewer 1:
The reviewer reported no indication that this project would be continuing further.

Reviewer 2:
The reviewer confirmed that there was no future work outlined.

Reviewer 3:
The reviewer agreed that no future work was proposed.

Reviewer 4:
The reviewer stated that it was unknown; no details were provided.

Reviewer 5:
The reviewer saw no need for future research.

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

Reviewer 1:
The reviewer thought that this project helped to advance the quality of safety testing for Li-ion batteries for PEVs. The reviewer reasoned that ensuring that the batteries used in PEVs are safe will help to support customer adoption of these vehicles, which will displace oil-consuming cars on U.S. roads.

Reviewer 2:
The reviewer felt this project did not provide any useful information based on the project's objectives. The reviewer judged the most relevant information was something done outside the stated objective, which was that DSC results may not be a good indicator of how a chemistry responds in thermal runaway caused by a nail penetration test.

Reviewer 3:
The reviewer saw nothing of significance generated in this project, which could be applied to materials and cell development for electrified vehicles.

Reviewer 4:
The reviewer reported that the actual technical content reinforced some similar past work by others.

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

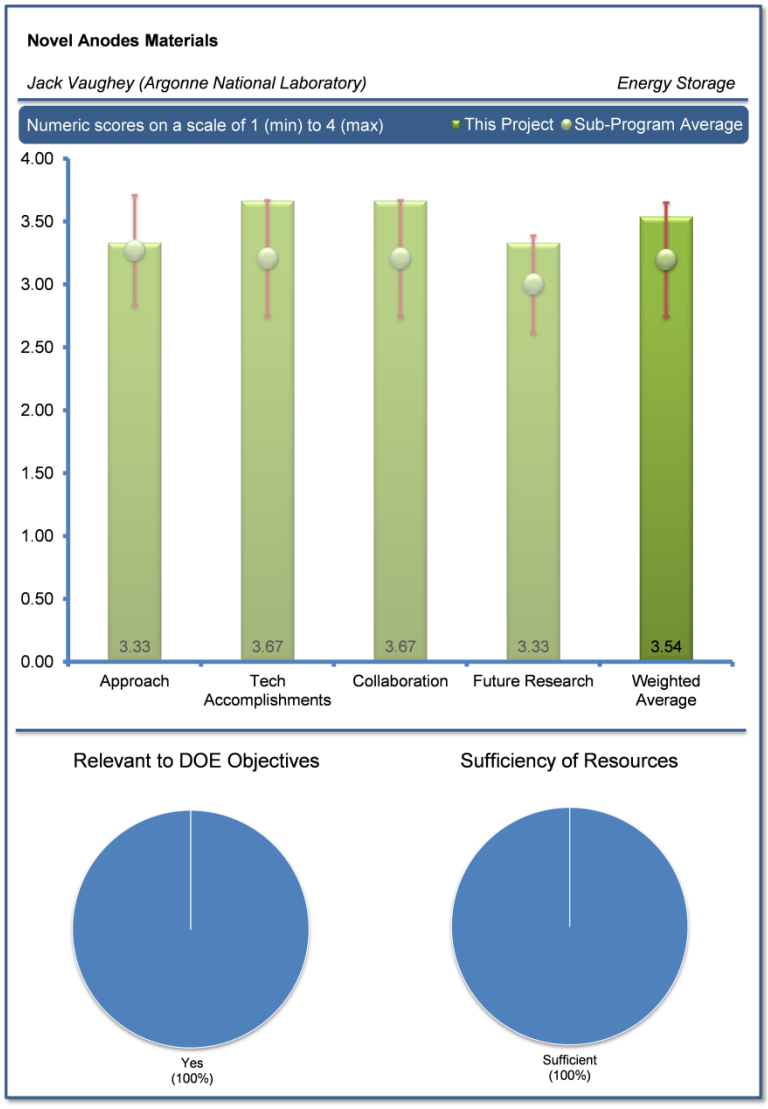
Reviewer 1:
The reviewer did not even know what the resources were, but the project team seemed to have completed the project all right.

Reviewer 2:
The reviewer reasoned that since no resource amount was identified and little new information was provided, the resources provided for this project must be excessive.

Reviewer 3:
The reviewer concluded that one engineer should have been sufficient, if the presentation represented all the findings of the project.

Reviewer 4:
The reviewer said that funding levels were unknown, as no details were provided.

Novel Anodes Materials: Jack Vaughey (Argonne National Laboratory) - es143



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

The reviewer thought that the approach taken in this project was excellent; well thought out and a clearly planned execution. The reviewer reported that investigators will characterize a series of silicon-based electrodes with a variety of 3-dimensional structures and then develop techniques to investigate the effect of cycling on the electrode. The reviewer felt that, if successful, this program will result in a better understanding of how the active materials interact with their surrounding during cycling.

Reviewer 2:

The reviewer reported that the approach combines a variety of methods to prepare silicon anodes with development of characterization tools. The best characterization methods need to be broadly applicable to discern differences between silicons made via different processes. The reviewer thought that these characterization tools – particularly the Si NMR and tomography are vital to understanding the technical barriers to practical implementation of silicon anode materials, as well as addressing those issues. The reviewer would like to see the characterization techniques applied more broadly – at the electrode level – to a variety of silicon materials and binders being marketed by organizations. The reviewer believed that the approach of tailoring the surface chemistry to get synergies with binders will very valuable in getting systems to work.

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

Reviewer 1:

The reviewer thought that the characterization work, particularly the tomography, was outstanding, and suggested that it should be applied more broadly beyond just silicon anodes. The reviewer found electrodeposition to be interesting as well, and would like to understand better the economics of this approach relative to other means to prepare silicon materials for use as anodes.

Reviewer 2:

The reviewer observed an excellent application of tomography to gain insight of Si interaction with other components in the electrodes.

Reviewer 3:
The reviewer felt that good progress had been made this year. The researchers have demonstrated an in-situ probe that will help the researchers make their assessment and have also identified methods to incorporate high levels of Si into the electrode structure. Various characterization methods (electrochemical and chemical) were used to assess the Si anodes.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer saw that an excellent group of collaborators have been assembled to complete this effort. The PI and co-PIs were partnering with outstanding investigators who could significantly contribute to this project.

Reviewer 2:
The reviewer reported that the researchers brought a broad range of skills – from deposition to characterization to electrochemistry, to this project.

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

Reviewer 1:
The reviewer concluded that the proposed future work was a logical extension of this year's results. Collaborative efforts will continue to examine the Si anode using various techniques.

Reviewer 2:
The reviewer was glad to see that the researchers will apply the tomography to the BATT silicon material, to provide a baseline for future comparisions. The continued focus on high quality characterization techniques is a big plus here. The next step needs to be use of the characterization techniques to explain real differences in competitive approaches to Si anode development and commercialization being done by a variety of companies/institutions. The reviewer suggested that the researchers emphasize the work described on electrolyte/silicon interactions.

Reviewer 3:
The reviewer felt that, to have a viable anode for high energy Li-ion cell, the researchers will need to demonstrate methods to incorporate Si at more than 5 mAh/cm^2; not the proposed 2 mAh/cm^2.

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

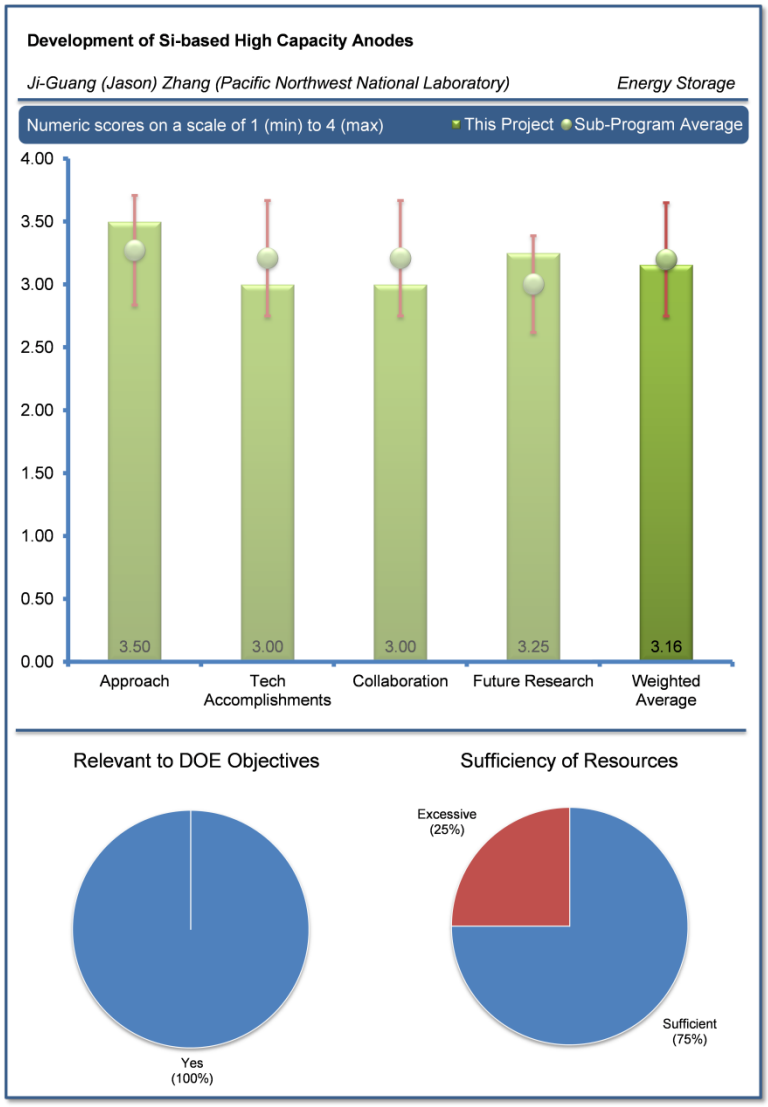
Reviewer 1:
The reviewer concluded that this project was relevant to DOE's petroleum displacement objective. It aims to develop high energy density anode materials that have good cycle life and are safe.

Reviewer 2:
The reviewer reported that there were a number of presentations on Si anodes at this review, showing slow progress in practical implementation of these materials. The researchers on this project are developing the tools necessary to understand and address the limitations. Ultimately, the reviewer judged that high capacity anodes will be required to get energy densities high enough for significant markets of BEVs.

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

Reviewer 1:
The reviewer found the resources allocated for this project to be appropriate, and should allow the work to be successfully completed in a timely fashion.

Development of Si-based High Capacity Anodes: Jason Zhang (Pacific Northwest National Laboratory) - es144



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer felt that the program had a very good approach to meeting the technical barriers confronting a Si-based anode. The investigators are focusing on mechanical and electrical stability of the electrode and these are key to its implementation in a cell.

Reviewer 2:

The reviewer found this to be among the best anode projects/presentations. There was clear focus on the end goal, hypothesis-driven experiments, and data driven next steps. The project addresses practical issues such as loading. One improvement could be an external evaluation of process economics. The reviewer pointed out that, although the research concluded that this was a low cost process, the assumptions/calculations needed to be shown.

The reviewer concluded that overall, the development of a process to make the anode material, coupled with subsequent improvements with binder and electrolyte optimization was well laid out in this project.

Reviewer 3:

The reviewer saw very creative approaches to mitigate the volume change issue of Si anode. The reviewer recommended raising the goal to more than 5 mAh/cm^2 to achieve the next generation high energy density Li-ion objective.

Reviewer 4:

The reviewer stated that there was a good and simple approach.

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

Reviewer 1:

The reviewer felt that good progress has been made this past year resulting in a number of publications and presentations. Several key milestones have been met, including improvement of the Si-based anode so that it deliverers at least 700 mAh/g over 150 cycles, and improving the columbic efficiency to more than 98%.

Reviewer 2:

The reviewer reported that the researchers had made good progress on achieving their targets. The reviewer would like to see more activity and ideas on pre-lithiation to help address poor first cycle efficiency. The reviewer asked the researchers to compare the FEC to a better baseline material.

The in situ TEM is superb, and the reviewer looked forward to seeing more in the future, as the reviewer felt it was a very powerful technique to differentiate SEI/electrolyte interaction effects on active versus inactive materials.

Reviewer 3:

The reviewer found it an interesting observation that volume expansion was about 66% after lithiation, which is much less than the approximately 300% volume expansion compared to other Si.

Reviewer 4:

The reviewer cautioned that the good cycling data was based on low loading, around 2mAh/cm^2 or less.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that good collaboration existed. The Pacific Northwest investigators were collaborating with the University of California, San Diego (macroporous Si), Princeton University (preparation and characterization of graphene), and the Vorbeck Materials Corporation.

Reviewer 2:

The reviewer judged the effort to be well coordinated.

Reviewer 3:

Other than the graphene suppliers, the reviewer did not see too much collaboration. The reviewer was not sure that it was hurting the progress, but thought that there could be benefits to broader interactions/collaborations.

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

Reviewer 1:

The reviewer concluded that the proposed future work was built upon recent efforts and should result in continued advancement of the Si-anode technology. The use of operando transmission electron microscope (TEM) should shed considerable light to the SEI on the Si-based anode and the capacity fading mechanism.

Reviewer 2:

The reviewer recommended that a holistic approach involving anode composition process as well as binders and electrolytes would be needed to be successful. The reviewer found that the future work addressed all of these aspects.

Reviewer 3:

The reviewer asked if there was any approach for improving first-cycle efficiency and irreversible capacity loss, or any plan to improve the Si loading and control the capacity fading rate.

Reviewer 4:

The reviewer thought that the PI needed to be more specific on plans to increase the loading to more than 5 mAh/cm^2 and on how to improve the cycling stability using additives.

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

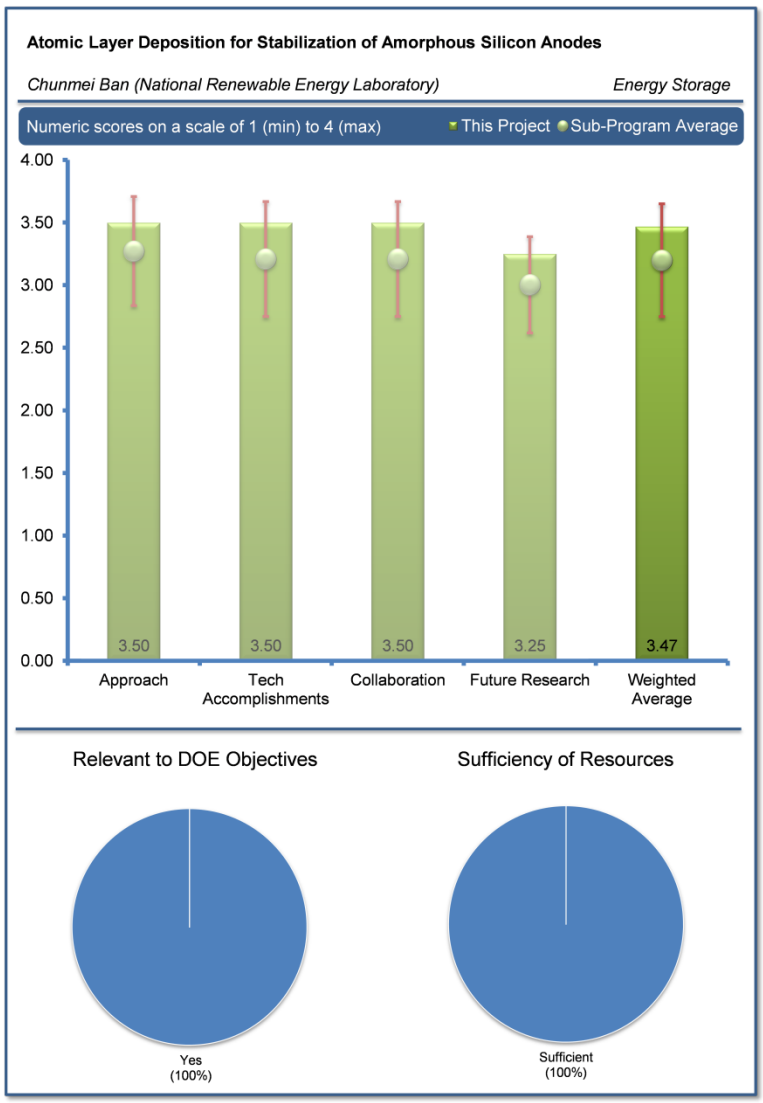
Reviewer 1:
The reviewer concluded that a practical, high energy anode is required to achieve widespread adoption of BEVs, and that this project's holistic approach can accelerate the development of such batteries.

Reviewer 2:
The reviewer explained that this program was relevant to DOE's objective of petroleum displacement because it sought to develop an affordable, high energy density anode material.

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

Reviewer 1:
The reviewer saw that the funding during FY 2012 appeared appropriate for the work to be completed.

Atomic Layer Deposition for Stabilization of Amorphous Silicon Anodes: Chunmei Ban (National Renewable Energy Laboratory) - es145



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer reported that the molecular layer deposition was novel, and a very different approach than others. The approach allowed control over many important parameters and the researchers are doing a great job in leveraging what is known in the literature to make a better SEI into designing their coatings. The reviewer asked if other chemistries would be explored, and how broadly this could be applied to other battery materials (e.g., cathodes).

Reviewer 2:

The reviewer saw this program as addressing two key technical challenges, energy density and rate capability, facing the implementation of a silicon-based anode. The proposed methodology is sound. The investigators will utilize atomic layer deposition processes and explore hybrid ALD and molecular layer deposition (MLD) coatings for improved mechanical integrity and electrochemical performance. The reviewer concluded that the resultant material should be both electronically and ionically conductive and mechanically strong.

Reviewer 3:

The reviewer felt the program had an innovative approach to control Si anode swelling at the electrode level.

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

Reviewer 1:

The reviewer saw that good progress had been made this past year. The investigators have developed a technique that improved the stability of a Si anode by an aluminum alkoxide polymer coating, and also demonstrated improved performance of a Si-polyacrylonitrile (PAN) composite anode.

Reviewer 2:
The reviewer reported that the milestones were very quantitative and that the researchers were hitting them. In addition, there were good hypotheses, and data to support/refute those hypotheses. The characterization was very appropriate and supported the approach. The reviewer would like to see some other performance targets such as power in the future.

Reviewer 3:
The reviewer felt the performance results of MLD coated Si anode was more promising than that of Si-PAN composite, and recommended that future efforts focus on the MLD approach.

Reviewer 4:
The reviewer stated that although ALD is a good approach, cost effective issues have to be addressed for practical applications.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that excellent collaboration existed. The PI has assembled a research team that is among the leaders in their field.

Reviewer 2:
The reviewer reported there was a broad range of collaborators, and thought that it was also nice to see this type of approach being applied to cathodes (see interaction with Burrell/ANL on Li-rich materials).

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

Reviewer 1:
The reviewer judged the proposed future work to be sound and built upon the efforts to date. Investigations to characterize the ALD/MLD coatings will be performed and the optimal concentration will be identified. In-situ structural characterization will be performed to gain a better understanding of the structural evolution of the coated electrodes during cycling.

Reviewer 2:
The reviewer thought that the approach looked promising enough that more work on scale-ability and practical implementation should be addressed.

Reviewer 3:
The reviewer reported that the proposed future plans were good, but again warned that cost issues have to be addressed.

Reviewer 4:
The reviewer felt that the researchers needed to demonstrate that the project can achieve similar good cycle life on a thicker Si anode (i.e., more loading) and also with a thinner MLD coating that does not compromise rate capability.

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

Reviewer 1:
The reviewer concluded that the program was relevant and supported the DOE objective of petroleum displacement. Efforts are directed toward developing a low-cost, high energy dense anode material that has good rate capability. A high performance battery will be necessary if the public is to accept an EV.

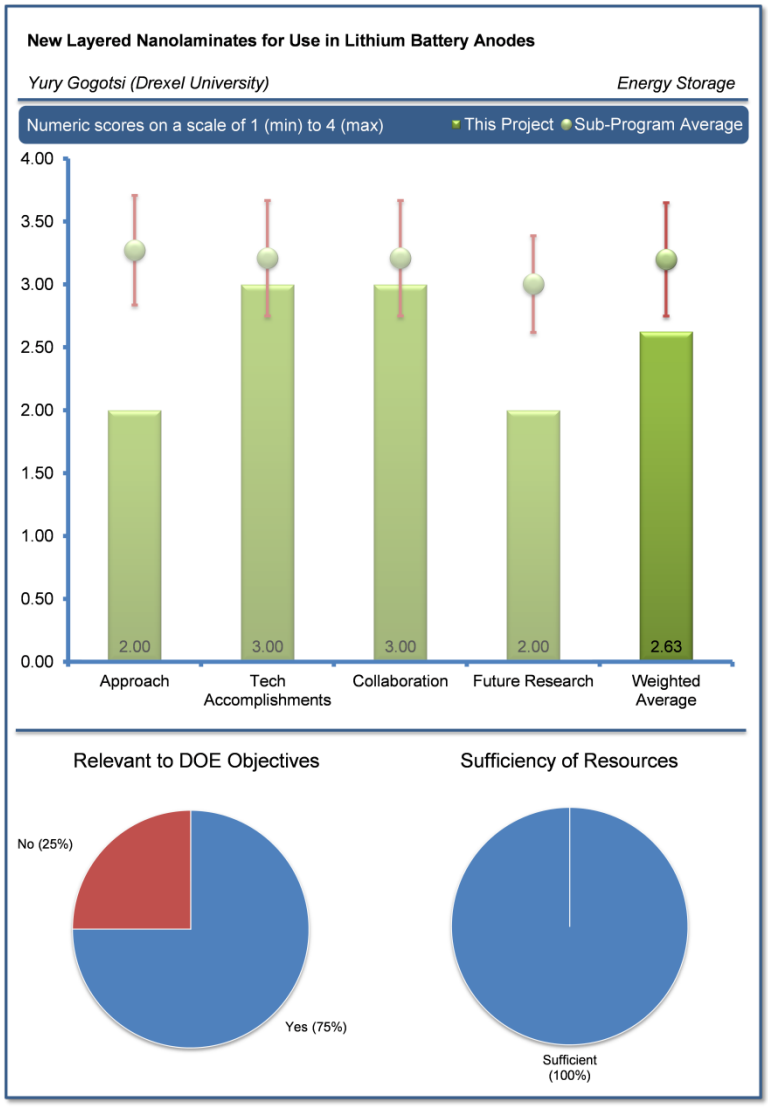
Reviewer 2:
The reviewer deemed that development of cost-effective high energy anodes is vital to technology required for widespread adoption of BEVs in the United States. The reviewer was hopeful that the learnings from this project may enable such an anode material.

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

Reviewer 1:

The reviewer reported that the resources appeared to be sufficient for this investigation.

New Layered Nanolaminates for Use in Lithium Battery Anodes: Yury Gogotsi (Drexel University) - es146



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer felt the approach was reasonable.

Reviewer 2:

The reviewer found that the technical approach is fair and addresses the technical barriers. The investigators will conduct a rapid screening of as many MXenes as possible to identify the most promising chemistry. The reviewer thought the project a little Edisonian in nature since it appeared that the effort was characterized by trial and error discovery. The investigators will also study the effect of carbon and binder additives as well the solid-electrolyte interface in order to improve electrochemical performance. The reviewer was disappointed that this system may have a narrow voltage stability window.

Reviewer 3:

The reviewer felt there was a need to identify other high energy anode materials with minimum swelling. The MXenes, however, were not attractive from an energy density perspective. The reviewer concluded that the theoretical lithiation/delithiation voltages were too high, making theoretical energy density of the couple comparable with that of SOA Li-ion couple at best.

Reviewer 4:

The reviewer questioned if this was the right material, despite seeing alternatives to graphite and silicon. The target is only 400 mAh/g at cycling rates of 1C, but the operating potential is higher than graphite. The reviewer did not think the target was aggressive enough, and did not have confidence that the performance of the material will even hit the relatively low target. The researchers need some guidance – theory/calculations to predict redox potentials and theoretical capacities. Otherwise, the researchers are just trying things. The reviewer asked if post-mortem analysis helped the researchers at all, because there was no hypotheses that the researchers could test against to further their knowledge and improve the success of subsequent experiments.

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

Reviewer 1:

The reviewer reported that the technical accomplishments achieved since the last program review were good and that the tasks were on schedule.

Reviewer 2:
The reviewer stated that the project has demonstrated feasibility at reasonable loading level for a new anode material.

Reviewer 3:
The reviewer saw that the researchers have made some progress, but felt that targets needed to be more aggressive and quantitative. A stable performance by the end of the year is not meaningful – the reviewer strongly suggested the need for an energy retention target at certain numbers of cycles. There needs to be a very clear go/no go decision on this technology. The reviewer recommended defining what the key problems were and addressing those first to determine the level of progress that was needed this year to encourage the project to go further.

Reviewer 4:
The reviewer revealed that the capacities are not even close to any of the recent SnCoC systems.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer saw that good collaboration existed and were appropriate. These included efforts with ORNL, Paul Sabatier University, and Linkoping University.

Reviewer 2:
The reviewer said that the collaboration was good.

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

Reviewer 1:
The reviewer felt that the proposed future work was fair. More M2Y MXenes will be produced and it appeared to the reviewer that some reasoning as to why certain materials should be good was taken.

Reviewer 2:
The reviewer thought that the proposed improvement for capacity had to be clearly defined.

Reviewer 3:
The reviewer saw no need to focus on low cost production until the researchers demonstrate interesting performance. The researchers need to develop and test hypotheses in the future. The plans are study, develop strategies, etc. The reviewer suggested to develop strategies now, based on hypotheses, and have future plans on the specific experiments to prove/disprove the theories.

Reviewer 4:
The reviewer recommended that, rather than focusing on making MXenes less expensive or reducing the first cycle irreversibility, future work needed to focus on tuning to lower the lithiation/delithiation voltage to make the Wh/L and Wh/kg attractive, and to identify other high capacity MXenes. The reviewer suggested a goal of identifying a MXene with a MXenes/cathode couple's theoretical energy density greater than 1,400 Wh/L and 390 Wh/kg.

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

Reviewer 1:
The reviewer concluded that this project was relevant to DOE meeting the objective of petroleum displacement. In order for the consumer to accept an EV, there must be an affordable, high performance battery. The reviewer reported that this effort seeks to develop novel anode materials that offer the combined advantages of graphite and silicon-based anodes with a higher capacity than graphite and less expansion, longer cycle life than the silicon nanoparticles.

Reviewer 2:

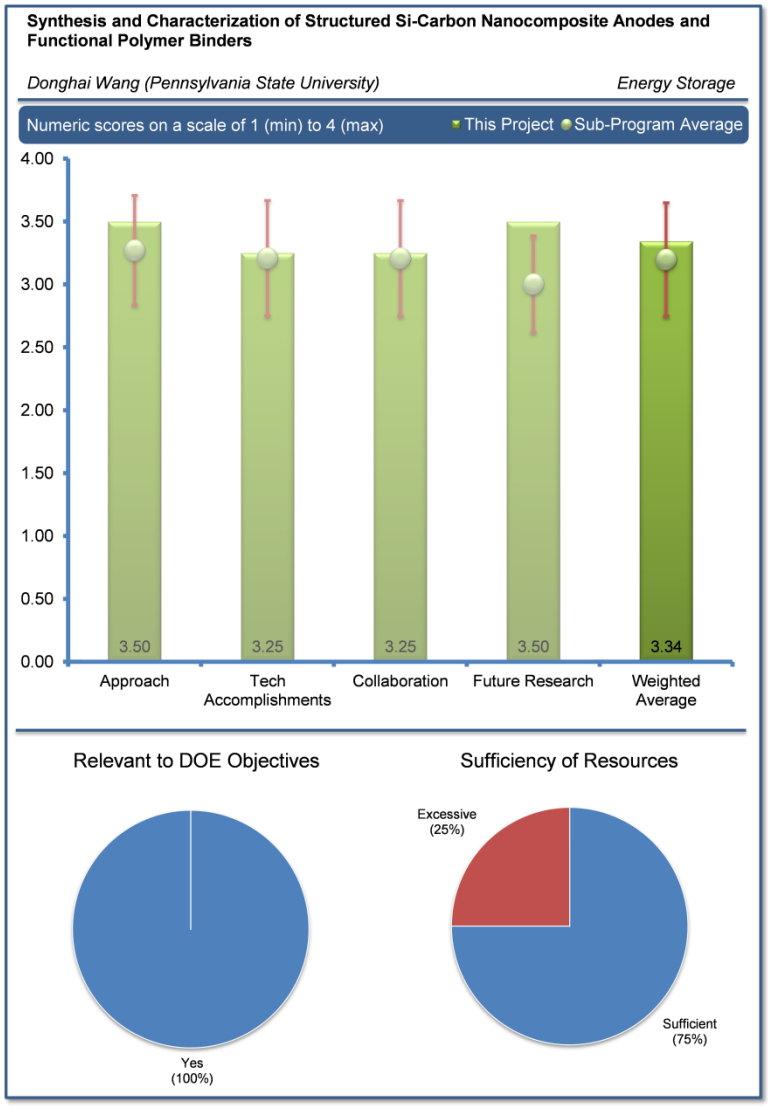
The reviewer felt that more aggressive targets were required, and that the targets as written will not have a significant impact on overall energy densities for automotive applications.

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

Reviewer 1:

It appeared to the reviewer that the project has sufficient, if not excessive, funds to complete the tasks successfully within the required time frame.

Synthesis and Characterization of Structured Si-Carbon Nanocomposite Anodes and Functional Polymer Binders: Donghai Wang (Pennsylvania State University) - es147



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer thought that the approach was good, and reported that the investigators planned to synthesize novel Si-C nanocomposites with controlled nanostructures and composition and to develop novel binder polymers for improved cycle life.

Reviewer 2:

The reviewer thought the project had a good approach.

Reviewer 3:

The reviewer felt this work was much needed to correlate performance of Si anode with controlled structure and composition.

Reviewer 4:

The reviewer thought the researchers were doing a good job exploring a multitude of different carbon/silicon microstructures. Data (electrochemistry and analytical) on these can be used to better design structures with adequate cycle stability. The approach is systematic and well designed – effects of particle size, pore structure, carbon coating are all investigated. The reviewer thought the hierarchical pore structure approach may be an excellent means to achieve a balance of properties. The reviewer concluded that the binder work exploring the relationship between swelling and ionic conductivity is very relevant and should be expanded to consider other properties (e.g., adhesion).

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

Reviewer 1:

The reviewer reported that there was excellent data that will help guiding design of Si anode, especially in reducing the fade and first cycle irreversible loss.

Reviewer 2:

The reviewer reported that the team was doing a large amount of work, and good progress was being made toward milestones. The reviewer would like to see more quantitative targets as the targets are currently given as increasing or decreasing, but do not quantify by how much. The reviewer could not tell how much overlap there was with the 2012 project, as the structures in the presentations look different. The reviewer concluded that this was the best systematic study of the effect of particle size that has been seen.

Reviewer 3:
The reviewer noted that fair progress was achieved this year. The investigators identified a Si-C nanocomposite material with a specific capacity of 1000 mAh/g over 200 cycles. Various aromatic binder materials were investigated and showed that the presence of carbonyl groups in the best performing material (SPEEK) was responsible for good cycling performance.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer saw evidence of good overlap and synergies between this project and the excellent work at PNNL, but asked the researchers to please take advantage of some of the novel techniques there – the in situ TEM for example.

Reviewer 2:
There appeared to the reviewer to be collaboration with other scientists (J. Zhang, J. Liu, G. Liu) as well as other organizations (Johnson Control, PA Nanomaterials), but the involvement was not clearly defined.

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

Reviewer 1:
The reviewer found the proposed future research to be sound, and based on overcoming technical obstacles. Efforts will continue to optimize the composition and nanostructures of the Si/SiOx-carbon composites for improved electrochemical performance as well as understanding the binder/Si-C interactions.

Reviewer 2:
The reviewer thought the future work was built well from promising results, but would like to see more specific targets with decision making points. The work on structure-property relationships on binder polymers is very important, and the reviewer was glad to see an emphasis on this.

Reviewer 3:
The reviewer suggested that future work should also focus on demonstrating similar good cycle life with increased loading, reduce swelling and demonstrate good cycle life using C coated Si approach.

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

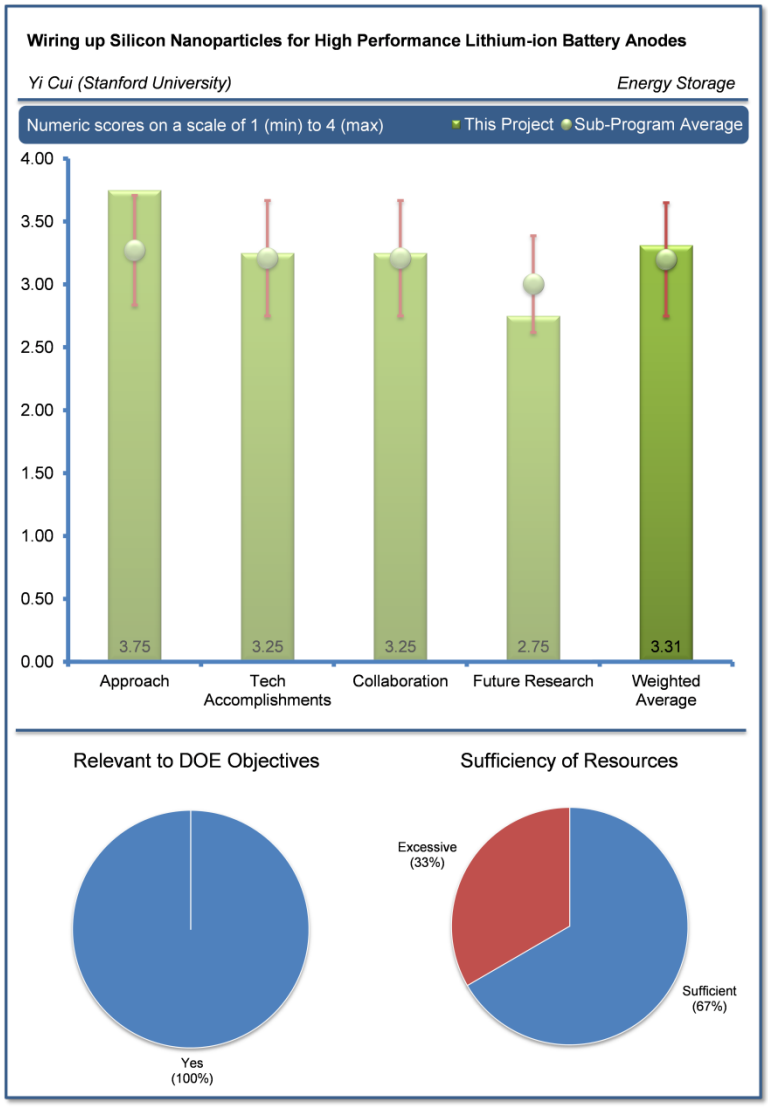
Reviewer 1:
The reviewer reasoned that this project is relevant. Promotion of EVs and the batteries that power them will reduce oil consumption. This project seeks to improve the anode for the lithium ion battery by investigating high performance silicon anode materials.

Reviewer 2:
The reviewer stated that silicon-carbon composites are a potentially attractive high energy density anode candidate that would enable BEV adoption. This project encompasses the space of carbon-silicon-binder in novel and interesting new forms/combinations to optimize performance.

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

Reviewer 1:
The reviewer judged that sufficient resources exist to complete this effort in a successful, timely manner.

Wiring up Silicon Nanoparticles for High Performance Lithium-ion Battery Anodes: Yi Cui (Stanford University) - es148



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer thought that the approach to understand the Si swelling issue and to mitigate the swelling was very innovative.

Reviewer 2:

The reviewer relayed that the researchers were exploring novel silicon structures, and did an excellent job getting fundamental knowledge on silicon expansion. These results can provide direction to the industry as to how best to get silicon to work. The cycle life/capacity on some of these structures looked very promising. The reviewer noted that the researchers were also looking at more practical concerns such as high electrode loading.

Reviewer 3:

The reviewer wrote that the approach was good.

Reviewer 4:

The reviewer reported that the effort seeks to develop Si anodes because Si anodes have a low discharge potential and the highest known theoretical charge capacity. Although Si anodes promise more than ten times higher capacity than existing graphite anodes, Si anodes have limited applications because Si's volume changes by 400% upon insertion and extraction of lithium. This results in significant capacity fading. The reviewer relayed that the project is focused on solving this problem and seek to understand and design novel nanostructure Si that can address these issues.

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

Reviewer 1:

The reviewer found that excellent progress was made last year. The investigators designed and fabricated a novel yolk-shell structure for silicon anodes. The reviewer relayed that the void space allows the silicon particles to expand freely with cycling without breaking the outer shell, which stabilizes the solid-electrolyte interface.

Reviewer 2:

The reviewer thought that the cycle life performance of some of these structures at high capacity looked very good. The researchers concluded that they have scalable low cost methods to make some of these structures. The reviewer would like to see the assumptions and models used to determine this conclusion.

Reviewer 3:
The reviewer reported very useful data on the critical Si OD and the feasibility performance data on the doubled-walled hollow Si.

Reviewer 4:
The reviewer felt that loading of silicon should be improved. The reviewer reported that PI has developed three types of Si: Carbon-silicon core-shell nanowires; hollow Si nanophere anodes; and Si yolk-shell structure, but asked how these were compared in terms of performance and stability.

The reviewer suggested that, since nanowires have been developed before, it would be better to indicate the importance of hollow Si nanophere anodes and Si yolk-shell structure. The reviewer considered that publishing results in a top scientific journal and receiving numerous invitations to speak in national and international conferences to be good, but not technical accomplishments.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer saw that good collaboration existed between the PI and other scientists. These collaborations can directly benefit the effort.

Reviewer 2:
The reviewer reported good collaboration.

Reviewer 3:
The reviewer was glad to see the coordination/collaboration with PNNL as well as a start-up, Amprius. The researchers are taking good advantage of available novel characterization techniques.

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

Reviewer 1:
The reviewer reported that the PI proposed to further understand the nanoscale design to optimize Si anodes. The project team also planned to develop surface modification to increase the coulombic efficiency. The reviewer found that these plans were sound and should lead to continued improvement of the Si anode.

Reviewer 2:
The reviewer asked if the PI had specific ideas or hypotheses on surface modification that would improve the first cycle efficiency. The reviewer would also like to see more specific work on the process economics to make any of the structures.

Reviewer 3:
The reviewer was not clear on how the surface modification will be performed to increase the first cycle coulombic efficiency, and recommended that future plans be better defined.

Reviewer 4:
The reviewer suggested that the PI reduce the first cycle irreversible loss and verify the good cycling data at a higher loading level of greater than 5 mAh/cm^2 for high energy density Li-ion cells.

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

Reviewer 1:

The reviewer felt that the project was relevant and that it supported the overall DOE objectives of petroleum displacement. The objective is to develop a high capacity anode material for Li- ion batteries. The reviewer stated that developing affordable batteries that offered long driving ranges was one of the biggest challenges to increasing the sales of hybrid or EVs.

Reviewer 2:

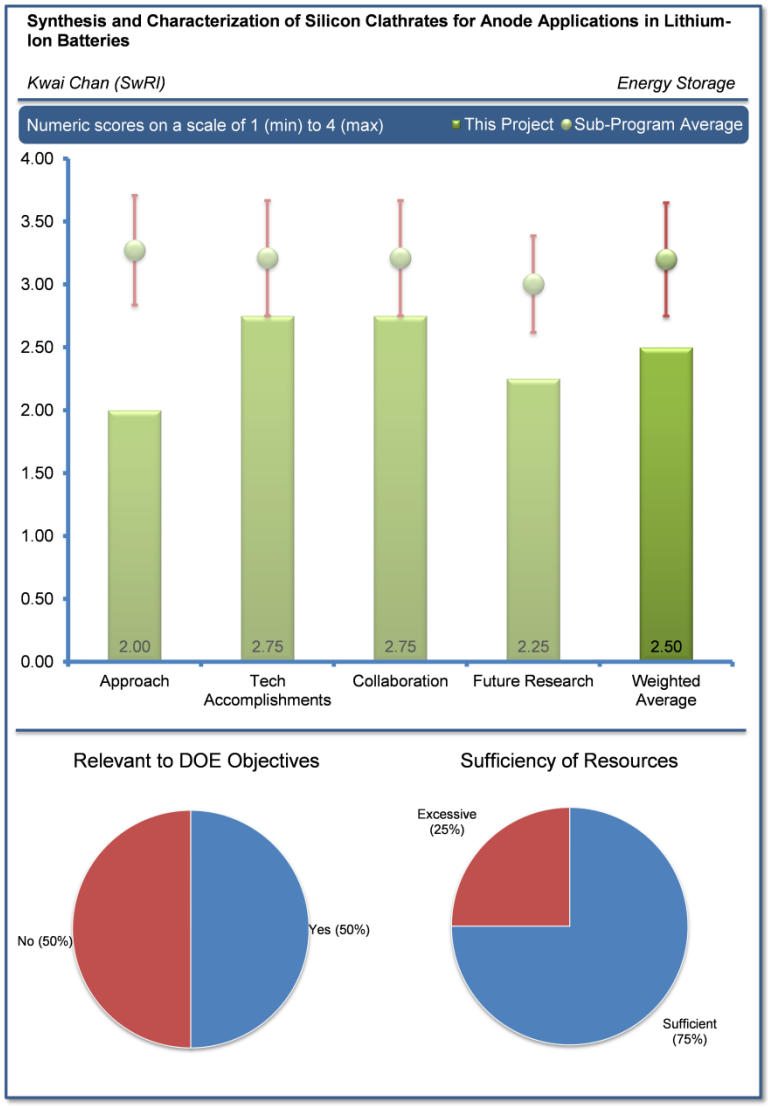
The reviewer reasoned that high energy Si anodes could enable long-range capability for BEVs which was required for widespread adoption. This project explored novel structures that may be required to get the desired performance.

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

Reviewer 1:

The reviewer thought that the funding appeared to be sufficient.

Synthesis and Characterization of Silicon Clathrates for Anode Applications in Lithium-Ion Batteries: Kwai Chan (SwRI) - es149



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer thought that using Si clathrate was an innovative approach to solving the detrimental volume change issue of Si anode, but mentioned that for a given cathode, even the highest capacity Si_{46} clathrate would result in a theoretical specific energy (Wh/kg) comparable to that of graphite/cathode couple.

Reviewer 2:

The reviewer evaluated the approach taken in this project to be fair. It aims to synthesize silicon clathrate anodes that are designed to exhibit a volume expansion much less than that which occurs during the lithiation of crystalline silicon. Because of the small volume changes during lithiation, silicon clathrate anodes have the potential for high specific energy density, while avoiding capacity fading and improving battery life. The reviewer was concerned about the volumetric energy density of this system.

Reviewer 3:

It was not clear to the reviewer if this was a high energy material or not - the electrochemistry did not look too promising. It was especially unclear to the reviewer why so much time was spent scaling up to 200g, as much smaller quantities than this could be ball milled and electrochemistry could be done on small samples. The reviewer worried that the researchers would spend a lot of time perfecting a synthesis of a sub-par material. Currently, it is outperformed by graphite and the reviewer did not see a clear path to improvement.

Reviewer 4:

The reviewer declared that clathrates are not stable phases, especially Si_{46}.

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

Reviewer 1:

The reviewer found that good technical accomplishments were demonstrated this past year. Several clathrates were synthesized and a possible reaction pathway for the formation of empty clathrates was identified. The reviewer also reported that patent applications were filed.

Reviewer 2:
The reviewer reported that the reviewers synthesized clathrates and demonstrated the feasibility of clathrates.

Reviewer 3:
The reviewer said that the project appeared to be way behind due to the scale-up/synthesis, yet it was unclear if this was needed. The reviewer asked the researchers to focus on improving the electrochemistry first, and pointed out that the theoretical capacity was only 478 mAh/g, which may not be a worthy target. The reviewer also wondered if the researchers thought that the learnings from the project might be more generally applicable to similar chemistries with the potential for higher energy density.

Reviewer 4:
The reviewer reported that the results of this project have to be verified after $Ba_8@Al_8Si_{38}$ samples are cycled at LBNL. XRD patterns of the new and old batch of $Ba_8@Al_8Si_{38}$ were confusing, leaving the reviewer to wonder why there was so much change in the pattern.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer saw that good collaboration existed in this effort. Collaborators included Dr. Chan (Arizona State University) who was providing materials and process expertise, Dr. Chen (CeSMEC) who was providing technical expertise on multi-anvil synthesis, and Dr. Peng (Arizona State University) who was providing first-principles computation expertise and density function theory (DFT) computations.

Reviewer 2:
The reviewer called the collaboration good.

Reviewer 3:
The reviewer suggested that this project would significantly benefit from collaboration with an electrochemistry and/or battery group. The reviewer did not think the project could be successful without it.

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

Reviewer 1:
The reviewer considered the planned future work to be excellent, and noted that it is built upon the progress achieved to date. The plan involved the characterization of Si clathrates previously synthesized as well as post-mortem analysis of previous clathrate anodes to gain a better understanding of the structural and mechanical states of the material at various lithiation levels.

Reviewer 2:
The reviewer stated that the samples cycled at LBNL are critical for this project.

Reviewer 3:
The reviewer asked the researchers to please focus on the electrochemistry and proving the material was worth more effort.

Reviewer 4:
The reviewer recommended that the researchers focus on reducing the lithiation voltage in order to be competitive with graphite’s energy density.

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

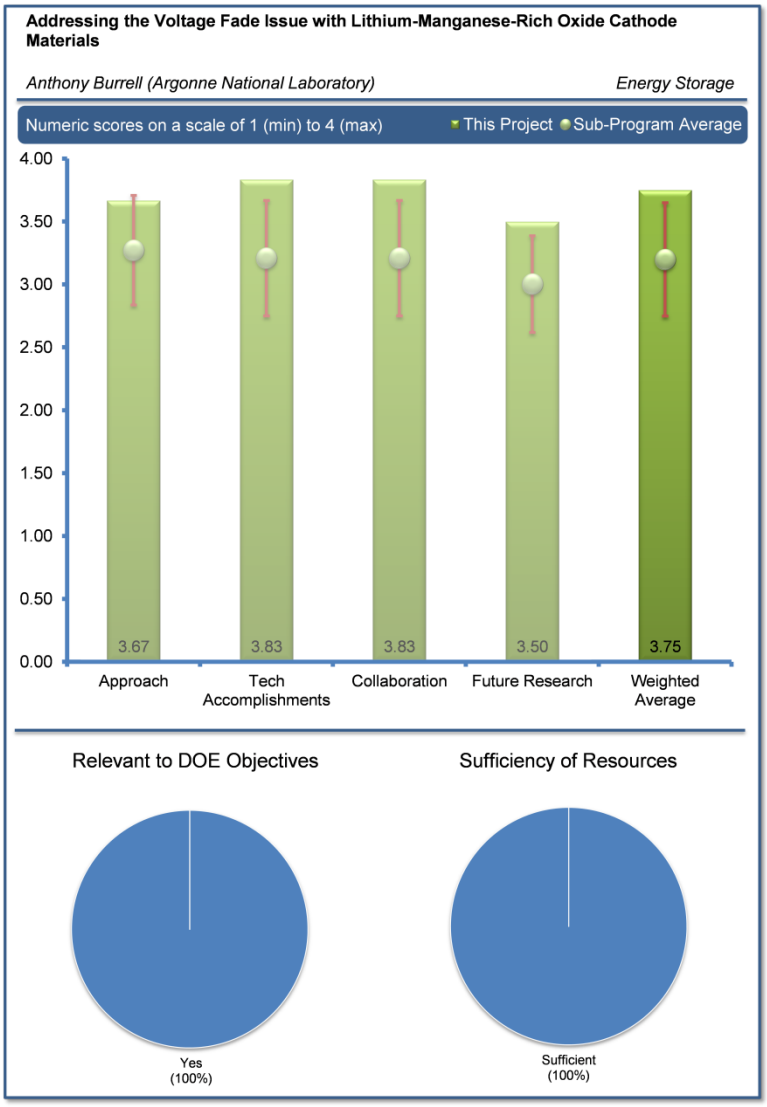
Reviewer 1:
The reviewer found this proposal to be relevant and supportive of the DOE objective of petroleum displacement. The reviewer reasoned that developing a high performance Li-ion battery that could offer a long driving range was the biggest challenge to electric/hybrid electric vehicles, and this work could potentially lead to the development of a high performance battery.

Reviewer 2:
The reviewer did consider this project to support DOE objectives at the current time, as the reviewer did not see energy density advantages.

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

Reviewer 1:
The reviewer thought the budget looked sufficient for the level of effort.

Addressing the Voltage Fade Issue with Lithium-Manganese-Rich Oxide Cathode Materials: Anthony Burrell (Argonne National Laboratory) - es161



Reviewer Sample Size

A total of 6 reviewers evaluated this project.

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

Reviewer 1:

The reviewer felt the approach was very thorough, and thought that focusing on the effects of synthesis and understanding the resulting phases would help.

Reviewer 2:

This seemed to the reviewer to be the best approach to solve this problem with the resources available. The reviewer thought that the author documented the teams and their designated functions well. The reviewer also liked the fact that time had been spent at the beginning of the project to define the protocols and test methods that were available to the team members and the public.

Reviewer 3:

The reviewer considered this one of the good presentations and a serious attempt to solve the problems associated with the Li-Manganese-Rich Oxide Cathode Materials (LMR-NMC) chemistry. The author provided several valid approaches towards understanding the VF issue with LMR-NMC chemistry and plausible mitigation steps. The reviewer stated that this was clearly teamwork, but the big question was if the project team could solve this within a short time frame.

Reviewer 4:

The reviewer thought this was a very difficult subject, almost a new area of research. The authors were tackling the problem from every possible aspect, and following a multi-disciplinary approach. The reviewer also reported that the project team was also identifying where the project should not concentrate its resources.

Reviewer 5:

The reviewer reported that the effort here was an integrated, all-out approach with an impressive team of several investigators and with methodologies ranging from experiment to theory to address an apparently difficult problem of VF (or energy loss) in LMR-NMC cathode materials. Based on the cost model, it is essential to increase the specific capacity of cathodes in a Li-ion cell to 250 mAh/g to meet the cost targets of the EV battery, and the LMR-NMC cathode is the only material that can provide such high capacities. Several experimental variables, including composition of oxide cathode, surface coatings and synthetic conditions, are being examined to quantitatively determine their effect on the VF. The reviewer reported that various sophisticated characterization techniques are being adopted to understand the changes in the local structures of the LMR-NMC cathodes during cycling (VF).

Finally, these experimental studies are being augmented by theoretical studies to understand the connection between the electrochemistry (irreversible capacity loss, hysteresis and VF) and structural aspects of the LMR-NMC oxides. The reviewer reasoned that since this VF is deemed as the most important deterrent factor for a successful use of these materials, these studies are extremely relevant and important. Thus far, the problem appeared to the reviewer more fundamental and related to inevitable structural changes occurring upon cycling, yet these studies will contribute to a good understanding of this phenomenon.

Reviewer 6:

The reviewer thought that there was nice clarification and definition of exactly what the problem was; for example, how VF is measured.

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

Reviewer 1:

It was clear to the reviewer that lots of work was being conducted in multiple directions and that there is considerable progress. The direction regarding coatings and additives has reached the no-go decision point, making it clear that these functions, while controlling capacity and fade, do not affect the VF.

Reviewer 2:

The reviewer thought that, within a year, the PI and team at Argonne had done very well to fix the VF issue associated with LMR-NMC chemistry. The reviewer felt that the new synthesis approaches, such as Li_2MnO_3 template and Na-exchange, were steps in right directions. The reviewer's worry is that anything that is new will take again 5-10 years for commercialization, which may be too late. The PI and team have the best synthesis and characterization team at their disposal to solve this issue.

Reviewer 3:

The reviewer said that good progress had been made towards understanding the VF of LMR-NMC cathode, a major issue for an otherwise promising class of materials for EV applications. After defining quantitatively the VF parameters, the effect of several experimental variables, including composition, surface coating and synthetic conditions on the VF have been studied. The reviewer reported that no clear-cut correlations have emerged from these studies, thus far. Meanwhile, various ex-situ (Neutron Pair Distribution Function, HRSXRD, etc.) and in-situ (TEM) techniques were being adopted to gain further understanding of these materials. Even though no mitigation strategy had evolved yet, it appeared to the reviewer that this problem needed to be worked around, by deliberately starting off with materials having pseudo-spinel or be conservative in the use of these materials (e.g., low charge voltages).

Reviewer 4:

The reviewer stated that understanding that surface modification does not help is a huge step.

Reviewer 5:

The reviewer knew how difficult the VF issue was and explained that the authors have clearly identified what not to do. Now, the authors should focus on additional research to identify what is clearly involved in VF. The reviewer felt that only when that is clearly identified then is there hope for a solution.

Reviewer 6:

The reviewer thought the combinatorial approach was smart, and noted different VF rates in different materials. The reviewer felt that the conclusion that additives and coatings do not affect VF was an important conclusion, and felt the single particle studies were very good.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer declared that there was awesome collaboration, going way beyond ABR.

Reviewer 2:
The reviewer said that this seemed to be an excellent effort – everyone the reviewer had talked with was supportive. The reviewer was also impressed that the team was growing so that other areas of expertise could be accessed and used.

Reviewer 3:
The reviewer reported that there were multiple team members and collaborators from ANL, other DOE laboratories and elsewhere, as was expected from the nature of the project.

Reviewer 4:
The reviewer observed that this was a very big, well-coordinated team, but thought that deeper engagement with the material makers, cell-suppliers, and OEMs might help.

Reviewer 5:
The reviewer felt that collaboration was clearly the strong point in this group. A variety of individuals have managed to work as only one team. The reviewer was hopeful that something should come out of this work.

Reviewer 6:
The reviewer felt that this was very collaborative and the PI and team have reached out to other national laboratories and partners for technical help and collaboration.

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

Reviewer 1:
The reviewer reported that the team had effectively eliminated some pathways, and that a clear pathway forward was defined. The reviewer stated that this was as good as it gets.

Reviewer 2:
The reviewer thought the project was headed in a good direction, and thought that very careful analysis of phases resulting from different synthesis conditions and formation conditions could additionally be revealing.

Reviewer 3:
The reviewer found the proposed work to be clear, and for the most part a lot should be able to be accomplished. The reviewer further suggested that maybe some effort should be focused on additional metal substitution in the composition to produce a more stable layered structure.

Reviewer 4:
The reviewer observed that the hysteresis seemed to play an important role in VF, and recommended that the authors should also study standard cathode powders and compare with powders associated with the VF.

Reviewer 5:
The reviewer said that from the very beginning, the PI teams were focused on overcoming barriers such as capacity and VF and thermal abuse tolerance. The reviewer gave full credit to the team in coming out with ways to quantify the VF and efforts towards standardization of the experimental results, and suggested that the project team should now do the following: like their electrochemical performance test protocol they should provide guidelines for standardizing a few compositions of Li-rich MNC that folks should work on and focus; the new composition should be guided by theoretical insights and modeling estimation.

Reviewer 6:
The reviewer relayed that the future plans were aimed at gaining a fundamental understanding of VF, first cycle irreversible capacity and voltage hysteresis of the LMR-NMC cathode materials. Since DOE had made considerable investment on these materials, and

these materials were the most promising cathodes for achieving high energy (and low cost) for Li-ion batteries, these issues (especially the VF) would have to be well understood and controlled, if possible. The reviewer reported that, in addition to continuing studies in this direction, future efforts would also look into studying the effects of dopants to design more tolerant oxide materials to the structural transformations occurring upon charge-discharge cycling.

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

Reviewer 1:
The reviewer thought that the project was very relevant to the DOE objectives of petroleum replacement. If the team managed to partially resolve or mitigate the VF issue, the goal will be significantly closer.

Reviewer 2:
The reviewer reasoned that high energy density Li-ion batteries would enable mass vehicle electrification which would then reduce dependence on fossil fuel consumption and reduce greenhouse gas emissions.

Reviewer 3:
The reviewer considered that this may be an important material for future automobiles, and is one of the best candidates. The reviewer concluded that this project is focused on the key issues.

Reviewer 4:
The reviewer observed that this type of cathode material was one of the few that has the capacity and energy density that could meet the USCAR requirements for EV/ PHEV. The reviewer went on to point out that unfortunately, this material has a serious drawback which could be a show stopper. The reviewer found it important to provide the effort and resources to solve this problem as quickly as possible, and declared that this approach offered such a way to do so.

Reviewer 5:
The reviewer thought that, for a successful utilization of Li-ion batteries in EVs, it was essential to enhance their gravimetric and volumetric energy densities, beyond what could be provided by the current technologies. The reviewer found high voltage high capacity cathodes in the class of lithium and manganese rich NMC (LMR-NMR) cathode materials, xLi_2MnO_3:(1-x)$LiMO_2$ (M equals Ni, Mn, Co), to be quite promising for high specific energies. However, these materials exhibited VF upon cycling and voltage hysteresis from charge and discharge. The reviewer concluded that to mitigate these effects it was important to have a good understanding of these phenomena in terms of the complex electrochemical – structural relationships of these materials.

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

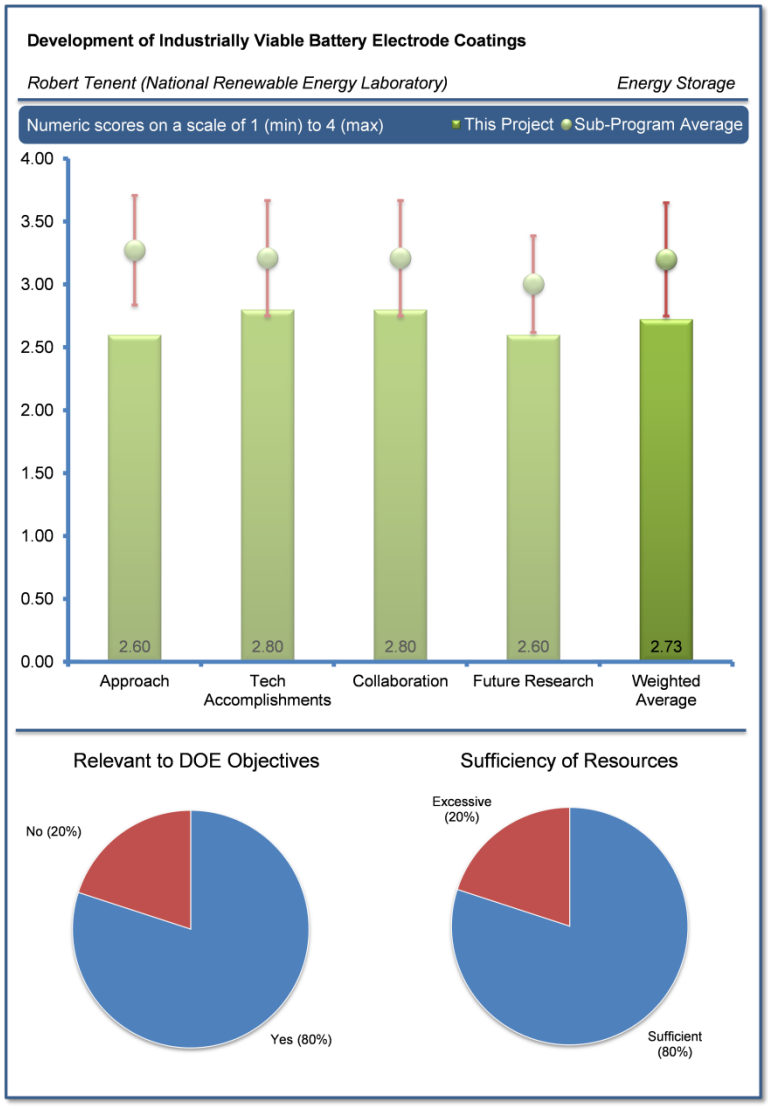
Reviewer 1:
The reviewer declared that we cannot wait for smaller teams to spend 10 years to resolve this issue; it needs to be done as soon as possible, so that the resources provided on this project are large but sufficient.

Reviewer 2:
The reviewer recommended that if the authors can show that improvements are possible, and manage to identify the VF mechanism, that the authors should request additional resources.

Reviewer 3:
The reviewer found the resources to be adequate for the project to achieve the milestones in a timely manner.

Reviewer 4:
The reviewer concluded from both the budget and resources that the PI and the team have more than the project team could ask for to solve the VF issue, but recommended that this support be continued until a good solution is found in the next one to two years. Then, suggested this reviewer, re-evaluate where things stand. The reviewer noted that, given the investment that was already made, it would be wise to bring it to some stage for automotive application.

Development of Industrially Viable Battery Electrode Coatings: Robert Tenent (National Renewable Energy Laboratory) - es162



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer declared that there was a good approach that would create significant impact if feasible.

Reviewer 2:

The reviewer found the approach to the work to be solid, and thought that the direction of working toward atmospheric pressure coatings was certainly important for obtaining a low cost process. The reviewer recommended that all efforts be directed to this goal as additional processing costs to the basic material cost are an important hurdle to overcome. It appeared to the reviewer that coatings will be very important to high voltage cells as the development of a truly stable electrolyte at high voltage has proven to be very difficult.

Reviewer 3:

The approach appeared to the reviewer to be straightforward and well thought out. There are several critical issues associated with a program such as this, and others within this group. The reviewer thought that one major consideration in developing advanced process capability to accomplish complex materials processes is to make sure that the impact of the proposed technique in achieving the desired performance gain continues to stay in step with the investment in a higher level process development. The reviewer concluded that if the product of the process does not show progress toward the targeted improvement, there needs to be oversight related to how far the process should be developed.

Reviewer 4:

The reviewer cautioned that while ALD is conceptually interesting, commercial viability is a concern, and it is questionable whether it addresses the critical needs of low cost and high throughput. There are other coating processes which may be more commercially viable. The reviewer found the initial assumptions about ALD troubling.

Reviewer 5:

The reviewer thought that binder compatibility concern at ALD process temperature was not adequately addressed, and reminded the team to be aware of binder recrystallization and potential changes in porosity after exposure to heat. The reviewer observed that tri methyl aluminum (TMA) precursor hygiene issues and cost were not addressed, but based on the discussion it appeared the best case was an added cost of 0.05 $/Wh.

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

Reviewer 1:
The reviewer stated that the detail on the process development was quite comprehensive and well done. The reviewer believes that careful analysis of the benefit of the product of the process as it relates to target performance improvement needs to continue so that the process development does not get ahead of itself.

Reviewer 2:
The reviewer reported that the workers have brought the project up to the point of demonstration of a full, ambient pressure ALD coating machine for large format electrodes. It may be more important that a fluidized bed particle coater has also received attention as complete particle coating may be essential for high voltage materials.

Reviewer 3:
The reviewer stated that progress was made with various technical challenges from 2012, but noted that there were still fundamental questions if this method would be practically feasible – coating uniformity and speed are still major challenges.

Reviewer 4:
The reviewer felt that some good things have been demonstrated related to the in-line atmospheric processing (AP)-ALD prototype and multi-deposition head, but that the results are indicative of the low feasibility of the ALD approach.

Reviewer 5:
The reviewer concluded that the process is far from scalability for application to coated electrodes at 20 m/min and more than 30 cm lane width. The reviewer felt that the project needed better definition of target and baseline electrode composition, architecture and success criteria.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer thought that collaborations appeared appropriate for the program.

Reviewer 2:
The reviewer saw what seemed to be a good collaboration, although observed no industrial participant.

Reviewer 3:
The reviewer noted that battery industry coating operation expertise was lacking.

Reviewer 4:
The reviewer stated that the necessary collaborations with national laboratories with facilities not available at NREL were important. The reviewer would also like to see some collaboration with material suppliers (especially US based companies) to keep a focus on costs and practicality.

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

Reviewer 1:
The reviewer pronounced this a solid program for future work.

Reviewer 2:
The reviewer felt that it might be worthwhile in the very near future to develop some go-no go criteria, or at least specific performance targets, for the continued development of the process based on impact at the cell level. The reviewer also suggested that generic process details be shared across the DOE space to other programs that might benefit from such a technique, even if not battery related.

Reviewer 3:
The reviewer said that the researchers seemed to be hedging on the push-pull approach, and thought that this project looked to be very questionable from a cost and line speed perspective. Also, the reviewer asked how this issue would be improved, as opposed to exacerbated, due to the difficulties related to non-uniformity on flat substrates in the push-pull approach.

Reviewer 4:
The reviewer thought this project could be a little bit more focused given the program maturity – too many options were still on table (e.g., push/pull versus reel to reel, powder versus electrode, AP or vacuum, etc.).

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

Reviewer 1:
The reviewer stated that high voltage materials are the best way to higher energy at the present. The coating of materials is probably going to be necessary for high cycle life cells.

Reviewer 2:
The reviewer judged that electrode coating was a viable candidate to pursue in terms of improving cell performance along a number of parameters.

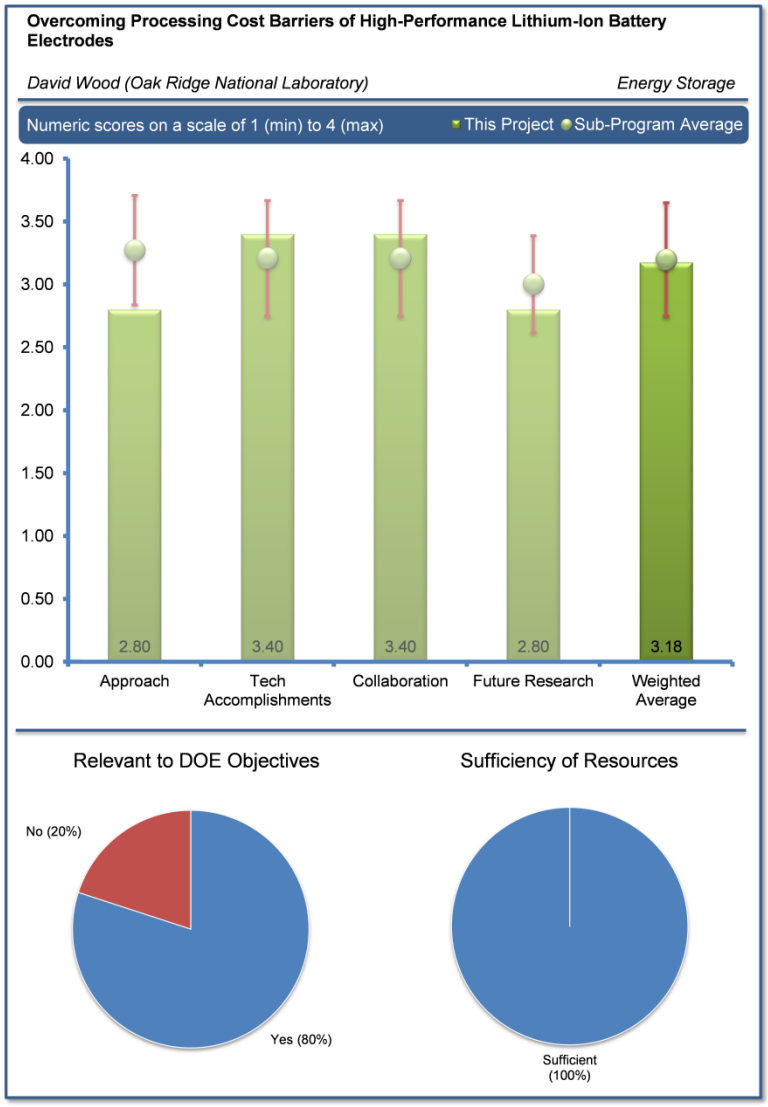
Reviewer 3:
It was unclear to the reviewer how this approach truly addressed the key needs related to cost and throughput. The abuse tolerance benefit seemed questionable, but the future testing at Sandia will be interesting.

Reviewer 4:
The reviewer suggested that the researchers consider a go/no-go decision based on the ability to meet cost and throughput if applied to coated electrodes.

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

Reviewer 1:
The reviewer observed that resources appeared adequate.

Overcoming Processing Cost Barriers of High-Performance Lithium-Ion Battery Electrodes: David Wood (Oak Ridge National Laboratory) - es164



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer thought the project had a very clear approach and objectives, and was well thought out.

Reviewer 2:

The reviewer predicted the work to have a significant impact, if it was feasible.

Reviewer 3:

The reviewer did not get the impression that the program encompasses a systematic coating formulation approach that would be required for a viable waterborne electrode coating. The approach uses common materials and does not seem to address issues such as rheology, wetting, film formation. application, and drying through the formulation parameters.

Reviewer 4:

The reviewer reported that the use of water based slurries has been in use in Japan and other countries for many years. It was difficult for the reviewer to see what advantages this work would bring to anodes, but the workers should at least show comparison to SBR-CMC based anodes to learn if any advantages can be obtained. The reviewer is also concerned about the use of hydrophilic polysaccharides such as xanthan gum and easily oxidizable materials such as the imine polymer. No studies of the stability of the polymers alone seem to have been done.

The reviewer was surprised that no discussion of material costs is presented, since cost is to be the main barrier to be addressed.

Reviewer 5:

The reviewer had concerns about residual water content and sensitivity to rehydration following bake-out, and therefore suggested adding a high self-discharge test to look for soft shorts associated with soluble oxidized transition metal oxides. The 88% active electrode material content seemed low to the reviewer, who suggested consideration of cost and return on investment (ROI) of modifying present coating capex for aqueous cathode processing. The reviewer asked how new binders affect electrolyte wetting, and recommended that high temperature stability evaluation look at Tg and binder recrystallization or reflow – TGA will not see this.

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

Reviewer 1:
The reviewer saw very good progress; and noted that the important aspects of providing a baseline for the study were developed. The important questions had been answered or were in the process of being answered. The reviewer remarked the project was well done.

Reviewer 2:
The reviewer felt that the results are moving in the right direction, but could be far advanced using the knowledge base of waterborne coating experts.

Reviewer 3:
The reviewer reported that progress was made with LFP cathode system, but cautioned that this system is unlikely to play a large role in automotive applications and there was still more work left to demonstrate success with NCM and other cathode systems.

Reviewer 4:
The reviewer thought that the performance of the Li- iron phosphate cells were below standard. The reviewer commented that the excellent room temperature cycle life of commercial cells was not even approached and that the rate capability was rather poor. The reviewer wondered if this was a matter of binder, processing or base material, and why no studies seemed to have been made.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that ORNL is doing excellent job involving industry and bringing process awareness to this program

Reviewer 2:
The reviewer thought that the project had a decent set of participants, but that more attention should be paid to paint and coatings manufacturers who have a wealth of knowledge in the issues at hand. The electrode formulations are essentially coatings, and there is a lot of knowledge that could be applied here.

Reviewer 3:
The reviewer reflected that it was good to see collaboration with commercially significant materials suppliers.

Reviewer 4:
The reviewer thought it would be useful to collaborate with HydroQuebec, who have done many studies of water based slurries for electrode manufacture, and who is also a participant in the BATT program. The other national laboratories have not shown much experience with these materials.

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

Reviewer 1:
The reviewer stated that the proposed future research was very good, and thought that the program should be able to provide a solid platform for materials suppliers to develop improved materials for this potentially significant process.

Reviewer 2:
The reviewer recommended that more elaborate testing of electrodes should be done in future work. Adhesion, cohesion, and other properties seemed to be ignored up to the present.

Reviewer 3:

The reviewer suggested that more effort should be put to demonstrate that surfactants used in slurry preparation will not negatively impact cycle life.

Reviewer 4:

The reviewer stated that rheology and film shrinkage are the major fundamentals to be addressed moving forward.

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

Reviewer 1:

The reviewer evaluated this to be very relevant. Moving from non-aqueous to aqueous deposition technology holds many cost and environmental benefits and the reviewer felt this was a very important program.

Reviewer 2:

It was not clear to the reviewer where the major cost reductions would come from. There needs to be major simplification in the coating, processing, and drying methodologies, enabled by true coating formulation, for this program to succeed.

Reviewer 3:

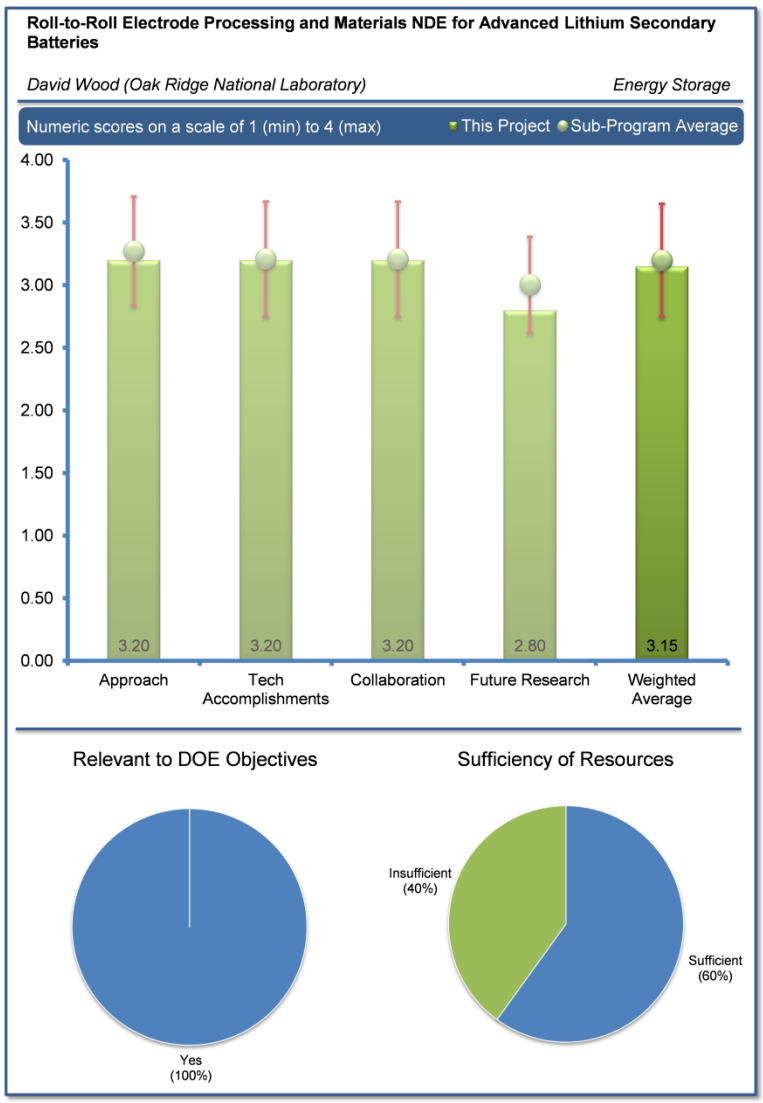
The reviewer said that the national laboratories have always had a problem in reproducing cells or coatings made in the industry, so this presented a real challenge to the workers. To be relevant, the project needs to have good comparisons with actual state of the art and not some in-house standards.

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

Reviewer 1:

The reviewer reported no issue.

Roll-to-Roll Electrode Processing and Materials NDE for Advanced Lithium Secondary Batteries: David Wood (Oak Ridge National Laboratory) - es165



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer found the combination of techniques to be very sound, but there did not seem to be a sense of the cost of such non-destructive evaluation (NDE). Also the reviewer hoped that partners would be willing to supply randomly selected electrode stock to compare with coated electrodes subjected to the full recommended NDE on an apples to apples basis. The reviewer concluded that if cost figures of conventional controls can be supplied by manufacturers that would also be a benefit for comparison.

Reviewer 2:

The reviewer judged the technical approach to be well defined and logically laid out. At the goal level, the reviewer thought it could be important to have more specific data on the justification for the program. The reviewer asked how much scrap was generated due to the issues addressed in this program, just how big an issue this was, and wondered what the size of the opportunity was. While it may be that techniques developed within this program could be used for fundamental study of materials properties related to performance (the secondary goal), the reviewer did not know that it should be convoluted within what is otherwise stated to be a quality control (QC) tool development program.

Reviewer 3:

The reviewer found that this program addresses some critical needs to the manufacturing process and needs to have significant effort dedicated to it. Some of the approaches may be questionable from a high throughput manufacturing perspective. The reviewer suggested that a thorough evaluation of QC protocols from conventional industrial coating processes may be helpful, as some lower technology methodologies may be sufficient.

Reviewer 4:

The reviewer revealed that development of in-line QC tools will have significant impact on production capabilities.

Reviewer 5:

The reviewer was not aware of a need to replace beta gage, and stated that it would be a valuable and appropriate national laboratory role to correlate observable defects with performance or life degradation. The reviewer wondered what the false negative/false positive rates and repercussions were. The reviewer would like the researchers to restate success goal as percent reduction in scrap at electrode

coating operation. The present 99% cell-level goal was unrealistic, and the root causes for failure include factors that would not be caught by the methods being developed.

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

Reviewer 1:
The reviewer thought that the results were certainly interesting. However, the reviewer had a concern about how the sampling was done. For example, the standard deviations in the selected sections of Toda 523 coatings seemed nice and small, but when observing the overall run, there were large motions in the measured thickness not reflected in the selected ranges. This called into question the operation of the slot die coater as it seemed to be somewhat out of control. Likewise in the graphite run, there seemed to be a steady drift up in the thickness of the electrode that was not reflected in the small sections. The reviewer wondered if the coater was operating under thickness control conditions.

Reviewer 2:
The reviewer noted the high precision thickness measurement, and thought that the results were interesting. The reviewer suggested that it could provide more relevance if it were compared to another (incumbent) measurement tool, and wondered if this was better than what is being used now. The reviewer also found the IR thermography to be very interesting, and asked the researchers to confirm if it was picking up issues not capable with currently used techniques, as the project team suspected. The reviewer thought that the material performance studies could perhaps be of interest, but should not necessarily be in this program.

Reviewer 3:
The reviewer thought that the thickness measurements seemed feasible, but that in-line x-ray fluorescence (XRF) was more challenging. Overall, the commercial feasibility of these approaches was still unclear.

Reviewer 4:
The reviewer had concerns over the standard deviations observed in the laser thickness measurements, and could not truly expect to be well below 2% in terms of accuracy to make this worth the cost. The reviewer agreed that cost improvements could be made by reducing scrap of the finished electrode film, but dispersion and deposition defects must be addressed to make substantial impact on cost.

Reviewer 5:
The reviewer noted the program change in scope to include LMR-NMC, and wondered if there were any adjustments in goals, objectives and resources. The reviewer saw nice technical progress with these materials, but noted that this competed for resources with original goals.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer thought that there appeared to be a good set of collaborators for the project.

Reviewer 2:
The reviewer said that collaboration seemed good with both battery manufacturers and the material suppliers involved. The collaboration with battery manufacturers would be greatly enhanced if an electrode sharing program could be implemented.

Reviewer 3:
The reviewer stated that the uniformity specifications were speculative and needed more industry feedback before further commitment to XRF.

Reviewer 4:
The reviewer felt that this project begged for an industrial coating partner, and asked if that had been considered or pursued.

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

Reviewer 1:
The reviewer suggested that data sharing programs with the industry to the extent that could be done without violating proprietary considerations would be a valuable addition to future work.

Reviewer 2:
The reviewer would like to see more emphasis on validating an improved QC capability that results in a measurable improvement in the overall process.

Reviewer 3:
The reviewer stated that the researchers should understand precision and long term stability of the proposed measurements, and understand commercial feasibility, perhaps by direct engagement with experienced cell makers.

Reviewer 4:
The reviewer found it reasonable for the existing focus on finished films, but would like to see a greater emphasis on, at minimum, the deposition process and a vision of how to integrate feedback loops and automation.

Reviewer 5:
The reviewer suggested that the researchers look at the possibility of in-line QA for real time assessment of moisture content and the possibility of optimizing line speed or drying rates e.g. it may be possible to ramp up drying rate once moisture content drops below a defined threshold.

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

Reviewer 1:
The reviewer stated that this program addresses some real deficiencies and needs with respect to the electrode manufacturing process.

Reviewer 2:
The reviewer felt that the national laboratories have always had a problem in reproducing cells or coatings made in industry, so this presented a real challenge to the workers. To be relevant, the reviewer suggested that the project team needed to have good comparisons with actual state of the art and not some in house standards.

Reviewer 3:
The reviewer thought that this would have relevance if a significant QC technique which could provide tangible cost and reliability improvement were to be developed.

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

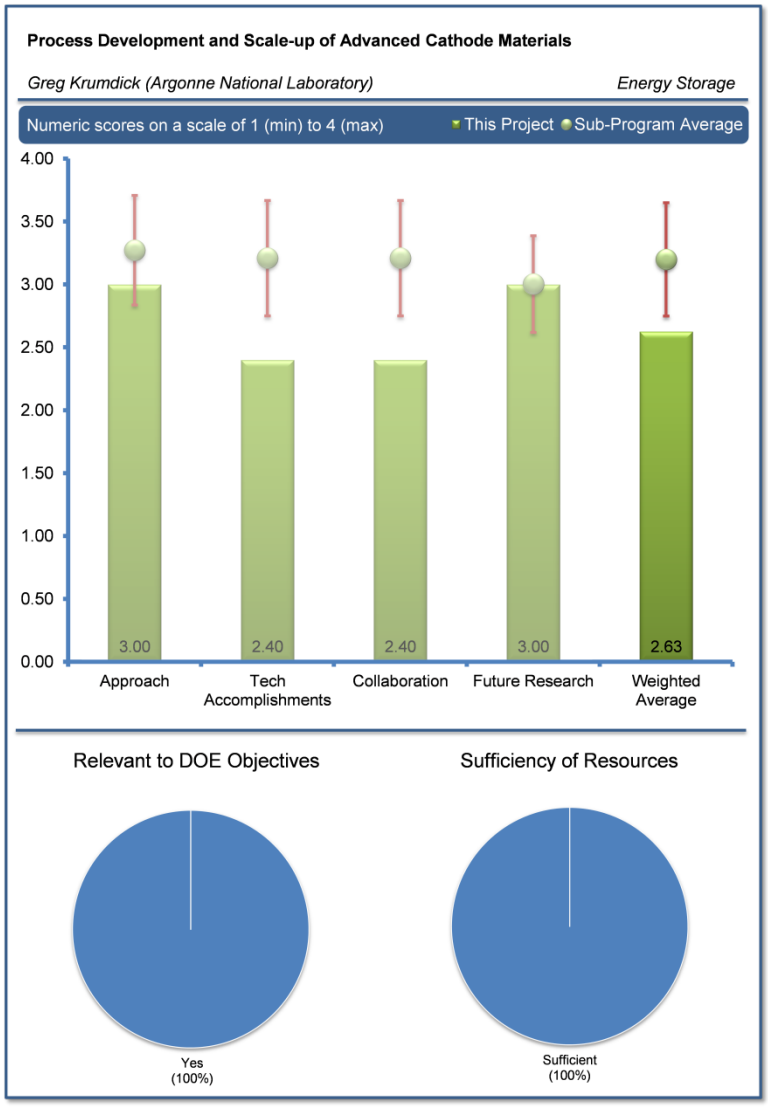
Reviewer 1:
The reviewer declared that this was not an aspect of manufacturing to treat lightly. In order to make U.S. manufacturing competitive and superior, this was an area to hit hard. The reviewer suggested that the researchers explore contribution from existing manufacturing experts, especially in the coating sectors.

Reviewer 2:
The reviewer thought that the program change in scope to include LMR-NMC should be noted, and wondered if there were any adjustments in goals, objectives and resources. The reviewer saw nice technical progress with these materials, but this competed for resources with original goals.

Reviewer 3:

The reviewer found the resources to be adequate.

Process Development and Scale-up of Advanced Cathode Materials: Greg Krumdick (Argonne National Laboratory) - es167



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer thought that the approach was generally good, but it was not clear how many preparations have been made and how statistics have been applied to the many variables listed in the work. The authors should be aware that many of these variables interact rather strongly. Also, the reviewer reported that the concentration on particle cracking did not seem to have a basis in cell performance, so it may not be a critical aspect.

Reviewer 2:

The reviewer judged the approach to developing a complex materials scale up to be well thought out and logically presented. Obviously with the significant effort required for this task, the choice of specific material to scale is of the utmost importance.

Reviewer 3:

The reviewer reported that the project focuses on addressing synthesis and scale up challenges with Li rich cathodes. The impact can be significant if the project is successful. The reviewer found the approach to be sound and based on detailed exploration of various synthesis and other parameters to understand the impact on cathode particle properties.

While the technical approach was sound, the reviewer felt there was not enough discussion around how practical various approaches were and what the potential penalties of different approaches were. It will be very important to understand if there are some fundamental issues with scaling of various approaches.

Reviewer 4:

The reviewer thought that it was a reasonable approach to evaluate a variety of advanced cathode particles, especially when there are not useful suppliers of such materials at sufficient scale.

Reviewer 5:

The reviewer noted that 82% of active material content in electrode was low. Fixing the binder percent with varying tap density and particle size may be unrealistic and contributing to differences in observed performance. Optimizing binder content and dispersion may require changes in formulation, but a rigid apples-to-apples comparison (fixed formulation) may not be appropriate. The reviewer thinks this will be a tough challenge, as it does expand the scope.

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

Reviewer 1:
The reviewer noted that two techniques for cathode material scale up have been developed. Highly detailed studies on the material characteristics developed by each process have been accomplished. The reviewer thought that it will be important to lay out the target criteria that define success. Material/process optimization can (and typically is) be an ongoing activity in the commercial world. The reviewer suggested that some significant thought should be put into the issue of whether there is a definable end point to this work, or if it is an ongoing optimization effort.

Reviewer 2:
The reviewer reported that good progress was made to understand the impact of various synthesis variables on particle properties and results are analyzed and summarized in a logical and useful way. It was hard for the reviewer to judge how much progress was made toward overcoming the key barriers. It seemed that the conclusion was reached that there will always be a tradeoff between tap density, particle stability, and performance, and that one would have to choose which property is more important and design the particle for specific application by accepting tradeoffs. The desired particle needs to be small, spherical and dense. The reviewer wondered if perhaps it was time to consider alternative approaches to synthesize Li rich materials with less tradeoff.

The reviewer also noted that there was no discussion on how this approach and its ability to vary particle size impacts one of the key barriers with Li rich materials which is VF. Surely there must be some data already available that will answer the question is smaller particle size beneficial for VF.

Reviewer 3:
The reviewer did not see any designed experiments involved in the scale up results. With the number of variables, there should be some effort to eliminate some of the less sensitive variables from the study.

Reviewer 4:
The reviewer found it troubling that the inconsistency of particle morphology between the bench scale and pre-pilot scale was not explained and did not seem to be addressed. One could question the value of that process. The reviewer relayed that the problem seemed to be overcome with the continuous particle growth improvement, but cautioned that scalability was still an issue.

Reviewer 5:
The reviewer felt that the presentation could have been clearer on critical to quality (CTQ) gaps and past progress against these gaps especially in terms of cracking, porosity and tap density.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
It appeared to the reviewer that the appropriate collaboration work was occurring within the national laboratory system. The work appeared well coordinated and highly detailed. As there were no commercial partners at this stage, it was unclear to the reviewer whether that was preferred at this stage or not.

Reviewer 2:
The reviewer would like to see some interaction with material suppliers to see what the suppliers would like to see in the way of a scaled up process in order to implement new materials received from national laboratories.

Reviewer 3:
The reviewer revealed a fairly limited team of contributors, and the absence of a small business with expertise in complex particle manufacture, which was needed.

Reviewer 4:
The reviewer asked how this work was coordinated with extensive outside efforts with LMR-NMC.

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

Reviewer 1:
The reviewer thought that, with such a large effort required for any new candidate material/process, it was critical to provide the proper guidance as to the specific choice and why.

Reviewer 2:
The reviewer concluded that the low tap density of the hydroxide material seemed to be the main problem with that preparation, and recommended that the focus should be to try to improve the tap density.

Reviewer 3:
The reviewer did not fully understand the cracking issue, and the path forward looked to rely too heavily on trade-offs.

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

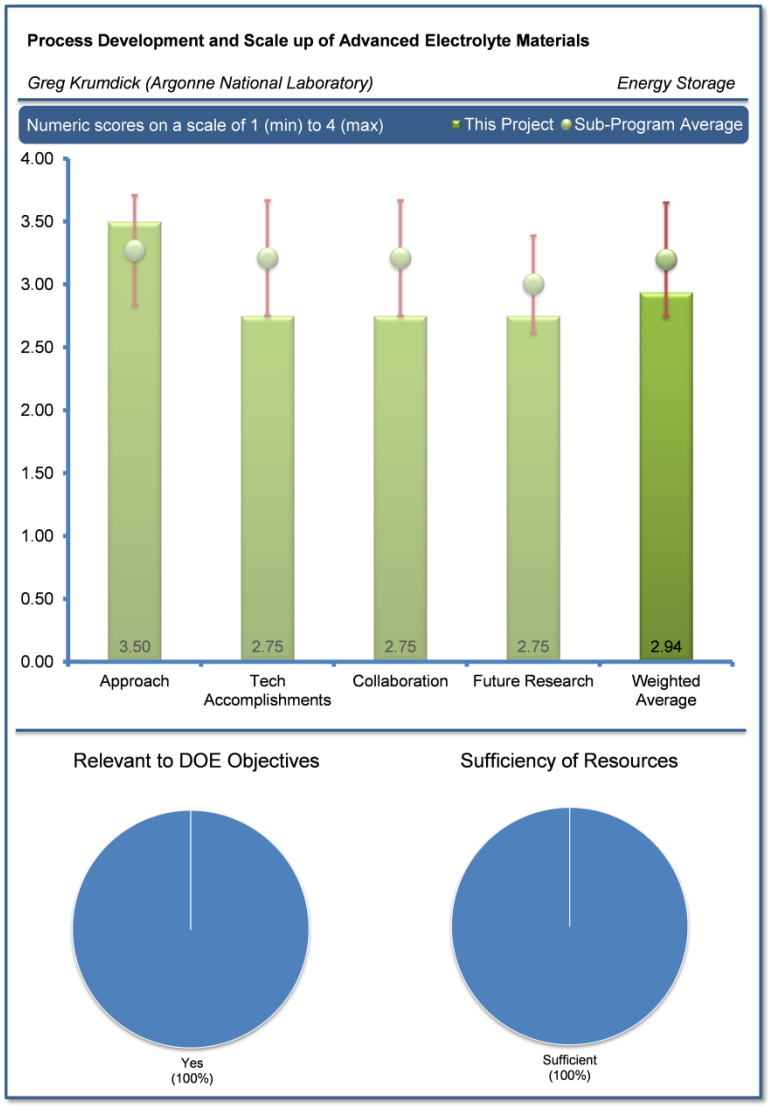
Reviewer 1:
The reviewer reasoned that advanced active material sets were a critical item in the development of higher energy, lower cost Li-ion battery technologies, and that advancing the field for highly promising candidates was a critical activity. The choice of work, as well as the general approach to interaction with industry is a critical aspect in achieving that relevancy.

Reviewer 2:
The reviewer stated that this type of capability is needed to help identify next generation cathode and anode materials to get to longer term DOE and battery industry goals.

Reviewer 3:
The reviewer recommended speeding up and validating material spin off to industry; this program could provide an interesting role.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
No comments were received in response to this question.

Process Development and Scale up of Advanced Electrolyte Materials: Greg Krumdick (Argonne National Laboratory) - es168



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer thought that the evaluation and scale up process was well laid out with documentation and decision points, and that the flow chart was easy to follow. More insight into how new materials are identified and introduced to the process would be helpful. The reviewer anticipated that the database should be a valuable tool and one would hope there would be insight into structure-property relationships, which is not addressed in the presentation.

Reviewer 2:

The reviewer felt the first half of the approach was spot on; essentially providing a database and perhaps a platform capability for the evaluation of new materials as components in electrolyte development. The reviewer declared that this is a complex task, as the electrolyte is a combination of materials that would typically require some optimization with the introduction of a new component.

The reviewer found the second phase of the approach to be a little tricky; determining which components should be scaled up, who should scale up, etc. is the key to this area. If this is mainly aimed at evaluating laboratory scale materials developed through, say, the national laboratory system, and then scaling up promising ones because there is no industry source, then that is a reasonable goal. The reviewer concluded that it needs to be a little clearer as to what the higher level objective of this part of the program is.

Reviewer 3:

The reviewer found that the funnel and selection criteria were working well. In some cases, it may make sense to toll manufacturer synthesis and focus program resources on blending and validation.

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

Reviewer 1:

It appeared to the reviewer that a very competent effort occurred in the scale up in a number of candidate materials. Complexity in the program must certainly come from the diversity of skill sets it might take to approach such a wide variety of synthetic techniques. The reviewer felt that the process of deciding which material was deserving of scale up still stood as a higher level issue.

Reviewer 2:
The reviewer observed that some new materials have been scaled to the kilogram scale and intellectual property protection initiated. With the level of funding and the simplicity of most of the synthetic routes shown, one might expect more materials to have been screened and scaled. The reviewer understood that there had been considerable effort into building the synthetic lab and pilot infrastructure and analysis protocol, which was great. The facilities seemed to lend themselves to high-throughput techniques, so this would be an expectation moving forward.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer reported good collaboration within the national laboratory network and some universities, but would like to see more outreach to industrial partners so this work can better impact commercialization.

Reviewer 2:
The reviewer revealed that although the outreach was aggressive, there was still a lack of industry response or follow through. The reviewer found that academia and national laboratories were collaborating well, but needed to create some incentive to get an industry response.

Reviewer 3:
The reviewer stated that no data was presented related to feedback from any of the materials that were developed. The reviewer asked if the project team went back to the originating organizations and validate at the functional level. Several presentations were listed, and this reviewer inquired as to a possible highlight from those relating to the use of the material.

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

Reviewer 1:
The reviewer felt the goals moving forward were a bit more aggressive and suggested that the researchers may want to push it even further, in terms of the number of electrolyte materials evaluated prior to scaling.

Reviewer 2:
The reviewer said that it was not clear what gaps were to be addressed.

Reviewer 3:
The reviewer would like to see more development of the justification process for the materials chosen to be scaled.

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

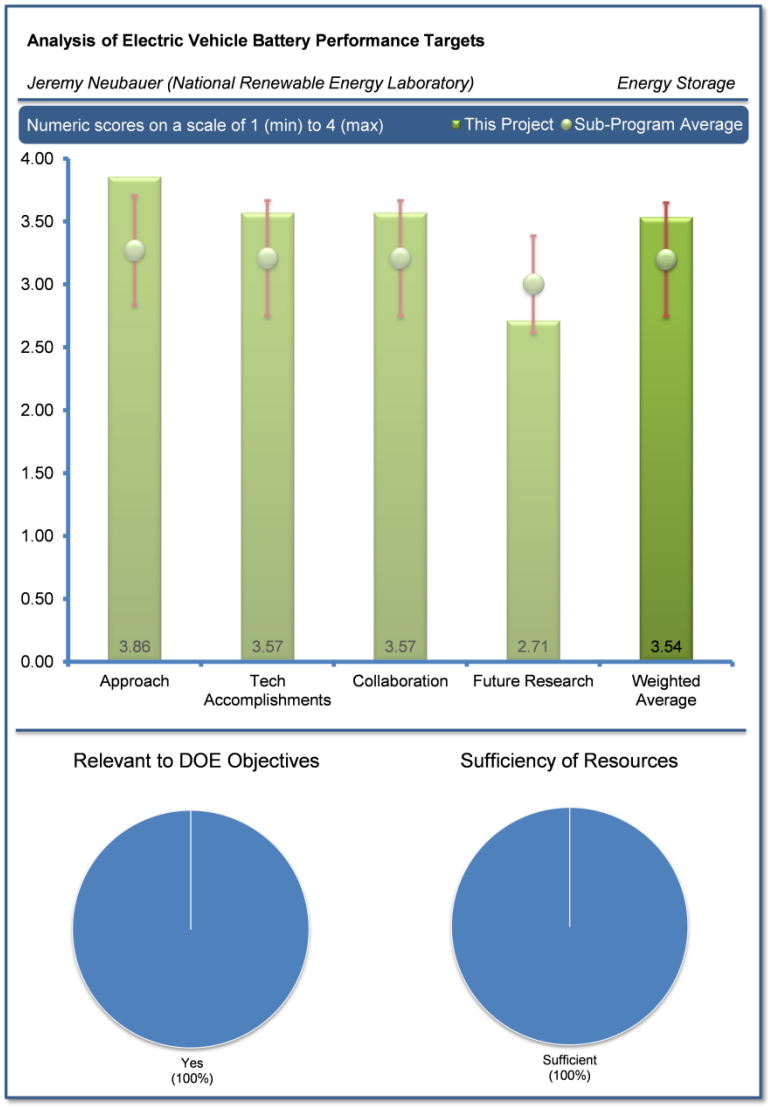
Reviewer 1:
The reviewer reasoned that electrolyte technology is a key part of improved battery performance in the future, and, that at a minimum, having a comprehensive database of materials and a platform for testing is very relevant.

Reviewer 2:
The reviewer felt that the program provided a needed link between battery electrolyte discovery and commercialization and was an effective way to validate new materials.

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

Reviewer 1:
The reviewer felt that funding seemed appropriate for the output.

Analysis of Electric Vehicle Battery Performance Targets: Jeremy Neubauer (National Renewable Energy Laboratory) - es174



Reviewer Sample Size

A total of 7 reviewers evaluated this project.

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

Reviewer 1:

The reviewer remarked that the approach was outstanding because it involved a great deal of interaction with the vehicle OEMs while providing vehicle relevant data, continuing refinement, and reviewing of the model with the DOE and the OEMs. The approach allowed for various vehicle types to be analyzed with respect to two different battery systems that are part of the DOE and vehicle OEM objectives. The reviewer also commented that the project demonstrated the versatility of the NREL Bill of Material (BOM) as well.

Reviewer 2:

This reviewer first commented on the need for this sort of work at the 2009 AMR and is very glad to see this effort is now underway.

Reviewer 3:

The reviewer observed a well-structured approach using a requirements cascade process while communicating on collaborating with the end-user.

Reviewer 4:

According to this reviewer, there is a need to update the performance matrix requirement. The reviewer added that the project had a sound tech target analysis approach.

Reviewer 5:

This reviewer commented that targets are derived from the OEM's vehicle and driving profile assumptions.

Reviewer 6:

The reviewer remarked that the results presented show End of Life (EOL) targets that correspond to given mass factors and driving ranges for a number of vehicle types. Although it is mentioned in the presentation, it is not explained which methodology will subsequently be used to translate the EOL performance and cost targets into their BOL equivalents. The reviewer stated that the same applies for breaking down pack-level targets into targets for the individual constituents.

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

Reviewer 1:
According to the reviewer, the intended goal of publishing the new battery electric vehicle (BEV) battery technology targets are on track to meet the project schedule.

Reviewer 2:
According to this reviewer, the complete list of targets was reported.

Reviewer 3:
The reviewer observed that the analysis is solid, which includes a generation of main parameters, which will affect the selection of final requirements. The reviewer pointed out that the input set was not exhaustive, but the analysis framework was capable of accepting additional inputs and constraints, while continuing to deliver meaningful outputs.

Reviewer 4:
This reviewer described that the project team made good progress but seemed slow since the project initiation in 2010.

Reviewer 5:
The reviewer stated that the project does not in itself address directly DOE goals, but is aimed at establishing targets to further guide program efforts. As such, it is a necessary element of the VTO. The reviewer noted that the progress realized within the project cannot be evaluated on the basis of the information provided in the presentation slides.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer remarked that the collaboration with USABC partners was excellent. The reviewer added that focused input from non-USABC OEMs could provide additional insights and output from the project.

Reviewer 2:
This reviewer observed that the project team was customer-oriented, with solid collaboration between industry end-users, as well as having a voice of customer inputs through other research groups.

Reviewer 3:
The reviewer stated that key stakeholders in this project have been intimately involved throughout the process, from establishing the approach to providing the data to establishing and refining the targets.

Reviewer 4:
The reviewer commented that the work approach, presented on Slides 7-11, has been developed with major stakeholders, which is absolutely required for assuring the relevance of the outcome. The reviewer cannot judge on collaboration or integration of the project activities with other program efforts.

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

Reviewer 1:
The reviewer stated that future work will be based on specific stakeholder input and feedback related to various selections. The reviewer added that the calculated target goal values will be based on those selections.

Reviewer 2:
The reviewer commented that technological target analysis should be expanded to include performance matrix at the materials level, and integrate the materials performance matrix with the cell and pack performance matrices, in order to meet the PHEV or BEV goals.

Reviewer 3:
The reviewer noted that performance inputs based on actual real-world driving (not just from standard reference profiles) could provide additional insights and outputs from this project.

Reviewer 4:
This reviewer opined that the next steps were notably ambiguous, given how the end users chose to utilize the results.

Reviewer 5:
The evaluator pointed out that future work identified did not include any effort on transforming EOL into BOL and pack into cell-level targets.

Reviewer 6:
This reviewer remarked that there was no need for future research.

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

Reviewer 1:
This reviewer stated that the program quantitatively defines the EV battery goals required for a practical plug-in electric vehicle, based upon voice of customer.

Reviewer 2:
The reviewer remarked that the DOE and the different OEMs need to clarify what is needed to make the all-electric vehicle competitive with the ICE vehicle. The reviewer added that this analysis will help identify the direction that battery suppliers and automotive OEMs should take to increase the probability of this to happen.

Reviewer 3:
This evaluator pointed out that program team indirectly arrived at updated targets that would guide further program efforts.

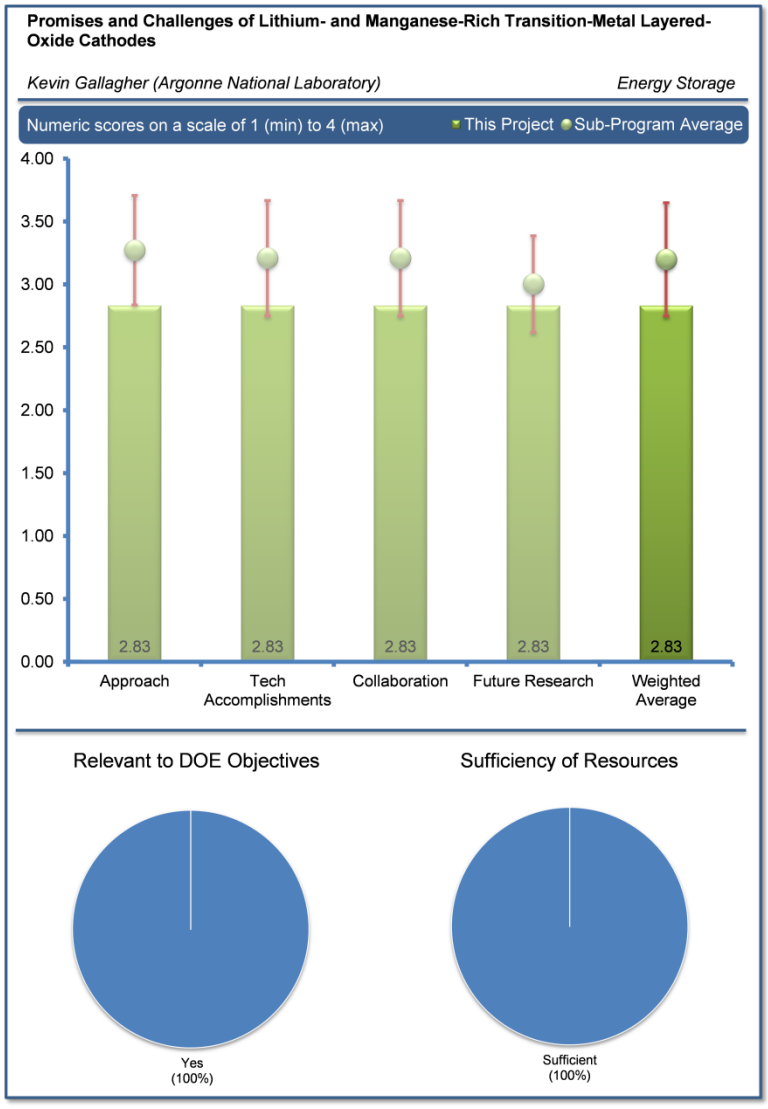
Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
According to this reviewer, the resources are sufficient with the involvement of the OEMs and DOE.

Reviewer 2:
This reviewer stated that there were no issues.

Reviewer 3:
This reviewer remarked that no information was provided on the budget share or was available to the project activity within the overall BOM project. Therefore question cannot be answered.

Promises and Challenges of Lithium- and Manganese-Rich Transition-Metal Layered-Oxide Cathodes: Kevin Gallagher (Argonne National Laboratory) - es177



Reviewer Sample Size

A total of 6 reviewers evaluated this project.

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

Reviewer 1:

According to the reviewer, the approach adopted was based on updating the cost model of the Li-ion battery pack. The reviewer stated that performance characteristics of the cathode material are required to have a quantitative understating of the material level performance effect on the overall cost. Specifically, the VF phenomenon of the LMR-NMC cathodes contribute to energy loss upon cycling. The reviewer added that this increases the cost of the battery pack, which this task quantitatively addresses. Thus, this task aligns well with the VF studies that are on-going at ANL while defining the performance metrics, i.e., specific capacity and average discharge voltage for the LMC-NMC cathode for the Battery Pack (BatPac) to meet the cost targets. The reviewer also noted that since the cost and performance are inter-related, it is important to understand the cost implication of performance shortfalls. The approach is based on using the battery pack developed earlier at ANL and the likely production cost estimates provided by OEM manufactures, with an assumption of a high volume production of modules by 2020. The reviewer concluded that the approach appears sound, but the results are still sketchy, mainly because of the inconsistent cycling data with the LMR-NMC cathode.

Reviewer 2:

This evaluator remarked that the project started only a few months ago, and very important results were obtained in a short period of time.

Reviewer 3:

The evaluator noted that the project work was based on projecting various performance targets of LMR-NMC using BatPac analysis. The work was very relevant towards addressing barriers associated with LMR-NMC cathode chemistry developed at ANL.

Reviewer 4:

The reviewer was concerned about the project's approach. The reviewer opined that both targets and evaluation should be done based on Wh/L and Wh/kg values, achievable at commercializeable mAh/cm^2 values, using real observed values for mAh/g, g/cc, voltage (V) average-discharge, first cycle, and efficiency. Full cell models should be used to evaluate the achievable Wh/L and Wh/kg values. The reviewer added that some validation is needed to show that the full cell models are believable. An example of how this is

important is that if one designs a lithium-rich material having 225 verses 275 mAh/g, not only is the average discharge voltage likely to change significantly, but also the achievable electrode density will also change significantly. The reviewer concluded that figuring out whether lithium rich materials can be valuable is important, but is concerned about this approach.

Reviewer 5:

This reviewer commented that the project uses ANL's model to map out the performance and cost space, but seems too much like an engineering exercise rather than a scientific project.

Reviewer 6:

This reviewer said that the project's approach to leverage ANL's VF Team and interact with OEMs and cell suppliers sounded good, but was not clear if this was achieved. The reviewer also noted that the schematic on Slide 4 was unclear.

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

Reviewer 1:

According to the reviewer, there was a very interesting correlation between positive voltage and capacity. The reviewer also noted that according to the authors, the cell voltage is clearly one of the most important parameters in a battery. The VF issue is clearly shown as one of the most important barriers.

Reviewer 2:

This evaluator commented that the project execution appears to be good.

Reviewer 3:

The reviewer remarked that PI has carried out a detailed analysis of the LMR-NMC chemistry and addressed the relevant barriers. Where these understandings can lead to address the current issues associated with LMR-NMC or similar high voltage (V) chemistry should be asked by the PI. The reviewer questioned where progress has been made in last year compared to year before. The lithiated transition metal oxides (Li_2MnO_3) templating is a synthesis attempt that may or may not solve the VF. The reviewer added if the PI can explain how his model is relevant to such an effort (Slides 14 and 15).

Reviewer 4:

According to the reviewer, reasonably good progress has been achieved in carrying out the cost analysis for the batteries for PHEV applications, particularly in the context of the VF and the resultant energy loss of the LMR-NMC cathode. The performance metrics for The LMR-NMC, which may be used as a guideline for the material development, have been updated with the required specific capacities comply with the cost target. The reviewer went on to say that as these cost projections require further validation by comparing with similar cost models or from real data, based on the information from an unspecified battery manufacturer and with the assumption of a high volume production. Otherwise, the actual costs do not mean much, and only trend from these results would be valid. The reviewer also noted that one difficulty associated with this model is that it is largely based on area-specific impedance (ASI) data. Instead, the model will be a more robust if it is based on the real-time performance data taken from the manufacturer's prototype cells over a range of temperatures, discharge rates, and lifetimes.

Reviewer 5:

This evaluator opined that the program should start with BatPac code, and then calculate cost to the OEM for building battery pack, assuming there is a future high volume system. The reviewer pointed out that the program identified a tradeoff between cell voltage and capacity, which may be useful, but was the only thing that has been done this past year.

Reviewer 6:

This reviewer observed that only one publically available software program was used. The reviewer adds that it would have been move interesting if the data had been used on several available programs, and a comparison of similarities and differences were made. The author pointed out that efficient calculations can be made in fraction of a second. Further, this reviewer commented that the data obtained from the software did not show anything that was unexpected.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer observed that the authors are collaborating with a large variety of researchers from the National Laboratories and industry.

Reviewer 2:
This reviewer noted that there were project team conversations with suppliers.

Reviewer 3:
The reviewer thinks that discussions with leading material suppliers could help guide the approach to setting cathode material performance targets. Otherwise, the reviewer said that the teamwork appears good.

Reviewer 4:
This reviewer expressed that the PI should discuss or provide a description of whether BatPac model is used by cell manufacturers and OEMs including their comments. This is important since most of the industrial partners have their own cost and performance models.

Reviewer 5:
This reviewer stated that project has no external collaborations being an entirely ANL in-house effort, but there is collaboration with the VF team. The reviewer added that there appears to be some collaboration with the battery manufacturers (OEMs).

Reviewer 6:
This reviewer pointed out that the author makes no reference as to how coordination with partners achieved or what information was sought or received. The reviewer suggests that the author should spend one minute discussing the coordination and information issues, even if the needed important information is unattainable.

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

Reviewer 1:
The reviewer remarked that with the given budget, the scope of the work is adequate. However, the PI should think beyond the LMR-NMC chemistry.

Reviewer 2:
According to the reviewer, next year's work is the most important part of the project. That is, to document State Of the Art (SOA) performance and barriers that may prevent commercial acceptance, and to research initial performance, life and safety performance, low-temperature performance, and system level State Of Charge (SOC) and power management issues. The reviewer was unsure if this research should have been done first, and then incorporated in to the computer model. The designers of the software should be considered to be a partner so that the model can be better customized.

Reviewer 3:
The reviewer said that the proposed future research should carry out further assessment of PHEV and EV battery costs with Li-ion battery packs containing LMR-NMC cathode material, after taking into consideration all the performance barriers of this material such as VF and hysteresis, poor low temperature performance, power capability, and poor cycle life. The reviewer added that this model will be extended to the EVs and PHEVs with advanced Silicon (Si) anode to generate similar cost information.

Reviewer 4:
This reviewer opined that it is important to increase the data base, and that a strong interaction with the industrial partners should be clearly encouraged.

Reviewer 5:
The reviewer commented that the future project was unclear. Although the challenges are listed, the reviewer questioned how the unclear approach gets close to finding an answer. Regarding future work, the reviewer stated that the project looks like it is ready for close-out.

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

Reviewer 1:
This reviewer said that the project is very relevant.

Reviewer 2:
This reviewer agreed that the project supports the DOE's objectives to increase petroleum displacement. The study focuses on the critical technical and cost issues.

Reviewer 3:
According to the reviewer, this project is quite relevant to the overall DOE goal of partly replacing conventional vehicles with HEVs or EVs, in order to minimize the national dependence on petroleum resources. The (high) cost of batteries for PHEVs is a serious impediment to a widespread use of Li-ion batteries in vehicles. The reviewer also pointed out that the overall project objective is to develop cost assessments that are based on the appropriate models and used for predicting the performance-based costs for battery packs that are relative to the cost goals. The project objective is in support of the overall goal of developing a PHEV-40 that has a price lower than $3,400, a weight not exceeding 120 kilograms (kg), and a volume 80 liters (L) or lower. The reviewer added that studies will guide the manufacturer and material researcher in addressing the cost barrier for Li-ion batteries, especially when including the high energy LMR-NMC cathode.

Reviewer 4:
This reviewer commented there should be support of computer modeling simulation calculations to prove or disprove the feasibility of the DOE objective for this project.

Reviewer 5:
The reviewer remarked that the project is useful, but nothing that should be done at a National Laboratory.

Reviewer 6:
The reviewer agreed that the project supports the DOE's objectives. However, due to a concern about the approach, the reviewer did not think the project will have a significant impact.

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

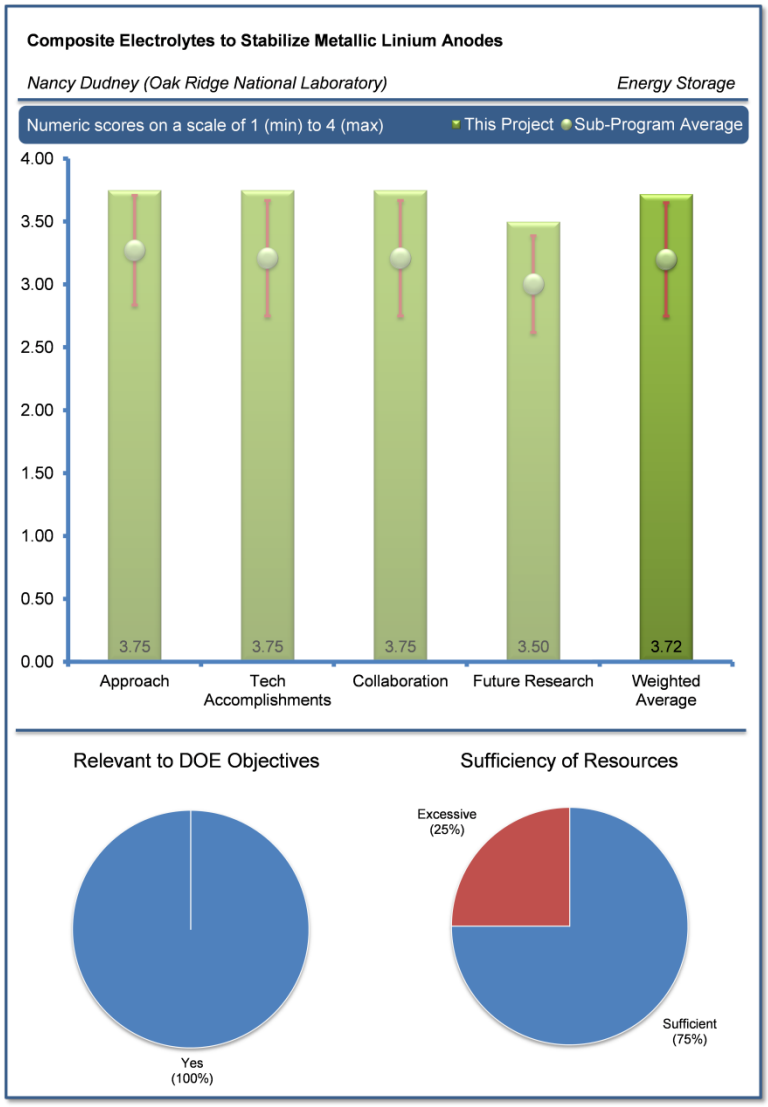
Reviewer 1:
This reviewer remarked that resources are sufficient. However, the authors should get additional support if the developments related to lower battery cost and VF improvements are clearly shown.

Reviewer 2:
This reviewer noted that the resources are adequate.

Reviewer 3:
The reviewer stated that the resources are adequate for the planned effort.

Reviewer 4:
The reviewer commented that resources are only required for one person where the project has a canned software already available.

Composite Electrolytes to Stabilize Metallic Linium Anodes: Nancy Dudney (Oak Ridge National Laboratory) - es182



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

This reviewer stated that the well-presented approach is very clear with outstanding and clearly useful results to date. Technical barriers are well understood. The reviewer added that a follow-on full cell testing is very important to the success of this program.

Reviewer 2:

This reviewer remarked that the approach was good.

Reviewer 3:

According to the reviewer, the approach is novel and also solid when backing up the experiments with modeling. The problems of interfacial impedance have likely been underplayed in past work because of the concentration on vacuum based preparations of micro batteries with small interfacial impedance. The reviewer added that for thick electrodes, the interfaces are critical.

Reviewer 4:

The reviewer opined that the project should develop a solid electrolyte cell with a Li metal anode using two dissimilar solid electrolytes with single Li positive conductivity. The reviewer went on to say that the success will result in cells with Lithium-Sulfur (Li-S) cells with 500 Wh/kg and Lithium-Air (Li-Air) cells with 700 Wh/kg. Progress will demonstrate the proof of principle for the composite electrolytes and a stabilized Li metal anode.

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

Reviewer 1:

This reviewer remarked that clear results in work to date show how approach leads to useful results. The reviewer added that the research team had learned quickly on all fronts of the project, and continued to have clear objectives for future work.

Reviewer 2:

This reviewer stated that reasonable progress has been obtained. The evaporated Li anode films have a lower resistive interface and protect the Li metal anode, which is the key to longer life.

Reviewer 3:
The reviewer indicated that the previous study from the group has shown decrease in impedance with the lithium phosphorous oxynitride (LiPON) coating on electrodes. The project currently shows that the LiPON coating increases the impedance for which the reviewer requested an explanation.

Reviewer 4:
This reviewer said that the technical accomplishments have shown the need for low interfacial impedances along with the interfaces that need to be worked on. Effort is now needed to lower these interfacial impedance values.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer expressed that the collaborations are very useful in that other teams are providing materials for test and evaluations.

Reviewer 2:
According to the reviewer, the collaborations are good and include many of the key players. The reviewer added that it might be useful to add John Kerr of LBNL to the collaboration list for his different approach to the polymer electrolyte and because he is very cognizant of the interfacial impedance roles.

Reviewer 3:
This reviewer affirmed the projects collaboration with Michigan State University, University of California, Berkeley, nGimat, and O'Hara Corporation.

Reviewer 4:
This reviewer commented that collaboration is good.

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

Reviewer 1:
The reviewer stated that the plans very clearly show how current work will lead to future work. The reviewer also affirmed the project's clear plans for overall evaluations and potentially useful results.

Reviewer 2:
This reviewer opined that the team should define the best combinations of polymer and ceramic materials for improved performance, develop a strategy to maintain the lithium metal-electrolyte interface, and characterize the performance of advanced cell designs.

Reviewer 3:
The reviewer was unsure on how the sintering of ceramic materials will be carried out in the presence of low melting polymers. The reviewer pointed out that while this sintering could be a difficult step, it seems essential to increase the area of particle to particle contact of the ceramic material. The reviewer affirmed that the area increase is best done by sintering.

Reviewer 4:
This reviewer observed that developing a dense and thin electrolyte will be challenging.

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

Reviewer 1:
The reviewer stated that the project relevance is high because of the need to solve the dendrite problem with lithium electrodes, and to be able to use thick lithium.

Reviewer 2:

This reviewer said that the project success will carry Li-Air and Li-S cells into competition for use EV batteries.

Reviewer 3:

According to the reviewer, the project is directly relevant to DOE's efforts to develop the high energy batteries needed for EVs to be used extensively in the transportation sector.

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

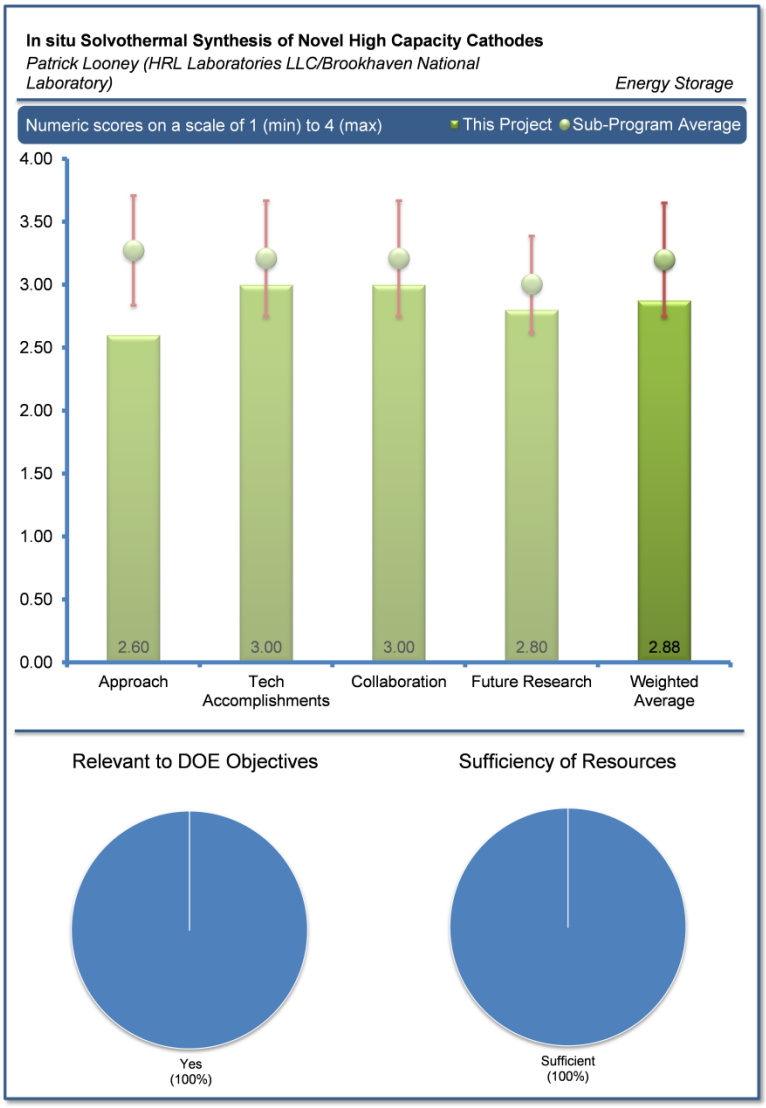
Reviewer 1:

This reviewer remarked that the resources were adequate for proposed program.

Reviewer 2:

The reviewer noted that program is adequately funded at this time. The reviewer added that it is important for program to have a follow-on phase with additional funding in future years.

In situ Solvothermal Synthesis of Novel High Capacity Cathodes: Patrick Looney (HRL Laboratories LLC/Brookhaven National Laboratory) - es183



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

This reviewer stated that the approach was good.

Reviewer 2:

According to the reviewer, the development of the in situ synthesis technique is outstanding and it should be applied to current battery materials. The reviewer was unsure why materials made in different ways perform so differently. There are often minor analytical differences that cannot explain the electrochemical differences. The reviewer inquired that perhaps the differences could be understood from what happens during synthesis. The novel cathode development was less clear to the reviewer. The cathode does not look like a high energy material because the voltage is too low. In addition, the reviewer questioned how the project team is going to lithiate it.

Reviewer 3:

The reviewer described the project as having a good approach to achieve a high energy density, via a high capacity cathode, versus a high voltage cathode. However, the reviewer added that $Cu_{0.95}V_2O_5$ is not the right cathode due to Cu^{1+} during discharge. The dissolved Cu^{1+} will plate on the anode and eventually produce shorts. In addition, the reviewer pointed out that the Vanadate materials have an approximate density of 3.6 grams per cubic centimeter (g/cc), and thus the volumetric energy density, Wh/L, will not be competitive with $LiCoO_2$.

Reviewer 4:

This reviewer commented that the project team should develop synthesis routes for phase pure CuV_2O_5 materials using a unique in situ reactor integrated with synchrotron characterization.

Reviewer 5:

The reviewer remarked that approach taken by this project is fair. The investigators will develop a specialized in situ reactor designed to investigate synthesis redactions in real time using time-resolved XRD. The reviewer added that one of the key hurdles in using solution-based synthesis techniques is the difficulty in understanding the reaction pathway, and thereby optimizing the reaction for the desired material properties. This technique will allow the investigators to explore reaction pathways and investigate the structural evolution of intermediate reactants in real working conditions. The reviewer pointed out that there is a concern if the $Cu_{0.95}V_2O_5$ is a viable material. The cycling performance does not look good at this point.

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

Reviewer 1:
According to the reviewer, good progress has been achieved to date. The in situ reactor has been developed that will allow time resolved XRD, which is key for the understanding of the synthesis reaction mechanism. The reviewer also stated that ability to probe synthesis reactions in real time will provide a better understanding of how temperature, pressure, time, and the initial concentrations affect the reaction pathways. The reviewer added that the project investigator has already synthesized some materials and determined the lithium reaction process, along with possible mechanisms responsible for poor cycling stability.

Reviewer 2:
This reviewer commented that the researchers should set some targets for the cathode development work, and ensure they are working on commercially relevant materials.

Reviewer 3:
The reviewer mentioned that the observed structural change of CuV_2O_5, decomposition and Cu formation, upon lithiation resulted in a unique in situ synthesis or characterization capability. However, the performance of CuV_2O_5 is limited.

Reviewer 4:
This reviewer queried how charge neutrality is maintained if the Cu is 2+ and V is 5+, initially. The reviewer observed good synthesis results and excellent in-situ studies.

Reviewer 5:
This reviewer expressed that the project did not produce convincing results for the application. The reviewer was also unsure on how to improve the capacity and the stability.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that the collaboration and coordination with other institutions was good.

Reviewer 2:
This reviewer pointed out that the project team has a diverse set of skills, and is more than just supplying samples.

Reviewer 3:
According to the reviewer, the PI has established collaborations both with BATT investigators and with external partners on technique development, synthesis, and characterization.

Reviewer 4:
The reviewer remarked that the project team is collaborating with a number of researchers.

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

Reviewer 1:
The reviewer expressed that project's proposed future work is excellent and the effort will continue to investigate CuVO cathodes by using the project's novel approach.

Reviewer 2:

This reviewer affirmed that the continuation with CuVO cathodes will provide fundamental information, but the proposed transition to olivine will provide more relevant information.

Reviewer 3:

As stated earlier, the reviewer expressed a request to see the in situ technique applied to more common battery materials. The reviewer is not sure that the project team should focus so much on development of new materials, for the team has a very unique opportunity to optimize synthesis of existing materials. This could result in improved performance and/or lower cost.

Reviewer 4:

According to the reviewer, the project needs to address Cu^{1+} dissolution issue if the project team wants to pursue CuVO cathode. The proposed Olivine cathodes are high voltage, not high capacity cathodes, and thus will need high voltage electrolytes. The reviewer encouraged the team to pursue high capacity cathodes that do not require the use of high voltage electrolytes to enable high energy density Li-ion cells.

Reviewer 5:

The reviewer said that the strategy to improve the performance and voltage stability is needed to be discussed.

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

Reviewer 1:

This reviewer stated that the proposal is relevant and supports the DOE objective of petroleum displacement. Developing a high energy density cathode material for a high performance Li-ion battery that could offer long driving range is the biggest challenge for electric or hybrid-electric vehicles.

Reviewer 2:

The reviewer noted that the project addresses the high energy density battery materials necessary for widespread implementation of BEVs in the United States.

Reviewer 3:

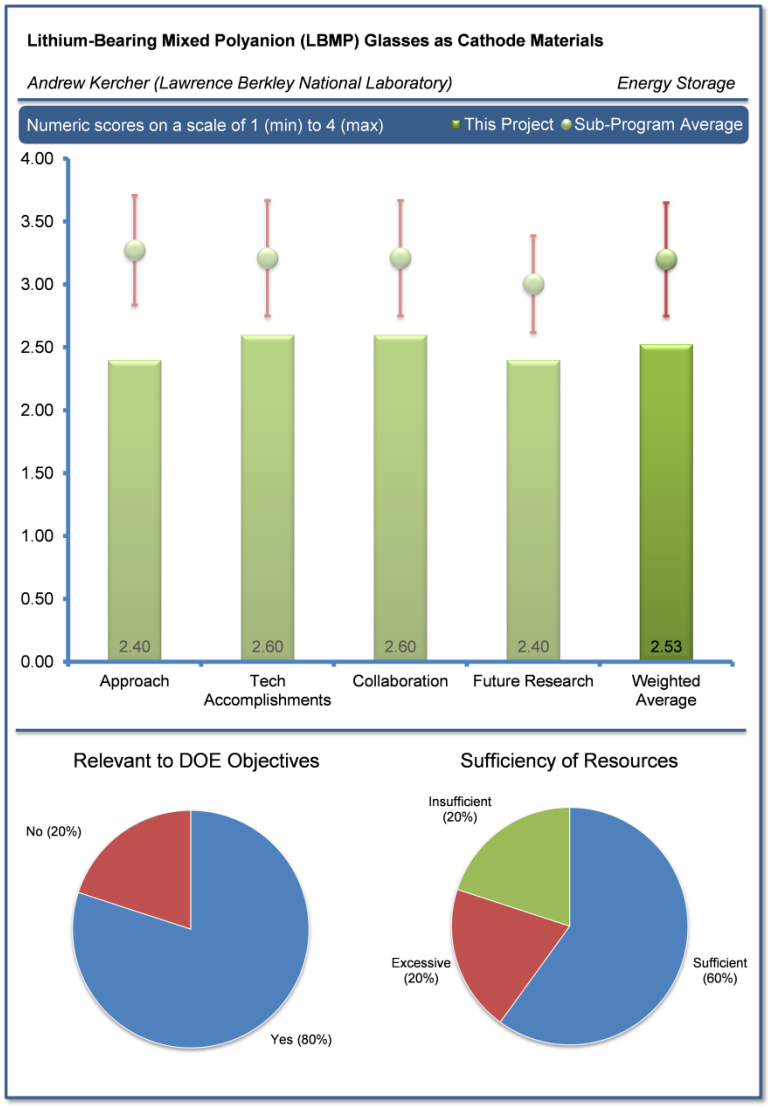
This reviewer commented that the project gives insight to cathode synthesis and degradation mechanisms.

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

Reviewer 1:

The reviewer remarked that resources appear to be sufficient to successfully complete the tasks in a timely fashion.

Lithium-Bearing Mixed Polyanion (LBMP) Glasses as Cathode Materials: Andrew Kercher (Lawrence Berkeley National Laboratory) - es184



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

This reviewer noted that the project has a new approach.

Reviewer 2:

According to the reviewer, the approach taken in this investigation is fair and is based on the high theoretical capacity and electrical conductivity of mixed polyanion glasses. The investigators will combine structure and property modeling with cathode glass processing or characterization and electrochemical testing. The reviewer noted a concern about low conductivities and the reversibly of this system.

Reviewer 3:

This reviewer observed that project was investigating Li glasses as an alternative to crystalline materials.

Reviewer 4:

The reviewer noted that even the most electronic conductive glassy active material with 10^{-6} S/cm will be masked by the much more conductive carbon (C) additive in the cathode. The reviewer then concluded that it was difficult to understand how the glassy phase will have improved performance over the crystalline phase. In addition, the reviewer was unsure if glassy materials will have more processing issues than crystalline materials.

Reviewer 5:

According to the reviewer, the work would benefit significantly with more collaboration on the electrochemistry. The reviewer added that the researchers need to make fair comparisons. The reviewer noted the example that $LiFePO_4$ is an interesting case where is a need to fairly compare the rate performance. Conventional $LiFePO_4$ has terrible conductivity, which is overcome by small (nano) particle size and carbon coating. The reviewer was unsure if the PI can do the same, and if so, does the glass have any advantage. The rate performance comparison may be a good example for a proof of concept. The reviewer expressed that the PI should ultimately be looking at higher energy density materials.

The reviewer also said that the researchers appear to lack some fundamental understanding of the baseline battery materials. In addition, there does not seem to be good knowledge of the electrochemistry happening in the materials being studied, where others could help with this lack of understanding.

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

Reviewer 1:
The reviewer observed that good progress has been achieved to date. The investigators have demonstrated an improvement in the rate of performance and specific capacity of the mixed polyanion content. The reviewer added that the project team has also developed a computational model of the electrochemical performance of a polyanion glass.

Reviewer 2:
The reviewer stated that the substitution seems to be important for conductivity improvement, and that improving the conductivity is a major challenge.

Reviewer 3:
The reviewer reported prepared delithiated FePOx glasses and investigated vanadium (V) substitution for phosphorous (P) demonstrating higher performance. This reviewer added that demonstrated mixed polyanion glass has higher performance than simple polyanion glass. The reviewer noted Computer Coupling of Phase Diagrams and Thermochemistry (CALPHAD) modeling to predict the performance.

Reviewer 4:
This reviewer affirmed that the project team had not done the sufficient work to validate the conductivity improvement and to demonstrate the charging in this feasibility phase.

Reviewer 5:
This reviewer remarked that the project results do not look very promising so far. The reviewer opined that the modeling should be emphasized to help improve the chances of success.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
According to the reviewer, good collaborations are occurring between the investigators and others who can assist the program. The reviewer added that discussions that are occurring between potential collaborators that are BATT program members, which include Vince Battaglia of LBNL, who may assist in the benchmark testing of the material in pouch cells.

Reviewer 2:
This reviewer stated that the collaboration was good.

Reviewer 3:
The reviewer noted that the collaborations were primarily planned.

Reviewer 4:
This reviewer is unsure if there is any evidence of collaboration outside ORNL so far. The project would benefit from LBNL participation.

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

Reviewer 1:
The reviewer remarked that the proposed future work is good and is based on the results achieved to date. This year, the investigators will pursue phosphate glasses of manganese (Mn), Cobalt (Co), and Nickle (Ni). The reviewer noted that these glasses promise to yield 30% greater specific energy densities that the lithium iron phosphate ($LiFePO_4$) system. The reviewer added that in FY 2014, the

investigators, guided by their model predictions, will explore borate and silicate glass systems. These materials have projected specific energies greater than 1000mWh/g.

Reviewer 2:

According to the reviewer, future work should focus on validating that the glassy phase has improved electronic conductivity. This will result in improved performance over crystalline phase in an electrode. The reviewer also mentioned that the volumetric energy density is a concern for these polyanion glassy phases due to the extensive diphosphorous septoxide (P_2O_7) and divanadium septoxide (V_2O_7) polyanions. In addition to pursuing polyanion materials with 30% higher specific Wh/kg energy than $LiFePO_4$, the project team should also aim for 30% higher Wh/L energy density.

Reviewer 3:

The reviewer observed that the researchers do not have many results to build from. The reviewer opined that the project team should prioritize their targets and determine what questions or data are needed to maximize the team's confidence that the prioritized approach is good, and then should only focus on answering those questions.

Reviewer 4:

This reviewer stated that the proposed future work is not clear. The reviewer was unsure the plan is to improve borate and silicate systems.

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

Reviewer 1:

This reviewer stated that the project is very relevant and supports the overall DOE objective of petroleum displacement. The reviewer adds that it is vital that a high performance, high energy dense battery is developed for electric and hybrid vehicles.

Reviewer 2:

The reviewer commented that the project had new cathode materials with potentially lower degradation mechanisms.

Reviewer 3:

Up to this point, this reviewer is unsure if there is promise with this project.

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

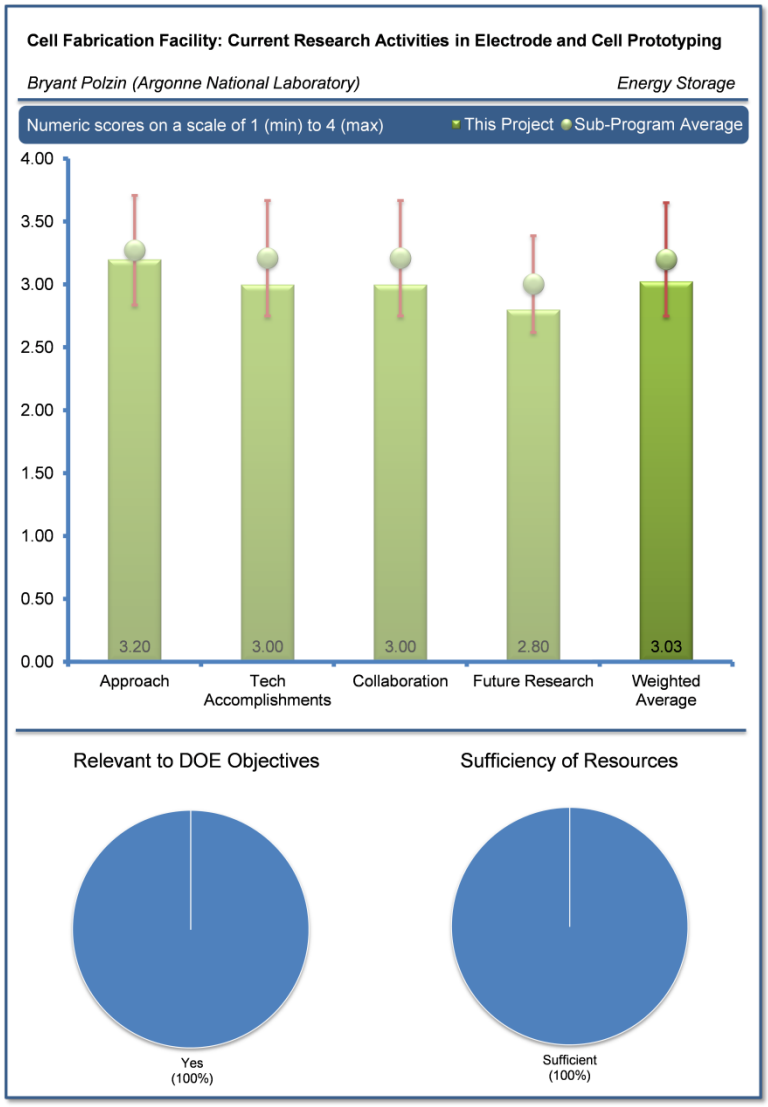
Reviewer 1:

The reviewer noted that the level of resources appear to be sufficient to successfully complete the tasks in a timely manner.

Reviewer 2:

The reviewer expressed a lack of confidence that milestones would be met in this project. The reviewer is also unsure if the solution is necessarily to add more resources or just re-structure the project.

Cell Fabrication Facility: Current Research Activities in Electrode and Cell Prototyping: Bryant Polzin (Argonne National Laboratory) - es185



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

According to the reviewer, the approach is good to be able to bring an advanced material to the facility and to have the engineers in the facility make the cells. However, the reviewer commented that would it would be desirous to see the facility have much higher throughput in order to give the engineers and operators more experience.

Reviewer 2:

This reviewer pointed out that the program brings in critical capability for cell prototyping in the quest for higher energy density batteries. The reviewer added that the partnership strategy was effective.

Reviewer 3:

This reviewer opined that the yield, throughput, reproducibility and failure mode statistics should be tracked and reported for each build.

Reviewer 4:

The reviewer affirmed that the effort is an important piece within a larger scope that is well described. The reviewer added that it would be helpful to provide a more specific description of the role of this specific effort within the larger scope. It is possible that the AMR format does not accommodate the review of multiple components of a larger program very well. The reviewer went on to say that it would be worthwhile to perhaps have some thought as to the best way to allow complex, multiparty programs to be reviewed.

Reviewer 5:

The reviewer was unsure of the real difference between project ES185 and ES030. The reviewer continued that having cell making capability that is open to various R&D groups is valuable, but wondered how this works in practice. The reviewer inquired how this is different and/or better from the TIAX, LLC model that also has a fully functional line.

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

Reviewer 1:

This reviewer noted the project's ability to prototype with less than 100grams (g) of developmental electrode is valuable.

Reviewer 2:
This reviewer said that the project did some good work on some very difficult topics. It could be helpful to provide a little more context for the individual accomplishment areas.

Reviewer 3:
According to the reviewer, the project team demonstrated ability to evaluate a wide breadth of electrode technologies.

Reviewer 4:
The reviewer opined that many more than nine cell builds should be done in a year's effort. The reviewer added that the capacities for the wound cells are quite low, where commercial capacities of 2.5 to 3.3 Ah and a 18650 cell size, are readily available. The group reports only 1.4 Ah for the test material. The reviewer states that it is somewhat more difficult to compare the pouch cell capacities. However, the project team should be trying to obtain better results for energy cells. The reviewer expressed the need to see more data at different rates as well.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that the project had a good collaborative team, at multiple levels.

Reviewer 2:
This reviewer indicated that the project seems to have the correct collaboration level.

Reviewer 3:
This reviewer commented that the collaboration is extensive, and that might be useful to have a partner, with more commercial knowledge, collaborate to indicate where the deficiencies are.

Reviewer 4:
The reviewer expressed a need to see more outside involvement and some goal for utilization that includes outside users.

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

Reviewer 1:
According to the reviewer, this program provides a very useful service within both the National Laboratory system, as well as in the commercial community. The intent of the future activities is quite appropriate. The reviewer went on to say that the key is to maintain a system of managing the choices made in relevant topics of interest. The reviewer affirmed that there are many competing ideas for the available time at this facility.

Reviewer 2:
The reviewer described that the capability would benefit from deeper awareness and skill in area of slurry mixing, rheology, dispersion uniformity and repeatability. The capability would benefit particularly pertaining to the ability to work with developmental anode materials and high voltage cathode materials that bring challenges to binders and conductive additives.

Reviewer 3:
This reviewer affirmed the continuation of existing plan, but perhaps to explore broadening utility and collaboration efforts would be useful.

Reviewer 4:
The reviewer expressed need to see a continuing review of the equipment used. For example, the winder seems very primitive, and to would be beneficial see where equipment should be upgraded.

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

Reviewer 1:
This reviewer noted that this is much needed capability for DOE.

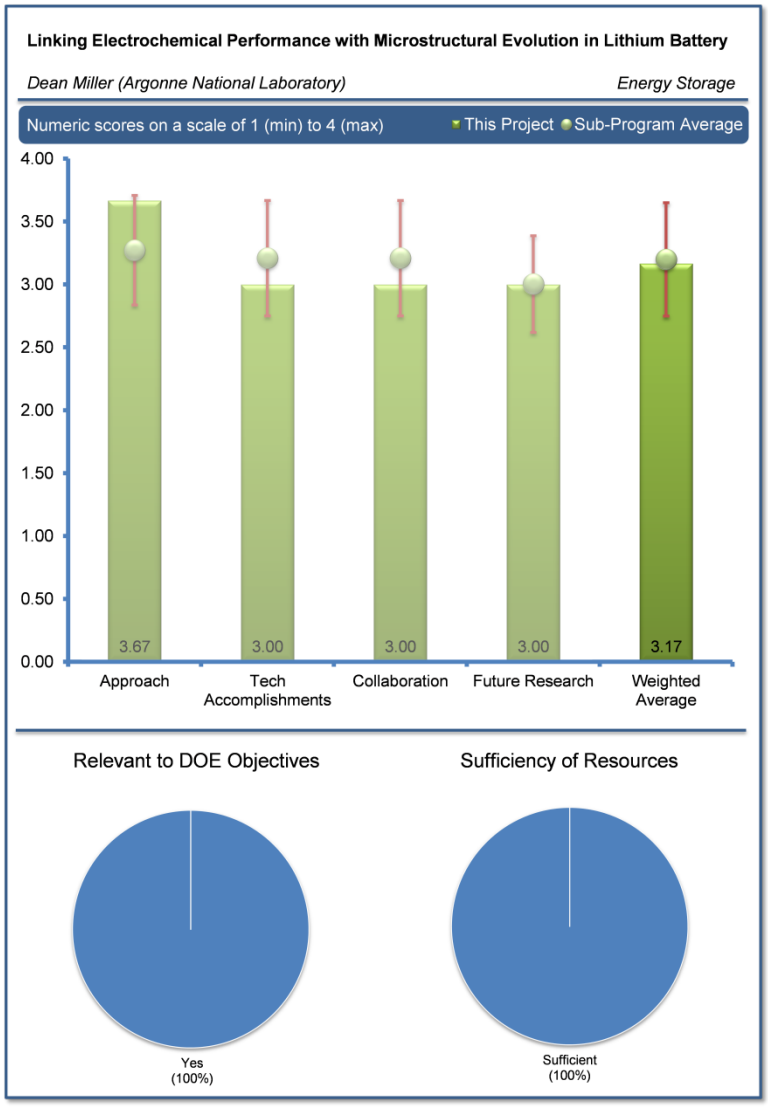
Reviewer 2:
The reviewer pointed out that as discussed elsewhere, there is a true need for a stable, yet flexible, demonstration platform to evaluate the benefits of new materials, etc., at the cell level. This is an important effort within the system, and the participants appear to be working very hard and providing a solid effort in the development of this platform.

Reviewer 3:
This reviewer remarked that it is important to developing new materials.

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

Reviewer 1:
The reviewer said that resources are sufficient for the stated milestones, but noted a concern with regard to the duplication of capabilities and the ability to keep technology updated at multiple facilities. At this point, the project seems to be an operating budget rather than development program. The reviewer was unsure what gaps are being addressed.

Linking Electrochemical Performance with Microstructural Evolution in Lithium Battery: Dean Miller (Argonne National Laboratory) - es186



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

This reviewer commented that very nice work was presented, in particular, the single particle electrochemistry. Additional work should probably be done with standard particle chemistry rather than only the high voltage ones.

Reviewer 2:

According to the reviewer, the project objective is to establish a correlation between electrochemical performance and the structural or morphological changes occurring in the battery active materials. Such fundamental understanding of the material changes is useful not only to understand but also mitigate the performance issues such as VF, hysteresis, and particle fracture upon cycling. The reviewer also noted that in this project, impressive in-situ techniques, such as the Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), and XAS, are being developed to study the single particle, single grain electrochemistry and characterization. In situ techniques are generally superior to ex situ studies, as they allow the monitoring of the material changes as they occur. The reviewer added that techniques are also more definitive without the issues of sample harvesting or preparation.

Reviewer 3:

This reviewer remarked that unlike other microscopy work, this work brings a certain sense of novelty by connecting local atomic structure with global electrochemical performance. The single particle work is also exemplary.

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

Reviewer 1:

This reviewer remarked that the progress is outstanding, considering the quality of the measurements and that the project only recently started.

Reviewer 2:

The reviewer expressed that good progress has been made in understanding the real-time material changes upon cycling, using the single particle electrochemical studies under SEM and in situ TEM. The reviewer points out that some of the interesting findings are

that there is considerable non-uniformity from particle to particle (TEM observations), and also that there is an evolution of microstructure in the cathode particle right from the start (cycling under SEM) that correlates well with the bulk performance. More interestingly, the single particle studies of the LMR-NMC cathode also show similar VF behavior as the bulk electrode, suggesting that this phenomenon is more fundamental and requires materials modification rather than engineering solutions. Overall, the reviewer said that these results are quite impressive.

Reviewer 3:
The reviewer pointed out that the PI has done a good job again in explaining the observed effect of VF in LMR-NMC chemistry, and correctly emphasized about the local inhomogeneity of the electrode. But, the reviewer added that the right question to ask is whether microscopy can provide any solution for mitigating of the VF rather than just characterizing it.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed that there are good collaborations within ANL and with the VF team.

Reviewer 2:
This reviewer mentioned that the collaborations could be better. The reviewer added that maybe in the future, an industrial partner may develop after the interesting results are presented.

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

Reviewer 1:
The reviewer observed that the type of in situ measurements, where a real particle is studied while the voltage is varied, is crucial. It could be of great interest to the real battery performance, including VF and cycle life. The reviewer added that the authors should consider the study of standard NCM powders too.

Reviewer 2:
According to the reviewer, the proposed future research is to continue similar single particle studies of the lithium-rich layered metal oxide composite cathode and correlate the structural evolution with the VF and hysteresis. Possibly working different ratios of the composite oxides, dilithium manganese trioxide (Li_2MnO_3) and NMC, will provide insight into the microstructural evolution upon cycling.

Reviewer 3:
This reviewer expressed that it would have been nice if the PI and project team had proposed to do similar work on doped or new LMR-NMC compositions to quantify with respect to base line HE 5050 chemistry. The reviewer added that it will probably be done as new compositions become available.

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

Reviewer 1:
This reviewer expressed that the project is very relevant to the DOE objectives of petroleum displacement. What happens on a single particle, while the voltage is changed, can provide invaluable information to real battery cathodes.

Reviewer 2:
According to the reviewer, the project is relevant to the overall DOE goal of partly replacing the conventional vehicles with HEVs or EVs to minimize the national dependence on petroleum resources. The high cost of batteries for PHEVs is a serious impediment to a widespread of Li-ion batteries in vehicles. The reviewer added that high energy density materials are expected to provide increased range and reduced cost, thus enabling a widespread use of EVs and PHEVs. Lithium-rich layered cathode material is promising in this

direction, but is hampered by issues such as voltage and hysteresis. The reviewer affirmed that it is essential to have a fundamental understanding of these phenomena to mitigate these issues, as it is being addressed in the present project.

Reviewer 3:

This reviewer noted that the project's effort, although very indirect, is directed towards studying the materials aspects of high energy density chemistry.

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

Reviewer 1:

This reviewer noted that additional resources should be considered, in particular if the authors manage to find an industrial partner interested in these types of studies.

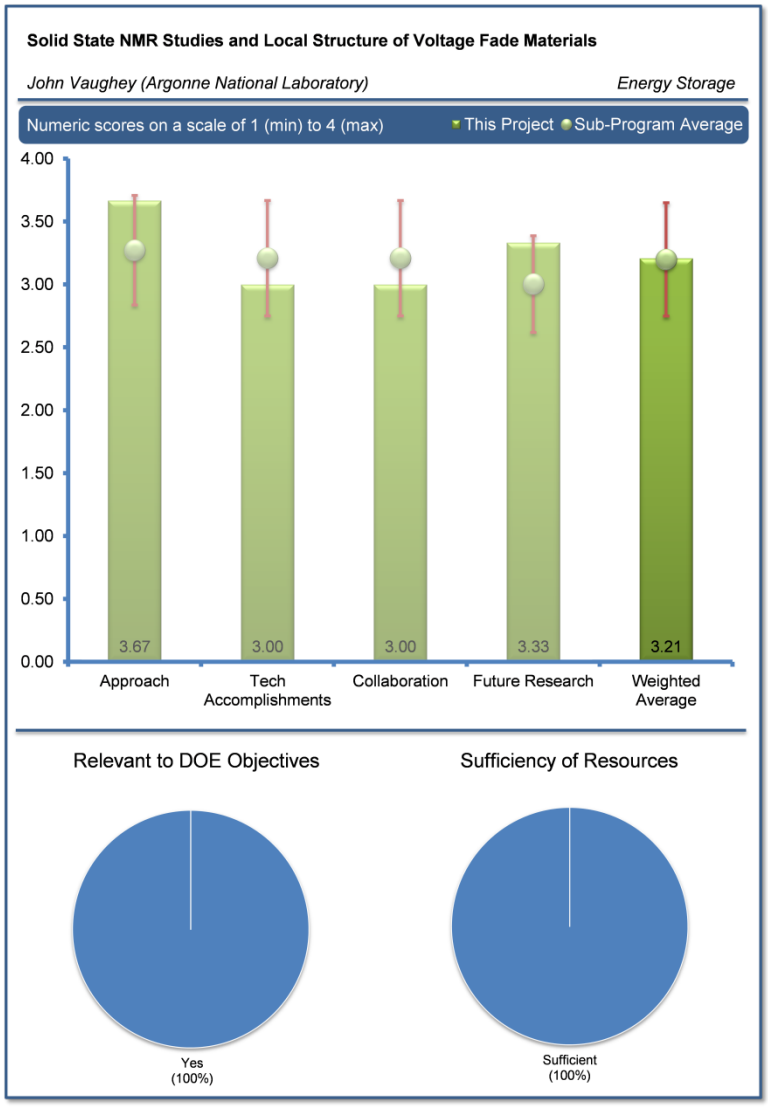
Reviewer 2:

The reviewer commented that the resources are adequate for the scope of the project.

Reviewer 3:

This reviewer said that the resources were okay.

Solid State NMR Studies and Local Structure of Voltage Fade Materials: John Vaughey (Argonne National Laboratory) - es187



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

This reviewer stated that the project has made very important progress for a project that only started a few months ago. The NMR studies are first rate.

Reviewer 2:

According to the reviewer, the objective of gaining a structure-based understanding of the VF behavior of LMR-NMC cathode materials, the approach being adopted in this project is to undertake a fundamental study to understand the structure factors (short-range and long-range) that contribute to the VF of Li-rich layered composite oxides, using solid-state ^{6}Li NMR. It was shown in the past that ^{6}Li NMR can be used to differentiate the local lithium environments (i.e., Li in the transition metal or in the Li plane). The reviewer added that this would be another useful technique to track the structural changes, together with the VF, in the LMR-NMC cathode upon activation (formation) or cycling. The reviewer also stated that the project is well designed to address the main technical barrier of the LMR-NMC cathode materials (its VF and hysteresis), and has good feasibility to provide the expected information on these cathode. Furthermore, the reviewer pointed out that this project is well integrated with the other projects on LMR-NMC cathode and will contribute to a good understanding of this phenomenon.

Reviewer 3:

The reviewer commented that the project has very good approach for studying the dynamics of the VF for LMR-NMC chemistry. But the reviewer is unsure how the approach helps towards discovering a new chemistry or cathode composition. The PI and team, no doubt, have a good fundamental understanding of the NMR method and their applicability to battery electrode materials.

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

Reviewer 1:

This reviewer observed that the NMR studies were very important and nicely presented.

Reviewer 2:

The reviewer commented that after setting up the on-site solid-state NMR facility, good project progress has been made towards understanding the structural changes occurring in the LMR-NMC cathode upon activation and upon cycling. For example, it was

shown that there is a significant lithium-transition metal disordering observed for LMR-NMC upon charge-discharge cycling, which is synchronous to hysteresis and VF. The reviewer added that also, the first cycle electrochemical activity of disordered Li_2MnO_3 studied separately is real via Li removal/insertion, and the loss of ordering is similar to the Li_2MnO_3 component in VF composites (LMR-NMC). Finally, there is no proton insertion into the structure of Li_2MnO_3 (as may be expected from acid-leaching), only surface deposition. The reviewer went on to say that these findings, though preliminary in some cases, are significant, suggesting that the solid-state ^6Li NMR technique could be used to track the disorder of LMR-NMC cathodes, which seems to correlate well with the VF (and may be hysteresis as well).

Reviewer 3:
According to the reviewer, the project had a good and in-depth study. The reviewer expresses the need for the agreement between the NMR results and neutron pair distribution function (PDF) study for cycled LMR-NMC electrodes. The reviewer added that this is nontrivial since comparisons are not easy. The PDF analysis is based on modeling and needs to be fully understood before interpreting those results. The reviewer remarked that the PI has a detailed guideline (Slide 18) as to how and what the project team will compare from both the results and the study. The reviewer expressed the need that for both studies, the cells are going to be cycled under identical conditions (VF protocol).

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer remarked that the PI had a relevant set of researchers from other National Laboratories to collaborate with.

Reviewer 2:
The reviewer said that there are collaborators from ANL's VF team.

Reviewer 3:
This reviewer mentioned that at some point, the authors should be able to find an industrial partner.

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

Reviewer 1:
This reviewer stated that the future research focused on additional analytical measurements seems very appropriate.

Reviewer 2:
The reviewer remarked that hopefully combining NMR and Neutron PDF will yield more information, and encouraged the PI to include work on the doped LMR-NMC composition available thus far. The reviewer provided as an example studying magnesium (Mg) and ruthenium (Ru) to see if any prevent Transition Metal (TM) migration or other results.

Reviewer 3:
According to the reviewer, future plans are to continue the Nuclear Magnetic Resonance (NMR) studies with the fully enriched cell, ^6Li enriched cathodes, and the $^6LiPF_6$ electrolyte to understand quantitatively as a function of sate of charge. Plans are also to continue to combine the quantitative NMR studies with electron paramagnetic resonance (EPR) and Neutron Diffraction data for a better understanding of the lithium-transition metal ordering. The reviewer added that all these studies are aimed to obtain further understanding of the VF of LMR-NMC cathodes.

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

Reviewer 1:
The reviewer noted that the DOE objectives are clearly supported in this project. The analytical measurements are giving invaluable information that can help resolve the VF issue.

Reviewer 2:

This reviewer said that yes, the project meets the DOE objectives.

Reviewer 3:

The reviewer stated that for a successful utilization of Li-ion batteries in EVs, it is essential to enhance their gravimetric and volumetric energy densities, beyond what can be provided by the current technologies. High voltage high capacity cathodes in the class of lithium and manganese rich NMC (LMR-NMR) cathode materials, xLi_2MnO_3:(1-x) lithium M dioxide ($LiMO_2$) where M equals Nickle (Ni), manganese (Mn), or cobalt (Co), are quite promising for high specific energies. The reviewer said that, however, these materials exhibit VF upon cycling and voltage hysteresis from charge and discharge. To mitigate these effects, it is important to have a good understanding of these phenomena in terms of the complex electrochemical, where structural relationships of these materials.

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

Reviewer 1:

This reviewer stated that the resources of $120,000 is adequate for the project to achieve the milestones in a timely manner.

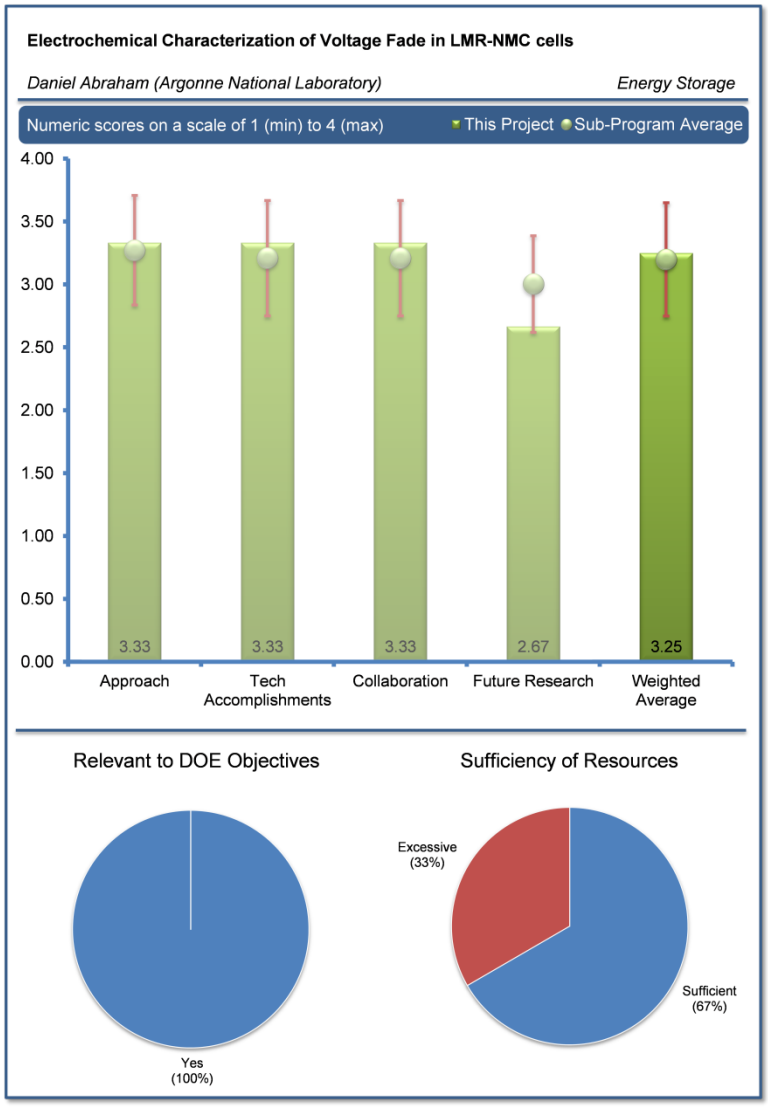
Reviewer 2:

This reviewer said that resources are okay.

Reviewer 3:

According to the reviewer, the resources seem to be sufficient. However, if the authors manage to find an industrial partner, and also give additional insight onto the voltage fade mechanism, they should ask for additional resources.

Electrochemical Characterization of Voltage Fade in LMR-NMC cells: Daniel Abraham (Argonne National Laboratory) - es188



Reviewer Sample Size

A total of 3 reviewers evaluated this project.

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

Reviewer 1:

The reviewer stated that the PI and project team have presented a very concise presentation capturing all elements of VF in LMR-NMC. Quantifying or benchmarking the electrochemical performance of LMR-NMC is very important for solving this issue. The reviewer also noted that the project's goal is to use this approach for any new chemistry that has the potential for minimizing or eliminating the VF.

Reviewer 2:

This reviewer noted that the electrochemical characterization, a powerful tool, is used in this research to evaluate diagnosis and compare cathode materials that are interested.

Reviewer 3:

This reviewer observed that the approach is a subset of a compendium of investigations. It focusses on the definition of baseline and its characterization.

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

Reviewer 1:

The reviewer opined that the presentation is a noticeably very clear poster presentation, which delivered the message with key bullet points and which also had placeholders for pointing work of other PI's on the VF team. The experimental results were arranged with clear conclusion and facts. The reviewer expressed a need for the synthesis PI's come up with a new composition for Daniel and his colleagues, and apply these diagnostics to show that there is voltage (or capacity) fade, or not. The reviewer expressed that the latter being the good news. The reviewer also pointed out that another noteworthy aspect that is the new or modified positive electrode composition that minimizes the resistance. This effort should be followed wide across the PI's.

Reviewer 2:

According to the reviewer, some interesting research work has been accomplished. The project demonstrated that VF is unaffected by changes in electrode constitution (oxide, carbon, binder ratios) and electrolyte additives. The reviewer added that the VF was also shown to not depend on electrode kinetics. The reviewer was unsure if the resistance-corrected voltage is accurate, considering the relaxation for the interruption technique employed.

Reviewer 3:
This reviewer noted that the project met the objectives of this test, but did not remove any barriers. The goal is to better understand the VF problem, in terms of bulk characteristics.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer indicated that the PI could deliver such nice results because of having all the key experts doing their job with a clear goal. This project's collaboration should be encouraged.

Reviewer 2:
This reviewer commented that the research team appears to have had good ongoing collaborations with other members of overall VF project.

Reviewer 3:
The reviewer stated that the project is predominantly an ANL effort, with recent expansion to National Laboratories along with some involvement with materials suppliers.

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

Reviewer 1:
According to the reviewer, future plans were to continue the electrochemical cauterization of the cathode materials with different composition and test conditions. Efforts also include coordination of other researchers' activities. The reviewer observed the plan seems to be sound, but recommended the team adopt an impedance spectroscopy study to gain more information.

Reviewer 2:
This reviewer said the project plan is good, but this project element does not intend to overcome barriers.

Reviewer 3:
The reviewer was unsure of what is the next step. As the reviewer previously mentioned, the PI should extend this work on other 5V systems as well, while also keep testing on new LMR-NMC composition, with dopants, that comes out of ANL and elsewhere.

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

Reviewer 1:
This reviewer said that yes, this task is aimed at high energy density batteries for automotive application.

Reviewer 2:
The reviewer stated that the project involves understanding VF in LMR-NMC. This is a material of appreciable interest in the goal of reaching the EV cell goals. The reviewer added that it should be noted that other cathode materials exist also with also promising potential performance.

Reviewer 3:
According to the reviewer, conducting electrochemical characterization of high capacity LMR-NMC cathode VF will help the development of advanced batteries, and this study is aligned with DOE objectives to reduce dependence on petroleum.

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

Reviewer 1:

This reviewer remarked that the PI and project team has everything at their disposal to meet the goals and milestones.

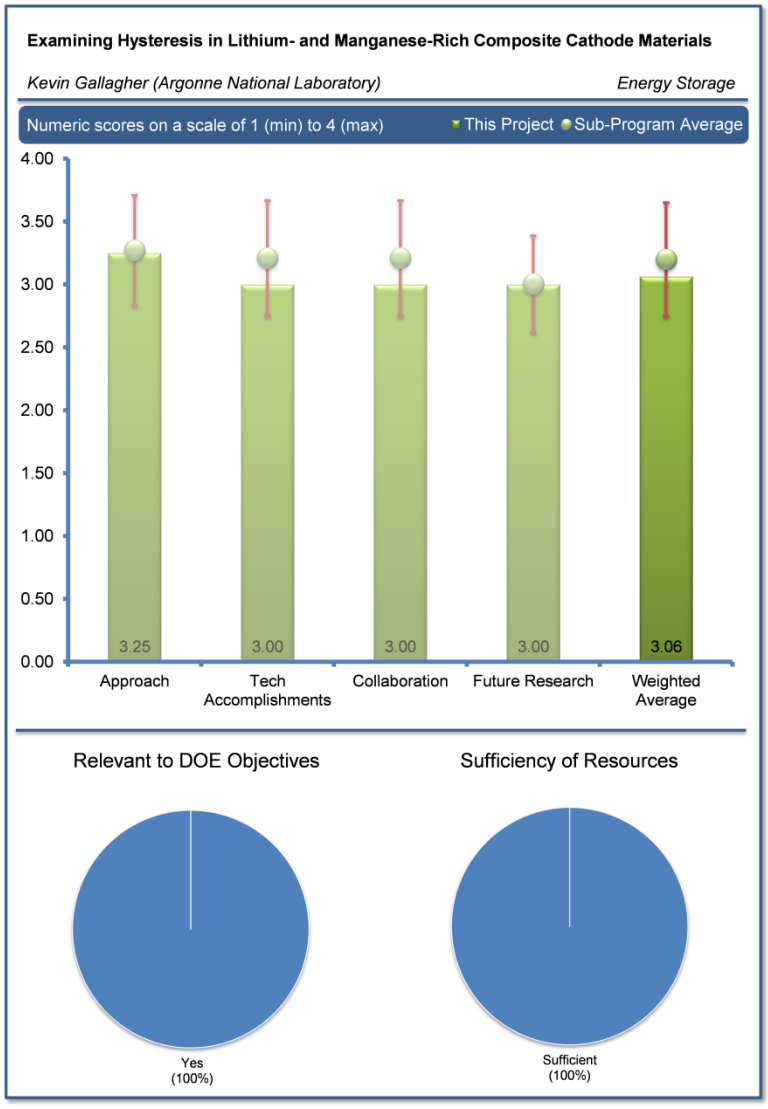
Reviewer 2:

The reviewer observed that funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 3:

The reviewer noted that resources are consistent with what a very large private firm would employ, but could be considered moderately excessive when compared to lean private organizations.

Examining Hysteresis in Lithium- and Manganese-Rich Composite Cathode Materials: Kevin Gallagher (Argonne National Laboratory) - es189



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

According to the reviewer, the work presents a comprehensive and well developed approach that includes an excellent balance between fundamental electrochemical evaluation and analytical characterization. This approach has provided a good foundation for continued success of the project.

Reviewer 2:

The reviewer remarked that the work is based on projecting various performance targets of LMR-NMC using BatPac analysis. The work is very relevant towards addressing barriers associated with LMR-NMC cathode chemistry developed at ANL.

Reviewer 3:

This reviewer noted the project has a solid organization and generation of hypotheses.

Reviewer 4:

This reviewer stated that the hysteresis examination was part of a multi-institution effort to identify factors that contribute to VF in lithium- and manganese-rich NMC oxides.

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

Reviewer 1:

This reviewer noted that the project's milestone achievement is tracking according to the PI's plan.

Reviewer 2:

This reviewer commented that the hysteresis has been well characterized and linked to VF. Testable hypotheses have been created.

Reviewer 3:

The reviewer said that the team has measured hysteresis and correlated it to VF. The hysteresis was correlated to Mn migration. The reviewer added that the temperature impact on hysteresis is unknown and hopefully can be included in the future plan.

Reviewer 4:
The reviewer noted the project's relevant analysis of decoupling capacity verses voltage effects and the cost. This reviewer also observed various performance targets.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that the research team appears to have had good ongoing collaborations with other members of the overall VF project.

Reviewer 2:
This reviewer noted that the coordination is mostly internal, although material has been made public.

Reviewer 3:
According to the reviewer, the collaboration inside ANL is good, but could better leverage expertise and capabilities at other institutions. The reviewer was unsure if relevant, but the consultation with Sethuraman and Srinivasan at LBNL on the topic of hysteresis may yield some useful synergies (this may be proposed on Slide 19).

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

Reviewer 1:
This reviewer noted that other groups will be the benefactors of this project. The goals for this project may, on its own, be overly ambitious.

Reviewer 2:
The reviewer stated that future plans were to continue the study hysteresis of VF mechanism and initiate open current voltage (OCV) numerical model for LMR-NMC.

Reviewer 3:
The reviewer said that the future work describes what is planned, but timeline should be carefully managed if completion is expected by September of 2013.

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

Reviewer 1:
This reviewer remarked that a cathode with a stable high energy density is critical for BEV applications. LMR-NMC is perhaps the best candidate at the present time, and should be aggressively studied to improve this VF issue.

Reviewer 2:
According to the reviewer, the project is conducting hysteresis study, which is part of the efforts to reduce VF of the LMR-NMC cathode, which would also enable it for use in advanced batteries. This study is relevant to the DOE objectives to reduce dependence on petroleum.

Reviewer 3:
This reviewer noted that project is in the context of comprehending hysteresis and VF so that LMR-NMC can be made into a material sufficiently robust to be considered for EV applications.

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

Reviewer 1:

The reviewer said that the resources appear to be managed effectively across all aspects of the project, including the diagnostics and modeling team.

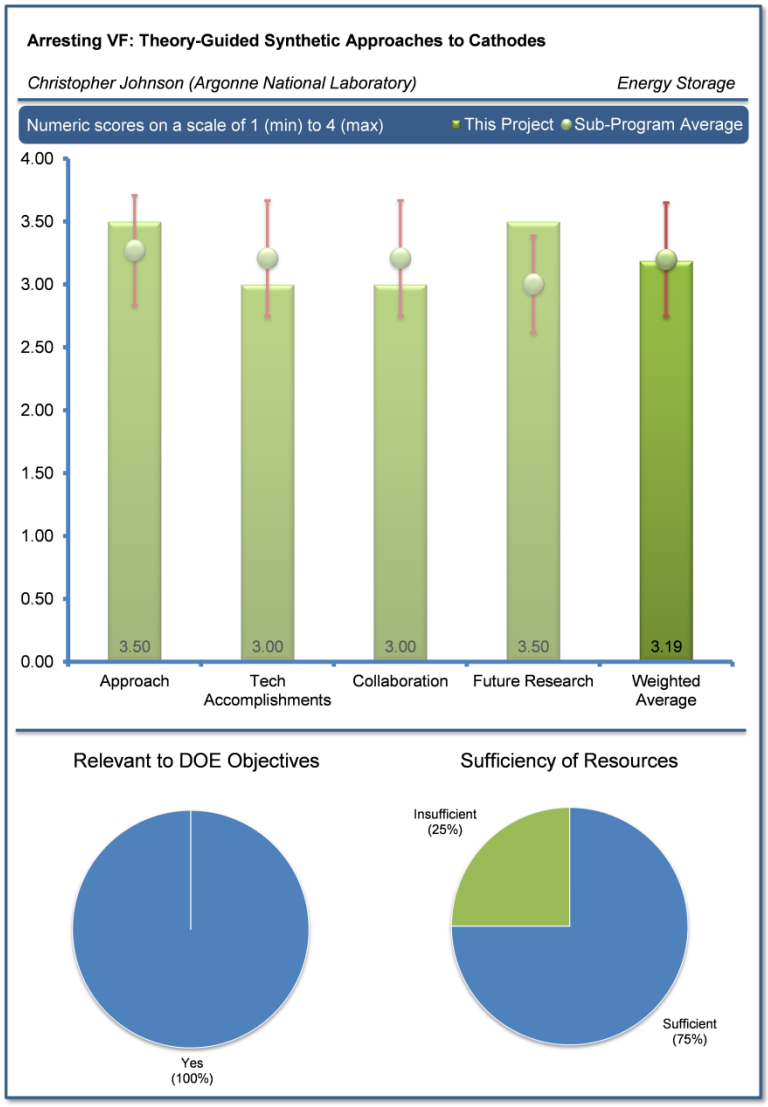
Reviewer 2:

The reviewer stated that the funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 3:

This reviewer noted that resources are potentially excessive when compared to private sector initiatives.

Arresting VF: Theory-Guided Synthetic Approaches to Cathodes: Christopher Johnson (Argonne National Laboratory) - es190



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that this was a presentation where the reviewer really saw how the PI's effort is tied into the overall goal of the VF team. This reviewer added that this effort is extraordinary and should be normal for other PI's presentations as well (Slides 6 and 7). Theory guided synthesis should be always undertaken rather than random intuitive efforts.

Reviewer 2:

The reviewer commented that the approach nicely compliments the other projects within the VF team, and is logical and well developed. The connection between theoretical and experimental aspects of the work is nicely demonstrated, specifically the work on the effect of alternative metals. The reviewer added that the effort is comprehensive, and the project team is not taking short cuts and doing a nice job.

Reviewer 3:

The reviewer noted that the approach was innovative and appeared to have good potential to reduce or eliminate VF.

Reviewer 4:

According to the reviewer, the project plan is solid, but as this is a synthesis exercise, the team should consider additional support from academia and industry, specifically those engaged in this material type of work.

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

Reviewer 1:

This reviewer noted that the materials approach is pretty solid although the project team still sees VF with the Ru substitution. To see that titanium (Ti) can suppress ozone (O_2) evolution from Li_2MnO_3 structure was encouraging.

Reviewer 2:

According to the reviewer, the output for this portion of the project exceeded expectations, and will positively impact DOE's goals and objectives. While the mechanism for VF has not been conclusively identified, the team has methodically addressed their project plan, and is making good progress on FY 2013 milestones. The reviewer went on to say that the exploration of different synthesis

routes, and the conclusion that all routes exhibit similar characteristics, is an important data point. This exploration sets the stage for productive experimentation in the coming months.

Reviewer 3:
This reviewer noted that much progress has been made in a methodical manner. Progress has been slow, given the magnitude of synthesis and characterization work required.

Reviewer 4:
The reviewer observed that the link between synthesis on LMR-NMC and theory (or modeling) was evaluated. Multiple synthesis routes to VF was evaluated and the investigation is promising. The reviewer added that the investigation of the temperature impact on VF of the new materials may be included in a future study.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that the research team appears to have had good ongoing collaborations with other members of the overall VF project.

Reviewer 2:
This reviewer said that the project team is good.

Reviewer 3:
This reviewer noted that the collaboration with existing partners is good, but further assistance is recommended.

Reviewer 4:
The reviewer stated that the project team should continue to develop and leverage analytical collaborations within ANL and outside, for example, Michigan Technological University (MTU). The shutdown period may be a good time to initiate and accelerate these collaboration activities.

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

Reviewer 1:
The reviewer was pleased to see the emphasis on iterating with the other groups. The future work is logical and the appropriate extension of past activities and conclusions.

Reviewer 2:
The reviewer noted that future plans, which seem to be sound, were to conduct more synthesis, characterization with advanced analytic techniques, and cell testing.

Reviewer 3:
This reviewer expressed that it would be positive to see what results the PI team can get for chromium (Cr) and molybdenum (Mo) substitution in some of the LMR-NMC compositions. The effect of Co, or no Co, should be studied since Co helps to maintain the layering.

Reviewer 4:
This reviewer remarked that tasks need to be completed, for insufficient progress has been made in VF resolution and to alter the current path.

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

Reviewer 1:
This reviewer observed that in the context of the project, the material studied is one of the optimal materials to meet the EV cell goals.

Reviewer 2:
According to the reviewer, the research of the LMR-NMC cathode VF will help the development of advanced batteries. The research is also aligned with DOE objectives to reduce dependence on petroleum.

Reviewer 3:
This reviewer noted that the R&D effort is directed towards the batteries for the automotive application.

Reviewer 4:
The reviewer commented that a cathode with a stable high energy density is critical for BEV applications. LMR-NMC is perhaps the best candidate at the present time, and should be aggressively studied to improve this project's VF issue.

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

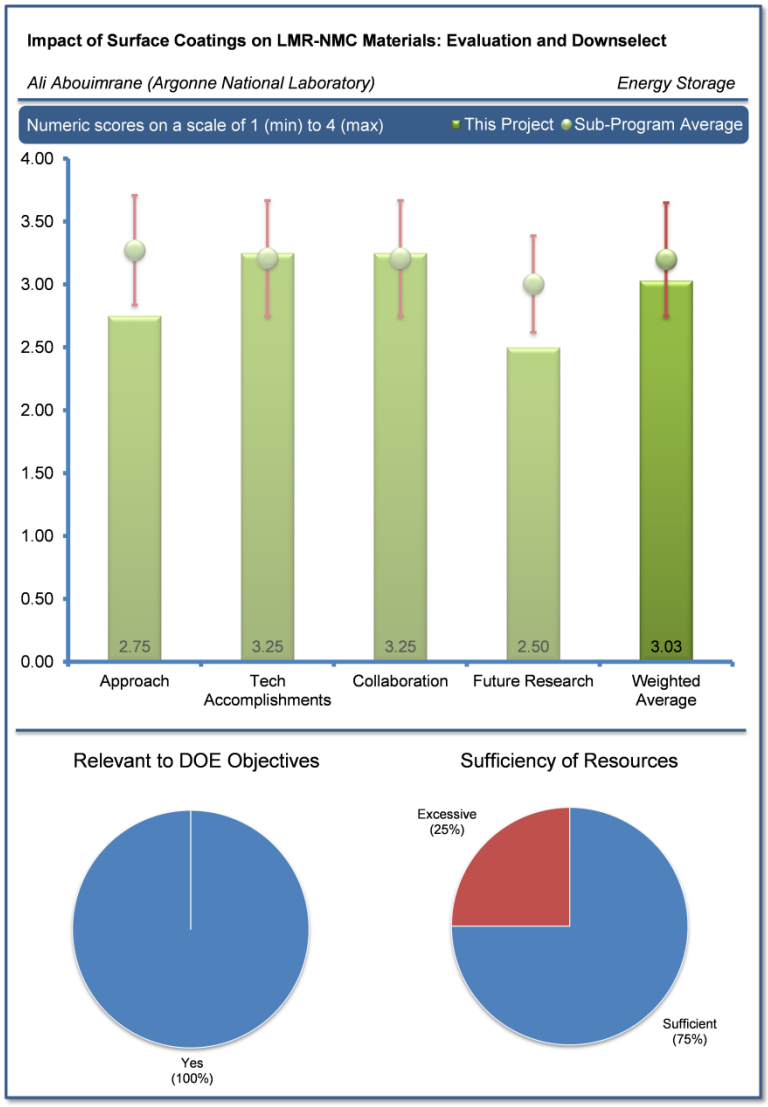
Reviewer 1:
This reviewer said that there is excellent coordination with other teams and to keep up the good work.

Reviewer 2:
This reviewer stated that the funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 3:
This reviewer noted that the resources are quite adequate.

Reviewer 4:
The reviewer expressed that additional resources should be canvassed from industry and academia. Much work is under way regarding of LMR-NMC variants. The reviewer added that the project work would benefit from collaboration with such LMR-NMC synthesis efforts.

Impact of Surface Coatings on LMR-NMC Materials: Evaluation and Downselect: Ali Abouimrane (Argonne National Laboratory) - es191



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

According to the reviewer, the technical approach is appropriate to test the hypothesis, the potential influence of surface modifications on VF, particularly in a high voltage system where interfacial conditions are likely very important. Furthermore, the project team has pursued a nice variety of surface modifications, ALD at particle and electrode level, aluminum phosphorus quadoxide ($AlPO_4$), and aluminum trifluorine (AlF_3), and evaluated their impact in a consistent and technically valid manner. The reviewer added that the team may have explored a broader set of electrolyte additives. Overall, the project is well designed and managed.

Reviewer 2:

This reviewer remarked that the approach is clearly a good effort towards studying the effect on various ALD based coating in the LMR-NMC composition.

Reviewer 3:

The reviewer stated that the approach was trying to reduce VF through coating and using electrolyte additives. The reviewer noted that the approach was interesting.

Reviewer 4:

This reviewer said that the project's theory was weak in that it assumed similar causes regarding impedance growth, as seen in other materials.

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

Reviewer 1:

The reviewer commented that the project team has successfully completed all relevant milestones in a relatively short amount of time. While not successful in solving the issue of VF relative to clear performance indicators, the team has evaluated a very plausible concept in a comprehensive fashion.

Reviewer 2:
This reviewer stated that the project clearly demonstrates that the coating does not solve the VF issue but can improve the stability with respect to high voltage cycling.

Reviewer 3:
This reviewer noted that it was determined that VF is not a surface chemistry phenomenon.

Reviewer 4:
According to the reviewer, the LMR-NMC surface modification with the coating and electrolyte additive seems that it could not fix the VF problems, although the coating helped to keep the capacity and did not increase resistance. That appears to link the VF to bulk structure (or properties) change.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed that the PI clearly had a good collaboration and working relationship with host of relevant organizations.

Reviewer 2:
The reviewer stated that the research team appears to have had good ongoing collaborations with other members of the overall VF project.

Reviewer 3:
This reviewer noted that the project team has broad collaboration within ANL, but not outside.

Reviewer 4:
This reviewer said that the collaboration appears to have been limited to ANL. Some consultation with external groups may have been beneficial.

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

Reviewer 1:
According to the reviewer, the project team's conclusion to stop surface modification efforts makes sense in light of the observed results of this study. The recommendation to focus on composition is consistent with several other projects from ANL. The reviewer added that there may be room to explore more electrolyte additives, although this may be addressed by other groups unknown to the reviewer.

Reviewer 2:
The reviewer stated that the future plans were to conduct more synthesis Ni (or Mn) and cobalt free LMR-NMC as well as substitute, Mn with Mg or chromium (Cr). The reviewer added that the plan seems to be sound.

Reviewer 3:
This reviewer noted that additional research will not likely impact the outcome of the study.

Reviewer 4:
This reviewer expressed a need for more explanation about next year's work. The proposed work seems to overlap with other PI's at Argonne, for example, doping of LMR-NMC with Mg or Cr.

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

Reviewer 1:
According to the reviewer, the development of high energy density cathode materials is essential to enable the next generation of Li-ion batteries. This work is directly aligned with these efforts, and supports the DOE's objectives of petroleum displacement.

Reviewer 2:
This reviewer affirmed in the context that the material studied is one of the optimal materials to meet the EV cell goals.

Reviewer 3:
The reviewer stated that the research of LMR-NMC cathode VF will help the development of advanced batteries, and that it is aligned with DOE's objectives to reduce dependence on petroleum.

Reviewer 4:
This reviewer commented that yes, the project work is in the area of batteries for transportation.

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

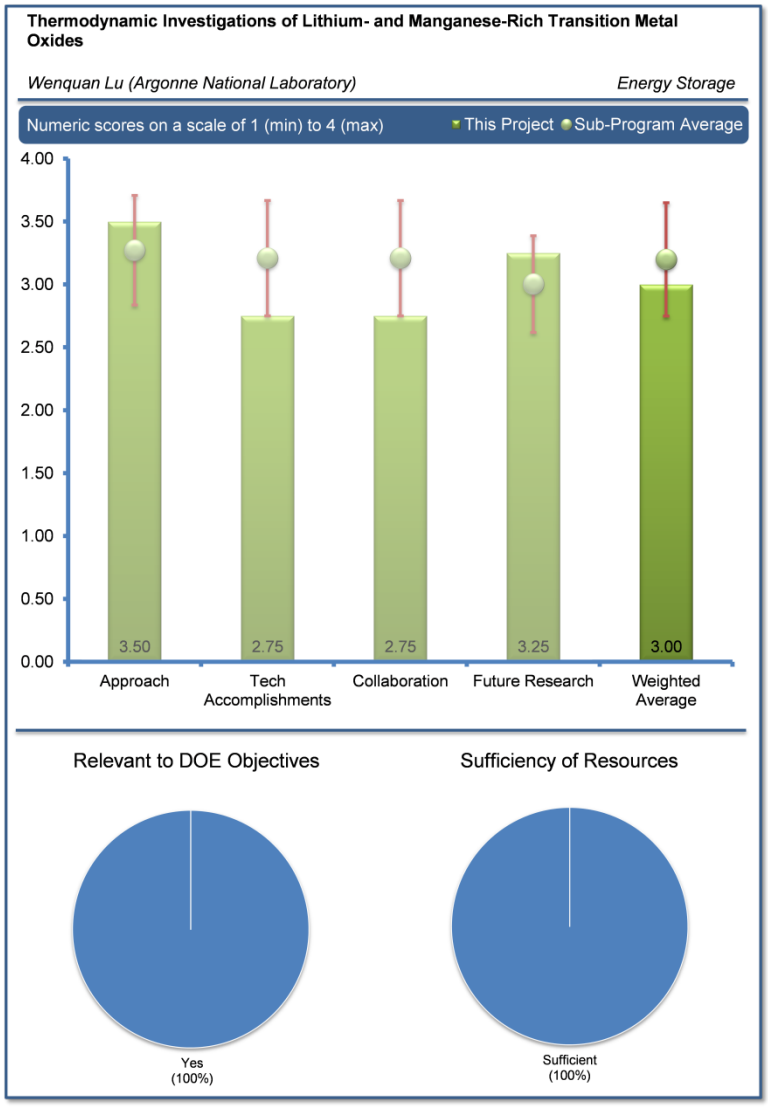
Reviewer 1:
The reviewer stated that the funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 2:
This reviewer noted that resourcing appears adequate.

Reviewer 3:
This reviewer expressed that the resources are okay.

Reviewer 4:
The reviewer opined that this particular project should be closed, and if deemed reasonable, the balance of tasks should be merged with other associated projects.

Thermodynamic Investigations of Lithium- and Manganese-Rich Transition Metal Oxides: Wenquan Lu (Argonne National Laboratory) - es192



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer commented that the approach has excellent structure to fundamentally characterize material thermodynamic behavior.

Reviewer 2:

According to the reviewer, the PI nicely connects fundamental aspects of entropy with electrochemical measurements, providing unique insight into the structural evolution of the LMR-NMC under high-voltage cycling conditions. The project is well designed, with a systematic approach to evaluating the electrochemical characteristics as a function of temperature and state of charge, and to yield the entropy as a function of state of charge. The reviewer said that furthermore, the effect of formation and cycling cut-off voltages is well presented and should provide useful information to other teams. Finally, the microcalorimetry study nicely compliments the other aspects of the project. The reviewer expressed that the PI did a nice job.

Reviewer 3:

This reviewer observed that the PI has a novel approach of measuring the entropy changes at the materials level in the form of disorder, and correlating this with observation at the cell level.

Reviewer 4:

The reviewer stated that the thermodynamic study of LMR-NMC was an interesting approach, and it may be helpful to understand the root cause of VF.

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

Reviewer 1:

According to the reviewer, the project team is making excellent progress on milestones, and has made valuable observations on the thermodynamic aspects and the impact of different cycling conditions on VF. The assessment of milestone completion is accurate, and the team is extending their work, where appropriate, to more fully understand the problem at hand.

Reviewer 2:
This reviewer pointed out that the project's analysis is generating a comprehensive understanding of how the role of each material structural element plays in its operation, and thereby leads to those features that are engaged with the VF phenomenon.

Reviewer 3:
The reviewer stated that the research revealed that the VF is affected by both formation and cycling cut-off voltages. It is suggested the impact of formation and cycling cut-off on VF at different temperatures can be included in the future study.

Reviewer 4:
This reviewer observed the project as a very in-depth study. The reviewer in unsure if the PI can correlate the entropy change measured indirectly from electrochemical & thermal measurement in terms of lithiation and delithiation with NMR and microscopy counterparts. The measured change can be useful since entropy should increase as there are more movements of TM and Li during high voltage cycling.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
According to the reviewer, the research team appears to have had good ongoing collaborations with other members of the overall VF project.

Reviewer 2:
This reviewer remarked that the project team is good, although additional assistance from external sources would be beneficial.

Reviewer 3:
The reviewer observed that limited collaboration is apparent for groups outside of ANL. However, it appeared that the internal scientists are more than competent to perform the work.

Reviewer 4:
This reviewer noted that collaborations are not listed.

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

Reviewer 1:
This reviewer remarked that the analysis is solid and iterative, particularly if (or when) coupled with findings from associated work groups.

Reviewer 2:
This reviewer commented that the project's future plan seems to be a sound plan. The reviewer added that the entropy change investigation will be helpful to lead to the better understanding of the root cause of VF.

Reviewer 3:
According to the reviewer, the proposed future work is appropriate, and it incorporates current technical progress into a clear set of extended efforts, entropy and microcalorimetry, along with new techniques such as Electrochemical Impedance Spectroscopy (EIS).

Reviewer 4:
This reviewer mentioned that microcalorimetry studies should be continued for all new compositions, coatings and electrolytes.

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

Reviewer 1:
The reviewer stated that the research of the LMR-NMC cathode VF will help the development of advanced batteries, and it is aligned with DOE's objectives to reduce dependence on petroleum.

Reviewer 2:
This reviewer observed that in the context of the project, the material studied is one of the optimal materials to meet the EV cell performance goals.

Reviewer 3:
The reviewer observed that program supports DOE's objectives of petroleum displacement by developing a high energy density cathode material that will significantly advance the next generation of Li-ion batteries appropriate for EV applications.

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

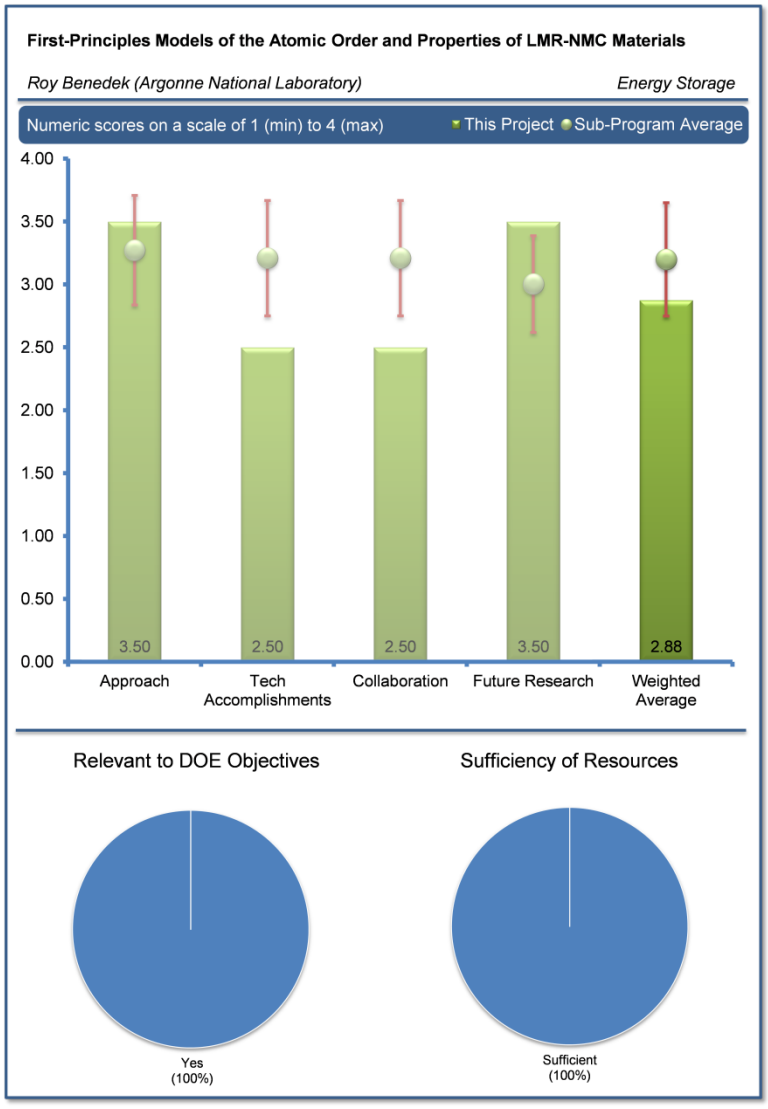
Reviewer 1:
The reviewer said that the project team is resourced appropriately to complete the planned work.

Reviewer 2:
According to the reviewer, funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 3:
This reviewer noted that the resources are okay.

Reviewer 4:
The reviewer encouraged the synthesis of this information into associated groups, as part of routine analysis.

First-Principles Models of the Atomic Order and Properties of LMR-NMC Materials: Roy Benedek (Argonne National Laboratory) - es193



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

The reviewer expressed that the approach was innovative to be able to understand the VF mechanism using first-principle modeling, and would help to lead to directions for materials synthesis.

Reviewer 2:

The reviewer stated that sound scientific principles are applied in a rigorous analytical manner.

Reviewer 3:

According to the reviewer, the project team is pursuing a theoretical approach to better understand the VF issue of LMR-NMC. The project is feasible and appropriate; however, the objective is somewhat open ended and the connection of the milestones with the broader objectives of the VF team could be clarified. The scope of calculations, number of configurations and number of atoms within the simulations, could be expanded to improve confidence in the conclusions. Furthermore, the reviewer added that including experimentally motivated imperfections may be illuminating.

Reviewer 4:

This reviewer pointed out that the theoretical modeling to determine stable dopants and/or estimating the interaction or activation energy to transition metals, Mn and Ni, in different environments is critical for understanding of the VF issue. The first principle approach is an idea for this.

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

Reviewer 1:

The reviewer stated that the first principles methods were successfully used to understand the atomic scale structure and voltage fade mechanism. It was a direct support to possible VF free LMR-NMC synthesis efforts.

Reviewer 2:

The reviewer commented solid analysis using first principles, and forms the grounds for the generation of a synergistic hypothesis with some associated projects.

Reviewer 3:

The reviewer remarked that the project team has calculated the properties of a reasonable number of atomic configurations for LMR-NMC. In some cases, it is not clear if the noted technical accomplishments were achieved or if they still remain as open questions, which may be related to presentation style. Within the perspective of this particular project, the progress relative to milestones has been good. The reviewer added that, as mentioned above, the milestones are definitely aligned with the rest of the VF project, but this association should be clarified for future meetings.

Reviewer 4:

According to the reviewer, the PI has demonstrated certain feasibility studies where different atoms such as first row and second row elements, Ti, Cr, V, Mo and Ru, could substitute the Mn atom to stabilize the phase. But, recent experimental results with Ru and Fe both show negative results as far as VF. The reviewer added that the modeling predictions clearly need to be more robust to narrow down to a few elements.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that the research team appears to have had good ongoing collaborations with other members of the overall VF project.

Reviewer 2:

This reviewer noted that authors are collaborating with Chris Wolverton's group at Northwestern University, which adds value to the work in terms of availability of Density Functional Theory (DFT) codes and other information.

Reviewer 3:

According to the reviewer, the simulation work has generated a series of recommendations related to the substitutions for Mn. These recommendations should be explored with the support of the synthesis team; however, the presenter indicated some resistance to this support. The reviewer expressed a need to propose that higher level program management revisit the deliverables and proposals of this project, and also to promote the program management’s exploration in the synthesis team.

Reviewer 4:

This reviewer noted that the collaboration is predominantly an internal effort. This project is at the point where collaboration with associated teams should occur.

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

Reviewer 1:

The reviewer stated that the future plan seems to be a good. The further theoretical study has the potential to lead to the better understanding of the root cause of VF.

Reviewer 2:

The reviewer noted that related to the comments above, the proposed compositional modifications should be addressed by the synthesis group. Furthermore, the correlation between the modeling results and analytical results will be an important validation point and is nicely addressed by the PI.

Reviewer 3:

This reviewer said that the next steps would validate or invalidate some of the predominant hypotheses for the source of VF.

Reviewer 4:
This reviewer expressed a need to anxiously look forward to what authors have promised in Slides 10 and 12, to know if certain substitution atoms such as Mo or Cr will form Li_2MnO_3-$LiMO_2$ phase, and if there are certain pathways to maximize the Mn-Ni interaction to prevent Mn atom migration.

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

Reviewer 1:
This reviewer said that the work is very relevant for narrowing down to a few compositions to mitigate VF.

Reviewer 2:
This reviewer observed that in the context of the project, the material studied is one of the optimal materials to achieve the EV cell performance goals.

Reviewer 3:
According to the reviewer, both the experimental and theoretical methods will be necessary to solve the problem of VF in LMR-NMC. This work contributes to the development of this promising cathode material, which will enable the next generation of high energy density Li-ion batteries.

Reviewer 4:
The reviewer stated that the theoretical research on LMR-NMC cathode VF will help the development of advanced batteries, and it is align with DOE's objectives to reduce dependence on petroleum.

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

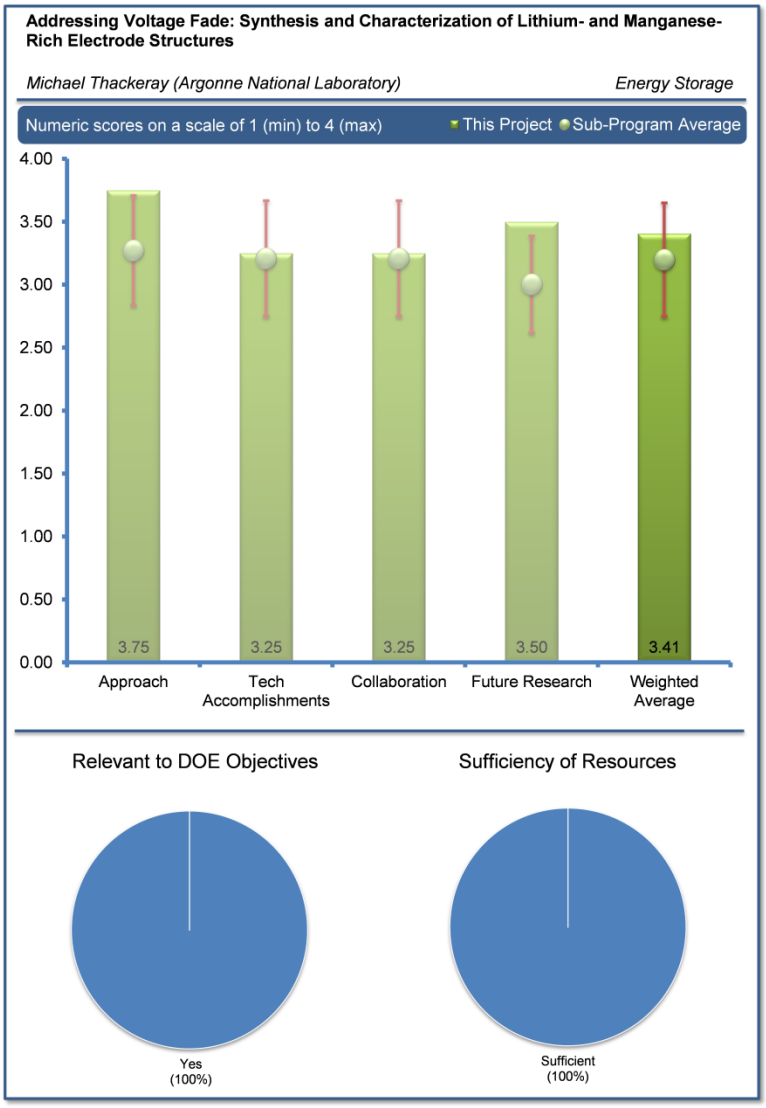
Reviewer 1:
This reviewer said yes to the resources.

Reviewer 2:
The reviewer stated that the funding and sources available for this project appeared to be sufficient to conduct the research work.

Reviewer 3:
The reviewer noted that further collaboration with associated project teams is encouraged.

Reviewer 4:
This reviewer had no comments, other than to get support for synthesis efforts from other ANL teams.

Addressing Voltage Fade: Synthesis and Characterization of Lithium- and Manganese-Rich Electrode Structures: Michael Thackeray (Argonne National Laboratory) - es194



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

According to the reviewer, the technical approach is logical, nicely described in the presentation, and exhibits novelty while remaining realistic and logical. While the VF issue still remains a challenge, the project team has made several relevant discoveries that can be attributed to their methodical methods and experimental approach.

Reviewer 2:

The reviewer stated that it was an innovative approach to synthesis LMR-NMC with integrated structure to attack the VF phenomenon.

Reviewer 3:

This reviewer noted that the approach sustained good program execution.

Reviewer 4:

The reviewer noted that various fundamental approaches have been demonstrated that could possibly overcome the barriers associated with LMR-NMC. These include incorporating a spinel component in the Li_2MnO_3-$LiMO_2$ structure, and making a certain composition Ni-rich as per the phase diagram analysis. The reviewer also said that these steps are all steps in the right direction.

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

Reviewer 1:

The reviewer commented that project team is developing the ability to control the synthesis of the material, although actual VF results were not shown within the presentation.

Reviewer 2:

This reviewer remarked that the completion of milestones is ongoing. However, significant technical progress has been made with both electrochemical analysis and materials characterization. The reviewer stated that the results are measured against appropriate metrics, and conclusions are made in a logical fashion and supported by a comprehensive data set. The reviewer added that the results presented nicely compliment other project elements and have relevance to the broader DOE objectives.

Reviewer 3:
According to the reviewer, the research appeared interesting. The reviewer added that the investigation indicated that a spinel component can reduce first cycle irreversible capacity loss, and may stabilize the layered-layered composite materials. The Ni content increases in high Co content and the layered-layered composites seemed that they can increase stability. The reviewer is not sure if the effect of the new approach on the true VF, without the IR contribution, had been investigated, or not.

Reviewer 4:
The reviewer noted that the proof of principle electrochemical cycling results are shown and discussed, but it is unclear if such approaches will any time soon address the limitation of LMR-NMC baseline chemistry. Any fundamental compositional changes need to go through the rigorous steps to make sure they meet the cycle and calendar life for automotive application.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer commented that the research team appears to have had good ongoing collaborations with other members of overall VF project and other academia and industry partners.

Reviewer 2:
The reviewer expressed that the team is good for addressing fundamental issues associated with LMR-NMC.

Reviewer 3:
This reviewer stated that the collaboration within ANL appears strong, but the project team could consider gaining feedback and interaction with industry partners.

Reviewer 4:
The reviewer noted that project team is utilizing commercial suppliers for research.

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

Reviewer 1:
This reviewer remarked that a well-developed and defined plan is in place to continue the project, leveraging the conclusions from previous results. This reviewer also expressed that there are no recommendations for improvement.

Reviewer 2:
According to the reviewer, the future plan seemed to be a sound plan. The further study on composition optimization of the layered-layered-spinel cathodes has the potential reduce the VF of that type of materials.

Reviewer 3:
This reviewer said that the collaboration with other project teams should stay within the realm of the future work.

Reviewer 4:
The reviewer would like to know the exact or approximate composition of layered-spinel compounds that is proposed for the study. The fundamental studies proposed such as XAS, PDF analysis are important. The reviewer said that additionally, the PI should use Neutron PDF and diffraction methods to characterize the structure as well. Combining x-ray and neutron information is critical for such compounds.

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

Reviewer 1:
This reviewer noted that in the context of the project, the material studied is one of the optimal materials to achieve the EV cell performance goals.

Reviewer 2:
According to the reviewer, the development of low cost, high-capacity cathode materials with good structural, electrochemical and thermal stability for PHEVs is aligned with DOE's objectives to reduce dependence on petroleum.

Reviewer 3:
This reviewer pointed out that the work is directed towards developing high energy batteries for PHEV and EV's.

Reviewer 4:
The reviewer stated that mitigating the VF of LMR-NMC is critical to enable the next generation of high energy density Li-ion batteries, which in turn supports the DOE objectives of petroleum displacement.

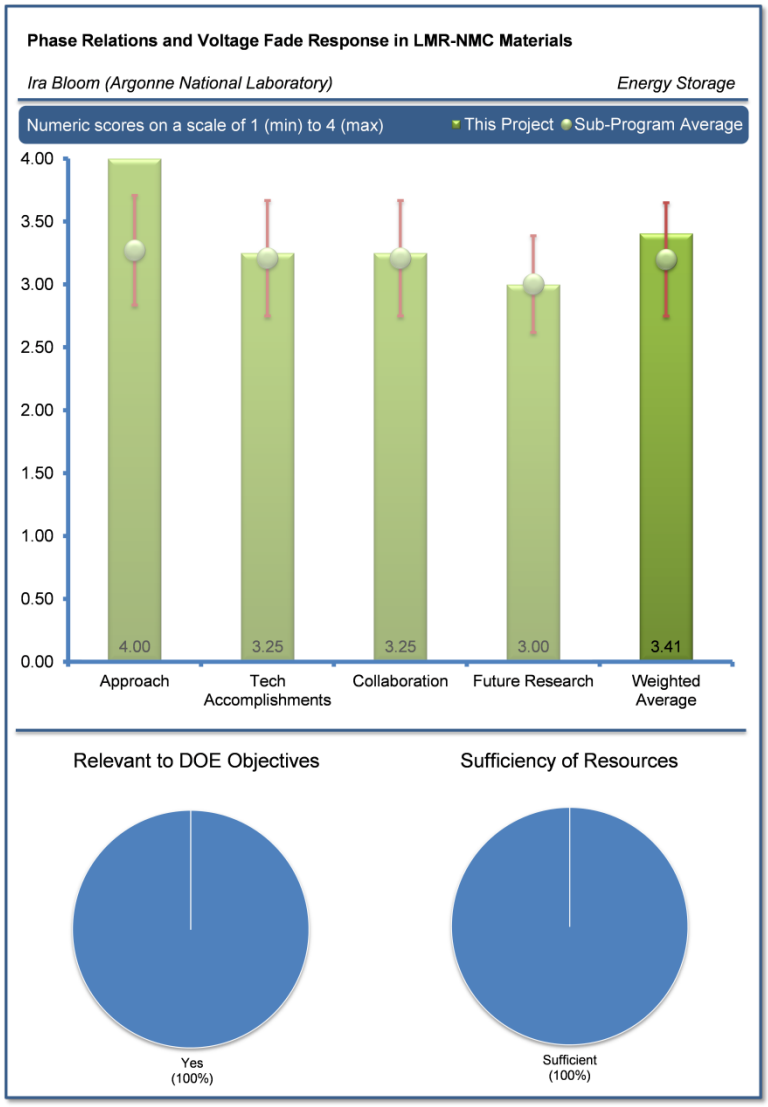
Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that the funding and resources available for this project appeared to be sufficient to conduct the research work.

Reviewer 2:
This reviewer noted that the resources are adequate.

Reviewer 3:
This reviewer stated that there were no comments.

Phase Relations and Voltage Fade Response in LMR-NMC Materials: Ira Bloom (Argonne National Laboratory) - es195



Reviewer Sample Size

A total of 4 reviewers evaluated this project.

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

Reviewer 1:

This reviewer noted the approach has combinatorial methodology with solid analysis.

Reviewer 2:

According to the reviewer, the project team has undertaken a well-defined experimental plan with clear objectives and deliverables. The team addresses the VF problem from both a compositional and electrochemical perspective, and is carefully analyzing the resulting data to define future work. The reviewer explained that generation of a common database for the ANL team and a common method for interpreting VF from voltage profiles [i.e., insulation resistance (IR) corrected average voltage (V)], are essential and will contribute to data integration across the project.

Reviewer 3:

This reviewer stated that the approach was innovative to synthesis LMR-NMC with integrated structure to attack the VF phenomenon.

Reviewer 4:

This reviewer noted that the combinatorial approach, guided by theory, should be the only way towards finalizing a new composition that has none or the least VF. This work should be closely tied with Chris Johnson's synthesis effort, so that ANL team can quickly converge on a new or modified high voltage cathode composition.

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

Reviewer 1:

This reviewer remarked that the development of a library for observations is excellent. It should be possible to simply expand the library, as more novel materials are investigated.

Reviewer 2:

The reviewer stated that the research appeared interesting. The investigation indicated a spinel component can reduce first cycle irreversible capacity loss, and may stabilize the layered-layered composite materials. The reviewer also noted that the Ni content

increases in high Co content. The layered-layered composites seemed to increase stability. The reviewer is not sure if the effect of the new approach on the true VF, without the IR contribution, had been investigated, or not.

Reviewer 3:

According to the reviewer, the progress and results presented suggest a path for overcoming the barrier of VF. Specifically, the evaluation of the kinetic factors associated with VF where this work indicates hot spots for compositions that will hopefully minimize or reduce the effect of VF. The reviewer added that the breadth of experimentation is impressive, as is the completeness of the data sets for the impact of the degree of activation and charging time.

Reviewer 4:

The reviewer commended the PI's approach towards standardizing the various efforts at ANL with respect to the LMR-NMC composition; phase, electrochemical results, and voltage fade analysis. This will help to summarize the results for cell suppliers, OEMS and others. The reviewer added that the kinetic model used for VF could be used a quick scan for evaluating the VF progression for new compositions. However, the reviewer is unsure of the limitations of this model, which looks like there are too many fitting parameters. The reviewer would like to know what are the constraints used in this project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

This reviewer commented that collaboration is optimal at this stage.

Reviewer 2:

The reviewer said that the research team appears to have had good ongoing collaborations with other members of overall VF project and other academia and industry partners.

Reviewer 3:

This reviewer noted that the collaboration was suitable for this phase of the project.

Reviewer 4:

The reviewer stated that the collaboration is local to ANL and the project team could consider consolation with the likes of Ceder.

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

Reviewer 1:

According to the reviewer, the future plan seemed to be a sound plan. The further study on composition optimization of the layered-layered-spinel cathodes has the potential to reduce the VF of those types of materials.

Reviewer 2:

The reviewer observed that the team proposes a logical iterative approach to future work, which includes synthesizing materials relative to the predictions of the model, evaluating these materials, and using the results to fine tune the model. The team should consider defining decision points or triggers to determine when exiting the development loop is appropriate.

Reviewer 3:

This reviewer commented that the project is focused on data collection and analysis (characterization), and cautioned that expansion of this effort by related teams should be carefully evaluated.

Reviewer 4:
This reviewer would like to see tangible results from this with the help from synthesis PIs from ANL and elsewhere. Apparently the project team now has a solid framework to evaluate new compositions, and quickly converge on the right one, instead of spending years on one or two compositions.

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

Reviewer 1:
This reviewer pointed out that project is very relevant, as the work is related to batteries for EV's.

Reviewer 2:
The reviewer commented that the development of low cost, high-capacity cathode materials with good structural, electrochemical, and thermal stability for PHEVs is aligned with DOE's objectives to reduce dependence on petroleum.

Reviewer 3:
This reviewer noted that in the context of the project, the material studied is one of the optimal materials to achieve the EV cell performance goals.

Reviewer 4:
According to the reviewer, that the project is consistent with DOE's objectives for petroleum displacement by advancing the development of high energy density Li-ion batteries that may find applications in EVs.

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

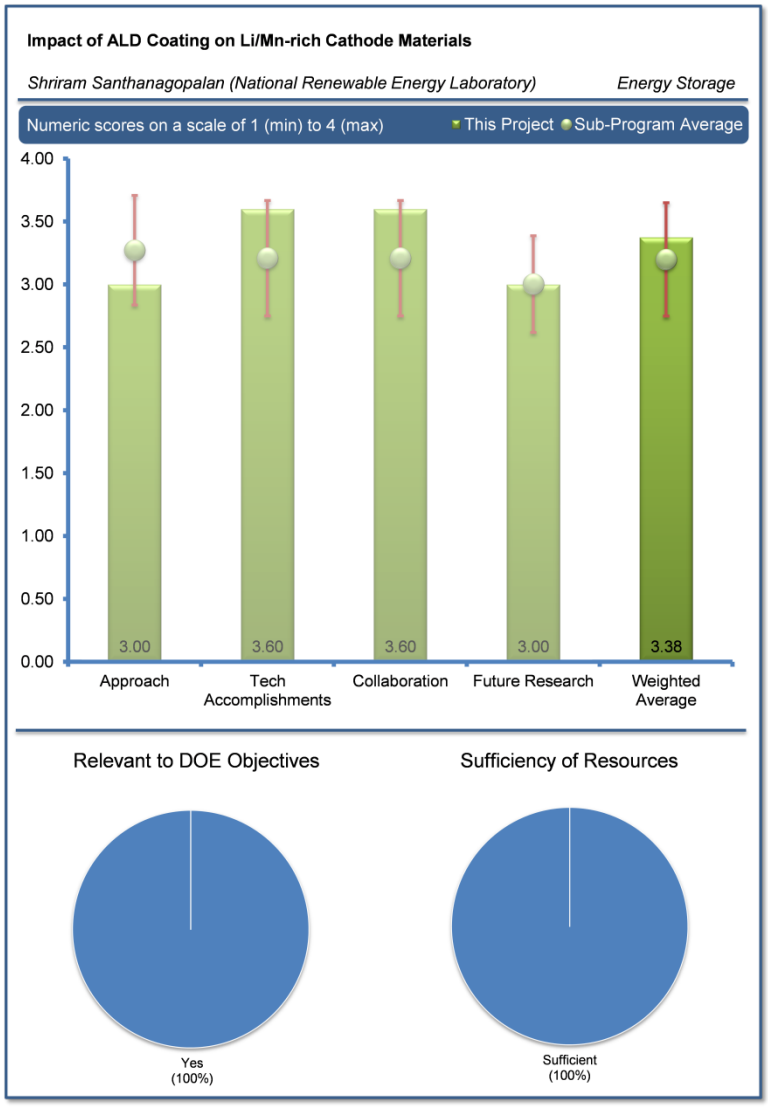
Reviewer 1:
The reviewer said that the funding and resources available for this project appeared to be sufficient to conduct the research work.

Reviewer 2:
The reviewer said that the resources are adequate.

Reviewer 3:
This reviewer remarked that no recommendations are needed.

Reviewer 4:
This reviewer stated that there are no issues.

Impact of ALD Coating on Li/Mn-rich Cathode Materials: Shriram Santhanagopalan (National Renewable Energy Laboratory) - es196



Reviewer Sample Size

A total of 5 reviewers evaluated this project.

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

Reviewer 1:

The reviewer said that the approach of laying out a scaled up plan to allow the evaluation of ALD, as a potential coating technique, is clear and well thought out.

Reviewer 2:

The reviewer stated that the short term approach has been valuable in increasing confidence in the ALD methodology.

Reviewer 3:

This reviewer remarked that this fast-track project is good.

Reviewer 4:

According to the reviewer, this quick hitting project is well focused, but addresses capacity fade and not voltage.

Reviewer 5:

This reviewer in unsure if the coating approach will really help with VF.

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

Reviewer 1:

The reviewer stated that there was impressive progress in a short period.

Reviewer 2:

The reviewer pointed out that three of the four milestones have been met with promising results, but would like to see some cost projections of utilizing ALD to manufacture these complex particles.

Reviewer 3:

This reviewer noted that this technical work appears solid, but it was hard to understand what was really done.

Reviewer 4:

The reviewer remarked that the technical accomplishments are not great, but consistent with the level of effort. If ALD can solve the capacity and VF problems, as well as allow high voltages to be applied to cathodes, the effort will be quite important.

Reviewer 5:
According to the reviewer, while the work in developing the process for the ALD coating process was well done, the issue of interpreting the impact of the results, as a justification for further work, is fairly weak. The small amount of results presented would not necessarily be compelling enough to justify continued work in this area, as these results were presented. The reviewer expressed a need to assume that the program ES162 takes this program forward and that this lack of results is a non-issue.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This reviewer affirmed that the collaboration is excellent, including a National Laboratory, small business, and university.

Reviewer 2:
The reviewer noted that the team is strong with an active, engaged industry partner.

Reviewer 3:
This reviewer noted that there is a high level of collaboration.

Reviewer 4:
The reviewer stated that the collaboration seemed appropriate for a short term, and that it is a fast track program.

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

Reviewer 1:
The reviewer expressed that there is a need to see the work extended, especially in the direction of fluidized bed reactors.

Reviewer 2:
The reviewer stated that in this well-coordinated program, it appears that the milestones will be readily met.

Reviewer 3:
This reviewer remarked that given the existence and justification of Program ES162, this program would likely be at its logical conclusion.

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

Reviewer 1:
This reviewer expressed that this fast track approach to generate data in support of ALD for electrode material applications is positive.

Reviewer 2:
This reviewer observed that high voltage cathodes are a key part of the program.

Reviewer 3:
According to the reviewer, coatings on cathodes are a viable approach to addressing some of the performance issues associated with various materials.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
No comments were received in response to this question.

Acronyms and Abbreviations

Acronym	Definition
°C	Degrees Celsius
3D	Three Dimensional
ABR	Advanced Battery Research
Ah	Ampere-hour
ALD	Atomic Layer Deposition
AMR	Annual Merit Review
ANL	Argonne National Laboratory
AP	Atmospheric Processing
ARRA	American Recovery and Reinvestment Act
ASI	Area-specific Impedance
ATR	Attenuated Total Reflectance
B	Boron
BatPac	Battery Pack
BATT	Batteries for Advanced Transportation Technologies
BEV	Battery Electric Vehicle
BMS	Battery Management System
BNL	Brookhaven National Laboratory
BOL	Beginning of Life
BOM	Bill of Material
C	Carbon
CAEBAT	Computer-Aided Engineering of Batteries
CALPHAD	Computer Coupling of Phase Diagrams and Thermochemistry
CB	Carbon Black
CMC	Carboxymethyl Cellulose
CNT	Carbon Nanotubes
Co	Cobalt
Cr	Chromium
CTQ	Critical to Quality
Cu	Copper
DFT	Density Functional Theory
DOE	U.S. Department of Energy
DSC	Differential Scanning Calorimetry
EC	Ethylene Carbonate
EDS	Energy Dispersive X-ray Spectroscopy
EELS	Electron Energy Loss Spectroscopy
EIS	Electrochemical Impedance Spectroscopy
EMC	Ethyl Methyl Carbonate

Acronym	Definition
EOL	End of Life
EPR	Electron Paramagnetic Resonance
EV	Electric Vehicle
EXAFS	Extended X-ray Absorption Fine Structure
F	Fluorine
Fe	Iron
FRION	Flame Retardant Electrolyte Ions
FTIR	Fourier Transform Infrared Spectroscopy
FY	Fiscal Year
GM	General Motors
GBL	Gamma Butyrolactone
GVL	Ester Solvent
HCA	High-capacity Anode
HCC	High-capacity Cathode
HE	High Energy
HEV	Hybrid Electric Vehicle
HRSXRD	High-resolution Synchrotron X-ray Diffraction
HV	High Voltage
HVC	High Voltage Cathode
HVM	High-volume Manufacturing
ICE	Internal Combustion Engine
INL	Idaho National Laboratory
IR	Insulation Resistance
IREQ	Institut de Recherche d'Hydro-Québec
JCI	Johnson Controls, Inc.
LANL	Los Alamos National Laboratory
LBMP	Lithium-Bearing Mixed Polyanion
LBNL	Lawrence Berkeley National Laboratory
LEESS	Lower-Energy Energy Storage System
LFO	Lithium Iron Oxide
LFP	Lithium Iron Phosphate
Li	Lithium
LMO	Lithiated transition metal oxides
$LiBF_4$	Lithium tetrafluoroborate
LiBOB	Lithium bis(oxalato)borate
Li-ion	Lithium Ion
$LiPF_6$	Effective electrolyte salt for lithium-ion battery
LiPON	Lithium Phosphorous Oxynitride
LiTFSI	Lithium Bis(Trifluoromethanesulfonyl)Imide
LMNO	Ni-substituted manganese spinel oxides
LMR	Lithium Manganese Rich

Acronym	Definition
LT	Low Temperature
MA	Maleic Anhydride
MB	Methyl Butyrate
MERF	Materials Engineering Research Facility (Argonne National Laboratory)
MLD	Molecular Layer Deposition
Mn	Manganese
Mo	Molybdenum
MXene	Exfoliated MAX phases (2D structures)
NASA	National Aeronautics and Space Administration
NCA	Battery cathode material (nickel cobalt aluminum oxide)
NCM	Nickel Cobalt Manganese Oxide
NCSU	North Carolina State University
NDE	Non-Destructuve Evaluation
NETL	National Energy Technology Laboratory
Ni	Nickel
NMC	Nickel Manganese Cobalt Oxide
NMP	N-Methylpyrrolidone
NMR	Nuclear Magnetic Resonance
NREL	National Renewable Energy Laboratory
O	Oxygen
OCV	Open Current Voltage
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
P	Phosphorous
PAN	Polyacrylonitrile
PDF	Pair Distribution Function
PEV	Plug-in Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
PHEV10	Plug-In Hybrid Electric Vehicle with a 10-mile range on a single charge
PHEV40	Plug-In Hybrid Electric Vehicle with a 40-mile range on a single charge
PI	Principal Investigator
PNNL	Pacific Northwest National Laboratory
PRC	People’s Republic of China
PSU	Penn State University
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
ROI	Return on Investment
RT	Room Temperature
Ru	Ruthenium
S	Sulfur

Acronym	Definition
SBR	Styrene Butadiene Rubber (Copolymer)
SEI	Solid Electrolyte Interphase
SEM	Scanning Electron Microscope
Si	Silicon
SIC	Single Ion Conducting
SIMS	Secondary Ion Mass Spectrometry
SMOG	Si/MgO/Graphite
Sn	Tin
SNL	Sandia National Laboratories
SOA	State of the Art
SOC	State of Charge
SPEEK	Sulfonated Poly Ether Ether Ketone
SUNY	State University of New York
TEM	Transmission Electron Microscope
TFSI	Bis(trifluoromethane)sulfonimide [(CF3SO2)2N]
TGA	ThermoGravimetric Analyzer
Ti	Titanium
TM	Transition Metal
TMA	Tri Methyl Aluminum
USABC	US Advanced Battery Consortium
USCAR	U.S. Council for Automotive Research
UV	Ultra Violet
V	Volts
V	Vanadium
VC	Vinylene Carbonate
VF	Voltage Fade
VTO	Vehicle Technologies Office
XANES	X-ray Absorption Near Edge Spectroscopy
XAS	X-ray Absorption Spectroscopy
XPS	X-ray Photoelectron Spectroscopy
XRD	X-ray Diffraction (Crystallography)
XRF	X-ray Fluorescence

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