3. Battery Development, Testing, Simulation, Analysis

Introduction

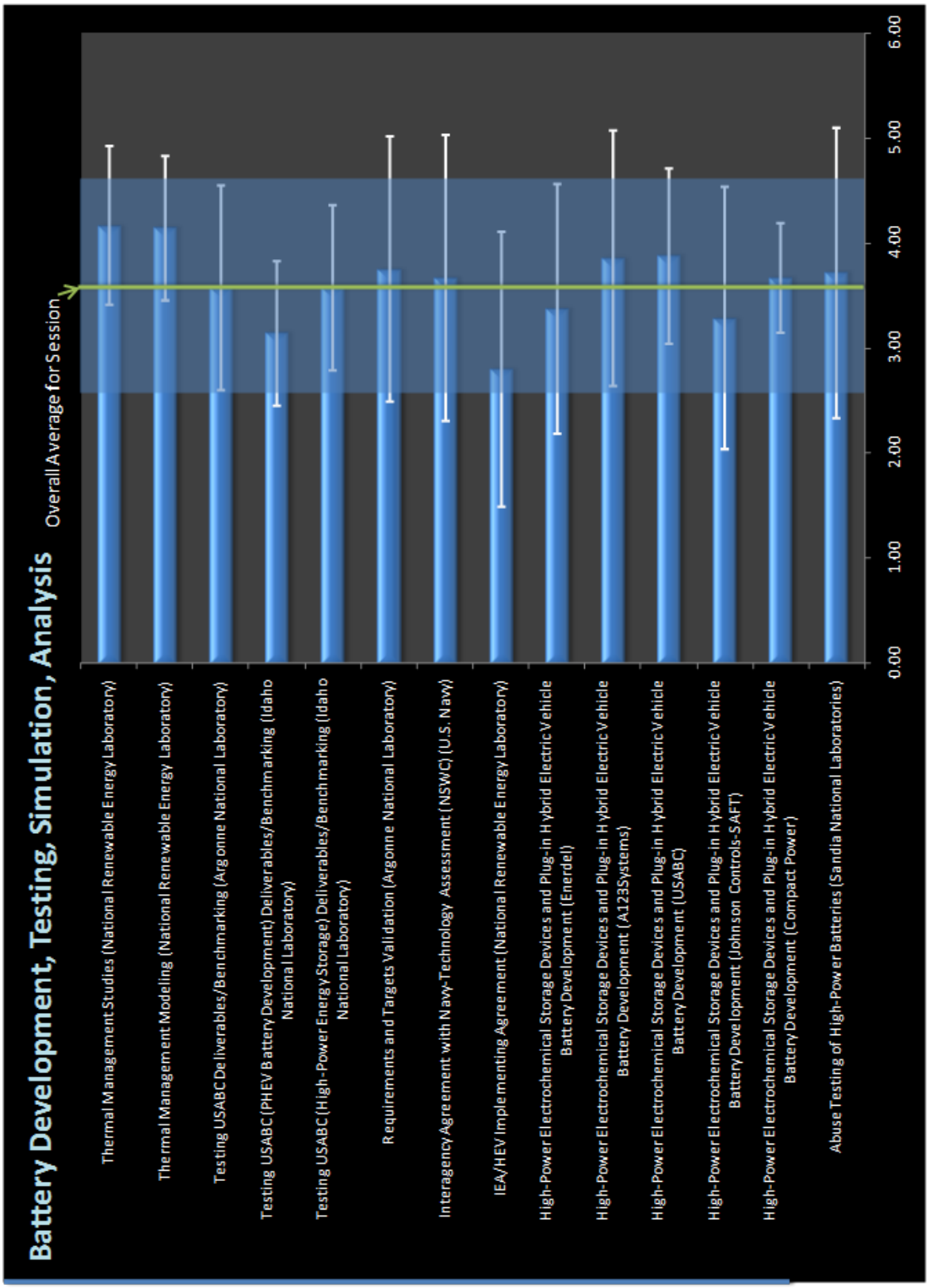
Battery systems research focuses on testing, evaluating, and developing energy storage technologies in close collaboration with developers and the automotive industry. This work is primarily accomplished through the United States Advanced Battery Consortium (USABC), a partnership among the U.S. Department of Energy (DOE) and DaimlerChrysler, Ford, and General Motors. Working with manufacturers and the DOE national laboratories, USABC pursues research and development (R&D) of advanced energy systems capable of providing future generations of electric vehicles with significantly increased range and performance. This work concentrates on three areas: full system development for electric and hybrid electric vehicle applications; assessment of laboratory-proven technologies and the technology developer's ability to develop and deliver a full-scale, fully packaged battery; and benchmark testing of emerging technologies.

This area maintains a balance between R&D projects that aim to directly aid the introduction of advanced energy storage technologies into the automotive marketplace. Work focuses on electrochemical energy storage systems, especially rechargeable batteries. Researchers maintain a balanced portfolio of R&D projects aimed at overcoming the barriers hindering the commercial viability of advanced energy storage systems in electric and hybrid electric vehicles.

In this merit review activity, each reviewer was asked to respond to a series of six questions, involving multiple-choice responses, expository responses where text comments were requested, and one numeric score response. 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 pictorial form in eight graphs as the last page of each project, and the expository text responses will be summarized in paragraph form for each question. A table and graph presenting the average and standard deviation for each project relative to the overall average and standard deviation for this session is presented below.

Page	Project Title and Principal Investigator	Project Average Score	Project Score Standard Deviation
3-4	Abuse Testing of High-Power Batteries (Pete Roth, Sandia National Laboratories)	3.71	1.38
3-8	High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Ahsan Hababb, USABC)	3.88	0.83
3-11	High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Andy Chu, A123Systems)	3.86	1.21
3-15	High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Mohamed Alamgir, Compact Power)	3.67	0.52
3-18	High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Naoki Ota, Enerdel)	3.38	1.19
3-21	High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Mike Andrew, Johnson Controls-SAFT)	3.29	1.25

Page	Project Title and Principal Investigator	Project Average Score	Project Score Standard Deviation
3-25	IEA/HEV Implementing Agreement (Ahmad Pesaran, National Renewable Energy Laboratory)	2.80	1.30
3-28	Interagency Agreement with Navy-Technology Assessment (NSWC) (Jim Barnes, U.S. Navy)	3.67	1.37
3-31	Requirements and Targets Validation (Dan Santini, Argonne National Laboratory)	3.75	1.26
3-34	Testing USABC (High-Power Energy Storage) Deliverables/Benchmarking (Tim Murphy, Idaho National Laboratory)	3.57	0.79
3-38	Testing USABC (PHEV Battery Development) Deliverables/Benchmarking (Tim Murphy, Idaho National Laboratory)	3.14	0.69
3-41	Testing USABC Deliverables/Benchmarking (Ira Bloom, Argonne National Laboratory)	3.57	0.98
3-45	Thermal Management Modeling (Ahmad Pesaran, National Renewable Energy Laboratory)	4.14	0.69
3-49	Thermal Management Studies (Ahmad Pesaran, National Renewable Energy Laboratory)	4.17	0.75
	Overall Session Average and Standard Deviation	**3.62**	**1.03**


Battery Development, Testing, Simulation, Analysis
Overall Average for Session
Thermal Management Studies (National Renewable Energy Laboratory)
Thermal Management Modeling (National Renewable Energy Laboratory)
Testing USABC Deliverables/Benchmarking (Argonne National Laboratory)
Testing USABC (PHEV Battery Development) Deliverables/Benchmarking (Idaho National Laboratory)
Testing USABC (High-Power Energy Storage) Deliverables/Benchmarking (Idaho National Laboratory)
Requirements and Targets Validation (Argonne National Laboratory)
Interagency Agreement with Navy-Technology Assessment (NSWC) (U.S. Navy)
IEA/HEV Implementing Agreement (National Renewable Energy Laboratory)
High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Enerdel)
High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (A123Systems)
High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (USABC)
High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Johnson Controls-SAFT)
High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Compact Power)
Abuse Testing of High-Power Batteries (Sandia National Laboratories)
0.00
1.00
2.00
3.00
4.00
5.00
6.00

Abuse Testing of High-Power Batteries (Pete Roth, of Sandia National Laboratories)

Reviewer Sample Size
This project had a total of 7 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One person noted that this activity provides critical support to the DOE objectives. Another person added that abuse testing is a key target of the DOE battery program, particularly for lithium batteries. Addressing safety was recognized as a critical element for DOE to cover. One person stressed that safety is the number one parameter that has to be met. They added that independent testing of safety is very critical to the success of the entire program. The reviewer finished, asking whether DOE has followers to Peter Roth that are being trained in the art. Another person agreed that safety is absolutely critical and Sandia's work is vital in doing independent tests on "real" batteries, not just ARC studies on small coin cells. The last reviewer commented that Roth and his coworkers at Sandia have established abuse tolerance tests that are capable of testing the safety of batteries for HEVs and PHEVs.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One person simply stated that the work is outstanding. Another person commented that the role and expected results from abuse testing are clearly described and motivated. One person highlighted that Roth has established several tests for single cells and is in the process of using these tests on high-power cells for use in HEVs and PHEVs. Another person commented that the project has repeatedly demonstrated flexibility and innovation in advancing capability and in achieving new technical understanding in lithium-ion abuse testing and phenomena, characterization, and interpretation. One reviewer pointed out that the safety investigations do not include other cell variables, such as void space, separator thickness and porosity, conductor levels, foil thickness, tab thicknesses and widths, etc. The reviewer felt that it would be useful to investigate some of the effects with the same system in cells made at Sandia to assess their safety impact. The last reviewer suggested that a use scenario study should be initiated because a lot more is known about HEVs now than what was the case a few years ago. They ask whether we have the appropriate methods for doing this or whether the tests be upgraded; this should at minimum be reevaluated.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
Comments to this question were generally positive. One person commented that SNL's efforts in this area are recognized within the related global industry and are a significant critical asset to the advancement HEV battery development in the U.S. and internationally. Another person noted that SNL has a state-of-the-art laboratory with very good, highly capable, staff. They felt that it was obvious that the investigators are learning continuously, based on comments from previous years. The reviewer acknowledged that the art has matured, which is nice to see. They added that the challenge is to take this to the next step and invent abuse testing that can differentiate between the most significant tests on a gradual scale. They concluded by asking how systems with more than on/off on a meaningful to manufacturers scale can be graded. Another reviewer highlighted that abuse tests are absolutely necessary to evaluate the stability of the batteries developed under various programs. They also mentioned that the group developed the abuse test manuals, has very good abuse testing facilities, and carries out the necessary tests. Another reviewer pointed out that the researchers are developing

methods of testing HEV battery modules for safety. The reviewer concluded by highlighting that these tests are extremely important and will provide important data for battery developers. Another reviewer commented that Sandia is often able to explain the results and provide essential feedback to both cell developers and program directors; they do not just describe the pass/failure results, but present the results in terms of what's happening inside the cell. They point out that they are also, excellent at quantifying what is inherently difficult to measure. Their work that identified separator integrity and breakdown voltage as major issues is novel and wildly recognized. This has in part led to an industry-wide search for more robust separator materials, some of which are already making it into commercial production in consumer applications. The reviewer acknowledged that most of this is from other talks given by the PI - this format does not enable presenters to give details. Other reviewers, however, were more critical. One person suggested that a broader investigation of variables would make the investigations even more useful. The final reviewer commented that the progress shown seems limited because it is not clear why only two USABC technologies have completed abuse testing.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

Comments to this question were positive. One person mentioned that results from observations conducted at SNL have influence on the direction of HEV battery development. Another person noted that this project is a fundamental activity to assist battery development and carmaker selection of safe technologies. Another person mentioned that technology has to be safe to be launched, so this will show if it is or not. The outcome is very binary, either you pass the test or not. The testing on systems with a removed "safety component" may fool people, so the researchers need more disclosure on this as the removal might not always be a "real life" scenario, it was not clear to this reviewer if this is the case or not. Another person commented that this work is critical for marketplace entry and Sandia is recognized as an important gatekeeper with methodology being widely respected and copied. The reviewer noted that the researchers seem to have for the first time developed specific safety guidelines for acceptable safety of these cells. The reviewer concluded by stating that really this should come from the auto makers, but in the absence of such leadership it is great to see Sandia pushing this forward. The last reviewer commented that the safety tests being developed at Sandia for high-power cells and battery packs will provide valuable data to battery developers. They mentioned that this data will reduce the development time for HEV and PHEV battery packs. The reviewer concluded by stating that Roth and his co-workers should work with others to analyze their data in light of a models of the tests that they carry out.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One person suggested that expansion of resources and activity in this area would be of critical utility to the advancement of the HEV battery industry. Another person mentioned that no comment was made on too little equipment to accomplish testing. The reviewer suggested training the "next generation" and that it is also good to have training programs to spread this knowledge throughout DOE, which is critical for future programs in any area of activity. They concluded by stating that the researchers have significant knowledge that many people within DOE can draw upon (and outside DOE). The last reviewer commented that the researchers have built up some very impressive test methods and equipment, however, this work is incredibly labor intensive and it is difficult to run large sample sizes. The reviewer also noted that variability among supposedly equivalent cells is very common in the battery industry. The reviewer suggested that the team needs a much higher degree of replication to be sure of the validity of the results. They concluded by stating that the researchers probably cannot outsource this work due to the hazards involved (and maybe the needs for absolute

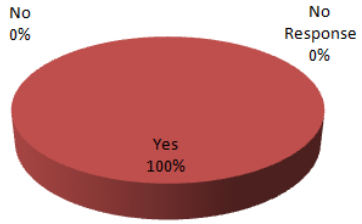
confidentiality since bad safety performance is a very touchy issue). One person simply stated that hard evaluation of not described resources and unclear planning. The last person thought that the funding is excessive for the level of testing and analysis carried out.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

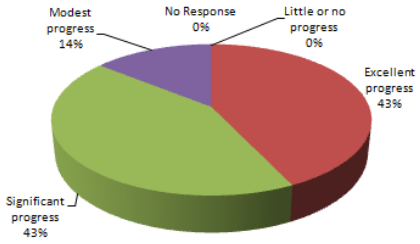
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Abuse Testing of High-Power Batteries

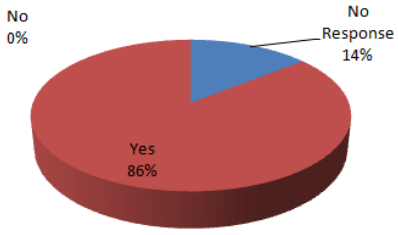
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



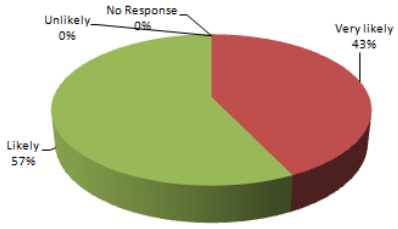
Question 3: Characterize the technical accomplishments and progress toward goals.



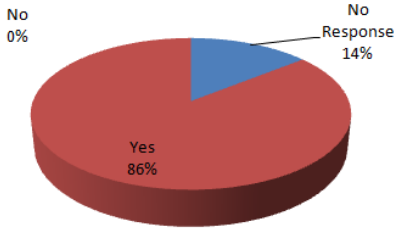
Question 2a: Are the goals of the project technically achievable?



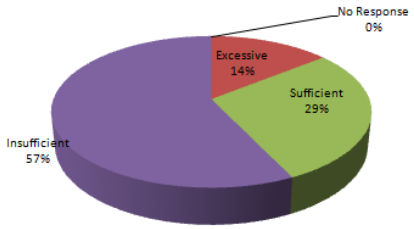
Question 4: How likely is the project team to move technologies into the marketplace?



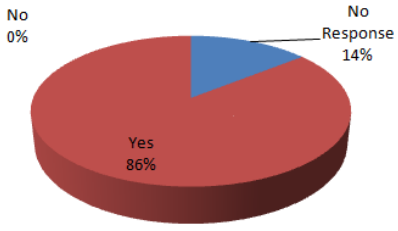
Question 2b: Have the technical barriers been identified and addressed?



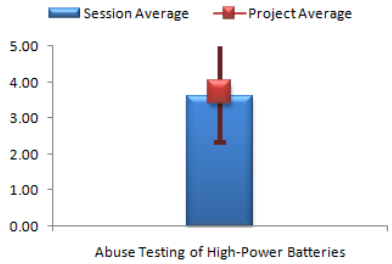
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Ahsan Habab, of USABC)

Reviewer Sample Size
This project had a total of 8 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Reviews to this question were generally positive. One person noted that USABC members work together to develop advanced batteries for HEVs and PHEVs. Another reviewer acknowledged that the USABC clearly addresses key enabling transport technologies to significantly support DOE objectives in the sector. Another person noted the importance of HEV and PHEV in the process to move to an oil-free era, but that energy storage is currently the key barrier. They pointed out that li-ion batteries and ultracapacitors are among the choices to develop by USABC with focuses on li-ion battery because of the current energy density advantages. The concluded by noting that the USABC has set goals for the research in batteries. One reviewer commented that USABC is actively involved in developing the energy storage systems (batteries and ultracapacitors) in close collaboration with developers. They added that the work covers the most known areas or aspects of li-ion battery technology and ultracapacitor technology. It was then noted that most of the characteristics of energy storage systems have been significantly improved and the technologies are ready for application in hybrid-electric vehicles. They concluded by stating that this effort certainly support the overall DOE objectives of petroleum displacement. The final reviewer suggested that the researchers focus on spider chart, noting that it was only on screen for a short time so they were not able to review it completely. They felt that the chart was OK, but noted that cost, low temperature and calendar life were shown, and they believe that safety is a huge "gap".

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One person simply stated that this project is a coordination project. Another felt that the program has identified key technical and economical barriers and defined acceptable steps to overcome them, but the activities on ultracapacitors need better specifications and efforts. One reviewer suggested that the researchers should consider involving more companies and universities, to diversify the research portfolio including investigating ultracapacitors and other chemistries in addition to li-ion batteries. Two reviewers had comments safety related comments. One reviewer commented that safety was not clearly addressed and that it was difficult for a reviewer to technically evaluate this aspect of the work. They added that only Johnson Controls' effort appears to have significant program management necessary for large-scale production in place. The last reviewer stressed that safety is critical and needs to have much more emphasis in the program. The concluded by stating that they did not believe that the DOE or USABC even has metrics for what the goals are at the cell and pack level.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One of the reviewers pointed out that no technical data was available, but then said that the technical data shows the "easy to get" targets. Another person simply stated that they were not able to comment much from an overview talk like that which was given. One reviewer noted that this project consists of coordination and goal setting, on which they felt the researchers have done a fairly good job. Another person commented that the progress has been very good with well organized actions to overcome technical barriers. Another person had similar comments, acknowledging that significant

progress has been made in the li-ion battery, including energy density and other aspects, however they felt that more aggressive targets may be possible.

The last reviewer had detailed comments stating that except for in the areas of cost, some abuse tolerance, cold temperature performance, and calendar life, most of the performance characteristics of energy storage systems have met the requirements established by the USABC. They pointed out that several automobile manufacturers have started using the batteries developed under the USABC contracts in their hybrid vehicles on the road today. They concluded by noting that all the USABC programs are concentrating their activities in those areas that still need improvements.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

One reviewer commented that the technology transfer may be limited by proprietary considerations. Another acknowledged that the support mostly goes to companies who has reasonable infrastructure which will ensure the long-term manufacturing of such batteries. One person highlighted the fact that the lithium-ion battery supplied by Johnson Controls, a company working with USABC, will be used by Mercedes in their S-Class hybrid-electric vehicles in October 2008. The last reviewer commented that the researchers are working with the right partners in most cases, although they questioned the choice of Celgard, since most of the advanced safer separators seem to be coming from other suppliers including LG.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

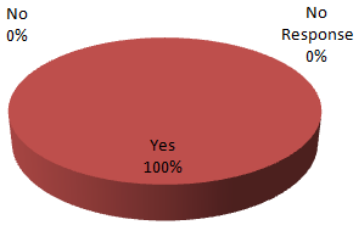
One reviewer commented that they were not able to answer the question without studying this in much more detail. Another person felt that the resources are important and adequate for the work already planned. One reviewer commented that the current funding is sufficient for the research, particularly with 1:1 match by the undertaking companies. They added that they would like to see the funding increase in the coming years in particular when universities and other non-profit organizations are involved in fundamental research. Another person agreed with the point that additional funding would be beneficial, stating that more funding would lead to domestic battery suppliers. The last reviewer commented that it was difficult to assess whether safety has been sufficiently addressed in these systems. They felt that it was not clear why the developing companies would have good PHEV systems.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

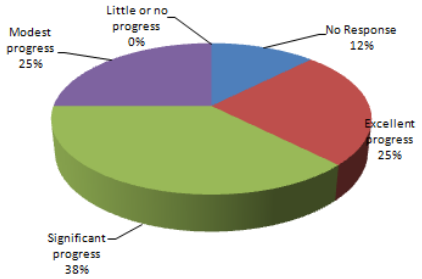
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development

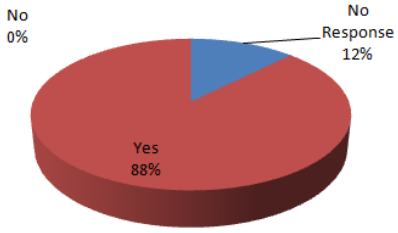
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



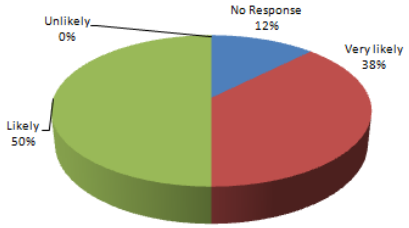
Question 3: Characterize the technical accomplishments and progress toward goals.



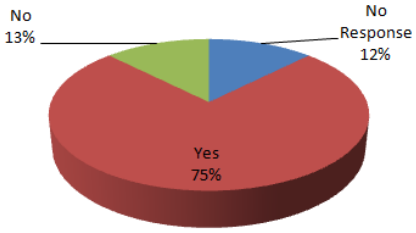
Question 2a: Are the goals of the project technically achievable?



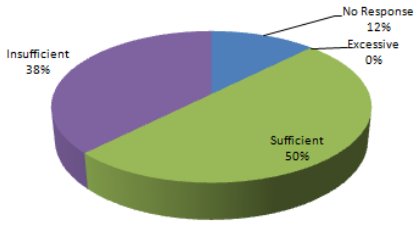
Question 4: How likely is the project team to move technologies into the marketplace?



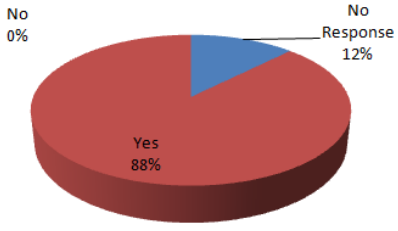
Question 2b: Have the technical barriers been identified and addressed?



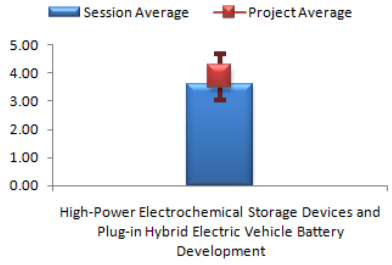
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Andy Chu, of A123Systems)

Reviewer Sample Size

This project had a total of 7 reviewers.

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

One reviewer acknowledged that the project looks at specific objectives of the DOE program, addressing key targets of the battery sub-program and that li-ion battery is the key technology presently targeted. Another person noted the importance of HEV and PHEV in the process to move to an oil-free era, but that energy storage is currently the key barrier. They pointed out that li-ion battery and ultracaps are among the choices to develop by USABC with focuses on li-ion battery because of the current energy density advantages. Another person agreed, adding that li-ion technology critical to HEV and PHEV structure. One reviewer pointed out that the focus of the work is high rate, low-temperature and safety, which are all keys for a practical HEV battery; however, they felt that the energy penalty with $LiFePO_4$ may be more of a stretch for application in PHEVs. The last reviewer acknowledged that A123 is making $LiFePO_4$ cells that are currently being used by DeWalt for their portable tools, which is an indication of their success in developing high-power cells needed for HEVs and PHEVs.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.

The strategy is reasonable even if only limitedly described. The technical barriers are well analyzed, but concerns remain about the cost target. One person pointed out that A123 is currently manufacturing batteries for power tools and that the company is making good progress in the USABC program. The reviewer felt that there is a good probability for A123 technology to be deployed for automotive applications. One person noted that A123 is addressing the goals of reducing the cost and improving the power of their cells; however, another person felt that the 20kW target for HEV applications is too low. Another reviewer also had a comment related to the power of the cells, stating that the approach was fine overall, but that a high-power cell may be less helpful in reducing pack size and cost for PHEV applications where energy needs are higher. They pointed out that the cells are a very good fit for PHEV, but they still would like to see more emphasis on safety of full packs. The last reviewer had detailed comments, pointing out that the program manager talks about electrode and materials development, but with a frozen design, which is not consistent. They felt that this inconsistency shows that the battery design is likely far from frozen which raises doubt regarding the cost-effectiveness of its implementation. They suggested that yields may be low in the factory or that materials supply has been difficult. They highlighted the fact that no data was presented for used cells and that the data that was shown was for non-critical scenarios. They felt that it was hard to comment on other factors, such as power performance, as this was not presented, adding that the presentation would have benefitted from some more insights on what is being developed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.

Comments to this question were mixed, but were generally negative. One reviewer commented that A123 has produced an outstanding battery in a very short period of time while continuing to produce better cells and have reduced the cost of their battery packs by approximately 40%. Another person stated that the presentation declares, and partially shows, the real progress on specific power and cost. They point out, however, that the abuse testing was carried out on a cell design different from the

HEV type. They suggest that some more quantitative results on life testing should not be of a confidential nature. One reviewer acknowledged that even though the batteries have been used in power tools, they are still in the pilot phase of HEV testing and that the cost (on a $/kW basis) is still high. They point out that the 20kW power target is not sufficient to drive a PHEV in electric-only mode and that a full hybrid will require about 30kW to 50kW; so a PHEV may require up to 100kW. They add that research has verified the life and abuse tolerance to be good. They concluded by stating that the testing results by National Labs is consistent, but more work is needed on increasing battery capacity and power rating. One person simply stated that the presenter did not provide any significant data, which leads to a negative impression of the work. The final reviewer had detailed comments, noting that the product is almost there already from the viewpoint of low-temp performance and cost, and that the safety is better in small cells. However, they were not sure that safety is good enough in large packs, pointing out that some of Sandia's testing looks pretty ugly on actual abuse tests. They caution that ARC and others are fine tools to study materials and even some designs, but that the final product safety is not the sum of the safety attributes of the components; the system design and thermal mass issues are key. The reviewer agrees that the lack of hot spots in the thermal imaging is nice, but that thermal management in large packs is going to be critical. They highlight the need to investigate what happens with a defective cell since they will be present in real-world large scale applications. The reviewer concluded by noting that the modeling work shown by a later presenter showed that the thermal imaging cannot in fact detect hot spots inside the cell, which undermines the whole thermal imaging work in my view.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

Comments to this question were all positive. One person acknowledged that A123 has truly outstanding employees who are working together to improve their cells and cell packs. Another person pointed out that the company has already shown capacity in developing and commercially producing li-ion cells for power tools in a very short time and demonstrated significant interest in HEV applications. Another reviewer highlighted the fact that the company has gone from a lab to a real product in such a short time as to be absolutely amazing. The reviewer was very impressed with A123's abilities and the ability to leverage funding to get to a real product so quickly. They pointed out that the company is using product sales in other existing markets help drive this work (e.g. power tool and electric bicycles) forward to implementation, which enables a step-wise lower risk implementation path. Another reviewer also noted that the company has already produced lithium batteries for other applications. They felt that the cost reduction projections of 40%, if reached, will be significant progress. One person simply added that the work on $LiFePO_4$ is important as this is a material with great promise. The final reviewer commented that the technology involved with this project may have a reasonable chance of movement into or toward the marketplace, based on the relative benefits and risks as a cell chemistry alternative to more mainstream cell chemistries.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Comments to this question ranged from some reviewers believing that the funding level is too high to others that felt that the company is adequately funded. One person commented that in comparison with development projects of comparable scope, this project should be able to demonstrate potential viability with a significantly lower resource level. Another person, however, commented that the resources are used efficiently and are adequate. One reviewer felt that the company is doing well with the funding they have. The reviewer felt that A123 had shown good commitment and suggested that their cells and chemistry be given priority in safety testing at Sandia. This reviewer would like to see what happens with a defective cell, since with the large number of cells per car that even one bad cell

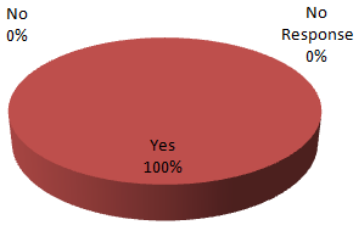
in 100,000 (0.001% failure rate) could lead to field problems. Another person; however, felt that the company should be given additional funding to assist them in their optimization program and to continue to improve the safety of their cells. The last reviewer stated that it is hard to evaluate this given the lack of results shown in the presentation, but they acknowledged that no insufficiency was mentioned.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

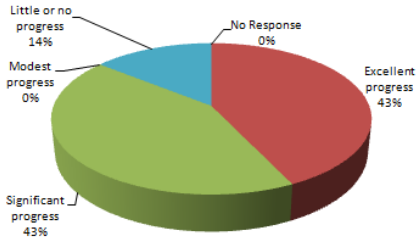
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development

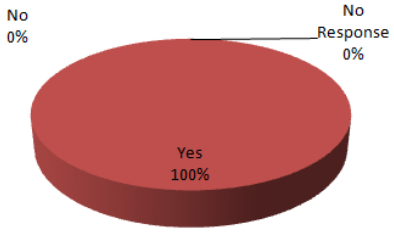
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



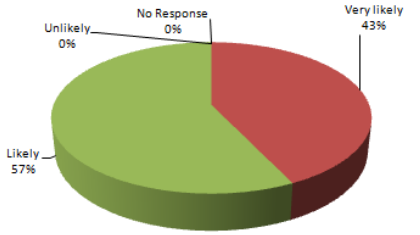
Question 3: Characterize the technical accomplishments and progress toward goals.



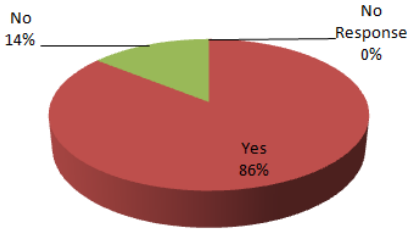
Question 2a: Are the goals of the project technically achievable?



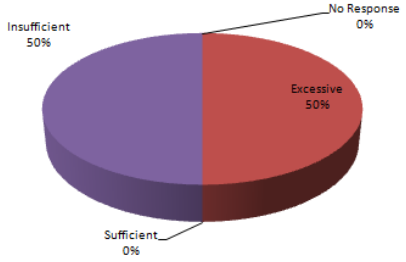
Question 4: How likely is the project team to move technologies into the marketplace?



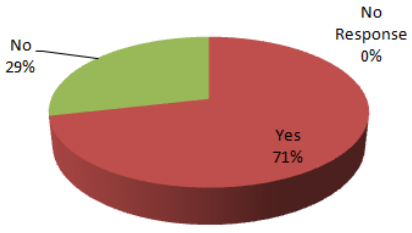
Question 2b: Have the technical barriers been identified and addressed?



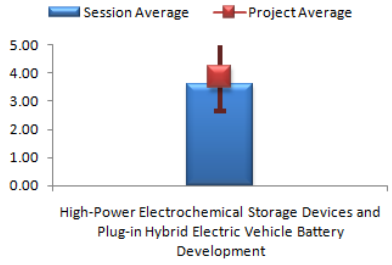
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Mohamed Alamgir, of Compact Power)

Reviewer Sample Size

This project had a total of 6 reviewers.

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

Comments to this question were generally positive. One reviewer noted that the project focuses on spinel cathode for very high-power lithium batteries, which is well in line with the DOE core battery technology for HEV and PHEV with a significant industrial financial commitment (65%). Another person noted the importance of HEV and PHEV in the process to move to an oil-free era, but that energy storage is currently the key barrier. They pointed out that li-ion battery and ultracaps are among the choices to develop by USABC with focuses on li-ion battery because of the current energy density advantages. One reviewer commented that Compact Power is working on a cell that may be able to deliver the required power for HEVs and PHEVs as well as developing a safe, low-cost cathode that will deliver high-power. The reviewer pointed out that Dr. Patil (Compact Power CEO) has significant experience in the auto industry and LG Chem is a world class company. The final reviewer noted the goals included making a low-cost cathode material practical, as long as it can meet the other criteria. The reviewer questioned whether the researchers will ever be able to meet the cost target, and if not, they asked why this work was even being performed. The reviewer concluded by commenting that the researchers should be able to do an end-of-the-line cost estimate with what they know now.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.

Comments to this question were varied. One person felt that the approach is reasonable and well structured with clear identification of key barriers. Another person acknowledged the fact that Compact Power/LG has been able to extend the calendar life of their cells as well as meeting the cold-cranking requirement. Another person, however, was more critical, stating that the presentation does not contain any details of the work the company is doing; and even did not say what type of battery they are developing. Therefore it is not possible for the reviewer to understand whether the company's goals are achievable; what barriers they have, etc. The last reviewer commented that the presenter stated that cost is unknown and at this stage, which should not be the case. They also pointed out that the safety in large packs was not addressed by the presentation. They concluded by saying that the separator approach is very nice, and that maybe it should be paired with A123 systems.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.

One person commented that again the spinel-based chemistry that they are using as the cathode in their cells is enabling them to improve the performance of their cells and packs. Another person acknowledged that the company was able to meet the cold cranking requirement, and that the $500 per pack cost target has not yet been met, but work in addressing this is underway. They felt that the presentation gave a poor description of the cell chemistry. The PHEV results shown seemed to be well in line with the project targets, but some info about HEV battery cycle life and performances would have been appreciated. Another person reiterated the project goals of achieving a $500 per pack cost target; 5 kW cold cranking ability (-30°C). The reviewer commented that the presentation did not mention what type of battery and technologies are being used and what barriers will need to be overcome, so more details should have been provided. The last reviewer noted that the presenter claimed to have overcome Mn dissolution issues, but added that they believe that lots of people have

done this, which made them unsure whether the researchers have done anything special in this regard. They point out that no data was shown to support the lifetime claims; this reviewer was not able to accept the claim of a 15-year lifetime on a new cell design. They added that there was no time for the presenter to show the basis of his claims. They concluded by simply stating that the separator work is interesting.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

One reviewer highlighted CPI's previous history as LG Chem in successfully developing and producing Li batteries. Another person commented that Compact Power/LG has demonstrated that they are using the latest technology to address such issues as following the state-of-charge of their cells using a state space Kalman filter approach. The reviewer felt that this advanced approach will enable them to be successful. Another person stated that LG has the muscle and dedicated internal buyers for these products to supply small cells as well as having a big interest in electric bicycles and HEVs. The reviewer felt the company had a good path to commercialization. They felt that the company's access to the less litigious Asian market may encourage more risk taking. The reviewer acknowledged the company's good long-term commitment in terms of internal funding. The reviewer expects this technology to go head to head with $LiFePO_4$ in the marketplace, much as is currently the case with portable power tools. The last reviewer simply pointed out that the company has delivered four PHEV packs for GM Volt, which provides a good indication of the company's progress.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

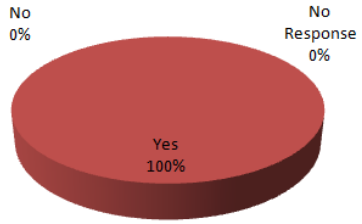
One person stated that the resources seem adequate. Another reviewer noted that the company has received additional funding recently and should have sufficient funding at this time to continue to demonstrate success. The last person commented that it seems to be a lot of people for what seems to be a cost savings/pack design process going forward (assumes the company has really solved the lifetime issue).

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

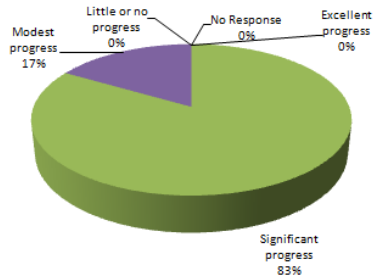
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development

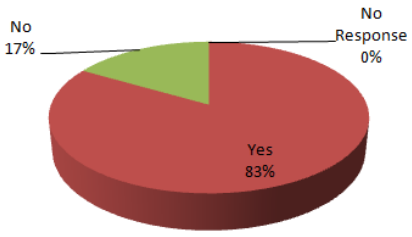
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



Question 3: Characterize the technical accomplishments and progress toward goals.

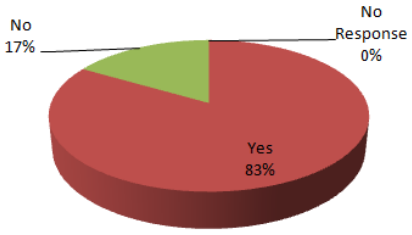


Question 2a: Are the goals of the project technically achievable?

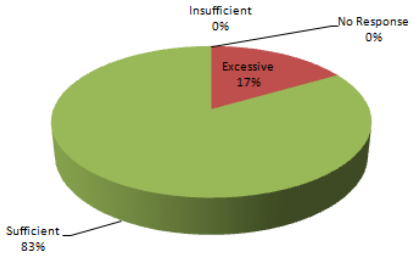


Question 4: How likely is the project team to move technologies into the marketplace?

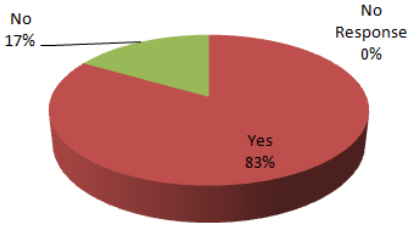
Question 2b: Have the technical barriers been identified and addressed?



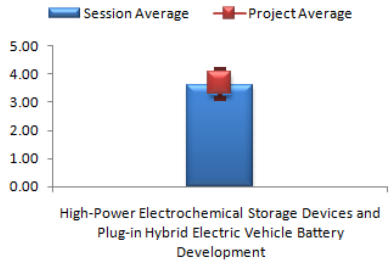
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Naoki Ota, of Enerdel)

Reviewer Sample Size
This project had a total of 8 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One reviewer commented that li-ion technology will be superior for HEV and PHEV applications, as soon as cost targets can be met. Another person stated that the project aims at lithium batteries for various transport applications, which is a key technology for the DOE objectives. Another person agreed, simply stating that the goals of this project activity would theoretically support the overall DOE objectives. Another person noted the importance of HEV and PHEV in the process to move to oil-free era, but that energy storage is currently the key barrier. They pointed out that li-ion batteries and ultracapacitors are among the choices to develop by USABC with focuses on li-ion battery because of the current energy density advantages. One reviewer felt that EnerDel/Japan has the experience and capability to develop battery packs for HEVs and PHEVs and that the safety of their cells is expected to help them be successful in the market place. The last reviewer commented that the work seems promising for HEV especially where long life is required (e.g. trucks, fleet and stationary applications). They commented that the higher anode potential leads to lower energy, which led them to believe that the system will not meet the PHEV energy goals. The acknowledge that the anode safety is good, which could be a fall-back position if the other systems cannot meet safety goals, so consequently, they thought that the work is important and should continue.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer commented that EnerDel has established the capability of producing their cells in large numbers using cell production technology from their Japan partners. Another person noted that the company has identified barriers and procedures to overcome them and that they have detailed information on the technology progress. The reviewer pointed out that the company has delivered packs for HEV applications, but that they need to further develop their PHEV pack (e.g., more power and more capacity). Another person felt that the presentation did not clearly address the project technical barriers, even if the description of the work and the experimental activities are well presented. One reviewer highlighted that the project has had difficulty in verifying sufficient progress in the basic performance and reproducibility of the raw materials and processing methods at the lab-scale or small-cell-scale. Another pointed out that nothing was mentioned about the production readiness of the raw materials; if these change due to cost constraints, then new development must take place, which will be time consuming. The last reviewer commented that the results seem promising for HEV, but they do not believe the system will have the energy to meet many PHEV goals. They added that the anode safety is good and small cell safety is claimed to be good, but that the testing needs to be expanded to include some large cell testing.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
Reactions to this question were mixed. One reviewer noted that EnerDel has licensed the titante anode technology that will provide high-power cells that are safe, from Argonne National Laboratory. Another person commented that the range for ASI and power capability is impressive. One person commented that the HEV project has reached significant progress with well justified results based on

cell research. They noted that the extension to full HEV battery systems is under investigation with characterization, including safety testing, and in-vehicle testing being done at ANL. Another reviewer pointed out that the company has made progress and have detailed strategies on the technology. They add that the company has delivered packs for HEV applications, but that additional work needs to be done on the PHEV pack, to increase the power and capacity. Other reviewers had more critical comments. One person highlighted that the life capability of EnerDel cells involved with this project has repeatedly been demonstrated as unexpectedly poor. They felt that there should be no inherent reason for this poor life capability due to the fundamental materials technology, and so there have apparently been repeated significant shortcomings in either cell manufacturing or raw materials. The last reviewer was critical stating that they did not like the nail penetration video, pointing out the smoking seen and some high temperatures from what is a small cell. They felt that there needs to be much more work to demonstrate their safety advantage, which they thought was mostly related to overcharging, and not to physical abuse.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

Reactions to this question were mixed. One person pointed out that the company has ambitious industrial mission and targets with significant financial commitment. Another reviewer noted that the company has good facilities and personnel, and that it seems, according to information provided by all the presenters, that the company may be the first ones to go into mass production. One person commented that EnerDel has selected their cell chemistry to develop into cells and packs that is safe and has high-power that will replace the NiMH cells in the near-term. Another person cautioned that mass production must be demonstrated and a pathway for cost shown, especially for a new material. Another person noted that the project performance does not currently provide strong confidence for ability to competitively progress toward the marketplace. The last reviewer cautioned that if other anodes can be made to work safely, then this anode is not needed since other cells would be smaller and cheaper. They added that being smaller gives additional benefits such as lower costs, smaller cooling system etc. The reviewer would still like to see this work continue as a back-up option. They concluded by suggest that DOE monitors how the company does in the power tool market versus A123 and carbon-spinel batteries.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

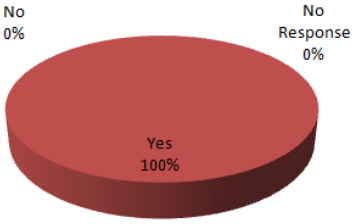
In general reactions to this question were positive. Two reviewers stated that the funding is sufficient for the current program. Another person agreed saying that considering the scope of the project in relation to the scope of other current similar projects, the project resources are sufficient. Another person felt that the question was hard to evaluate based on the presentation, but resource constraints were not mentioned. One person had a differing opinion, stating that the company deserves the same magnitude of support as A123 and others since their work is about the same; and their progress on the technology as well as technology and manufacturing progress are comparable. The last reviewer commented that the project needs more help in the area of safety testing and linkage to "real" car makers in the USABC. It was not apparent to the reviewer whether the company has the expertise and staff to move to pack design, so suggest that they either need a pack builder partner or to add staff to handle pack and systems integration.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

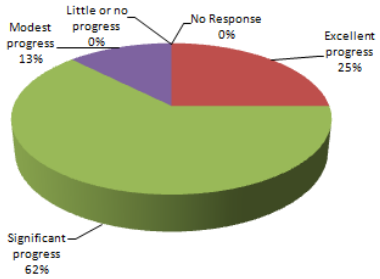
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development

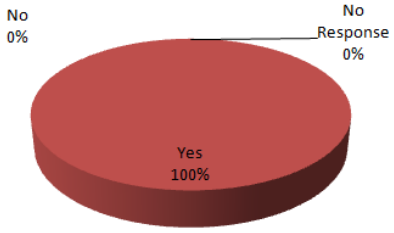
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



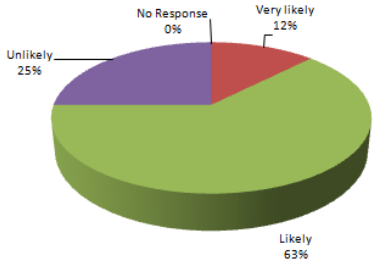
Question 3: Characterize the technical accomplishments and progress toward goals.



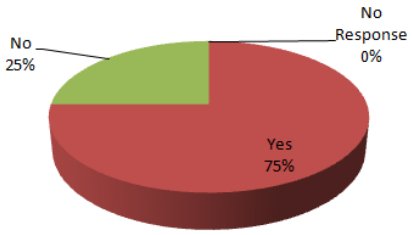
Question 2a: Are the goals of the project technically achievable?



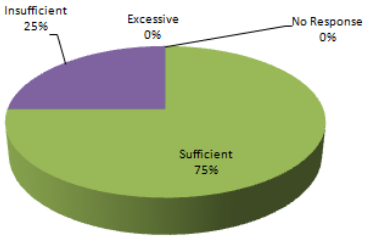
Question 4: How likely is the project team to move technologies into the marketplace?



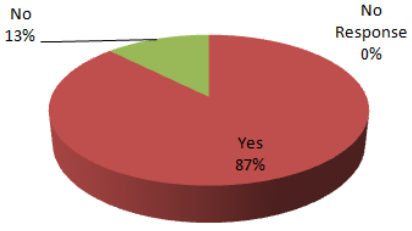
Question 2b: Have the technical barriers been identified and addressed?



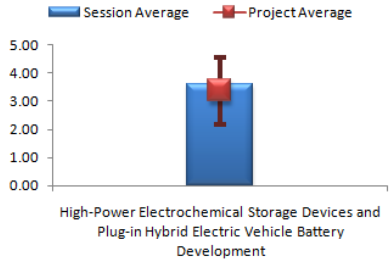
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development (Mike Andrew, of Johnson Controls-SAFT)

Reviewer Sample Size

This project had a total of 7 reviewers.

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

One reviewer mentioned that the targets of the projects are clearly in line with DOE objectives in term of li-ion battery advancement in USABC technical and cost performances, adding that the presentation addressed HEV applications. Another person commented that the project has demonstrated useful life performance for an NCA cathode cell chemistry and has developed detailed cost model information. One person stated the presentation mentioned that the company has detailed information on the technology progress and that they have delivered packs for HEV applications. The reviewer suggests that the company needs to work on the PHEV pack application to improve the power and capacity. Another person commented that Johnson Controls-Saft is a joint venture of two outstanding companies that are well known for their success in batteries and are capable of producing high quality cells and packs to meet the needs of HEVs and PHEVs. The last reviewer mentioned that the cost goals for the program seem to be unrealistic for a Co-based cathode, particularly if this ever gets implemented and the demand drives the cobalt cost even higher.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.

One reviewer commented that the key technical challenges are analyzed and described; adding that they felt that the project is well-organized, complementing Johnson Controls and Saft expertise. The reviewer noted the concentration on low-temperature performance and mass production costs shows confidence in the selected chemistry (which was not described in the presentation). The reviewer concluded by stating that providing the reviewers with some more details on the chemistry would allow for better evaluation and reviewing. Another person commented that Johnson Controls/Saft has demonstrated that they can meet the low-temperature requirement. They further acknowledged that the companies are working on the important systems and electronics development for the efficient performance of their battery packs, and that the companies are currently on track to meet the cost requirement. One reviewer indicated that the presenter did not provide technical details; but felt that overall the approach is achievable. Another person simply stated that they do not believe NCA can meet safety requirements for HEV or PHEV. The final reviewer had detailed comments, stating that they think this project entails excellent technical work, but does not really target the PHEV/HEV business since, like the previous comment, they do not believe the NCA costs will ever meet the goals. The reviewer remarked that they may be useful for specialty applications that are less cost sensitive, which they felt may explain Saft's interest. The reviewer is not convinced that this program is in the interest of DOE. They felt that eventual U.S. production seems very unlikely, and that even if Johnson Controls produces the cells, they will likely go offshore for this unless they are mandated by the government to produce them in the U.S., which is presumably not an option for a commercial business. In the end, the reviewer did not buy into the "made in USA" scenario. They concluded by mentioning that the plant that Saft is building in France has a very small production capability and does not represent a big investment.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.

One reviewer indicated that they believe Johnson Controls /Saft has met many of their goals and have outstanding plans to meet the cost goal. Another person commented that technically, the program is fine, although they pointed out that all the presentations are so short that there is no "meat" to really critique, no science is presented, just conclusions. They concluded by commenting that based on other presentations, Saft seem to have done a very nice job at improving the low-temperature performance of their system. One person highlighted that the progress has been shown only in relation to the key issues of low-temperature behavior. They add that no results or considerations about safety aspects as a consequence of the changed electrolyte were presented. The last reviewer felt that progress is a little behind milestones. They suggested that the 40kW power target and price target of $1,200 for a 40kW pack is moderate and could be more aggressive.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

The joint venture between Johnson Control and Saft has the clear goal to reach the market faster with more competitive and performance lithium batteries. Another reviewer shared a good opinion of the companies, observing that Johnson Controls /Saft have track records of producing and selling batteries for many applications, so they will be successful with their packs for HEVs and PHEVs. Another reviewer noted that both NiMH and li-ion are under investigation for HEV and PHEV; and that the joint venture comes with experience of Johnson Controls and Saft to leverage the battery development. Another person remarked that although the lack of significant li-ion consumer cell mass-production manufacturing background is a drawback to this project, the project has demonstrated a reasonable chance of moving the technology toward or into the marketplace. The final reviewer had detailed comments, stating that they think this project entails excellent technical work, but does not really target the PHEV/HEV business since they do not believe the costs will ever meet the DOE goals. The reviewer remarked that they may be useful for specialty applications that are less cost sensitive, which they felt may explain Saft's interest. The reviewer is not convinced that this program is in the interest of DOE. They felt that eventual U.S. production seems very unlikely. They also mentioned that the plant that Saft is building in France has a very small production capability and does not represent a big investment. They commented that raw materials costs are likely to be an insurmountable barrier to implementation that is not amenable to more R&D efforts. They concluded by arguing that even though this technology is actually likely to make it into the marketplace, it will only be in niche markets, not the markets that DOE is cares about.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Two reviewers felt that Johnson Controls/Saft have received sufficient funding at this time. Two other reviewers, however, felt that the project was over-funded. One person commented that according to the invoices, the work completion and the results, the initial budget seems to be overestimated; however, the reviewer admits that the description given in the presentation hardly assists reviewers in properly analyze resource allocation and uses. Another person cautioned that the scope of the project is sufficient or (if anything) excessive relevant to some other similar projects. The final reviewer praised the fact that Saft has excellent people and Johnson Controls has good business linkages, however this reviewer's main issue is that they are working on the wrong materials. The reviewer remarked that the project is basically funding a French company's business plan. The reviewer stressed that they do not believe that this is a good use of taxpayer funding unless the work can be redirected to only work on lower cost cathodes. They added that raw materials costs are likely to be an insurmountable barrier to implementation that is not amenable to more R&D efforts. They

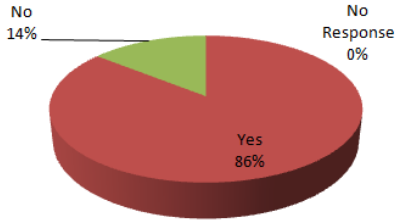
concluded by suggesting that another approach might be to fund this at the DOD who they believe are most likely going to be the beneficiaries of this work.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

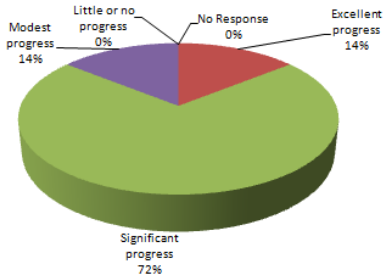
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: High-Power Electrochemical Storage Devices and Plug-in Hybrid Electric Vehicle Battery Development

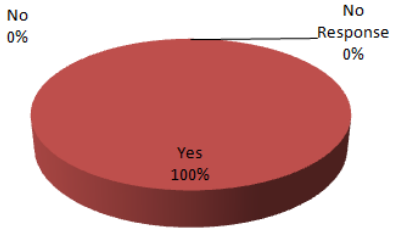
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



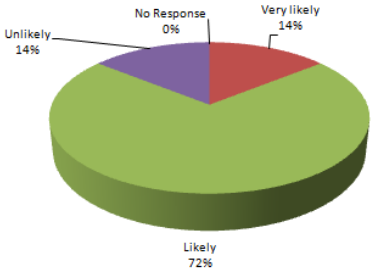
Question 3: Characterize the technical accomplishments and progress toward goals.



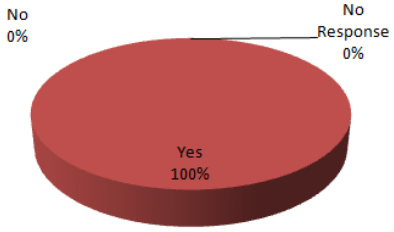
Question 2a: Are the goals of the project technically achievable?



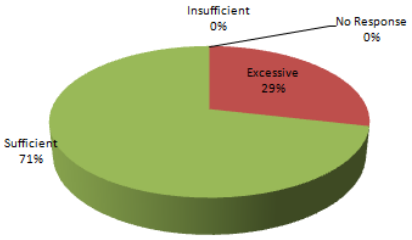
Question 4: How likely is the project team to move technologies into the marketplace?



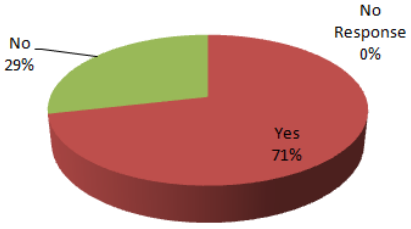
Question 2b: Have the technical barriers been identified and addressed?



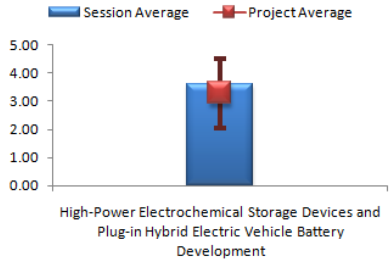
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



IEA/HEV Implementing Agreement (Ahmad Pesaran, of National Renewable Energy Laboratory)

Reviewer Sample Size
This project had a total of 5 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
All comments to this question were positive. One reviewer highlighted the fact that the U.S. alone does not do the majority of HEV/EV activity in the world, ergo, most is done elsewhere, and this program could be a valuable resource for tapping in to that base so we can learn from others and collaborate where it makes sense. Another person agreed that international collaboration is instrumental to achieve DOE targets in the battery sector. Another remarked that NREL supports the IEA/HEV implementation agreement in energy storage; international collaboration is a critical aspect for mankind. The last person commented that the IEA/HEV agreement will help all participants reduce oil consumption by sharing critical information about battery pack development for HEVs and PHEVs.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer simply commented that the presenter did not provide many details about the project. Another person felt that the project addressed a limited number of barriers. Another person acknowledged that the agreement will help achieve the goals of the DOE through cooperation across international borders. The last reviewer commented that the project seems to be greatly undervalued as a resource to learn something. The reviewer noted that they never heard of an example of anything they have gained from this exchange; this reviewer was very concerned that the program suffers from a U.S.-centric/ "not-invented-here" mentality. The reviewer highlighted that we really need to learn from others and not try and do everything ourselves. They concluded by stating that this project should be viewed as a major effort, not just a something to do to be nice to the rest of the world activity.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One person simply noted that the presenter did not provide many details of this project. Another person agreed, stating that a useful assessment of the project's accomplishments cannot be determined from the presentation. One person commented that a limited effort is required to pursue this international collaboration. Another person noted that the agreement is new and is expected to bear fruit in the future. The last reviewer remarked that they had never heard of one example of anything the researchers have gained from this exchange. They concluded by asking whether this is an exchange, or if they are just reporting what DOE is doing.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One person commented that the question does not apply since NREL is helping, not producing technology, under this project. Another person pointed out that the project seems to be undervalued and ignored. One person felt that the project allows for international exchange of information. The last person commented that the European members of the agreement are probably closer to placing HEVs and PHEVs in the marketplace.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

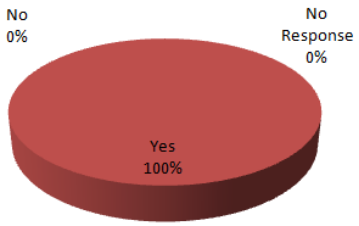
The reactions to this question were generally positive, but reviewers offered suggestions to improve the program. One person commented that a useful assessment of the sufficiency of resources cannot be determined from the presentation or otherwise. Another person simply stated that the role and involvement is adequate. Another person agreed, mentioning that the funding for this agreement is sufficient. One person asked whether the projects needs more resources, or just more commitment from leadership. The last person remarked that they would like to rate this very high in a summary rating, but this seems to be given such a low importance that it actually has low value as currently implemented.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

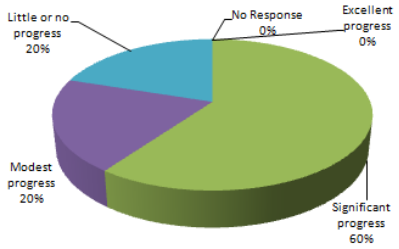
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: IEA/HEV Implementing Agreement

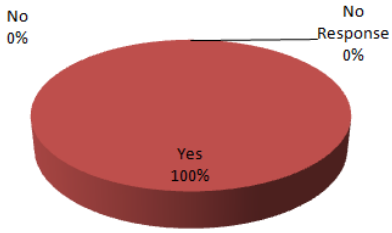
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



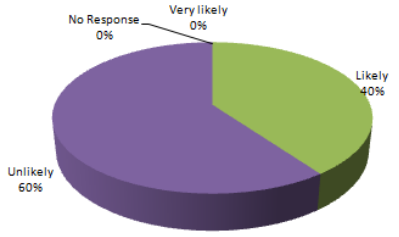
Question 3: Characterize the technical accomplishments and progress toward goals.



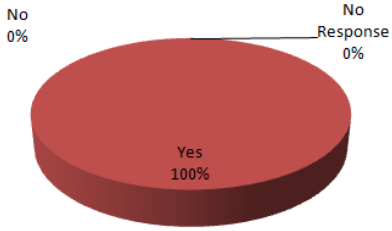
Question 2a: Are the goals of the project technically achievable?



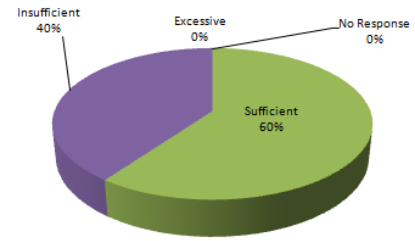
Question 4: How likely is the project team to move technologies into the marketplace?



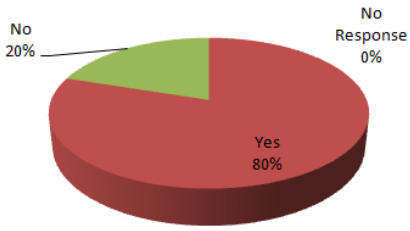
Question 2b: Have the technical barriers been identified and addressed?



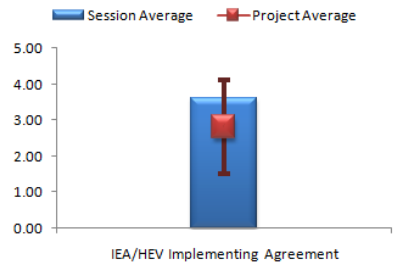
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Interagency Agreement with Navy-Technology Assessment (NSWC) (Jim Barnes, of U.S. Navy)

Reviewer Sample Size
This project had a total of 6 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One person mentioned that the project is part of the DOE activities to support program objectives and improve use of available resources. Another person mentioned that this agreement will help small companies contribute to the goal of reducing oil dependency. One person noted that the project involves soliciting ideas from outside the DOE, rather than being driven by DOE's vested interests. They felt that the project is blue sky work and insurance against missing opportunities. The last person commented that collaboration and coordination between different government agencies are critical to ensure the technology and developed in collective effort. The reviewer pointed out that battery, power electronics and other related technologies are applicable to DOE, DOT, Navy, and military applications. They concluded by indicating that the new focus on cutting edge technology is good.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer commented that the project has clear targets and process steps to overcome basic high risk barriers by soliciting different types of research approach (SBIR). Another person mentioned the project's focus is on cost, performance, abuse, tolerance, etc., which are appropriate for SBIR/STTR research. Another reviewer highlighted the fact that the SBIR and STTR programs have already been shown to be successful as illustrated by A123 and TJ Technologies, for example. The last reviewer commented that the program is high risk, but if focused correctly can be a very powerful risk mitigator and very good at leveraging outside resources in identifying new opportunities, at a relatively low cost.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer simply noted that the project involves a high risk to reward ratio. One person commented that the approach is challenging and offers possibilities to search for real scientific and technological breakthroughs. They pointed out that the Interagency Initiative optimizes the governmental efforts. Another reviewer mentioned the project has resulted in several successes in the past, especially in light of expected low likelihood of success of the portfolio. They caution that success in future may not be high, but the potential impact is large. The reviewer felt that a good selection process was used and that they are open to off-beat ideas but they do not waste money on bad science, of which there is a lot being pedaled. One person provided examples, stating that A123 Systems products, TJS technologies, and EEI move to production were the result of Phase 1 SBIR. Another person felt that this interagency cooperation has lead to outstanding success and the development of small companies into major potential suppliers of batteries for HEVs and PHEVs. The last person reiterated that A123 Systems received Phase 1 and Phase 2 SBIR grants, and as a result have developed to be a significant player/manufacturer of li-ion batteries, which is a good accomplishment.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

One reviewer mentioned that the program involves a high risk to reward ratio. Another person indicated that a small portion of SBIR/STTR were successful but is sufficient to break through. Another person observed that the Phase 2 of the project is likely to start up more industrial initiatives after an exploratory phase. Another commented that the SBIR/STTR program has already demonstrated success by A123 Systems in their development of cells for power tools. The reviewer felt that it is highly likely that their success will be duplicated by their developing battery packs for HEVs and PHEVs. The final person commented that getting small companies through to the implementation stage can be very difficult, but maybe the invention just gets picked up by larger companies if it is promising enough.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

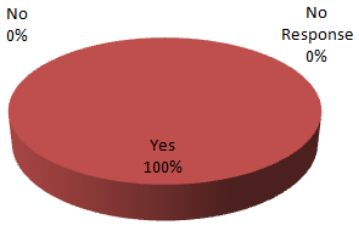
One person commented that the scientific and technological challenges of lithium technologies require an exploratory phase (bottom up approach) complementing the already existing sub-program of BATT. One person commented that the program has funded six Phase 1 and four Phase 2 projects for energy storage, which seems to be reasonable. They highlight that if one of them successful, it will make a huge difference. Another person felt that a reasonable number of projects have been funded and that the project is a good use of public funds. The reviewer stated, definitely do not reduce this work, even though the near-term focus is on implementation, we still need to cover our bases with these kinds of projects. The last reviewer commented that funding level for STTR in this program is too small and should be increased by a factor of 10 to be on par with the SBIR program.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

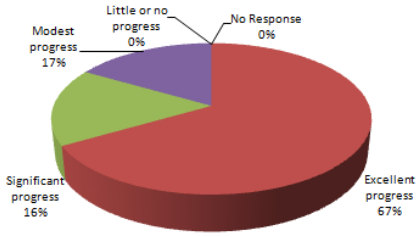
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Interagency Agreement with Navy-Technology Assessment (NSWC)

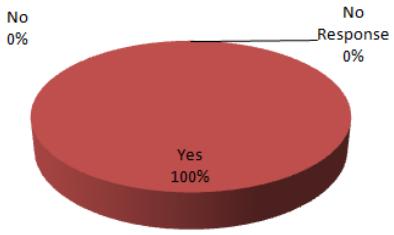
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



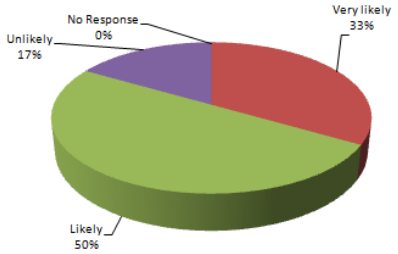
Question 3: Characterize the technical accomplishments and progress toward goals.



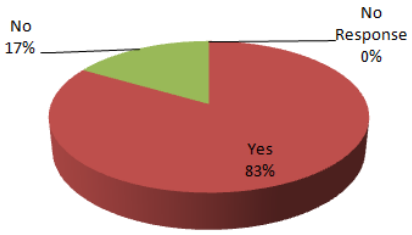
Question 2a: Are the goals of the project technically achievable?



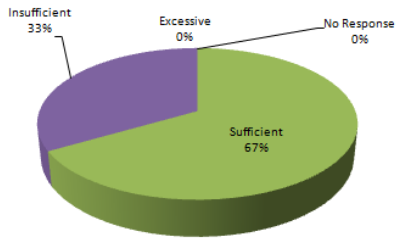
Question 4: How likely is the project team to move technologies into the marketplace?



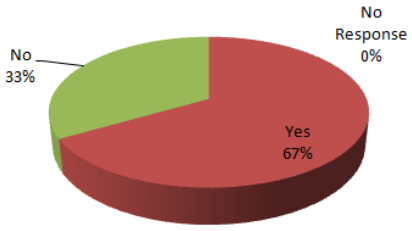
Question 2b: Have the technical barriers been identified and addressed?



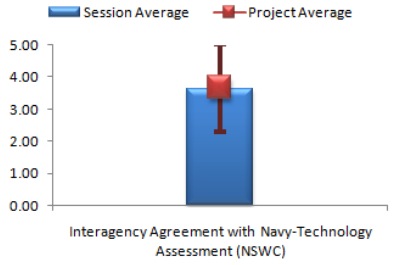
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Requirements and Targets Validation (Dan Santini, of Argonne National Laboratory)

Reviewer Sample Size
This project had a total of 4 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One person simply noted that the researcher seems to be looking at the big picture. Another person commented that the project supports the use of PHEVs with evaluations for various scenarios and the battery choice and design specifications. The reviewer added that the project also evaluates consumer advantages and proposes possible incentive schemes. The last person commented that the project will lead to reduction of oil consumption by validating the utility of PHEVs.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One person commented that the question is not really relevant to this presentation; it should be used as a basis for making decisions. Another person, however, felt that key barriers and conditions are well described and studied with specific analytical models. The last person commented that the project is a comprehensive study of PHEVs with EPRI will probably lead to a definite study that presents clearly to citizens and politicians the value of PHEVs.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer mentioned that the project compares simulation results and different studies to properly evaluate the best way to introduce PHEV. The reviewer suggested to further complicate the analysis by introducing other impact factors related to the use of conventional vehicles (external costs related to accidents, air quality impact in urban areas and health effects of pollutants). Another person noted that the project seems to have looked at a bunch of concepts, but that it was hard to follow everything in such a short talk and that they were not sure what the bottom line was. The reviewer asked whether the researchers had overall recommendations, and if so, what were they and are they politically acceptable? The reviewer added that the PI seems to be very clued in to what others are doing and that it is nice to see them using others' studies, not just doing another one of their own. The last reviewer commented that the study will clarify the value of PHEVs to the public at various levels of market entry and will have a tremendous impact on the future of PHEVs. The reviewer felt that it is likely that the study will show the true value of PHEVs as the cost of battery packs is reduced.

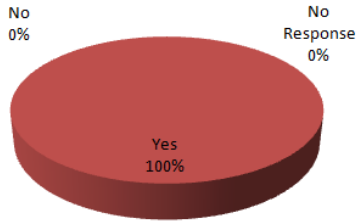
Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One reviewer commented that it sounds as though the researchers are being open and trying to get at the reality behind some of these scenarios and models. Another reviewer indicated that the study will clarify the goals for HEVs and PHEVs for near-term and long-term value of these vehicles. One person felt that the results may support policy, governmental measures and also assist industrial commitment in the sector. The last person commented that the study provides useful consideration, but is based on theoretical scenarios, which in some cases are themselves based on the outcome of other theoretical scenarios or estimations. The reviewer added that it is possible that the study could have some influence on market direction and may be useful for consideration of future scenarios, but the scope of considerations included in the study may be too great given the current status of actual development in the real world.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
One person simply commented that the funding is sufficient for this project. Another agreed, stating that the effort seems to be adequate in respect to the available budget. The last person commented that the researchers are good at learning from outside resources and that they seem to do a lot with what they have.

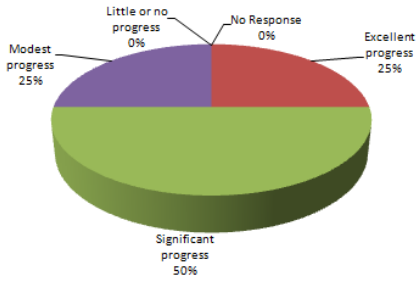
Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Requirements and Targets Validation

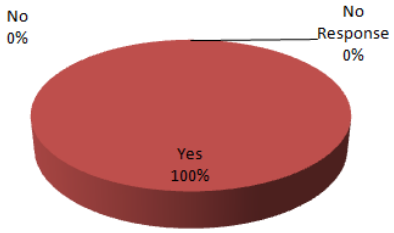
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



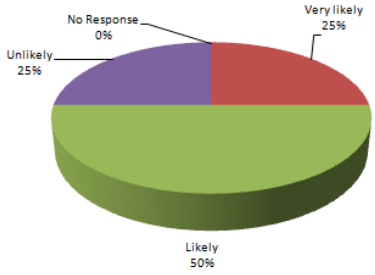
Question 3: Characterize the technical accomplishments and progress toward goals.



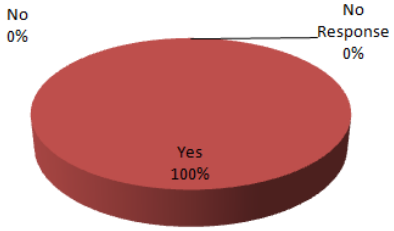
Question 2a: Are the goals of the project technically achievable?



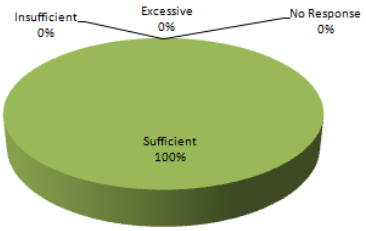
Question 4: How likely is the project team to move technologies into the marketplace?



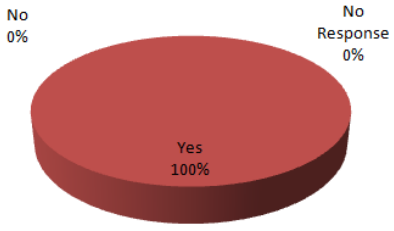
Question 2b: Have the technical barriers been identified and addressed?



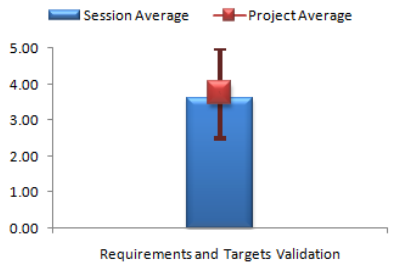
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Testing USABC (High-Power Energy Storage) Deliverables/Benchmarking (Tim Murphy, of Idaho National Laboratory)

Reviewer Sample Size
This project had a total of 7 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Comments to this question were all positive. One person acknowledged that the project is functional in assisting and verifying DOE targets and program results. Another person indicated that INL provides useful and timely verification of and/or alternative measurements to developer characterization and life observations. One reviewer observed that the independent testing and validation of the deliverables is a critical activity that can help detect issues with systems developed that also standardizes the performance between the systems, which are all critical for evaluating the technologies. Another person commented that it is crucial to know where you are and to generate independent testing using agreed-upon test criteria. They added that linking the results to the physical and other testing is extremely important. The last reviewer noted that INL is developing and carrying out testing of cells that may be used in HEVs and PHEVs. The reviewer acknowledged that the lab is maintaining a close working relationship between their activities and those at Argonne.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
Responses to this question were generally positive. One reviewer pointed out that the technical and economical barriers are well identified and include specific performances, cost, and abuse behavior. They felt that the project approach is reasonable and well structured to assist the comprehension of the program progress on batteries and ultracapacitor technologies. Another reviewer remarked that the testing of developed batteries is an essential part of all the battery development programs and thus it is very important part of deployment strategy. Another person noted that the researchers seem to have things well in hand, but that they would have to do an audit to actually test the testers so to speak. One person noted that INL is developing standardized tests and test equipment that will be used to test cells that have been developed for HEVs and PHEVs. They concluded by highlighting that the testing protocols include analysis to help develop predictive models. One reviewer suggested that the number of testing stations should be increased, because as multiple companies move into the area of HEV technology, the need for independent evaluation is becoming important so having the facilities to accommodate this will be necessary. They add that the longer term studies for the more promising technologies will tie up stations. They concluded by cautioning that the 15-year validation is in risk unless that continues on an independent basis. The final reviewer had a differing opinion, arguing that most of the barriers identified by this project are outside the scope of the project's responsibility.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer noted that the presentation claims to have good cross-checks in place. Another person commented that test procedures have been issued in timely and validated manner and that the delivered batteries have been tested according to the established planning. They add that the test results were not presented, but the test campaign was described. They cautioned that there is a discrepancy between the cell type under development by Johnson Controls VL6P and that tested at INL VL7P. Another reviewer commented that the testing appears to be standardized and that it will

be hard to show significant "rapid" progress for this group, hence their rating. However, they added that it appears that group has detected "non-standard" behaviors, which is critical, and that is significant progress. Another person mentioned that standardized ongoing testing has been well-supported and well-documented by INL. They highlighted that support for the development of life prediction models has apparently been insufficient to achieve significant progress. The final commented mentioned that INL produced PHEV battery test procedures that can be used by battery developers and battery users. They have also completed long-term calendar life testing and combined calendar life/cycling tests.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

One commenter observed that INL is developing tools that will enable battery suppliers to improve their cells to meet the DOE goals and that these tools (testing and analysis) will assist battery developers reduce the time needed to develop new PHEV batteries. Another person agreed, stating that the experimental work supports the product development and the industry validating in an independent and objective manner batteries and ultracapacitors for various applications. One reviewer felt that the validation and standardization process will enable selection of the critical technologies for funding, all which contributes to implementation into market place. Another person simply stated that the industry needs these methodologies to make unbiased decisions. Another reviewer, however, pointed out that it is more likely that methods will be adopted by industry than new technologies will move toward marketplace. The final reviewer indicated that it is possible that the project will be able to influence accepted life prediction methodologies towards improved methods, but that it is of equal or greater likelihood that efforts within industry have, or will, supersede or more expeditiously achieve progress than those of this project.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reactions to this question were mixed. One reviewer commented that INL's funding is sufficient for the projects they have underway. Another stated that the resources were not described in the presentation, so hardly can be analyzed. One person remarked that while there appear to be sufficient personnel available for useful support of standardized verification testing and related interaction with developers, there apparently are insufficient resources dedicated to, or available for, life prediction methodology development and support.

One reviewer had detailed comments, suggesting that the researchers probably need additional testing stations (based on number of cells tested). They agree that benchmarking, and the statistical significance of it, is important. They encourage looking at alternate low-cost suppliers for this, where data can be generated to less cost, suggesting that multiple Chinese vendors exist for instance. The reviewer was not clear if statistical methods are used for validation of the performance attributes. They suggest working with Johnson Controls and augment their own results with testing made at their factories to achieve statistical significance, in cases where too few test stations are available. They concluded by suggesting that the researchers develop and publish accelerated testing methods, which is useful for the whole industry.

The final reviewer also had detailed comments. They commented that the interpretation of the data is very high-added-value and that some of the testing has safety issues that require in-house testing. However, they urged that, in view of the high overhead costs associated with the government labs, much of the routine testing could be outsourced. They provided the example that consumer companies do this all the time for advertising substantiation and for getting data to support and defend law suits. They add that confidentiality should not be an issue as you should get the cells back once

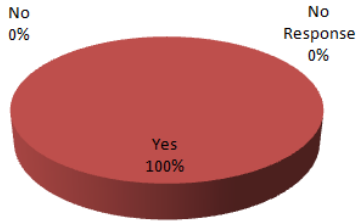
testing is completed. They highlighted that the labs still need to be heavily involved in analyzing the data, since their strengths lie in their brains and not in their equipment. They concluded by indicating that maintaining test equipment running correctly is actually a very demanding, full-time job that is often underfunded; so suggested leaving it to those who already do this for a living.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

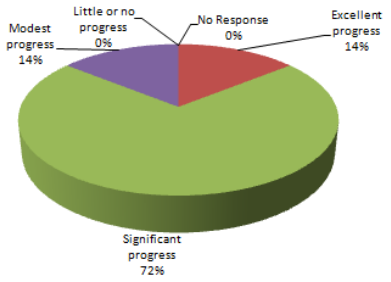
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Testing USABC (High-Power Energy Storage) Deliverables/Benchmarking

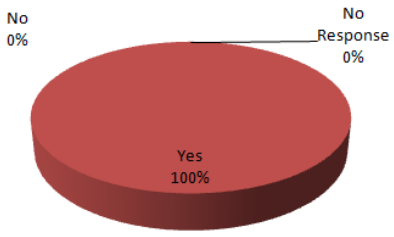
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



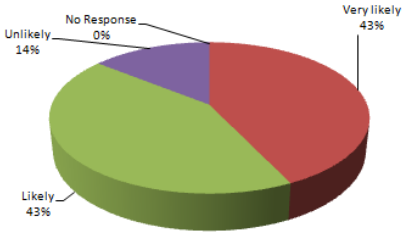
Question 3: Characterize the technical accomplishments and progress toward goals.



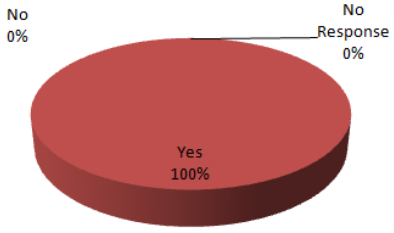
Question 2a: Are the goals of the project technically achievable?



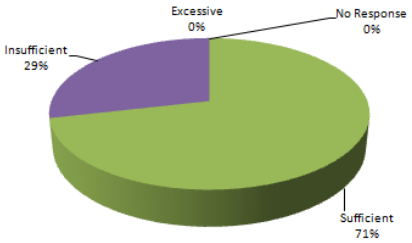
Question 4: How likely is the project team to move technologies into the marketplace?



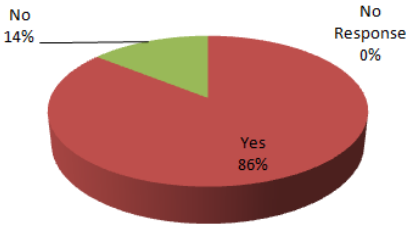
Question 2b: Have the technical barriers been identified and addressed?



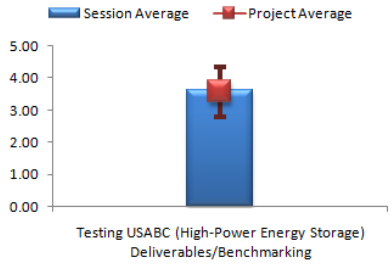
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Testing USABC (PHEV Battery Development) Deliverables/Benchmarking (Tim Murphy, of Idaho National Laboratory)

Reviewer Sample Size
This project had a total of 7 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One reviewer simply stated that this work is important for the new PHEV products evaluation. Another person agreed that INL provides useful and timely verification of and/or alternative measurements to developer characterization and life observations. One person acknowledged that INL is developing and carrying out testing of cells that may be used in HEVs and PHEVs and are maintaining a close working relationship between their activities and those at Argonne. One person pointed out how crucial it is to know where you are and to generate independent testing using agreed-upon test criteria. They added that the linking of the results to the physical and other testing is extremely important. The last reviewer commented that the independent testing and validation of the deliverables is a critical activity that can help detect issues with systems developed. It also standardizes the performance between the systems, all critical for evaluating the technologies. They asked whether there is a need to upgrade for PHEV conditions, for instance, to verify calendar life for various driving scenarios, which affects the state-of-charge used during "storage".

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One person noted that INL is developing standardized tests and test equipment that will be used to test cells that have been developed for HEVs and PHEVs. They add that the testing protocols include analysis to help develop predictive models. Another person commented that the researchers seem to have things well in hand, but would have to do an audit to actually test the testers so to speak. Another person, however, commented that the project is not yet described but seems to be similar to that for HEV battery. The final reviewer pointed out that most of the barriers identified by this project are outside the scope of this project's responsibility.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
Reactions to the question were mixed. One person observed that INL has produced PHEV battery test procedures that can be used by battery developers and battery users and have completed long-term calendar life testing and combined calendar life/cycling tests. One person noted that the researchers claim to have good cross-checks in place. Another reviewer mentioned that standardized ongoing testing has been well-supported and well-documented by INL. They indicated that support for the development of life prediction models has apparently been insufficient to achieve significant progress. Another person noted that the testing of developed batteries is an essential part of all the battery development programs and thus it is very important part of deployment strategy. The final reviewer, however, felt that the activities do not seem yet started.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One person stated that INL is developing tools that will enable battery suppliers to improve their cells to meet the DOE goals, adding that these tools (testing and analysis) will assist battery developers reduce the time needed to develop new PHEV batteries. Another person simply noted that the project

is functional to new PHEV battery development. Another person acknowledged that the industry needs these methodologies to make unbiased decisions. The last reviewer suggested that it is possible that the project will be able to influence accepted life prediction methodologies towards improved methods, but it is of equal or greater likelihood that efforts within industry have, or will, supersede, or more expeditiously achieve, progress than those of this project.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

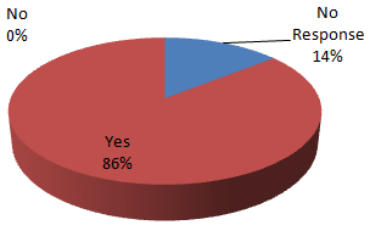
One reviewer felt that the information available is not sufficient for an adequate evaluation. Another person felt that INL's funding is sufficient for the projects they have underway. One person cautioned that while there appear to be sufficient personnel available for useful support of standardized verification testing and related interaction with developers, there apparently are insufficient resources dedicated to, or available for, life prediction methodology development and support. The last reviewer reiterated similar comments to a previous question, stating that the interpretation of the data is very high-added-value and some of the testing has safety issues that require in-house testing. However, they suggest that in view of the high overhead costs associated with the government labs, that much of the routine testing be outsourced. They point out that consumer companies do this all the time for advertising substantiation and for getting data to support and defend law suits. They pointed out that confidentiality should not be an issue since the cells will be returned once testing is completed. They remarked that the labs still need to be heavily involved in analyzing the data, since their strengths lie in their brains not their equipment. They concluded by mentioning that maintaining test equipment running correctly is actually a very demanding, full-time job that is often underfunded; so why not leave it to those who already do this for a living.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

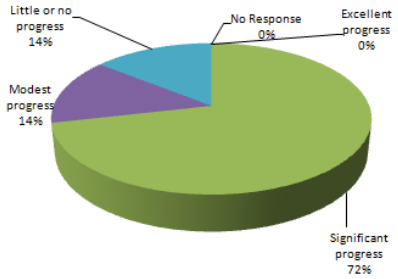
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Testing USABC (PHEV Battery Development) Deliverables/Benchmarking

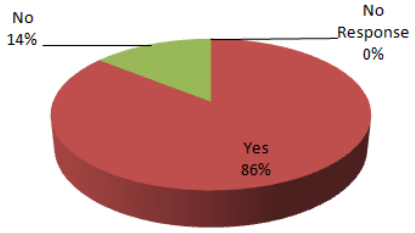
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



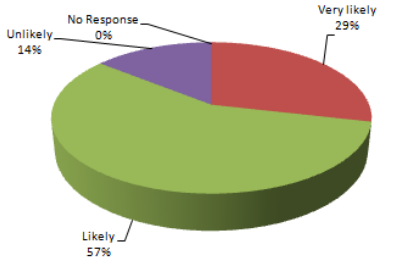
Question 3: Characterize the technical accomplishments and progress toward goals.



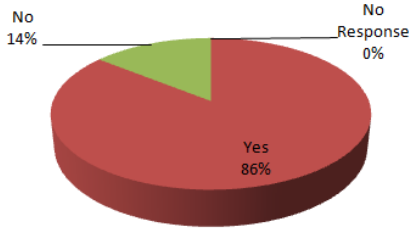
Question 2a: Are the goals of the project technically achievable?



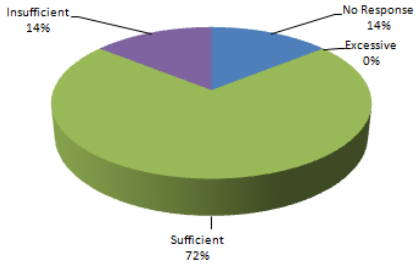
Question 4: How likely is the project team to move technologies into the marketplace?



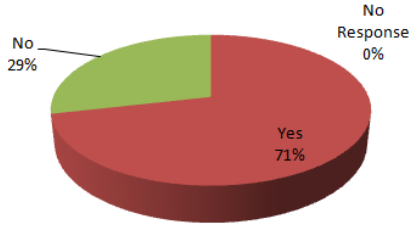
Question 2b: Have the technical barriers been identified and addressed?



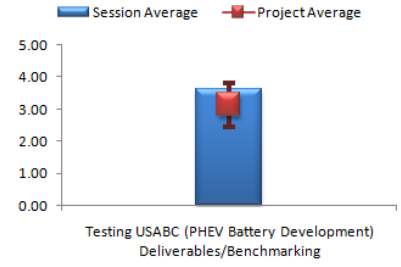
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Testing USABC Deliverables/Benchmarking (Ira Bloom, of Argonne National Laboratory)

Reviewer Sample Size
This project had a total of 7 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One reviewer pointed out that the project assists the verification of DOE objectives in the battery area. Another person acknowledged that it is critical to get good reliable data and to link the data to fundamentals so you can understand them. Another person noted that the independent testing and validation of the deliverables is a critical activity that can help detect issues with systems developed. They added that this also standardizes the performance between the systems, which are all critical for evaluating the technologies. The last reviewer indicated that the researchers' work at ANL is leading to the capability of characterizing cells produced by potential suppliers. The tests and the analysis procedures that they are using have been established and are well-known, so they are using this experience now to develop similar tools for the batteries intended for PHEVs. They concluded by acknowledging that the researchers are performing calendar life and cycling tests that

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One person remarked that the work on protocols and testing is fundamental in assuring comparable results and feedbacks to USABC and developers and that the benchmarking and program deliverable testing is extremely important to trace the progress of the technology. Another reviewer commented that with benchmarking the challenge is to find accelerated protocols that differentiate earlier would be a significant achievement for this group. They suggested that the group should look for cheaper testing methods and deploy this for increased capability. One person commented that in general, the project has been able to overcome the barriers which have been identified by the project, with the exception of significant progress in the technology life validation method and related manual development. The last reviewer pointed out that the researchers are working together to use empirical modeling to analyze the data they are collecting. The reviewer felt that they are publishing this information in a timely manner, which enables others to use their results or extend their results to meet their needs. The reviewer concluded by mentioning that the researchers are developing new testing protocols to reveal important features of cells that have been stressed at high charge and discharge rates, as needed for PHEVs.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer simply stated the straightforward battery testing in support of program. One reviewer noted that the benchmark testing, especially, is an integral art to identify the advanced battery technology. Another person indicated that the progress has been clearly shown and justified against planned milestones and deliverables, but suggested that accelerated tests may give significant information reducing costly tests for rapid technology application. One person noted that standardized ongoing testing has been well-supported and well-documented by ANL. They added that the level, or sufficiency, of support for benchmark testing is unclear from the presentation or otherwise, and that support for the development of life prediction models has apparently been insufficient to achieve significant progress. One reviewer noted that the unbiased nature of testing and the disclosure of the methods used are very important and well thought out. They added that the ability to separate out causes of problems is very important in guiding developers and understanding how good the systems will likely be under real world situations. Another person felt that it was hard

to show rapid progress for this group, as test is somewhat standardized. They applauded the work on the test manuals, but they asked whether a review of these was needed. The reviewer asked whether the tests are the best tests, given what we know today. They suggested that significant progress for this group would be to discover alternate tests that even further enhance the testing and interact with car companies for review of user models, which may have changed with fuel prices and environmental awareness. They concluded by asking whether we need to change the test of the batteries as the electrical engines are improved, or as the battery system chemistries are developed. The last reviewer pointed out that work has focused primarily on empirical or semi-empirical data analysis, but that they should include analysis of data using models such as those developed by Newman et al.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

Comments were generally positive. One person indicated that this project provides valuable support to USABC and developers to improve the technology and set plans for commercial availability. Another mentioned that the work is helping battery manufactures by providing test results and curve fitting of those results. One reviewer highlighted the fact that without understanding, progress will be hit and miss, so the project results are increasing our knowledge, not just accumulating data; very nice work. Another person commented that the differentiation brings a selection of the best technologies and additional funding will come that stimulates market deployment, which is very important. The last reviewer suggested that it is possible that the project will be able to influence accepted life prediction methodologies towards improved methods, but it is of equal, or greater, likelihood that efforts within industry have, or will, supersede or more expeditiously achieve progress than those of this project.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One reviewer commented that the information seems to be adequate because the planned milestones seem to be reached in timely manner. Another person noted that while there appear to be sufficient personnel available for useful support of standardized verification testing and related interaction with developers, there apparently are insufficient resources dedicated to, or available for life prediction methodology development and support. They concluded stating that the sufficiency of resources relative to benchmark testing is unclear from the presentation or otherwise. One reviewer suggested that likely more testing stations are needed (the reviewer stated that they always have to make this comment since it is critical). They felt that the funds were well spent, as long as manpower follows, also suggesting that the group should be challenged with coming up with additional acceleration and maybe a protocol for tests that removes a cell from testing to give a place for other technologies that are more promising if it fails a certain sequence. The reviewer felt that this would essentially result in leveraging the most testing for the best technology. They acknowledged that the presenter shows critical thinking and discovery of degradation factors, which is healthy feedback for the developers - well done. The reviewer concluded by stating that the researchers have made good choices for next year's activities. Another reviewer noted that the researchers are doing well, but I believed that they should not be burdened with so much testing that can really be outsourced. Instead, they would like to see them having more time to utilize their considerable expertise in interpreting results and guiding the developers. The reviewer stressed that It is not just the cost - having these people do routine testing is a waste of their brainpower; they do not have time to do more value-added activities. In this area, the reviewer thought that more of their effort should be spent on diagnostics, not testing. The reviewer added that when the researchers see changes in behavior during testing, they need to have time and resources to understand and explain this - unless the developers are going to do this on their

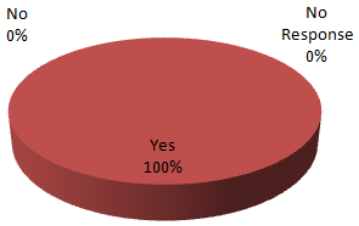
own. (Some may be capable of doing this, but the smaller ones are not). The final reviewer felt that the funding is excessive for the results produced.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

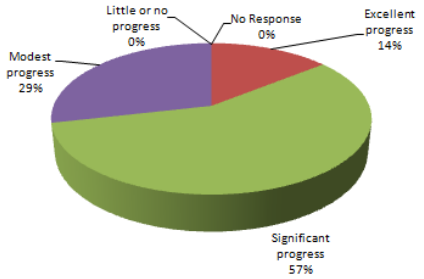
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Testing USABC Deliverables/Benchmarking

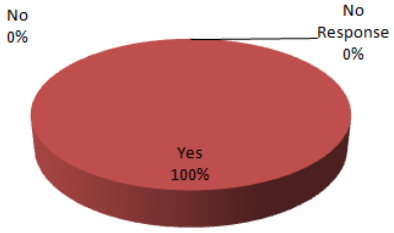
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



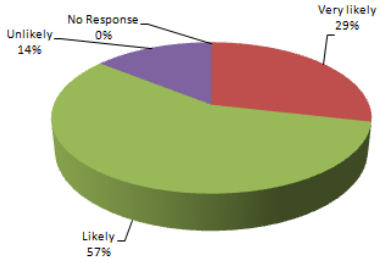
Question 3: Characterize the technical accomplishments and progress toward goals.



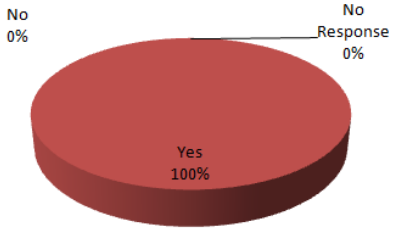
Question 2a: Are the goals of the project technically achievable?



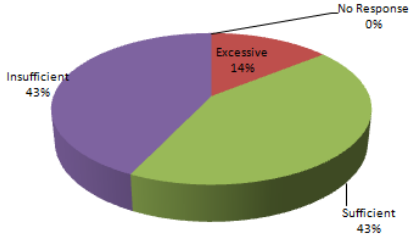
Question 4: How likely is the project team to move technologies into the marketplace?



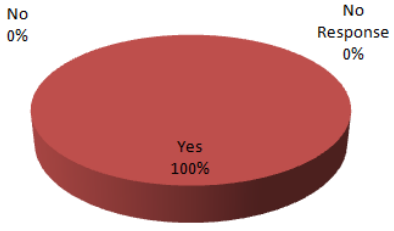
Question 2b: Have the technical barriers been identified and addressed?



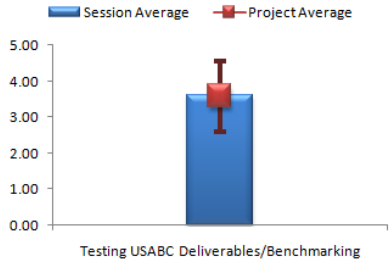
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Thermal Management Modeling (Ahmad Pesaran, of National Renewable Energy Laboratory)

Reviewer Sample Size
This project had a total of 7 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Comments were positive. One person simply stated that the project supports battery development targets. Another reviewer commented that large pack safety and performance is critical and thermal management seems to be key. One person acknowledged that thermal modeling is important for batteries in HEV and PHEV applications. Another person agreed, adding that thermal management is absolutely necessary for the energy storage systems to be safely implemented before the DOE objective of petroleum displacement can be met. Another added that thermal systems design is important for safety and performance, and that the capability of this laboratory can in a major way support those designs, since they have necessary instrumentation that would not be easily available at a company. Therefore, this activity will shorten the time to market. One reviewer commented that the program has provided useful thermal abuse modeling characterization to HEV battery system development, and that NREL's activities in this area to date appear promising. Another person agreed, stating that NREL's thermal management modeling will be very helpful to auto and battery companies to reduce the development time for safe battery packs for HEVs and PHEVs. The final reviewer remarked that the modeling of the different sizes was a good idea and will support cheaper batteries, as the size could potentially be reduced, which could potentially achieve an easier cost target for developers.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One person simply stated that the project is well thought out and well organized. One reviewer commented that the researchers had a good strategy, highlighting that the idea on modeling differently sized system is good. Another person agreed that the researchers have shown a good approach, and added that the modeling supports to the experiments are very important for a full understanding, which can help define the systems that control the thermal properties of the pack and its geometry. Another person commented that there is a clear identification of barriers related to thermal behavior of lithium batteries. The indicated that the thermal model is well developed to analyze different module configurations and gives feedback to improve design and thermal management needs. The last person commented that NREL's strategy of combining physics-based models with thermal data for cells will lead to better understanding of the performance of the battery packs and the required thermal management systems.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One person noted that the results clearly show the progress and the potential advantages. Another person felt that researchers have shown great test set-up and very good implementation of the modeling, which can be immediately validated through the good test station set-up. They added that this is very hard to do for a battery company and would take a few years to set up and learn, so it is critical for launch of new technology and will shorten time to market. One person commented that the project has repeatedly demonstrated flexibility and innovation in advancing capability and in achieving new technical understanding of the thermal behavior of HEV batteries. They concluded by mentioning that the more recent work with thermal behavior modeling appears to be promising and useful and should be expanded. Another reviewer pointed out that NREL's combined approach

developing battery pack, thermal management, and vehicle simulation programs will reduce the development time for battery pack developers. The reviewer added that NREL has used their modeling approach to demonstrate the time lag between a thermal run away event occurring in a cell and being seen by temperature sensors mounted on a cell's surface. They have also developed similar tools for shorted cells. Another person observed that the project implemented li-ion reaction chemistry into a finite volume three-dimensional cell model addressing various design elements and simulated oven test and internal short-circuit events, examined impact of cell design parameters. The reviewer also mentioned that propagation of abuse reaction through a module was also simulated taking into account of the balance between heat transfer network and dispersed chemical sources. They pointed out that this work showed that the balance is affected by module design parameters such as cell size, configuration and size of cell-cell connectors, and cell-cell heat transfer medium.

The last reviewer had detailed comments, commenting that the project is off to a good start and that the thermal imaging is nice, but the reviewer questioned whether the imaging system can really identify hot spots inside the jellyroll since the metal case could well mask them. They asked whether the researchers have done validation studies to show that if a hot spot were present they could see it; in fact, the modeling work the researchers showed later seemed to explicitly show that the outside case temperatures does not in fact show a thermal hot spot. This, in the reviewer's view, undermines the studies done using heat cameras. They added that they appreciated the acknowledgement of cell to cell variability. They concluded by stating that the work base on the assumption that one cell will actually go into thermal runaway and look at the propagation of that event should lead to the kind of robust design needed for successful implementation.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

One reviewer noted that this is more an assessment study, so the question does not apply to this project. Another person felt that the results are very interesting and give direction to improve cell design and battery systems. One person commented that the modeling can help provide direction for a developer, which enhances speed to market. Another person agreed with this, stating that the project will shorten time to market with a facility that is not available at the "typical" battery manufacturer. One person highlighted that viable systems will not be possible without thermal management; adding that thermal management systems need to be part of the entire system design and cost estimates. The last person commented that NREL's efforts coupled with battery and auto companies' use of their results will reduce the time to market for HEVs and PHEVs.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

One person simply pointed out that the amount of work shows good and timely results. Another commented that the funding is sufficient for this effort. One person noted that the presenter made no comments on this, so they are probably sufficient. The reviewer argued that DOE should continue funding this effort and build staff knowledge beyond the principal investigators. Another person commented that nothing was mentioned regarding insufficient resources, but they felt that it was unlikely that less funding would give the same good results. The reviewer commented that as the field is growing, DOE will need to train more staff in the skill set of the PI and this should probably start now. The reviewer felt that providing the program with more funding would help achieve this, but maybe use next year to hire staff and fund one year later after initial training would be appropriate. One person remarked that the funding level seems to be OK, but may need more people as developers get closer to making a final battery pack as opposed to single cells. The reviewer suggested that DOE revisit the needs for this program more frequently as likely to need a rapid increase at some point in

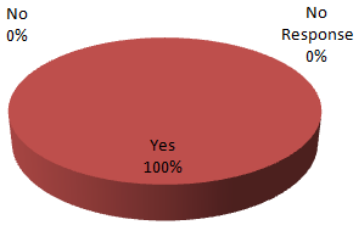
time. The last reviewer commented that NREL's analysis of HEV & PHEV requirements and work in the area of battery life modeling is useful. They cautioned however, that battery life modeling in particular may be better accomplished by battery developers and OEM's working together and may be most relevant to the competitive commercial activity between battery developers and OEM's. Additionally, they felt that NREL may not have sufficient resources to sustainably include HEV & PHEV requirements analysis and battery life modeling within the scope of its total activities and that NREL's focus of activity may be most useful if re-directed and more closely targeted on thermal characterization and thermal abuse reaction modeling.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

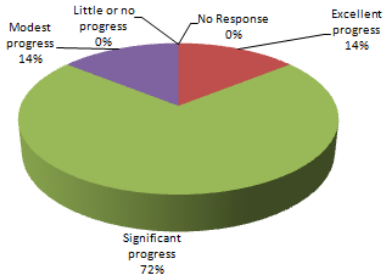
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Thermal Management Modeling

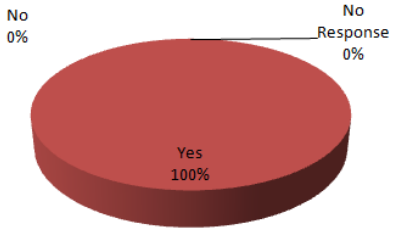
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



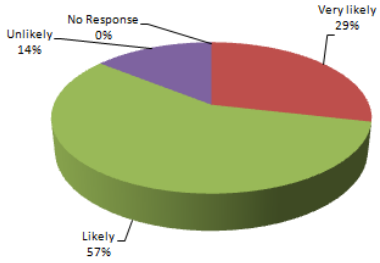
Question 3: Characterize the technical accomplishments and progress toward goals.



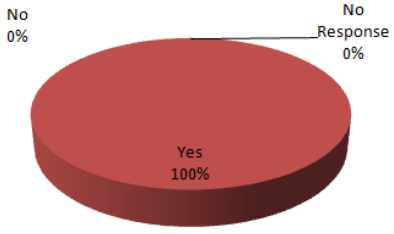
Question 2a: Are the goals of the project technically achievable?



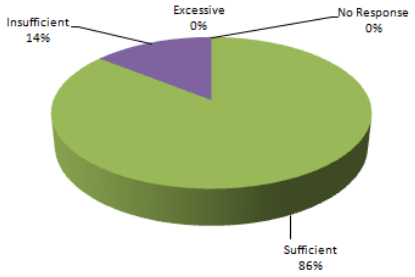
Question 4: How likely is the project team to move technologies into the marketplace?



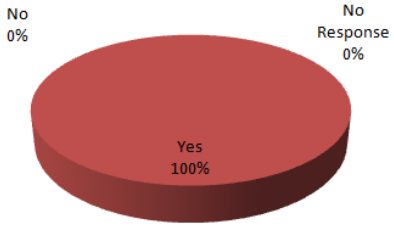
Question 2b: Have the technical barriers been identified and addressed?



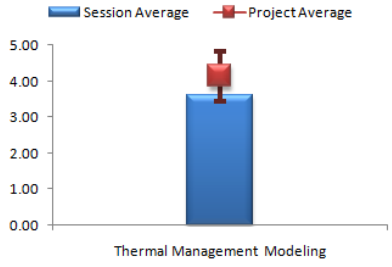
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating



Thermal Management Studies (Ahmad Pesaran, of National Renewable Energy Laboratory)

Reviewer Sample Size
This project had a total of 6 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Comments to this question were generally positive. One person commented that the project clearly addresses key DOE battery program objectives. Another stated that large pack safety and performance is critical and thermal management seems to be key. Another person indicated that battery thermal is an important aspect to widely promote HEV and PHEV. One person noted that NREL's work on thermal testing of battery packs will lead to better understanding of the thermal management requirements for battery packs for HEVs and PHEVs. One reviewer highlighted that useful thermal characterization is a critical aspect of HEV battery system development and is a shortcoming in capability within most automotive OEM's and battery developers; NREL's activities significantly address this shortcoming. The last reviewer commented that the design of thermal systems is important for safety and performance and that the capability of this laboratory can in a major way support those designs, instrumentation that would not be easily available at a company, but necessary; therefore this activity will shorten time to market.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One person felt that the research is well organized with all objectives laid out and that problems are identified and approaches are identified to solve them. Another person mentioned that thermal management is a key barrier in lithium battery use and the approach is very appropriate to assist the solution of the technical and practical problem. One reviewer felt that the researchers have used a good approach with modeling that provides support to the experiments are very important for a full understanding, which can help define the systems that controls the thermal properties of the pack and its geometry. The last person commented that the work to combine data gathering and data analysis for battery packs will lead to battery packs that will be safe.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer simply noted that the objectives are well addressed. Another person commented that NREL's battery pack testing will aid battery suppliers and auto companies with valuable data for thermal management design. One person felt that the results are well described and support the development of lithium technologies. They added that the thermal analysis and modeling are well progressed in order to adequately support battery technology development and application in various electrically-driven vehicles. Another reviewer commented that the project has repeatedly demonstrated flexibility and innovation in advancing capability and in achieving new technical understanding of the thermal behavior of HEV batteries. Another person had favorable comments, stating that the researchers have shown great test set-up and very good implementation of the modeling, which can be immediately validated through the good test station set-up. They highlighted that this is very hard to do for a battery company and would take a few years to set up and learn, so it is critical for launch of new technology and will shorten time to market. The last reviewer had detailed comments, commenting that the project is off to a good start and that the thermal imaging is nice, but the reviewer questioned whether the imaging system can really identify hot spots inside the jellyroll since the metal case could well mask them. They asked whether the researchers have done validation studies to show that if a hot spot were present they could see it; in fact, the modeling work

the researchers showed later seemed to explicitly show that the outside case temperatures does not in fact show a thermal hot spot. This, in the reviewer's view, undermines the studies done using heat cameras. They added that they appreciated the acknowledgement of cell to cell variability. They concluded by stating that the work base on the assumption that one cell will actually go into thermal runaway and look at the propagation of that event should lead to the kind of robust design needed for successful implementation.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.

Reactions to this question were mixed. One person simply stated that this project is more of an assessment study, so the question does not apply to this item. Another person commented that NREL's studies will help battery and auto companies develop thermal management systems for battery packs for HEVs and PHEVs. Another person noted the project's goal is to shorten the time required to reach the market and that the lab's facility is not available at the "typical" battery manufacturer. Another person mentioned that most of the results have a manifold impact on the final commercial products in terms of cell design and material selection, working conditions, control needs and module and system engineering. The last reviewer commented that the system will not be viable without thermal management; thermal management systems need to be part of the entire system design and cost estimates.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

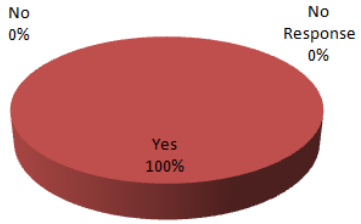
One reviewer felt that the amount of results and supporting studies well justifies the used budget ($1.2 million). Another agreed, adding that the resource seems to be reasonable in this effort. Another person agreed, stating that NREL's results are consistent with their funding level. One person indicated that the presenter made no comments on this subject, so probably sufficient. Please continue fund this effort and build staff knowledge beyond the principal investigators. Another commenter observed that the funding level seems OK, but may need more people as developers get closer to making a final battery pack as opposed to single cells. They suggested that DOE should revisit the needs for this program more frequently as likely to need a rapid increase at some point in time. The final reviewer commented that NREL's analysis of HEV & PHEV requirements and work in the area of battery life modeling is useful; however, battery life modeling in particular may be better accomplished by battery developers and OEM's working together and may be most relevant to the competitive commercial activity between battery developers and OEM's. Additionally, NREL may not have sufficient resources to sustainably include HEV & PHEV requirements analysis and battery life modeling within the scope of its total activities. They concluded by indicating that NREL's focus of activity may be most useful if redirected, and more closely targeted on, thermal characterization and thermal abuse reaction modeling.

Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.

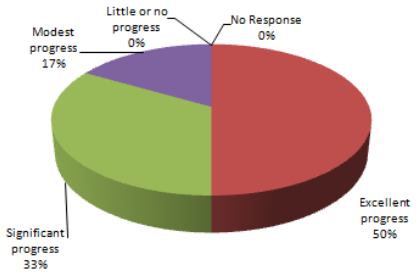
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Thermal Management Studies

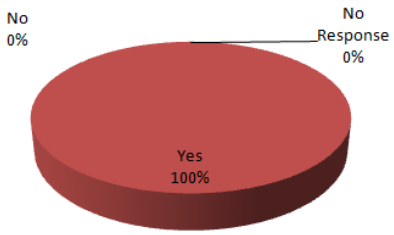
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



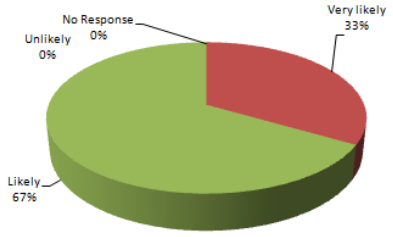
Question 3: Characterize the technical accomplishments and progress toward goals.



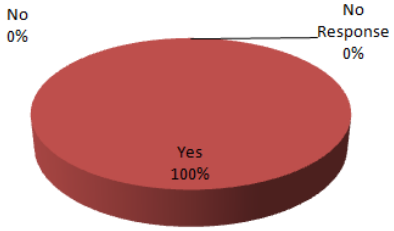
Question 2a: Are the goals of the project technically achievable?



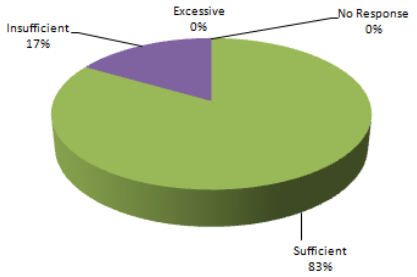
Question 4: How likely is the project team to move technologies into the marketplace?



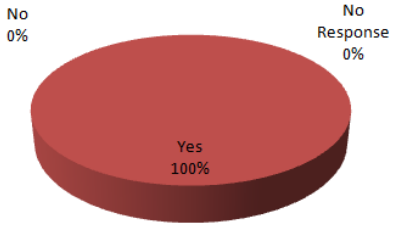
Question 2b: Have the technical barriers been identified and addressed?



Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



Question 2c: Is the proposed work likely to overcome technical barriers?



Question 6: Overall Rating