U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

3. Power Electronics and Electrical Machines Technologies

Advanced electric drive vehicles such as hybrid-electric vehicles, plug-in hybrid electric vehicles, fuel cell electric vehicles, and pure electric vehicles, require power electronics and electrical machines (PEEM) to function. These devices allow the vehicle to use energy from the battery to assist in the propulsion of the vehicle, either on their own or in combination with an engine. Advanced technology vehicles such as hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), fuel cell hybrid electric vehicles (FCHEVs), and electric vehicles (EVs) can help meet important DOE goals, such as petroleum reduction. However, modern day PEEM technology is not sufficient to enable market-viable PHEVs, FCHEVs, and EVs. So, the Vehicle Technologies Program aims to develop these technologies by setting strategic goals for PEEM, and undertaking research projects that are carried out through collaboration among government, national laboratories, academia, and industry partners. Achieving the PEEM goals will require the development of new technologies. These new technologies must be compatible with high-volume manufacturing and must ensure high reliability, efficiency, and ruggedness. These technologies must also reduce cost, weight, and volume. Of all these challenges, cost is the greatest. PEEM project partners work together to ensure that technical attributes, vehicle-scale manufacturing, and cost sensitivities are addressed in a timely fashion and that the resulting technologies can be adopted by companies willing and able to supply products to automakers.

In August 2009, the Department announced the selection of ten projects totaling $495 million that will help accelerate the establishment of a globally competitive, domestic infrastructure for advanced electric drive vehicle manufacturing. ARRA-funded Power Electronics and Electrical Machines Technologies activities support programs to enable production and commercialization of advanced electric drive vehicles, which help to reduce petroleum consumption. Activities include developing low-cost electric propulsion systems; supporting an increase in production capacities for electric drive components, manufacturing plants, and parallel hybrid propulsion systems; and supporting development of electric drive semiconductors. Additionally, AARA-funded activities that support commercialization include accelerating the launch of HEVs/PHEVs through efforts including localizing the design and production of transaxle systems, and developing a lower-cost, higher-control standardized platform.

During this merit review, each reviewer was asked to answer a series of questions using multiple-choice responses (and with explanatory comments when requested), as well as using numeric scores *(on a scale of 1 to 4)*. In the following pages, reviewer responses to each question for each project are summarized, the multiple choice and numeric score questions are presented in graph form, and the explanatory text responses are summarized for each question. The summary table below lists the average numeric score for each question and for each of the projects.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
A Segmented Drive Inverter Topology with a Small DC Bus Capacitor	Gui-Jia Su (Oak Ridge National Laboratory)	3-4	3.00	3.00	3.00	3.33	3.04
† Benchmarking of Competitive Technologies	Tim Burress (Oak Ridge National Laboratory)	3-7	3.60	3.60	3.60	3.40	3.58
Wide Bandgap Materials	Madhu Chinthavali (Oak Ridge National Laboratory)	3-9	3.33	3.33	3.33	3.00	3.29
High Dielectric Constant Capacitors for Power Electronic Systems	Uthamalingam Balachandran (Argonne National Laboratory)	3-11	3.50	3.33	3.33	3.67	3.42
High Temperature Polymer Capacitor Dielectric Films	Shawn Dirk (Sandia National Laboratories)	3-14	3.43	3.57	3.57	3.57	3.54
† Glass Ceramic Dielectrics for DC Bus Capacitors	Michael Lanagan (Pennsylvania State University)	3-17	3.00	3.00	3.00	3.00	3.00
Beyond Rare Earth Magnets	Iver Anderson (Ames)	3-19	3.50	3.00	3.00	3.00	3.13
Air Cooling Technology for Power Electronic Thermal Control	Jason Lustbader (National Renewable Energy Laboratory)	3-21	3.50	3.25	3.25	3.25	3.31

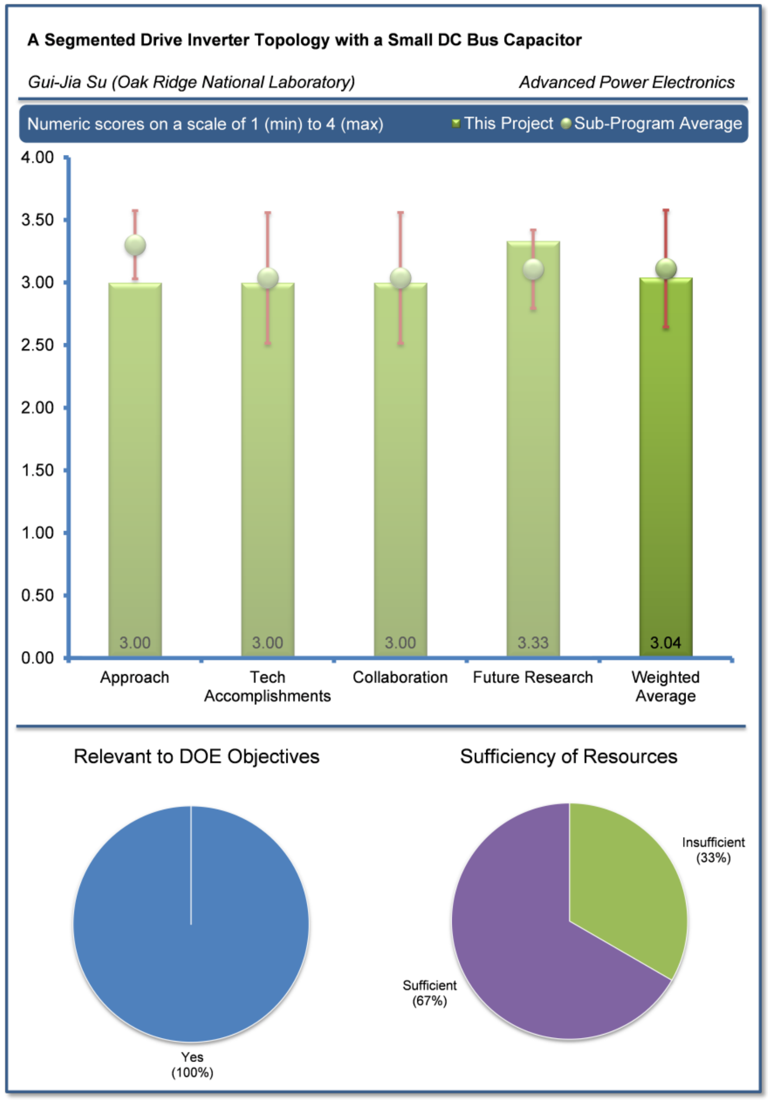
Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Power Device Packaging	Zhenxian Liang (Oak Ridge National Laboratory)	3-23	3.00	2.67	2.67	3.17	2.81
Electro-thermal-mechanical Simulation and Reliability for Plug-in Vehicle Converters and Inverters	Allen Hefner (National Institute of Standards and Technology)	3-26	3.75	3.75	3.75	3.50	3.72
Development of SiC Large Tapered Crystal Growth	Philip Neudeck (National Aeronautics and Space Administration)	3-28	3.33	3.33	3.33	3.33	3.33
Thermal Performance and Reliability of Bonded Interfaces	Doug DeVoto (National Renewable Energy Laboratory)	3-31	3.67	3.67	3.67	3.33	3.63
Electric Motor Thermal Management	Kevin Bennion (National Renewable Energy Laboratory)	3-33	3.33	2.67	2.67	3.00	2.88
Interim Update: Global Automotive Power Electronics R&D Relevant To DOE 2015 and 2020 Cost Targets	Christopher Whaling (Synthesis Partners)	3-35	3.80	3.80	3.80	2.40	3.63
Converter Topologies for Wired and Wireless Battery Chargers	Gui-Jia Su (Oak Ridge National Laboratory)	3-38	3.33	2.67	2.67	3.00	2.88
Integration of Novel Flux Coupling Motor and Current Source Inverter	Burak Ozpineci (Oak Ridge National Laboratory)	3-40	3.00	2.00	2.00	2.50	2.31
Motor Packaging with Consideration of Electromagnetic and Material Characteristics	John Miller (Oak Ridge National Laboratory)	3-42	3.00	2.75	2.75	2.75	2.81
† Physics of Failure of Electrical Interconnects	Doug DeVoto (National Renewable Energy Laboratory)	3-44	3.33	3.67	3.67	3.67	3.58
† Two-Phase Cooling Technology for Power Electronics with Novel Coolants	Gilbert Moreno (National Renewable Energy Laboratory)	3-46	3.50	3.00	3.00	3.00	3.13
Compact, Light-Weight, Single-Phase, Liquid-Cooled Cold Plate	Sreekant Narumanchi (National Renewable Energy Laboratory)	3-48	3.20	2.80	2.80	3.20	2.95
Next Generation Inverter	Greg Smith (General Motors, Advanced Technology Center)	3-51	3.40	4.00	4.00	3.25	3.76
Air-Cooled Traction Drive Inverter	Madhu Chinthavali (Oak Ridge National Laboratory)	3-53	3.40	3.40	3.40	3.20	3.38
Alnico and Ferrite Hybrid Excitation Electric Machines	John Miller (Oak Ridge National Laboratory)	3-56	2.80	3.00	3.00	3.00	2.95
Unique Lanthanide-Free Motor Construction	Jon Lutz (UQM Technologies)	3-58	3.25	3.25	3.25	2.50	3.16
Alternative High-Performance Motors with Non-Rare Earth Materials	Ayman El-Refaie (General Electric Global)	3-60	2.75	3.25	3.25	2.50	3.03
† Smart Integrated Power Module	Leon Tolbert (Oak Ridge National Laboratory)	3-62	3.33	3.00	3.00	3.33	3.13
† Integrated Module Heat Exchanger	Kevin Bennion (National Renewable Energy Laboratory)	3-64	3.50	3.00	3.00	3.00	3.13
† US Electric Drive Manufacturing Center	Judith Gieseking (General Motors)	3-66	3.33	2.33	2.33	3.33	2.71
† Low-Cost U.S. Manufacturing of Power Electronics for Electric Drive Vehicles	Greg Grant (Delphi Corporation)	3-68	3.50	3.00	3.00	3.25	3.16
† Electric Drive Component Manufacturing Facilities	Richard Thies (Allison Transmission, Inc.)	3-70	3.67	3.67	3.67	3.33	3.63

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
† ‡ U.S. Based HEV and PHEV Transaxle Program	Kevin Poet (Ford Motor Company)	3-72	3.50	2.00	2.00	3.25	2.53
† ‡ Providing Vehicle OEMs Flexible Scale to Accelerate Adoption of Electric Drive Vehicles	JJ Shives (Remy, Inc.)	3-73	3.33	3.33	3.33	3.33	3.33
† ‡ Electric Drive Component Manufacturing Facilities	Luke Bokas (UQM Technologies)	3-75	2.67	2.00	2.00	3.00	2.29
† ‡ Electric Drive Component Manufacturing Facilities: Magna E-Car Systems of America, Inc.	Brian Peaslee (Magna E-Car Systems of America, Inc.)	3-77	3.33	2.00	2.00	3.00	2.46
† ‡ DC Bus Capacitor Manufacturing Facility for Electric Drive Vehicles	Johnny Boan (Kemet)	3-79	3.00	2.67	2.67	2.67	2.75
† ‡ Construction, Qualification, and Low Rate Production Start-up of a DC Bus Capacitor High Volume Manufacturing Facility with Capacity to Support 100,000 Electric Drive Vehicles	Ed Sawyer (SB Electronics)	3-81	3.00	3.00	3.00	3.00	3.00
† ‡ Electric Drive Semiconductor Manufacturing (EDSM) Center	Duane Prusia (Powerex, Inc.)	3-83	3.33	2.67	2.67	3.00	2.88
Overall Average			3.30	3.04	3.04	3.11	3.11

† denotes poster presentations

‡ denotes ARRA funded projects

A Segmented Drive Inverter Topology with a Small DC Bus Capacitor: Gui-Jia Su (Oak Ridge National Laboratory) – ape004



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All of the reviewer comments to this question were favorable. One person stated that the project is focused on meeting the goal of reaching the 2015 cost, 2020 cost, volume, and weight targets. Meeting those targets will help enable the market for electric-drive vehicles (EDV) which will in turn reduce our dependence on foreign oil. Another person asserted that the project is appropriate due to the possibility of improved efficiency for hybrid-electric vehicles (HEV), plug-in hybrid-electric vehicles (PHEV), and electric-vehicle (EV) usage which will increase the viability of these vehicles. The implementation shown is probably more indicative of an EV usage rather than a multi-motor hybrid but the concepts are still viable. The final evaluator had detailed comments, noting that the project attempts to solve capacitor problems encountered in the development of inverters for electric vehicles. The reviewer expanded that capacitor cost and capacitor heating are significant roadblocks to meeting the U.S. Department of Energy (DOE) cost targets for EV inverters. This reviewer added that this work uses interleaved and segmented power electronics architecture to reduce capacitor ripple current, thus reducing the size of the capacitor required and thus the cost and volume of the capacitors.

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

Responses to this question were mixed. One person stated that collaboration of other Oak Ridge National Laboratory (ORNL) and industry groups is good. Another person, however, expressed that the details of the approach are not clear because the design is under patent review. One person commented that the results show very good results, but the presenter did not explain why. This person felt that it was not clear that increasing the number of switches (even if the silicon area stays the same) and the number of connections to the motor will reduce cost. The reviewer concluded by observing that the arrangement of separate caps for each switch is good. One reviewer expressed that that they are not an expert in inverters and motors, so they felt that it was difficult to assess how well the technical barriers were assessed and whether there are better approaches, but the results thus far are impressive. The final reviewer had detailed comments, stating that the segmented inverter approach relies on a segmented motor, and to say the segmented inverter is approaching the 2015 or 2020 targets, does not address the system question related to the targets. The reviewer asked whether the segmented motor (which is larger, heavier and more costly than the conventional design) offsets the gains of the segmented inverter. The reviewer suggested that perhaps the motor and inverter presentations should have been scheduled adjacent to each other, and the system gains summarized. Otherwise, a stand-alone presentation discussing the system thinking that showed the tradeoffs of this approach could have been presented.

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

One commenter pointed out that the first prototype 55 kilowatt (kW) inverter resulted in dramatic reductions in capacitor, battery, and motor ripple currents, which permitted a 60% decrease in direct current (DC) link capacitor size. Another person noted that the “Design, build and test....” activity from the Project Objectives is progressing very well, but observed that the details of the design are not clear. One project evaluator was concerned that the extra motor windings required by this architecture may possibly increase the cost/weight of the motor. Another commenter asserted that the goal of eliminating the capacitor hurdle for high-temperature operation was not directly addressed; smaller size and lower ripple caps were addressed but not the high-temperature. One reviewer reiterated comments nearly verbatim to the previous question, stating that this segmented inverter approach relies on a segmented motor, and to say the segmented inverter is approaching the 2015 or 2020 targets does not address the system question related to the targets. The reviewer asked whether the segmented motor (larger, heavier and more costly than the conventional design) offsets the gains of the segmented inverter. The reviewer suggested that perhaps the motor and inverter presentations should have been scheduled adjacent to each other, and the system gains summarized. Otherwise, a stand-alone presentation showing the gains of this approach could have been presented. Another commenter pointed out that the results indicate that the concept is working, however, further data relative to pressure drop and flow rate for the heat sink is required as well as a cost analysis of the total cost of the switches versus the tradition inverter. The expert added that a comparison of the motor cost impact for the segmented approach is needed. The final expert mentioned that project addresses the goal of reaching the 2015 cost, and 2020 cost, volume, and weight targets. The reviewer felt that the researchers appear to be making progress toward the targets on the prototype; however, as pointed out in the presentation, integrating the inverter into the motor (which was not described in the presentation) needs to include vibration and thermal modeling. The reviewer added that the thermal modeling needs to include drive cycles and further asked what the ambient environment is for this inverter packaged on your motor. The reviewer posed two other questions for the researchers’ consideration. Specifically, the reviewer would like to know whether the researchers can comment on other components ratings required to survive in the environment. Additionally, the reviewer would like to know if the researchers can also perform electromagnetic interference (EMI) emission testing on the completed assembly.

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

Reactions to this question were mixed. One reviewer felt that the collaboration was adequate for the level of funding and that the use of the in-house ORNL packaging group reduces cost and lead-time. Another person observed that using automotive industry suppliers are a good choice for providing parts to prove the concept. The reviewer added that capacitors are interesting looking, but asked if the vibration environment has been considered and specified when selecting parts. One evaluator felt that it was not clear how the various switch manufacturers or capacitor suppliers were involved in the design. This person asserted that collaboration needs to include input from the suppliers, not just from the component suppliers/developers. The final reviewer would like to know why 1,200-volt devices are needed for this inverter (mentioned on Slide 12).

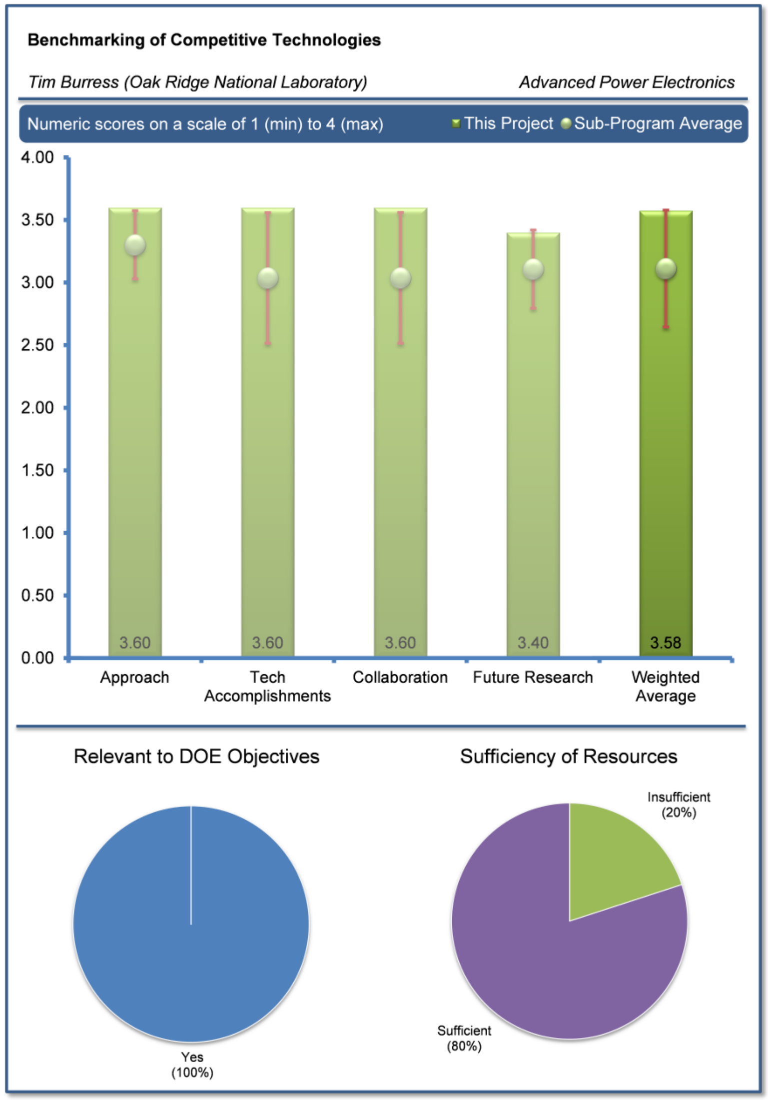
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Responses to this question were generally positive. One person simply stated that the researchers have used a great approach and that the updates should be based on results. Another reviewer felt the plans were adequate for this stage of program, adding that the plans include assembling and testing of the final, refined prototype. One commenter described that the future plans include building and testing a second prototype to be integrated with the motor including thermal and vibration modeling/vibration with a focus on targets is the next logical step. One final reviewer reiterated detailed comments to two previous questions, nearly verbatim, stating that the segmented inverter approach relies on a segmented motor, and to say the segmented inverter is approaching the 2015 or 2020 targets does not address the system question related to the targets. The reviewer asked whether the segmented motor (larger, heavier and more costly than the conventional design) offsets the gains of the segmented inverter. The reviewer again suggested that perhaps the motor and inverter presentations should have been scheduled adjacent to each other, and the system gains summarized. Otherwise, a stand-alone presentation discussing the system thinking that showed the tradeoffs of this approach could have been presented.

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

Three reviewers responded to this question, one stating funding was insufficient, with the remaining two stating it was sufficient. One person commented that the researchers had made good choices selecting partners. The other reviewer to comment observed that the project is at the point it should be based on the resources versus the plan.

Benchmarking of Competitive Technologies: Tim Burress (Oak Ridge National Laboratory) – ape006



Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Responses to this question were positive. One person simply stated this was a good project. Another reviewer commented that benchmarking work should always be a funded activity since it defines the work that has gone into released products (representing many thousands of man-hours). One expert expressed that this work provides a method of understanding the state-of-the-art in production vehicles. This understanding then allows for an understanding of strengths and weaknesses of current production technology and allows for better decisions to be made for research and development. Another evaluator noted that, though not explicatively stated, competitive assessment allows for a detailed look at what is current in the marketplace. The reviewer added that this detailed look develops a set of technical metrics for comparisons to future designs which helps to improve those future designs to meet the DOE Vehicle Technologies Program (VTP) 2015 and 2020 targets, which in-turn helps to lower the cost of EDVs and reduce our dependence on foreign oil. The final reviewer affirmed that this project is one of the best investments of DOE funding; the information provides invaluable guideline for other projects to benchmark their proposed technologies. It also helps DOE to decide funding strategy to achieve the final goal.

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

Reactions to this question were mixed. One person stated that it appears the barriers have been overcome. Another commenter stated that the systems chosen are appropriate and leading edge in the market; the work presented improves every year, getting to the key attributes of the benchmarked systems. Another reviewer, however, remarked that they would like to see some cost analysis and comparisons. The final evaluator pointed out two issue-solution pairings from the presenter’s barrier slide and critical assumptions. The first identified issue was integrating ORNL-developed controller with original equipment manufacturer (OEM) components, and the corresponding solution was to take measures similar to that of previous years wherein troubleshooting, circuit analysis, and literature research is used to identify appropriate technique to interface and communicate with OEM equipment. The second identified issue was adapting a non-standard motor assembly to test cell, and the corresponding solution was to closely inspect functionality of subsystem to ensure any modifications will not aid or hinder operation in comparison with that of typical operation within the vehicle.

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

One person simply stated that the research team seems to have met the project objective. The reviewer added that they liked the summary comparison on Slide 30. One person commented that the project does not directly achieve the targets, but it focuses the efforts and also allows potential issues for reliability and durability to be identified. One reviewer had several comments in response to Slide 3. This reviewer mentioned reveal compositions and characteristics of key components; trade-offs (e.g., magnet strength versus coercivity); general cost analysis; compare results with other HEV technologies; and identify new areas of interest. This reviewer suggested that the researchers evaluate the advantages and disadvantages of design changes; for example, evaluate the complexity of the Lexus LS 600h double-sided cooling system. This expert acknowledged that the researchers have done many teardowns and analysis, which were all done very well, but the reviewer asked whether there are summary slides comparing all the systems that summarizes what enables better power density, higher peak specific power or lower cost from system to system. This commenter asked if it is better thermal, better magnets, smaller caps, better control algorithms, new materials, etc. Additionally, when the investigators evaluate bulk capacitors, this reviewer would like to know if the investigators can also do an impedance plot and measure the bulk cap inductance at the connection points. The final reviewer acknowledged that important results from the Hyundai Sonata were presented, from inverter components and suppliers to the key attributes of the motor. This reviewer questions whether the HSG has an 8-pole rotor; the slot count and resolver lobe count would lead this reviewer to think it is either a six- or 12-pole rotor. The reviewer also wondered if the Nissan Leaf motor really uses 3/0 alternating current (AC) wire gauge or if it uses 3 American wire gauge (AWG) gauge (i.e., 3/0 is substantially larger then 1/0 AWG). The reviewer added that even if these are mistakes (which they may not be), that they always look forward to the new reports and find them very useful in guiding U.S. development work.

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

Comments to this question were primarily positive. One person commented that the collaborations were heavy on government agencies, but that this is probably required considering the project scope. Another reviewer suggested that it would be useful to have an industry partner that may notice different attributes as part of the teardown and testing activities. The final evaluator commented that it appears everyone is working together to provide the appropriate information.

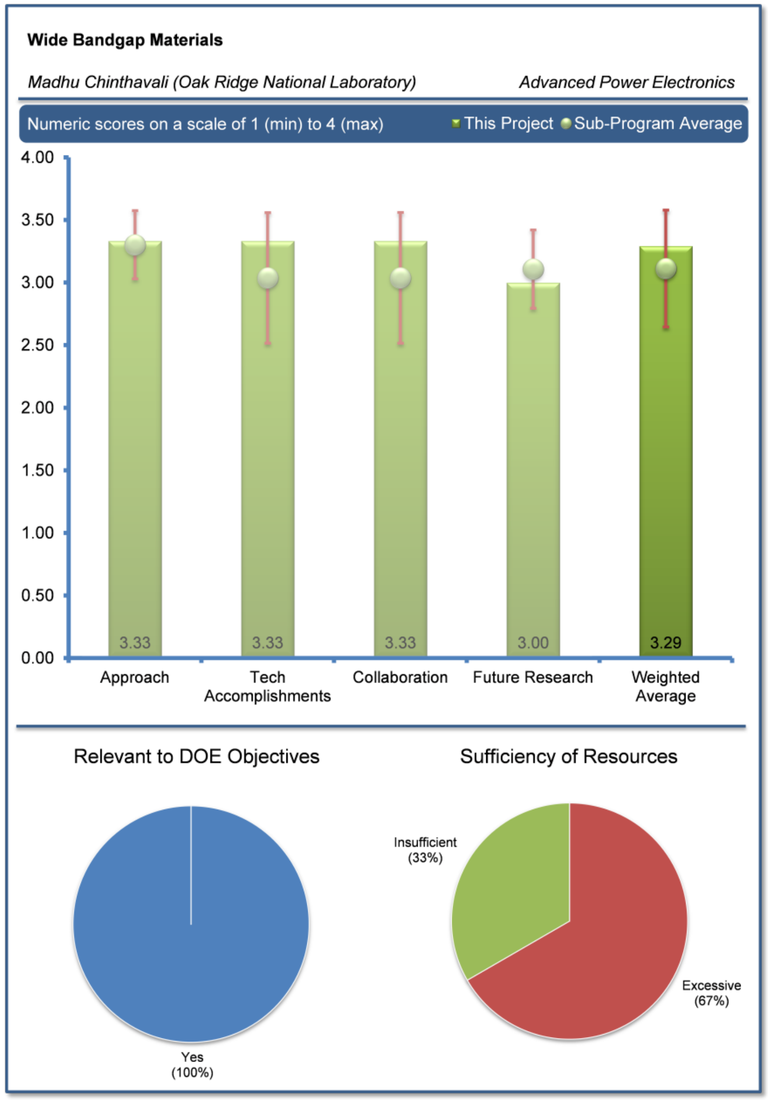
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were mixed. Some reviewers answered the question, while others simply provided related thoughts. One reviewer felt that it was not really clear what the future work will be based on slides. Another person commented that competitive assessment seems to be a never ending program; this shows the market is still changing and designs are still evolving. This reviewer observed that many of the DC taxis are hybrid vehicles. The reviewer noticed that taxi ridden in had approximately 120,000 miles on the odometer, which spawned the thought that it may be interesting to do a teardown analysis of one of these high-mileage hybrid vehicles. This reviewer added that hopefully, the taxi company can also provide the service history. One expert asserted that a detailed analysis of the Nissan Leaf system is an excellent use of time spent on this program. Another commenter stated that the speed of work done is very important for its relevance.

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

Reactions to this question were mixed, but four of the five reviewers to comment stated funding was sufficient, with the remaining person stating it was insufficient. **One reviewer provided an additional comment stating that the r**esources are applied to the right tasks, but suggested a larger budget and more resources due to the number of new vehicle offerings coming into the market. The other reviewer comment asked whether having more resources would get the job done sooner.

Wide Bandgap Materials: Madhu Chinthavali (Oak Ridge National Laboratory) – ape007



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were positive. One person commented wide bandgap (WBG) semiconductors, silicon carbide in particular, are highly relevant to the future of automotive traction drive systems. Another person commented that the project is focused on possible efficiency gains possible with WBG power devices, particularly by reducing switching losses. The final reviewer had detailed comments, stating that the device characterization activity has intrinsic value in providing a central repository of emerging WBG material-based power switching and rectifying devices. The reviewer pointed out that the effort has evolved to the point that it has become a highly valuable national asset providing unbiased evaluation of these devices. The move toward die level assessments has been very valuable and enables a better comparison. These material systems will provide significantly improved efficiency over Si insulated gate bipolar transistor (IGBT) technology and enable greater range per gallon of hybrid vehicle performance and improved range for plug-in electric vehicles (PEV).

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

The first reviewer to comment stated that die-level work is a large improvement. The reviewer would like to see capacitance (input primarily) measurement metrics normalized to a per amp or per cm^2 die area for all the device technologies represented. The reviewer suggested that a metric relating this capacitor to the measured switching losses as a figure-of-merit (FOM) may be also useful. The reviewer noted however that the typical on resistance capacitance metric may be sufficient and that the techniques used to accurately estimate junction temperature should also be included for information. The reviewer concluded by suggesting that the researchers include package thermal impedance (measured) to infrared (IR) measurements of the devices/die under characterization. The other reviewer to comment had detailed comments stating that acquiring parts and performing testing has become a global activity with many reports becoming publically available in the last year (an entire session was devoted to this topic at PCIM in Nuremberg, Germany last week). The same reviewer added that the technical approach is similar to standard methods with the laudable addition of building a PSPICE model for one of the metal-oxide semiconductor field-effect transistors (MOSFET), which is innovative. However, the reviewer added, the effort seems pretty focused on the SiC MOSFET with little justification in terms of the project's stated objective (evaluating wide bandgaps for commercial viability in the automotive industry). In this respect, there are probably better competitive analyses going on in industry and academia and now being reported at different open-source forums, like APEC and PCIM. The reviewer suggested that perhaps ORNL could consult those researchers or their publications for data and methods to address a broader selection of wide bandgap technology.

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

One reviewer commented that the large current MOSFET data and characterization results were very good. The reviewer felt that the inclusion of threshold voltage as a function of temperature was also very relevant for these devices. The only other person to comment remarked that the results are consistent with the methods employed and similar to other reports. The reviewer noted that there seems to be a bias toward the MOSFET which is not found in the more objective open-source reports that are now widely available. The reviewer was concerned about the resistive loading for the dynamic testing; this is not particularly relevant for automotive traction drives and virtually unused by the larger community doing competitive research on power semiconductor technology.

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

Reactions to this question were generally positive. One person noted that there has been excellent inclusion of all the relevant WBG device producers, even those not production viable but with device designs of future interest. The other person to comment stated that the project is pretty much an internal effort with varying degrees of collaboration with technology providers.

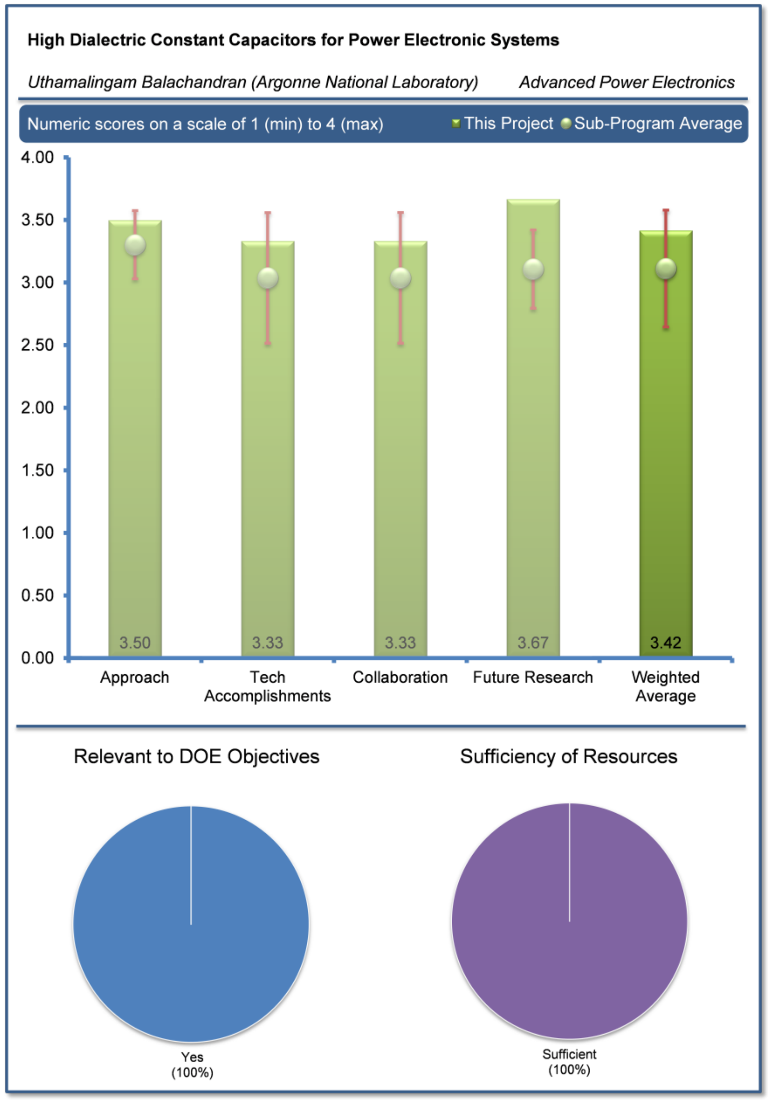
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One evaluator observed that this project is appropriately focused on a continued execution of these characterization activities as devices evolve and designs mature and scale with current rating. The other commenter described that the primary plan seems to be to await the latest developments in SiC MOSFETs and then test, which possibly misses a more diverse technology competition going on in the commercial market place. The reviewer offered that one explanation for this is the reliance on relationships with product vendors, some of which are cultivated by those vendors. The reviewer noticed that Rohm is not on the researchers' collaboration list even though within the last two years Rohm has begun moving the market in SiC MOSFETs faster than Cree.

Question 6: 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 felt resources were insufficient, and two people felt the resources were excessive. One reviewer commented that the project needs more funding to test more devices. Another person mentioned that excellent competitive studies are proliferating and suggested that some aspects of this project could probably be achieved by studying third party reports. This reviewer suggested that although the vendor survey was bravely conducted, acquiring data reports from more experienced market players (e.g., Yole and Darnell) may have offered cost savings.

High Dielectric Constant Capacitors for Power Electronic Systems: Uthamalingam Balachandran (Argonne National Laboratory) – ape008



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person asserted that the project supports the Advanced Power Electronics and Electric Motors (APEEM) program goals for a DC bus capacitor to operate at higher temperatures (140 ºC at 450 V), and also addresses the challenges to reduce cost, weight, and volume of capacitors in inverters. Another reviewer agreed that pursuing a ceramic-based DC Link capacitor with goal to reach two-inch cube. This person also stated the project's cost target range is $30 to $50 which they pointed out meets DOE goals of 1) cost focus and 2) good understanding of targets and goals. One commenter remarked that capacitors are a necessary component within the inverter, and as such, need to be improved. The reviewer added that this project addresses the need to reduce the size of the component while maintaining or improving the desirable attributes of the device. Another person also asserted that DC link capacitors are critical component in power inverters. This reviewer also mentioned that capacitors with high thermal stability can address the thermal management challenges in HEV power inverters and that it is known that ceramic capacitors have higher thermal stability than commercial polypropylene film capacitors. The final reviewer had detailed comments, explaining that reducing the cost of EV is a vital step toward consumer acceptance and use. A less expensive and lighter weight DC-link capacitor will reduce the inverter cost in all electric vehicles and hybrids, but it is only one of many technical and manufacturing steps needed to slash EV costs by about half to attain consumer affordability. Attaining that goal will create the need for an EV charging infrastructure that supports higher consumption rates of electricity. That electrical demand also creates the additional problems of insufficient grid capacity and much higher outputs from coal and natural gas fired power plants.

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

Comments for this question were generally positive. One person simply stated that the approach was very methodical. Another reviewer had similar thoughts, stating that the approach was methodical and systematic and that the goals of the DOE for the DC Link Capacitor were all met or exceeded based on the trajectory of the project. One commenter felt that the approach and strategy are clearly focused on the research and development of the next generation capacitor with high-dielectric-constant, high-temperature ceramic films on base-metal foils, that are either stacked on or embedded directly into printed wire boards, and addresses the technical barriers in an innovative manner. One evaluator remarked that the mitigation of electrical breakdown in the PLZT layer by an additional layer of TiO_2 is innovative and effective. The reviewer thought that this advancement makes a significant step forward in turning a laboratory activity into a functioning capacitor. Simultaneously, the reviewer felt that it is a step backward from producing a commercial product because it adds another expensive process step (TiO_2 sputtering by RF) to an already expensive process. Additionally, DC-link capacitors for EV will always be a relatively small market for new material process techniques, so the reviewer asked whether there is another, much larger-market use for a PLZT-TiO_2 sandwich that will stimulate private-sector investment in all this work. Another expert noted that the ceramic compositions are designed and optimized to combine high thermal stability, high dielectric constant, and low dielectric loss. However, the reviewer felt it was unclear from the presentation what the advantages are for the film on foil design as compared with traditional multilayer ceramic capacitors (MLCC). The final reviewer affirmed that the work on the capacitor is great and relevant to solving the issue of reducing the size of the bulk capacitor, however the reviewer did not think that the typical inverter will mount the bulk capacitor within a printed wiring board (PWB) as described – most designs try to keep high currents off of the PWB board. The reviewer added that there has been some work done relative to thick copper PWBs which might be appropriate. The reviewer concluded by noting that packages more conducive to mounting on bus bars should be investigated as well as how this technology will help reduce the temperature limit of the cap.

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

Reactions to this question were generally positive. One expert simply stated that good progress has been made. One reviewer highlighted the outstanding achievements and accomplishments in this project including patents, publications, awards, and technical results. Argonne National Laboratory's (ANL) film-on-foil has the potential to be the next generation capacitor to demonstrate high dielectric constant at high voltages, exhibit high-temperature capability, and meet volumetric and cost targets. Another project evaluator agreed that progress on the capacitor approach is very good and shows promise; this technology has a very good chance of being successful but needs to be packaged in a manner that will allow inverters to be built. Another evaluator commented that the team has successfully improved the dielectric breakdown strength and reduced the dielectric loss by introducing TiO_2 layer. According to this reviewer, 10-layer capacitors were fabricated and tested and that systematic tests were performed to evaluate the effect of sample diameter and temperature on the breakdown strength and lifetime. This reviewer felt that it seems that the team understands the challenges associated with scaling-up the capacitor from a mm size patch to large size 1,000 μF capacitors, although the test results show the significant drop in performance even at 20 mm size capacitor. The improvement in dielectric breakdown strength by using segmented design is quite interesting, as it is widely used in PP film capacitors. This expert suggested that as the dielectric layer of PLZT will be 3-5 μm for the 450 V DC link capacitors, spin coating is not the best process to produce capacitors; traditional tape casting and MLCC are more practical. Another reviewer had scale-up concerns, stating that the performance of the small test capacitor was acceptable, but that the challenge will be to scale it up to a larger size. The reviewer concluded by mentioning that the innovative sputtering of the titanate had a major impact on breakdown voltage. One reviewer felt that the project is making good technical progress, within the confines of the contract and the stated problem; progress toward larger DOE goals in the energy marketplace, however, is not so clear.

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

Comments for this question were generally positive. One person simply stated that there was a good set of partners and suppliers. Another reviewer pointed out that the researchers are working with Penn State University, Delphi, Sandia National Laboratories (SNL), and ORNL. Another person had similar comments, acknowledging that the collaboration with Penn State University, SNL, and Delphi is very good. This expert also mentioned that test results have been verified by Delphi, the potential customers. The reviewer suggested that since the technology is related to ceramic capacitors, that it would be great if there is an industrial partner who is producing commercial ceramic capacitors (e.g. KEMET, AVX, or Murata) on the team. The reviewer suggested that these production capacitors can help the team to scale-up the capacitor manufacturing using their established production process and tools. One evaluator commented that the level of R&D collaboration appropriate, but also recommended expanding industry collaboration and coordination in order to adequately address manufacturing and end-user requirements. Another commenter observed that the results show full participation from the team which is appropriate for the where the project is at this time; test data correlates which is good.

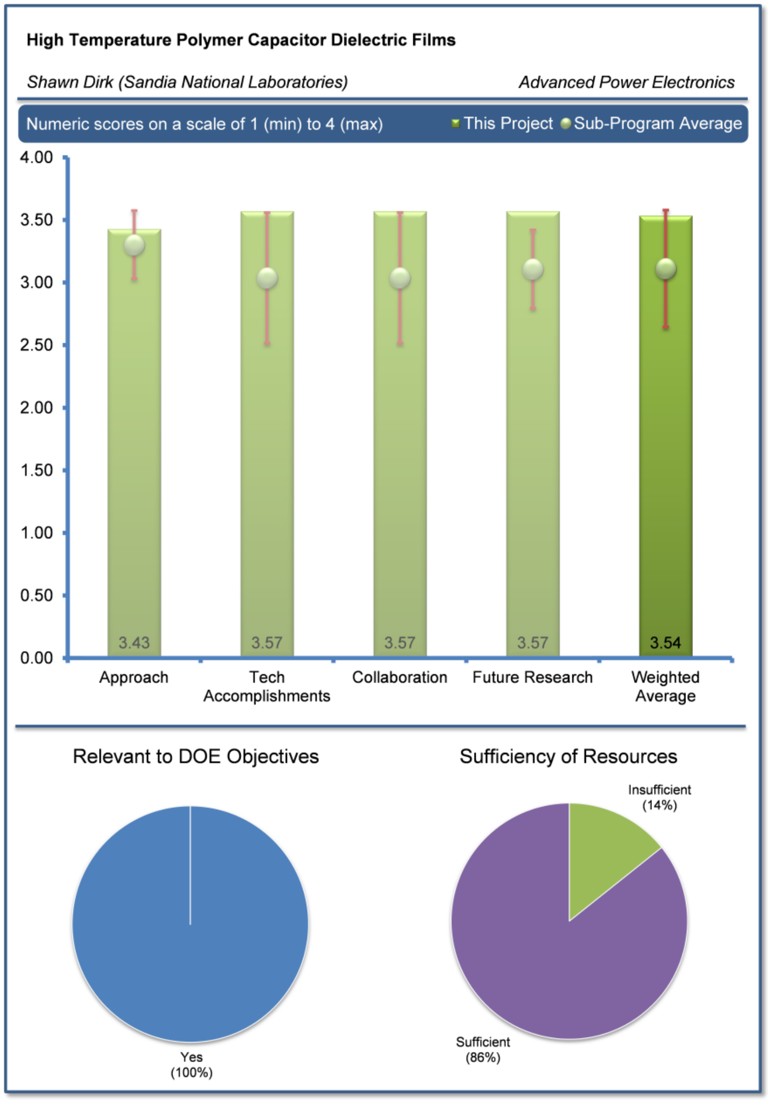
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One evaluator commented that the researchers presented a very detailed path forward to extrapolate the research and lead to prototype at 1,000 μF, 450V which is the size needed in automotive applications. This reviewer reinforced that industry is looking for a low-cost, volumetrically efficient, high-temperature reliable DC Link capacitor. Another person agreed, simply stating that they like the plan. One expert commented that the future work is planned in a systematic order and achievable; emphasis to advance proven laboratory scale and overcome technological barriers is clearly defined, and with alternate pathways. One reviewer commented that the presented plans indicate a logical plan towards meeting the goal. The reviewer felt that the 10 μF capacitor is reasonable for filtering use in a PWB and should provide meaningful data in terms of achieving the goal of 1000 μF bulk cap. The reviewer concluded by suggesting that the researchers may want to include a separate package for mounting on a PWB. Another evaluator reinforced that the DOE VTP goal is to produce large size 1,000 μF capacitors with 450 V rating which can be directly tested in a power inverter, adding that the team has been working on this goal in the last two year. The evaluator said that it will be great to see a large size capacitor delivered to Delphi and tested in a real power inverter with ambient temperature of 140 ºC. This reviewer suggested that engineering and production scale-up should be the single priority for the next year. Another person stated that the future work proposes experimental activities that are sensitive to important issues, including the following: sub-scale capacitor at full voltage; process cost reductions; graceful failure with advanced electrode design; and multi-layer construction. This reviewer commented that unfortunately, the future work provides no criteria for success or failure. They felt that the research simply cascades on into the future to discover the next problem and apply the next fix. The reviewer concluded by asking when will the work be judged as a practical or impractical solution to power conversion in EVs.

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

All six reviewers to comment felt that the resources were sufficient. Several reviewers provided additional comments. One person agreed that the project appears to have adequate resources established and defined in order to achieve stated milestones and Go/No-Go decisions. Another commentator asserted that the team, together with their collaborators, has all the material and test expertise and facilities. The same person suggested that the researchers may need help from MLCC manufacturers on the fabrication of the 1,000 μF capacitor bank.

High Temperature Polymer Capacitor Dielectric Films: Shawn Dirk (Sandia National Laboratories) – ape009



Reviewer Sample Size

This project was reviewed by seven reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were generally positive, with some tempering reactions regarding the relative importance of the results of this project. One person agreed that the project supports the overall DOE goals to reduce cost, weight, and volume of capacitors, and simultaneously increase operational temperature (greater than 140 ºC) through the development of inexpensive high-temperature polymeric material systems and nanofillers. Another evaluator agreed that this is very relevant work for reducing cost and size of bulk capacitors required for traction motor inverters, required by electric and hybrid-electric vehicles that can substantially reduce the requirement for petroleum by personal and commercial vehicles. One person simply commented that the project addresses the bus capacitor issue with appropriate goals. Another evaluator agreed that the project is relevant because the industry is looking for a low-cost, volumetrically efficient, high-temperature reliable DC Link capacitor. Another person had similar comments noting that a low-cost, high-temperature film would be a very important breakthrough of the DC Link capacitor manufacturers. One person agreed that the project is relevant because widespread adoption of HEVs and EVs will reduce the use of petroleum in the United States, and high-temperature DC link capacitors will facilitate the reduction of the HEV and EV cost. The final reviewer cautioned that reducing inverter weight and cost is a small step toward reducing EV costs, which moves closer to widespread consumer acceptance and use. The reviewer continued that this small step seems even smaller when one considers that EVs must slash their current cost by about half to foster enough consumer interest to affect petroleum consumption. Additionally, consumer interest also hinges on the cost of a recharge infrastructure to support EV ownership and practical operating convenience.

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

One reviewer observed that the approach is focused on the development of a high-temperature extrudable film for a DC Link Capacitor and obstacles, such as the hydrogenation, were overcome as they presented themselves. Another person simply stated that the project uses a good approach. A third expert observed that the team has been working on the optimization of the polymer composition to address issues related to future large-scale film production. The design of the polymer chemistry is consistent with theory and the results are consistent. One expert pointed out that as found in many of previous development efforts, it is very challenging to balance the dielectric constant, dielectric loss, and thermal stability in polymeric materials; high dielectric constant will almost always lead to high dielectric loss. adding nanoparticles to polymers may not work as found in many other projects.

The reviewer described that high loading nanoparticles (greater than 30%) is necessary to achieve enhancement in K, but it will reduce dielectric breakdown strength by over 50%. Nanoparticles will also increase the cost of the film. From the standpoint of final device cost and performance, a low-cost high-temperature polymer and a low-cost film production process may be the final solution. A fourth project evaluator remarked that the project approach is novel in it uses inexpensive monomers/fillers to develop a high-temperature polymer dielectrics capable of forming very thin films, and controlling polymer composition and molecular weight. This reviewer added that the project demonstrates intense and aligned work with industry to remove technical barriers. Another expert cautioned that it appears that the benefits of this work will hinge upon a new nano-particle filler material that is yet to be defined. The reviewer added that the work appears well-suited to uncover a polymer that can improve the temperature capability, as needed, but it is not yet clear that the work will lead to a capacitor that can reduce size and cost, as also needed. Regardless, this person felt that there is important learning taking place here for the U.S. capacitor knowledge base altogether, to move beyond the limitations of the conventional BOPP film capacitors. Another commenter also agreed that the approach is reasonable and methodical and limited to the characterizations of the test film using small laboratory-grade capacitors in foil-film packages. This person thought that the approach is a great start, but criticized that it does not address the three issues that must be answered for a new film capacitor to be commercially viable: whether it can be metalized; whether clear defects exist; and whether it will accept an end-spray electrode. The reviewer did not see any small-scale test to indicate a yes to all three; without it, the film is not ready for commercial investment. The final evaluator acknowledged that the work performed to date is very good and relevant, but no plans were mentioned relative to packaging. This person asserted that to achieve the 150 ºC operating temperature the package will have a big impact. The reviewer also suggested that working with industry suppliers for the film and construction method is very appropriate at this point and that the researchers might also want to investigate methods of removing heat from the inner layers without impacting performance.

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

Reviewers had positive input about progress. One reviewer affirmed that showing a pathway to extremely low-cost and high film quantity is the next big step. This commenter pointed out that the following achievements are great: 1) producing a high-temperature thermoplastic by ROMP, 2) defeating polymer cross-linking by hydrogenation, 3) increasing dielectric energy density by nanoparticles, and 4) producing a method to control nanoparticle distributions. A second evaluator noted that good progress has been made in a lab environment and thinks that it will be interesting to see what ECI can do with this material in a manufacturing environment. Another expert remarked that the research team has been able to build small test wound and stacked capacitors, but that they need to expand to full DC Link size. The evaluator added that the researchers have an approach to deal with the dispersion of the nanoparticles. The fourth evaluator remarked that the project demonstrates excellent progress and results towards objectives and has appropriately transitioned the development of high-temperature polymer films from a laboratory to a pilot scale operation. This reviewer recommended continuing work, problem solving, and emphasis with developing a polymer casting or extrusion process and efforts to reduce capacitor size with inexpensive nanofillers. One expert observed that good learnings have been made to date, particularly with respect to improving the temperature capability; however, it might be time to step back and compare the alternative materials for films, to address volume and cost, in addition to the needed higher temperature capability (as a surrogate for reliability/durability). Another project evaluator remarked that significant progress has been made and the new Commercially Available (CA) material looks promising and it appears that the team is following their development plan and making good progress. The final commenter offered that great efforts have been contributed to the pilot scale production of capacitor film using both solvent cast and melt extrusion. It is very impressive to learn that 3 μm thick film has been produced using extruder from Dr. Collin. The team has also tried to produce prototype capacitors using film/foil design and stacking design in the lab.

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

Reactions to this question were generally positive. One person acknowledged that the team has close collaboration with Penn State University, ANL, and ECI. The reviewer felt that Penn State provides very unique expertise on dielectric test and ECI is very valuable on capacitor film production and capacitor winding. The reviewer also remarked that the work with Dr. Collin is also very impressive, but added that to achieve the cost objective, the capacitor film MUST be produced using melt extrusion, not solvent casting. The reviewer concluded by suggesting that the team may need an expert in polymer dielectric materials. Another reviewer reiterated that the group is working with ANL, ECI, and Penn State University, while another person acknowledged the researchers have a good set of suppliers and partners. Another reviewer stated that the project has appropriate collaboration with laboratories and institutions. This reviewer felt that overall the project demonstrates a sense of urgency, intense coordination, and focused problem solving with industry to manufacture and commercialize polymer thin-film capacitors. Another expert observed that the researchers are working well with other National Labs, universities and industry, to leverage the full knowledge base available. The final person commented that the results show the impact of working with the commercial partners and that feedback of what the partners see as roadblocks and strengths of the approach would be beneficial assuming that it is not proprietary.

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

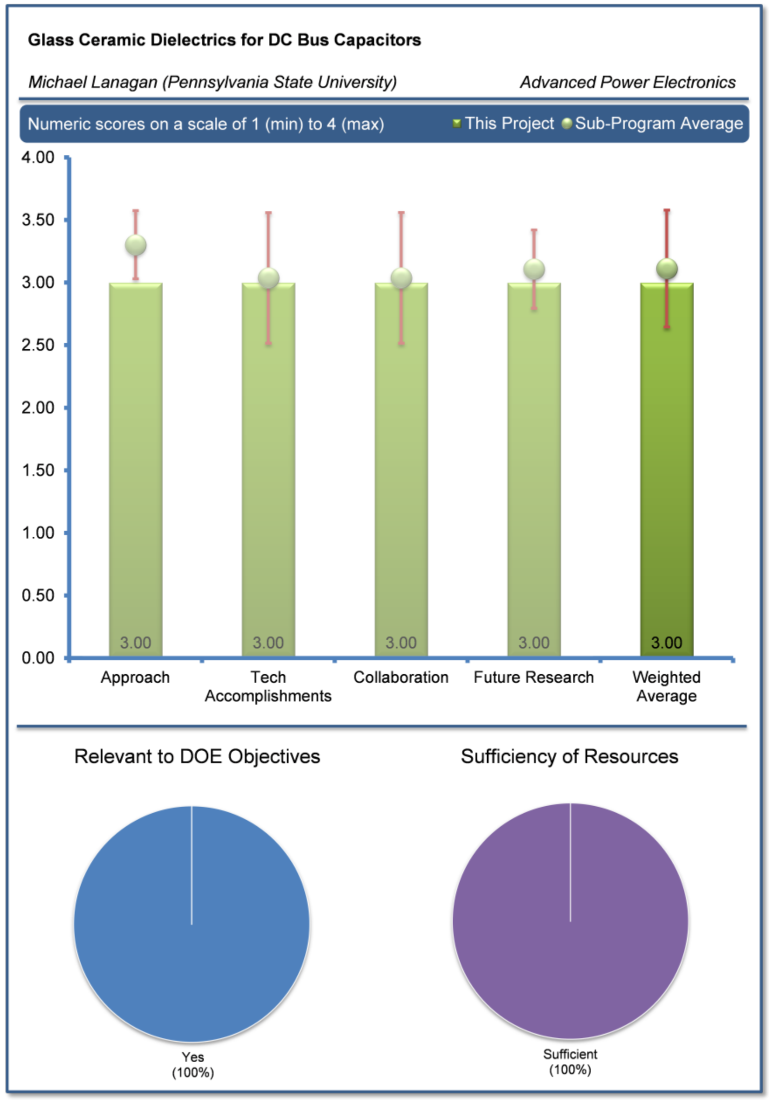
One person simply stated that the researchers had presented a good plan to move forward. Another person stated that the path forward was clearly stated dealing with nanoparticles and dispersion, extruding, investigation of alternate commercially available material, etc.

A third project evaluator pointed out that the future work builds on past progress and effectively plans for alternate development and pathways, by considering the transition of polymer film technology to industry (fabrication of capacitors with film produced from hydrogenated polymer) and utilizing larger scale experiments with nanoparticle loaded materials. One person detailed that they saw a dual approach to further work where the custom SNL high-temperature film is developed alongside the CA high-temperature film already in use as a packaging material; both must satisfy the temperature and energy-density goals of the R&D contract and both must be capable as commercial capacitor films. The reviewer continued stating that in the world of plastic material processing, the capacitor market is very small and the cost of film materials cannot be supported on EV needs alone. The reviewer noted that the big difference between the two film candidates are that CA is already supported by an adjacent industry and the SNL custom film is not. The reviewer concluded statements by asking whether SNL film has another huge, terrific use beyond capacitors that will drive down the final cost. One expert remarked that the plan is logical but needs a decision point as to when a selection will be made as to the best approach, not sure that all of the approaches need to be continued once the capacitors have been built and tested. Another person felt that the future plans could become, or be made, clearer when more info is made available, or developed, on the nanofill material, as well as reviewing the multiple advantages being pursued (cost, size for weight/volume, temperature capability for reliability/durability), compared to conventional baseline biaxially oriented polypropylene (BOPP) capacitors. The final person noted that the project will be completed by end of fiscal year (FY) 2012 and future work may use existing commercial high-temperature polymers such as polyetherimide, polycarbonate, or others considering the cost target for the film capacitors.

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

Reactions to this question were mixed, with six reviewers stating it is sufficient and one stating it is insufficient. One reviewer explained that the resources are sufficient since the researchers are getting an extruder. Another person commented that the project appears to have adequate resources to achieve milestones and complete work by September 2012. Another commenter expressed that the project team does have the resources to complete the project in a timely manner. The researchers have also been actively looking for new resources such as Dr. Collin during the project. The final person commented that it is somewhat unclear whether the resources are sufficient or not, because it is unclear if the CA polymer material being worked is potentially advantaging or not, compared to others. It might be or it might not be, but that it is just not clear at this point. The reviewer clarified that apparently this is not clear, due to the need to address IP protection, so ultimately the better answer was that they cannot determine this.

Glass Ceramic Dielectrics for DC Bus Capacitors: Michael Lanagan (Pennsylvania State University) – ape010



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer simply commented that they just like the idea of flexible glass as a potential dielectric material for capacitors. Another person described that the project is an investigation into utilizing ultra-thin, low sodium glass from the liquid crystal display (LCD) panel industry for the construction of DC Link Capacitors to address higher temperature operation.

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

One reviewer commented that the researchers proved the concept by constructing a small simple capacitor. The reviewer cautioned that significant development will be needed to migrate this into a platform usable in a HEV inverter. Another expert expressed that they would like to see thinner material (5 µm or less) quicker. This reviewer would like to see more focus on cost, adding that for any of this stuff to be commercially viable it has to be a lower cost solution to current offerings. The reviewer added that the technology roadmap for any capacitor manufacturer is to build capacitors that offer more capacitance in a smaller package at a lower cost.

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

One person simply stated that good progress has been made to date. The only other person to comment noted that the researchers have demonstrated winding the thin glass coated with silver into a functional small capacitor and taking performance data. The evaluator described that the December 2012 goal is to wind another capacitor and test at greater than 1 kV and 140°C. This reviewer concluded their comments by stating that work also needs to be done related to self-healing by possible application of a polymer layer.

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

One evaluator acknowledged that the collaborators include a good mix of government laboratories, academia, and suppliers, but the reviewer would like to see some end-user exposure. The only other person to comment added details that the collaborators included ANL, SNL, ORNL CA, SPS, and NEG.

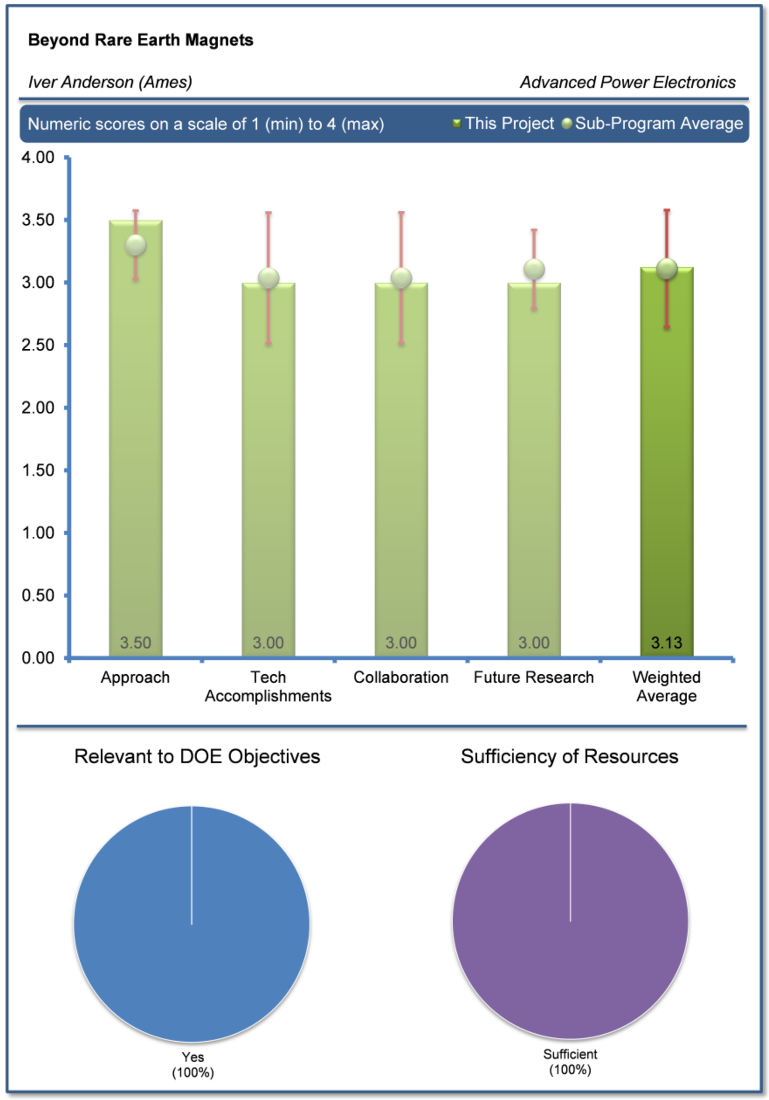
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One commenter described that the future research includes construction of a glass capacitor from thinner glass and characterizing it at voltages above 1 kV and 140 °C, which will move the technology closer to the goals of the HEV inverter industry needs. The final person to comment stated that the researchers have to get the material thinner and at a commercially viable cost.

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

All three reviewers to comment stated that the funding was sufficient. One reviewer, however, remarked that budget was not discussed. The only other reviewer comment agreed that the project has the right mix of resources, but that the plan could use some exposure to end-user (i.e., OEMs).

Beyond Rare Earth Magnets: Iver Anderson (Ames) – ape015



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All reviewers had positive comments to this question. One person stated that the project supports the objective of petroleum displacement by developing non rare-earth (RE) magnet materials; if successful these new materials would reduce the cost of permanent magnet (PM) machines, which would enable a faster market introduction of HEVs and EVs. Another person pointed out that the project is aimed at reducing cost and improve thermal management of electrical propulsion systems. One expert affirmed that elimination of RE elements from magnets would provide the high efficiency of interior permanent magnet (IPM) motors at lower cost and in sustainable supply; these all facilitate market adoption of HEVs and EVs. The last evaluator commented that the PM is an important component for electrical machines. The reviewer added that recent rare earth supply chain crisis made it more important for the clean technologies, so development of permanent magnets with less or no rare earth element is critical.

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

All reviewer comments to this question were positive. One expert stated that the approach is a good circular approach between modeling, synthesis and characterization. Another evaluator felt that that approach uses a very good combination of known principles and empirical data to guide direction of investigation. The reviewer also thought that the approach is a great use of multiple approaches and teams to improve chances for success. One person commented that the direct texturing strategy showed reasonable feasibility, but with limited potential. The reviewer acknowledged that development of rare earth free magnets is still at its early stage. The final reviewer had detailed comments, stating that the main goal of the project is the development of new permanent magnet materials with reduced cost and improved performance. A multitude of sub-projects have been defined to achieve these goals. The first general approach is the reduction or elimination of the most expensive component in rare-earth magnets (Dysprosium), both in bonded and sintered magnets. The second general approach is the “Beyond Rare Earth Magnet” initiative in which existing materials are improved (e.g., AlNiCo) and completely new material compositions are synthesized. The commenter concluded by pointing out that the overall approach is very well-designed and it could be extended, or changed, if necessary, depending on the intermediate results of the sub-projects.

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

Reactions to this question were all positive. One person simply commented that the results are promising so far, while another person stated that the milestones are met. One person commented that the Technical Accomplishments are good so far and the research team is within the project schedule. They added that significant progress has been made to overcome barriers, which is a difficult achievement due to the fundamental research nature of this project; in other words, the technical progress of the sub-projects is somewhat unpredictable and several of the sub-projects might not result in a viable solution in the end. A significant achievement in the improvement of rare-earth magnets is the reduction of Dysprosium by diffusion in the grain boundaries. The commenter added that one important next step in this sub-project should be the prediction of the specific cost reduction for this magnet material due to this change in material composition; this cost prediction has to include the changes in manufacturing process. Continued this reviewer, one of the most promising achievements in the Beyond Rare Earth Magnet initiative is the potential improvement in AlNiCo magnets. It was mentioned that a 3-times increase in coercivity might be achievable. The collaboration with an electric machine supplier, which is developing a new AlNiCo PM machine concept, is an excellent set-up that will guide the work on both sides in the right direction.

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

Reactions to this question were positive. One person simply stated that there was a good collaboration network. Another reviewer commented that there was a good combination of industry, university, and national lab partners. The last expert to comment said that a number of research organizations and universities are collaborating on this project with Ames Laboratory as a lead. The assignment of the separate tasks seems to be based on the specific expertise of the research organizations and is thus well coordinated. Recently, collaborations with electric machine suppliers have been defined with specific focus on the permanent magnet material improvement needed for the different electric machine design concepts.

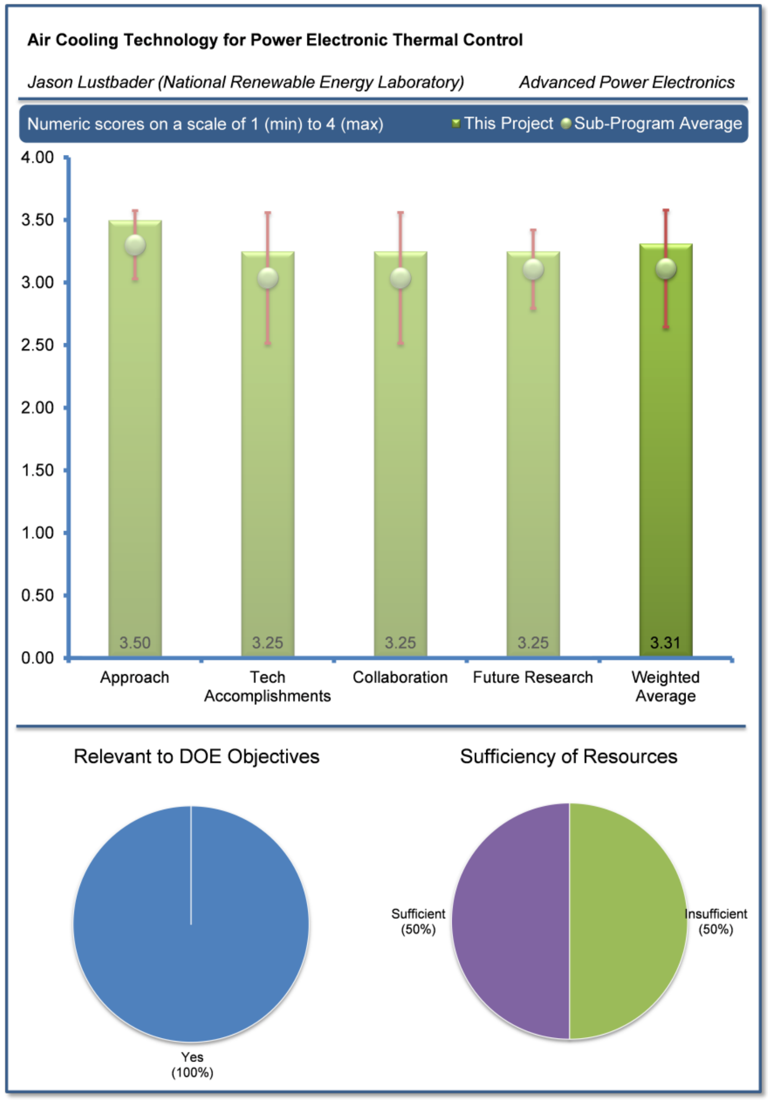
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Only one person commented to this question, stating that the project has well-defined milestones for FY 2012 and a clear plan for FY 2013. The future research plans are based on the past progress and the barriers are identified as good as possible. The identification of barriers is difficult at times due to the fundamental research nature of the project which makes predictions of future progress difficult or even impossible.

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

All four reviewers to comment to this question stated the funding was sufficient. One person stated that the project has sufficient resources for the defined tasks. The other person to comment described that the allocation of the resources to the sub-projects seems to be good.

Air Cooling Technology for Power Electronic Thermal Control: Jason Lustbader (National Renewable Energy Laboratory) – ape019



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer remarked that the presenter's introduction before the Overview slide really hit this point home and offered thanks for such a great overview on the impact to not only the DOE objectives but also for the industry. Another person agreed that air-cooled inverters for automotive traction drives are very relevant to the goals of VTP. This project examines feasibility, which is consistent with the current S&T need. The final reviewer commented that efficient, optimized thermal management systems will be key to the broad implementation of hybrid vehicle technologies. Two primary considerations will drive this fact. First, cost as a fundamental driver of the ultimate market penetration is impacted dramatically by undesirable dedicated cooling loops presently used for power electronics cooling. Secondly, the optimization of thermal subsystem interactions and performance will enable reduced operating temperatures and enhanced performance/reliability. The reviewer added that factors will ultimately dictate the pervasiveness of these technologies in the market and that greater penetration equals reduced petroleum consumption. The reviewer concluded by stating that this is a well-designed project with detailed focus on key areas requiring development.

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

One reviewer asserted that the project is well-designed around scope. The reviewer added that the dynamic environment will be the next barrier to technology. Another evaluator said the project is a well-balanced steady heat transfer project and experiment design. The reviewer's score would have been a 4.0 with the inclusion of some second law analysis to provide fidelity to the dynamic heat load conditions and thus management. Another commenter felt that the use of diagrams and images to describe the approach was great and it really helped tie everything together. The last reviewer to comment provided very detailed comments, stating that this is the second half of a well-conceived air-cooled inverter program. Frankly, delaying Madhu's project a year to allow professional thermal people to contribute was a wise decision. The reviewer found the engineering on this project to be outstanding and compelling; it is far better than past attempts to do the thermal part of the air-cooling. One issue that was raised in the Q&A period should be addressed in the future, and that is the consideration of all first order operating conditions on the thermal design of the system (meaning the power semiconductors, NOT just the conventional thermal management system). In other words, continues this reviewer, the thermal system begins with the semiconductor junctions and so steady-state analysis, no matter how good the engineering (which was quite good in this case), may not meet a real-world traction drive requirement. Al Hefner's presentation gave an excellent example of a use case that a real-world air-cooled inverter would have to consider (e.g., short-circuit conditions). In this reviewer's opinion, any design reported to meet the DOE VTP metrics for size/weight/cost could be invalidated on the spot if key operating conditions like this are ignored, for example, because the margin needed to meet the additional requirements was already consumed in the steady-state design. The reviewer added that one can argue that such considerations could be left to a later prototype, but this is not an acceptable position to me because the DOE VTP metrics, set by the automotive industry, are intended for real-world systems, not objects of research where key characteristics of a working system are ignored. The reviewer encouraged the project team to resist the natural inclination of a research project to make this kind of compromise. After the session the reviewer got the impression that this excellent group of researchers has no intention of knowingly falling into this trap.

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

Reactions to this question were nearly all positive. One person commented that the researchers have shown very good progress shown over 2011 review. Another evaluator noted that a good approach to determine feasibility and step through fundamental achievements was used. One person offered that the researchers' accomplishments thus far are great, but the reviewer felt that it seems that the researchers are much farther along that what the project time would have allowed. The reviewer concluded by stating that this was one of the best project presentations they saw this year, and commented, nice work. The final person to comment said that with the exception of the transient conditions addressed in previous questions, which the researchers showed an eager interest in learning more about after the issue was brought to their attention by the excellent work of Al Hefner, one reviewer though that the researchers have down an outstanding job with the thermal engineering side of this project.

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

Reactions to this question were mixed. One person lauded that this is one of the few projects where intelligent decisions about dividing work between National Labs have been made. The reviewer felt that the decision to delay the ORNL work in FY 2011 to allow a well-qualified thermal engineering team from National Renewable Energy Laboratory (NREL) to contribute has been reflected in the outcomes: engineering that is more than the sum of the collaborators. Another expert wanted to see interaction between Dr. Hefner's device dynamic temperature response project and this cooling activity. This reviewer also felt that greater inclusion of dynamic heat loads will make the project much stronger. The final commenter remarked that they would have been interested in hearing a little more about the work with other partners (besides ORNL). The reviewer concluded their comments by asking what the researchers are doing with the OEMs, suppliers, etc.

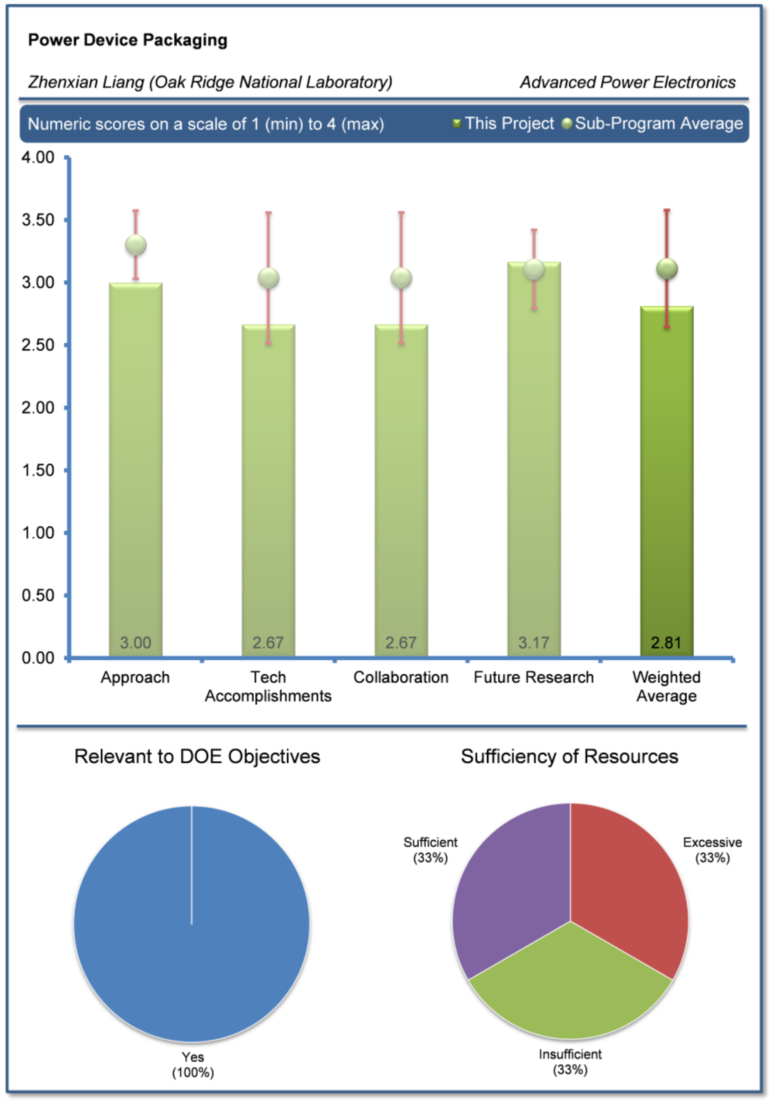
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were all positive, with one person offering a suggestion for improving the research plan. One person simply noted that the project's 2012-2013 task plan is very well organized and appropriate for the project objectives. Another reviewer agreed that future plans are outstanding (rather than just good) after the totality of a full-scale air-cooled inverter requirement is addressed in the specification of the working prototype. This reviewer was confident that the electrical and thermal teams working together can incorporate a real-world requirement into their objectives. Another evaluator highlighted the great description of the approach of the future work and breaking them down by year. The reviewer added that again, the diagrams and detailed descriptions in the verbal presentation were wonderful; one of the best this reviewer saw this year. The final person to comment suggested that dynamic system environment should be considered as early in the work as possible.

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

Reactions to this question were mixed with two reviewers stating funding was insufficient while two reviewers stated it was sufficient. The only person to provide detailed comments mentioned that it seems like a great match of resources with project approach and milestones. Nice work!

Power Device Packaging: Zhenxian Liang (Oak Ridge National Laboratory) – ape023



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive, with one person providing suggestions. One expert commented that the power module is the primary cost and performance driver in the EV inverter. The reviewer explained that this work has two purposes: 1) to reverse-engineer and benchmark existing state-of-the-art in power modules, and 2) use that knowledge and innovation to develop higher performance, lower cost power modules. This person pointed out that electric vehicles are necessary to reduce the U.S. consumption of gasoline. One commenter stated that the project is directly related to the highest cost component in the inverter; increasing the ability of the power switch to handle more current and dissipate heat better will allow smaller, higher power density and more reliable power electronics to the vehicle which will enable a more attractive product and will thus enable more sales. Another project evaluator had detailed comments, describing that power packaging is a critical aspect of hybrid and electric vehicle technology due to the primary dependence of vehicle reliability on electronics functionality. Thermal cycling, thermal exposure and voltage stresses will dictate useful life and thus cost of ownership viability. As such this effort is key to determining competing technology efficacy to provide the highly efficient and reliable parts for traction drive inverters and converters for drive train application. Integration of WBG devices and the resulting characterization has to be accomplished to determine if the material system performance entitlement can be leveraged to achieve the efficiencies required to measurably displace petroleum use. The final reviewer affirmed that electronics packaging is an essential technology for automotive electric traction drives; it drives performance, size, weight, reliability, and cost. One evaluator agreed, stating that the project supports APEEM Vehicle Electrification Technical Targets to reduce cost, weight, and volume in power electronics within the packaging device, including packaging innovations for higher temperature operation. This reviewer suggested a simple glide path matrix demonstrating targets from current to 2020 calendar year. The reviewer added that the 40% cost reduction and 60% power density targets reported were not transparent to the reviewer, so asked to what baseline and metric were they being compared.

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

Reactions to this question were mixed, with all but one having positive comments. One reviewer stated that benchmarking state-of-the-art modules is a good approach to assess what technologies are promising. This reviewer observed that the funding level only permits one or two independent new developments. This reviewer mentioned that the existing new module development is good since it addresses three key issues: reducing parasitic inductance, reducing thermal resistance and potentially reducing cost. This reviewer added that the collaboration with other ORNL projects is also a plus. Another evaluator asserted that the researchers' approach is correct in addressing the items listed. The reviewer stated that they would also include the needs of the inverter packaging since that will also impact the design of the package. The reviewer concluded by pointing out that the focus is clearly on the package and determining the weaknesses and how to improve them but eventually these packages have to be used in power electronics. One expert agreed that the approach of benchmarking existing power device packaging was appropriate for baseline data and analysis; however, the reviewer questioned why domestic device packaging was not assessed and evaluated in the comparison. The reviewer concluded by stating that thermal, electrical, and structural analysis of state-of-the-art benchmark modules represented strong testing and results. Another reviewer commented that the characterization tasks focused on existing Toyota Prius, Nissan Leaf, etc. modules was well-executed and focused on relevant aspects of packaging performance and construction. The novel module design aspect of the subject project was less compelling. First, the advanced integrated cooler should have been more detailed in terms of what were the typical pressure drops, flow rates, convective heat transfer coefficient, and water channel dimensions. Electronics cooling in an integrated package necessitates a detailed design with consideration of the device loss characteristics (including dynamic effects) to specify the cooling system boundary conditions. Thermal cycling reliability testing must be completed on the planar laminated package to determine suitability for the intended application. The final person explained that they could not understand what the Technical Objectives or approach are for this project. The long introduction seemed to suggest something about improving packaging.

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

One reviewer asserted that the development of the Planar_Bond_All (PBA) power module packaging technology was brilliant and innovative. This person felt that the analysis and results of PBA electrical and thermal properties are significant to support further testing, application, and commercialization. The reviewer concluded by mentioning that the progress and milestones appear to be on schedule and suggest on-time project completion. Another reviewer also noted that the accomplishments and progress to date are very promising. The PBA package addresses the weaknesses identified and the results are an improvement over the existing designs. It was not clear to the reviewer was how this package will be used in a mainstream inverter. They asked whether the cost impact of a dual-sided cooled package versus a single-sided package has been investigated. The reviewer also asked if the costs to support dual-sided cooling using this package versus additional switch area in a single sided cooled version of this package are known. One person commented that the researchers had done a good comparison and characterization of the import vehicle module packaging. The reviewer added that the custom module design needs additional information and characterization data hopefully included next year. Another person, however, observed that the reported results were mostly a survey of OEM traction drive packaging, followed by a chart showing the various custom packaged parts done for other projects (which were not commercially relevant). The reviewer added that the discussion of the planar bond power module was mostly pictures and then some results without meaningful benchmark against the state-of-the-art. The reviewer's confusion about the results was a natural consequence of confusion about the objectives and technical approach. Another person explained that the PBA package exhibited significant reduction in parasitic inductance and thermal resistance, which is a good proof of feasibility, but needs more work before it is mass-production ready. The reviewer added that their concerns about this package are assembly yield due to blind locating of components, temperature cycling capability, and dielectric isolation (internal and external) due to close proximity of layers.

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

Reactions to this question were mixed. One person commented that collaboration with NREL, other ORNL and university groups is adequate. Another person agreed, stating that cooperation among the team is clearly very good and that the results are impressive. Other reviewers had more critical comments. One person pointed out that the project seems to be mostly an internal effort of one National Lab. The reviewer felt that it is not clear if it is at the state-of-the-art with the community of electronic packaging, let alone automotive packaging. The reviewer remarked that the cited partners seem selected more for convenience than for excellence in packaging technology. Another expert commented that there are many groups performing excellent packaging development and research on rugged packaging for power applications. The reviewer did not feel that these resources were being leveraged to the degree possible. The final reviewer recommended coordination with industry to strengthen manufacturing engineering, design, and process with the PBA application. The reviewer cited the Principal Investigator (PI) for identifying reliable bond of multiple large-area planar layers, dies, and substrates as a manufacturing problem and critical issue.

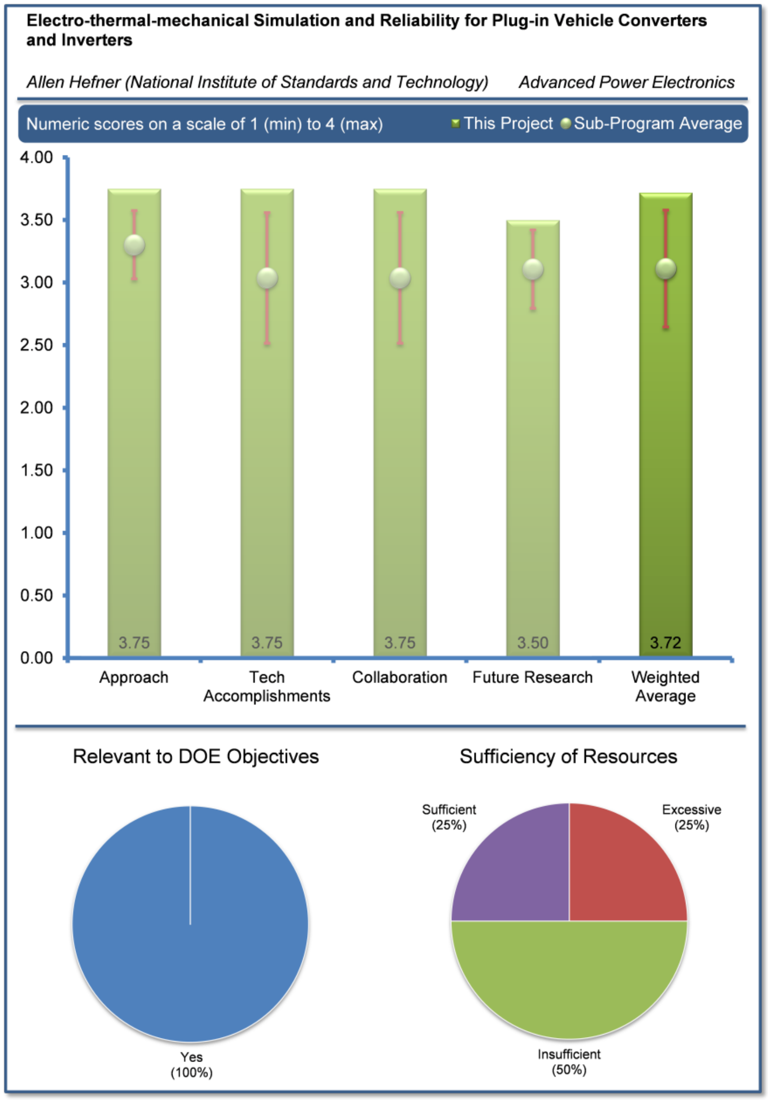
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were mostly positive. One person simply stated that the proposed benchmarking should continue. This reviewer added that the proposed high-temperature and reliability testing of PBA package is necessary for proper evaluation of the technology. One reviewer remarked that hopefully this critical technology research focus will evolve into the areas of deficiency described above. The reviewer felt that the project has a potential for outstanding contribution. A third commenter asserted that the future work is logical, defined and proceeds with ongoing development and reliability improvements with the PBA technology, while recognizing the need to continue benchmarking state-of-the-art (SOA) technologies within module performance, materials, and processing. The reviewer suggested stronger focus and emphasis with industry and commercialization of PBA power module packaging technologies – manufacturing cannot be negotiated, the PBA module must be designed for manufacturing and assembly at low-cost, and superior quality, reliability, and durability. Another reviewer felt that the future work is the next logical step in the development of the package and would benefit from additional input from inverter developers. The performance of the package in terms of inductance is very good, but the reviewer asked if any work has been done in terms of how the fast switching performance of WBG devices will behave in this package. They concluded by asking what the limitations of the package are in terms of current and voltage spacing. The final reviewer to comment simply hoped that maybe it will get better.

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

Reactions to this question were equally mixed, with two people each responding that resources were insufficient, sufficient, and excessive. One expert warned that future funding may be insufficient considering the broad scope of the program. One person commented that resources appear sufficient and well within the requirements of meeting stated milestones on time. Another person remarked that the appropriate resources are apparent at all of the collaborators. The final person suggested that the government's objectives might be better served by competitively awarding this to somebody else.

Electro-thermal-mechanical Simulation and Reliability for Plug-in Vehicle Converters and Inverters: Allen Hefner (National Institute of Standards and Technology) – ape026



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person described that this work develops computer models for the power modules in an EV inverter, aiding the designer in developing higher performance, higher reliability modules and inverters. The reviewer continued stating that the coupling of the device performance and reliability models have not been done before and will provide designers with the ability to characterize and improve reliability. Another person affirmed that this modeling is very important to improve the efficiencies of modules in electric vehicles and will aide in decreasing the time to market and thus meeting the objectives. The reviewer applauded that this is a great project and truly beneficial to the whole industry. One expert pointed out that an integrated tool considering electrical, thermal, and reliability mechanisms in a coupled self-consistent way would be very valuable to the larger power module industry, not just automotive. The last person to comment had detailed comments, describing that better physics-based models and modeling activities will enable the optimal leveraging of power device performance capabilities based on material property entitlements. The subject effort is an outstanding example of an application of device subject matter experts being brought to bear on a crucial aspect of electric power, namely dynamic adiabatic heating events in devices and the resultant predicted impacts to reliability. Reliable, high efficiency electrical drive components will be a requirement prior to widespread adoption of the PHEV vehicle paradigm.

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

Reactions to this question were all positive. One person agreed that the approach is good and that this work builds on prior work done at National Institutes of Technology (NIST) and accesses the reliability work done at CALCE (UMD). The reviewer added that the approach combines model development followed by validation by simulating modules developed/tested under other DOE Advanced Power Electronics (APE) Programs. Another person expanded that the technical approach builds upon decades of experience and is thoroughly thought through, as is typical of an Al Hefner project. One expert explained that the technical approach of the modeling was explained very thoroughly and easy to understand the value of the approach and outcomes. The reviewer affirmed that the researchers have developed a very good approach, but added that they did not get an understanding of the approach beyond what was already accomplished though. The final person explained that fundamental physics-based modeling activity is being applied in highly relevant electro-thermo-mechanical prediction capability establishment activity which is ultimately focused on reliability prediction of electric power components. As such, the effort is focused on the physics driving adiabatic dynamic events and their implications as well as the prediction of steady-state junction temperatures. The extension of the E-T-M models to include reliability prediction models, can dramatically impact PHEV design activities and result in more reliable packaging and operating space definitions leading to enhanced vehicle performance, reliability, and customer acceptance.

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

Reactions to this question were generally positive. An expert remarked that the slides and verbal explanation were very thorough; adding that the progress for such a short usable time (after the NIST issues) was wonderful. The reviewer concluded by mentioning that it seems that the researchers are much farther along than what was told in the original overview slide. Another project evaluator observed that excellent progress was demonstrated during the first year of the effort. This person would have liked to have seen more of the progress related to the reliability prediction modeling effort. Another commenter stated that the technical progress on both the Viper and the Virginia Tech modules seem significant. The reviewer, however, felt that it was a bit hard to understand what the metrics for progress are from the presentation. One person commented that the progress has been good against the current milestones. The agreement between simulations and experimental results shown was quite good. The reviewer concluded by criticizing that there was little discussion about the reliability modeling; they were not sure if this was due to lack of results or lack of presentation time.

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

Reactions to this question were positive. One person applauded that the collaboration between NIST, CALCE and NREL constitutes the country's leading experts in their respective areas of research. The reviewer added that the modeling/testing of industry-supplied modules developed under other DOE APE programs is a good move. Another person highlighted that close collaboration, even with collaborators in the room, was shown. The reviewer also noted that Al is extremely well networked in a way that promotes the quality of his work. One expert observed that this is a great use of private, public, and educational collaboration. The reviewer noted that the researchers have a wide range of contributors, adding that it would be interesting to see how these areas all managed through the program and what issues you might have realized. The final reviewer suggested that it would be interesting to see what a second law analysis would predict for the adiabatic heating events.

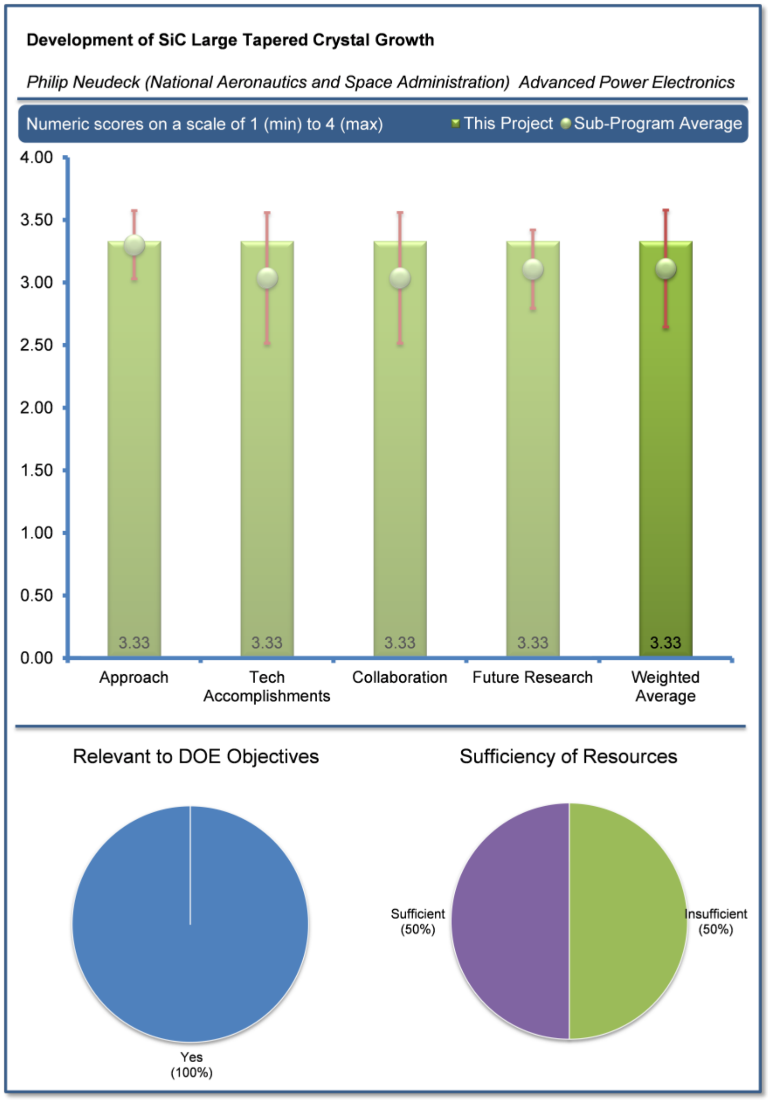
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the FY 2012 and early FY 2013 goals/work were very detailed and good; however, the future work listed in Slide 22 is very broad and probably too broad for the existing funding levels. The reviewer suggested that the future work needs to be re-examined later this year/early next year in light of the progress made and the focus needs to be refined at that time. Another person encouraged the researchers' commitment to extend device models to the junction gate field-effect transistors (JFET). The final person to comment stated that the talk focused a lot of attention on what has been accomplished and the approach; unfortunately, this came at the cost of a little less effort on the future work. The reviewer offered that since the researchers have significant time left in the program, that the reviewer would have been interested in hearing a little more of what you are going to do throughout 2012 and 2013.

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

Reactions to this question were mixed, with two people stating they were insufficient, one person stating they were sufficient, and one person feeling the resources were excessive. The first expert pointed out that the resources seem to be insufficient, particularly if a significant level of reliability testing needs to be performed to validate the reliability model. Another reviewer simply stated that the resources look well-funded, but certainly not excessive. One person stated that it seems like a great match of progress and resources thus far. The reviewer concluded by applauding the great work.

Development of SiC Large Tapered Crystal Growth: Philip Neudeck (National Aeronautics and Space Administration) – ape027



Reviewer Sample Size

This project was reviewed by six reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person commented that scaled production of efficient power electronics is vital to electrification technologies. Another expert noted that one of the methods of increasing the efficiency of today's electric vehicles is to use the more efficient WBG switches. This requires that these devices be economically viable also and this project is addressing a method to reduce the cost of SiC switches. One commentator described that this project supports research and development objectives to improve power electronics performance, in addition to weight, volume, and cost reductions. The reviewer stressed that it is important to recognize the complexity of the project and tasks and that the benefits of SiC power semiconductor devices extend beyond electric vehicle applications and have potential to significantly advance industry-wide technology to a next generation. Another evaluator remarked that silicon carbide power semiconductors are recognized innovations leading to achieving DOE VTP APE objectives and that this project is a high risk, high reward exploratory development project targeting, ultimately, improved SiC economics. One reviewer affirmed that advanced semiconductor devices are one of the keys for future reduction of size and volume of power electronics system. The reviewer added that this will further help push electric and hybrid vehicles into the market place and that the work on SiC material is important in terms how to produce material for advanced wide band gap semiconductor devices; hence it is relevant to the DOE overall objectives of petroleum displacement. The final person had detailed comments, describing that one of the primary impediments to widespread SiC power technology adoption has been the cost of utilization in products and systems. Certainly, limited production volumes that presently characterize the manufacturing supply base contributes, however, fabrication yield limiting factors are significant. Understanding that the subject project is fundamental science and as such high risk, it has the potential to dramatically impact SiC material defect densities and thus directly enhance device yields. Widespread adoption of SiC power technology will significantly enhance and improve component efficiencies which directly reduces fuel consumption. Thus, the subject project has the potential to contribute to petroleum use reduction.

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

Reactions to this question were mixed, but were generally positive. One person simply stated that the researchers have presented a clear scope of barriers to be addressed through experiments. Another person expressed that the technical approach is innovative and the team uniquely qualified for the work. The reviewer added that extreme risk is an appropriate description for the technical approach. One expert said that the project approach is unique in that it developed a new alternative SiC growth process from the present vapor transport. The NASA Large Tapered Crystal (LTC) growth patent opens a new technology glide path and learning cycle to produce large diameter SiC wafers, with improved dislocation at lower cost. The reviewer offered accolades to the PI and team for demonstrating resilience and tenacity to overcome technical barriers, cost, and schedule challenges, and misfortunes (i.e., the RF generator). Another evaluator described that the project uses lateral and vertical growth simultaneously and continuously (creates tapered shape) instead of the traditional growth method that leads to limited crystal thickness. If successful, the reviewer added, it will radically change the SiC growth process geometry to enable full SiC benefit to power systems. One commenter observed that this project is very focused on one method to grow wafers. The reviewer felt that the approach could prove valuable if it is successful, so need to continue to monitor the alternative approaches to supplying wafers as the field is not standing still. The final reviewer criticized that the fundamental premise is not well established thermodynamically. They added that whether the screw dislocation-growth coupling is a cause or effect is not compelling one way or the other at this point; however, the focus to establish the required components of lateral growth and SiC whisker or fiber formation should enable a determination of the suitability of continuing the development of this process in the future.

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

Reactions to this question were mixed, with several people mentioning progress falling behind the anticipated schedule. One person felt that excellent progress and significant accomplishments were made during the last year. The reviewer described that controlled experiments and quantitative data demonstrated a gain in epitaxial growth rate, film thickness diameter being mostly epitaxial, and smooth tapered hexagonal facets. The progress and results suggests that risks will be mitigated or eliminated, and barriers will be overcome. Another evaluator pointed out that the project is behind schedule, but it seems barriers can be overcome in the short-term and additional progress will be made to accelerate the project. The reviewer added that the team has demonstrated epitaxial radial (lateral) growth of a 5 mm diameter boule starting from a simulated SiC fiber crystal and laser-assisted fiber growth of a SiC fiber crystal greater than 10 cm in length. The reviewer asserted that these demonstrations are key to further demonstration of the project objectives, i.e., LTC. One expert mentioned that progress has been good in spite of setbacks; progress continues to show promise but technical issues remain. Another person commented that it is still very unclear that the results show promise, but the project team is doing everything within their power to overcome scientific and technical obstacles. The final reviewer had detailed comments, asserting that the initial growth results are not compelling. They added that the difficulty is evaluated to be one of preventing the nucleation of new defects during growth from the polytypic nature of SiC in general or the relaxation of thermal stresses during crystal growth. Suppressing these other defect formation mechanisms has to be a primary focus of the effort from this point forward. The preliminary growth on surrogate SiC fibers showing lateral crystal expansion is encouraging. Evidence exists to indicate that cubic crystal formation will be problematic as the project moves forward.

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

Comments to this question were all positive. One person commented that the project has appropriate collaboration and coordination with institutions and subject matter expertise. The reviewer recommended continued augmentation of funding to permit wider search of parallel paths with industry in order to realize SiC fiber growth and shapes. Another person simply stated that there was a solid team and that Mike Dudley is key to credibility of outcomes. One expert observed that the research team has collaboration with academia institutions and also highlighted that it is also important to work with SIC device companies to validate the technology. The final person noted that the collaboration appears to be very good as the technical issues are being overcome. Additional partners added to support risk mitigation.

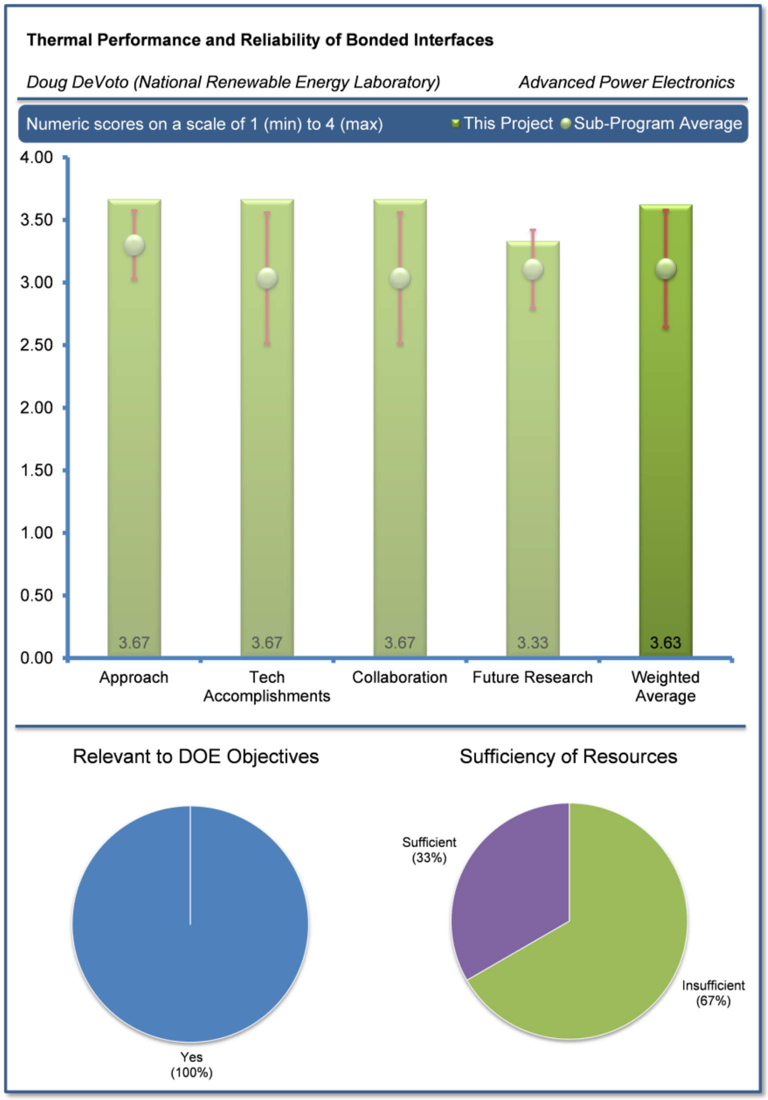
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reactions to this question were mixed, with several people making suggestions for improvement. One person noted that the plans are directed toward solving demonstrated problems, but suggested that it could include financial benchmarking analysis. Another reviewer pointed out that the future work appropriately planned for radial/lateral CVD Epi-Growth, growth of larger mini-boules, and Fiber Growth (smaller, well-ordered seed with hexacone tip). The reviewer stated that the project clearly recognizes that crystal size, crystal quality, and production rate are central to the NASA LTC technology effort and a Go/No-Go decision milestone. Another project evaluator commented that the focus on the smaller float zone seed interaction area is prudent and appears necessary to success. This reviewer noted that fiber formation will be problematic and the inclusion of a new NASA partner with expertise in this area is excellent. One expert explained that the future work is planned to support solving the technical issues seen to date as well as an alternative risk mitigation plan. The reviewer would like to see the potential cost savings of this process versus today's standard industry progress. Another commenter asserted that the process is very complex and fraught with show-stopping problems in serial process steps. They described that the point-faceted seed crystal is both critical to future success and cool looking. They concluded their comments by stating that this is good for risk-management that NASA can do this step internally, but is also investing in an alternative to the LHFZ process. The final person reported that it is not certain whether the project will be able to make sufficient progress and match the milestones.

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

Reactions to this question were mixed, with two people stating the resources were insufficient and three stating they were sufficient. One person simply noted that there was good support from NASA. Another person expressed that the project appears to have adequate resources to achieve stated research milestones and go/no-go decision, in spite of challenging goals, behind schedule, and obstacles (i.e., equipment malfunction). The reviewer added that the project has demonstrated significant quantitative milestones and quality metrics over the last year, and must continue to focus and overcome the technical barriers with producing desired long, single-crystal fibers. The final reviewer suggested that more resources might de-risk, but cost-benefit of a successful outcome remains unclear.

Thermal Performance and Reliability of Bonded Interfaces: Doug DeVoto (National Renewable Energy Laboratory) – ape028



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Both reviewer comments to this question were positive. One person commented that the reliability of bonded interfaces is an essential concern when integrating power semiconductors into automotive traction drives. The other person remarked that the presenter clearly communicated the benefits to the thermal performance of bonded materials with a very nice explanation.

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

Reactions to this question were all positive. One person appreciated the up-front analysis and use of existing production techniques for samples. Another person noted that the technical approach appears scientifically sound and quantitative in most aspects. The last reviewer to comment felt that the approach seems to be a very straight-forward approach to performing the work. They added that it was very clear and concise, but did not know what performance specifications the researchers were going to be testing in the future work.

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

One evaluator described that the up-front analysis addressed potential failure modes and technical issues to date are understood. Another expert commented that the presenter is highly knowledgeable and the results reflect depth in understanding them. The final reviewer to comment stated that that the presentation gave a very good explanation of the delamination results, but added that they would have been interested to see more Hi-Pot testing results, but that might be more relevant for next year's AMR presentation. Ultimately, the reviewer felt that the presenter gave a very clear and descriptive explanation of the charts and graphs.

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

Reactions to this question were positive. One person commended the presenter’s collaboration slide was very nice in that it not only stated who you were working with, but also described how/what each partner is contributing to the project, which they found to be very helpful. The other person commented that the collaboration appears adequate or better, especially with industry such as Semikron.

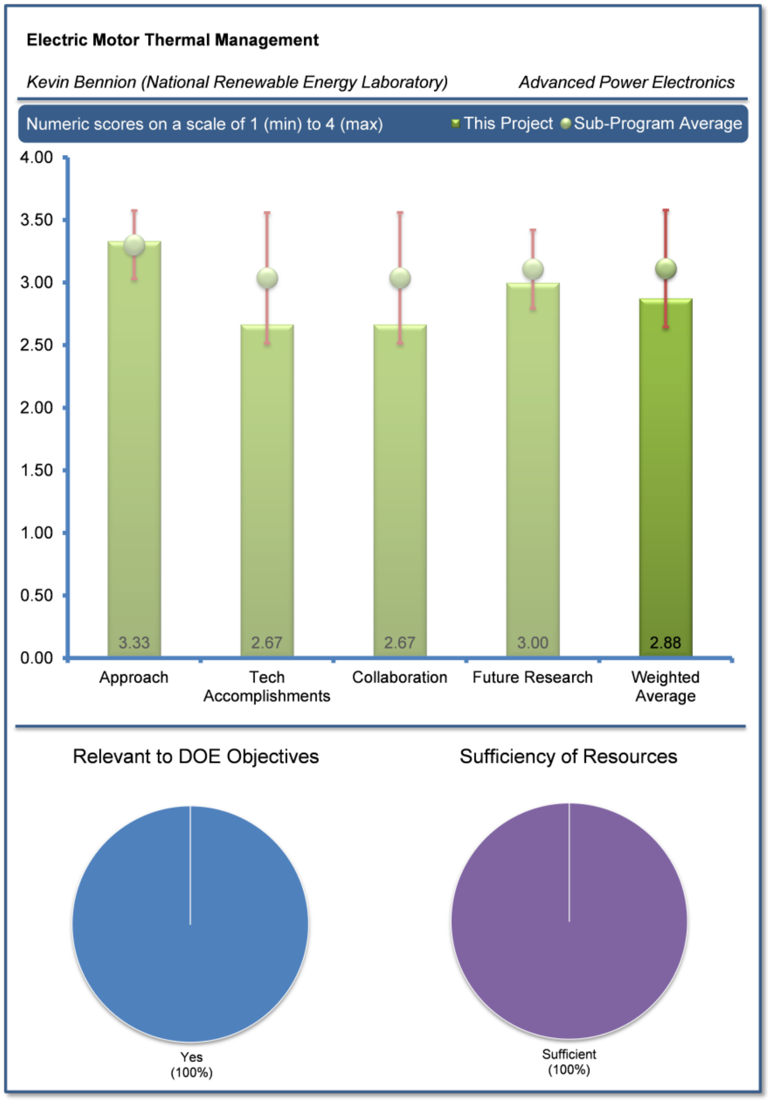
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the presentation showed a good list of alternate materials identified. One person pointed out that it was hard for them to say much about the future plans, but the research seems well-conceived. The last reviewer mentioned that the presenter seemed to go a little too fast over the future work. The reviewer was not clear what was different in the next year than was done in the prior year, asking if it was just more cycling or were other materials going to be added to the test.

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

Reactions to this question were mixed. Two people felt the resources were insufficient while one person thought they were sufficient. One person commented that it seems like a very efficiently managed program and the resources used are appropriate. They concluded their comments by praising the nice, clear presentation.

Electric Motor Thermal Management: Kevin Bennion (National Renewable Energy Laboratory) – ape030



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person described that thermal improvement on electrical machines is key to size and price reduction. Another person agreed, adding that the project supports the objective of petroleum displacement by improving the thermal performance of electric machines. If successful this improvement would result in smaller machines with higher power density, which would enable a faster market introduction of HEVs and EVs. The final reviewer acknowledged that improving thermal management for motors allows motors to run cooler, which improves efficiency and enables use of lower Dysprosium content in magnets. The reviewer added that these improvements reduce operating cost and initial cost, which facilitates adoption of HEVs and EVs in the market.

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

Reactions to this question were all positive. One person explained that the main goal of the project is the cooling parameter sensitivity analysis for electric machines and the derivation of improved cooling techniques. The approach consists of material property tests and thermal finite element analysis (FEA) modeling of different PM machine types. Test and simulation results in publications from other researchers and test results from other National Labs are included in the validation of the simulations and tests in this project. This reviewer observed that the overall approach is very well-designed and the technical barriers and limitations of the simulations models and test procedures are identified. One evaluator noted that the project is identifying trend for improvements added to making intelligent choices by using different type of motors and comparing model and test results seems to me to be a good approach to reach valuables results. The last person commented that this is a very broad and multi-faceted subject, and so difficult to tackle. The reviewer felt that the research team has done a good job of systematically breaking down the subject, working from basic building blocks (measuring material properties) and working toward more complex system issues. Their approach also lends itself to providing data useful for many motor types (e.g., IPM, induction, etc.).

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

Reactions to this question were all positive. One person stated that the Technical Accomplishments are very good and the results are summarized in an excellent manner. This expert highlighted that some of the test results for the determination of thermal material properties confirm the data in the literature, which is a good achievement. The reviewer added that additional results, as the thermal conductivity of lamination stacks, are valuable for the electric machine industry. This expert also observed that thermal sensitivity analyses were conducted for both surface and interior PM machines and the results will support the optimized design of these electric machines. The reviewer noted that the researchers successfully tried to generalize the results in order to avoid results which are only applicable for a specific machine design. Another evaluator commented that the project used good analysis of the targeted area to improve relative to motor usage. The final person commented that the project accomplished a very good characterization of stator materials, lamination stacks, and winding. The reviewer added that the data would be more useful if it was in terms of quantities that are more familiar to motor designers (e.g., stacking factor instead of lamination stack pressure, so it is very difficult to know what stack pressure is retained after the lamination stack is welded and assembled into a housing). They concluded by suggesting that the researchers should also consider real-world interface resistances between wire and slot liner and liner and lamination.

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

The responses were generally positive, but with some questions being raised. One person noted the good use of industry motor designer experience, as well as other National Labs. The second reviewer acknowledged that the researchers are collaborating with another National Lab and a university on this project and that the contributions from the collaborators are mainly in the area of electric machine design support. This expert cautioned that although collaborations with industry representatives are mentioned, it was unclear what areas are covered by these collaborations and who are the partners. The reviewer felt that it would be beneficial if the collaboration with OEMs could be intensified in order to guide the work in the right direction regarding the choice of machine topologies of interest.

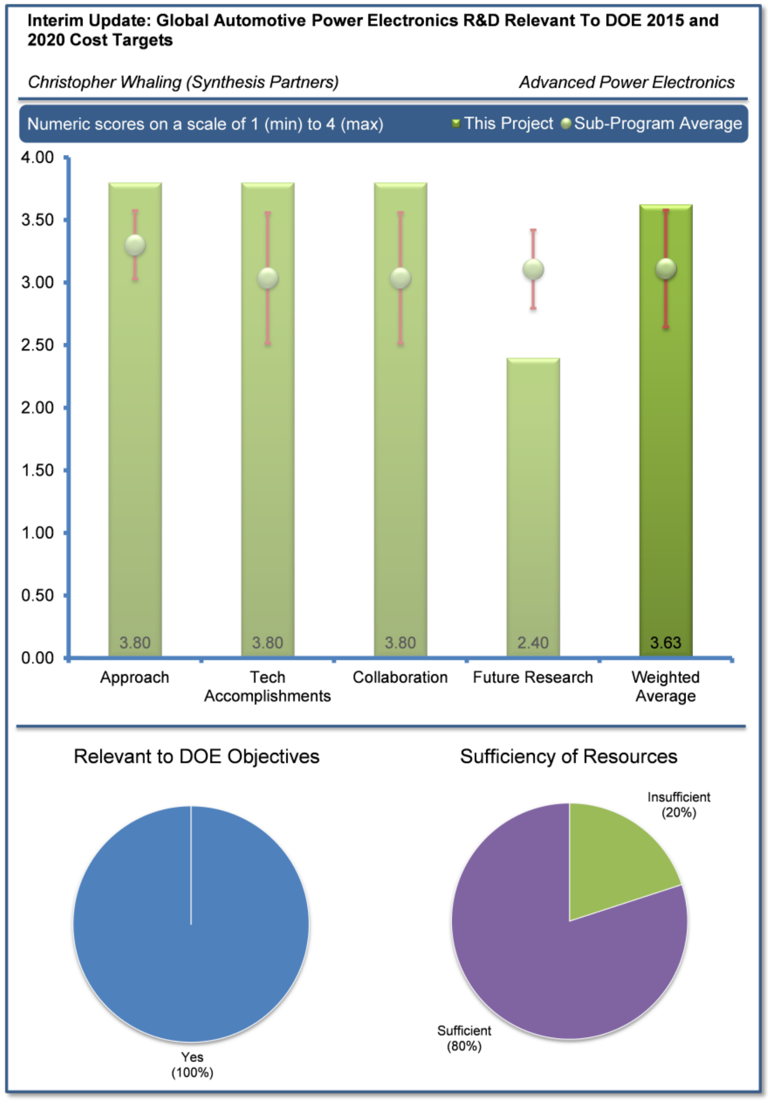
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One person suggested that the future effort should be more emphasized on cooling technology. Another person suggested adding the effect of rectangular wire (versus round wire) in distributed and concentrated windings. The final person had detailed comments, describing that the project has well-defined milestones for FY 2012. The future research plans are based on the past progress and the barriers are identified as good as possible. The researchers plan to extend the project scope to oil cooled machines, starting with oil cooling for the stator winding. This is a very good choice as this cooling technique is of great interest for the industry due to the significant machine performance improvement. In a second step it would be good if the investigation of oil cooling is extended to the rotor.

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

All three reviewers to comment stated that the resources were sufficient. One person added that the project has sufficient resources for the defined tasks and that a milestone review in September 2012 will determine the work and resources for FY 2013.

Interim Update: Global Automotive Power Electronics R&D Relevant To DOE 2015 and 2020 Cost Targets: Christopher Whaling (Synthesis Partners) – ape032



Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person noted that yes it does meet DOE's needs, as it is looking at the cost structure roadmap to see if it will meet cost targets. The reviewer noted that all data were taken from publications, OEMs, National Labs, etc. Another reviewer agreed, stating that the project supports cost targets, roadmaps, and information for the DOE to make future decisions with power electronics. This reviewer viewed the pending data and reports useful to the DOE when evaluating future R&D projects and funding. One expert commented that in a way looking for radical reductions in propulsion system costs to achieve DOE 2015 and 2020 VTP targets addresses the objective of petroleum displacement. They added that if you can find the architecture, part or process that helps to lower cost, thereby enabling the EDV market, which in-turn reduces our dependence on foreign oil. They concluded their comments by asking how that information will be shared. One evaluator explained that the project is a valuable tool to help the DOE assess the current status of Global Automotive Power Electronics Market; this tool will help adjust the targets for DOE goals. The last reviewer had very detailed comments, noting that this work is very important for understanding the cost reduction and performance improvement potential for inverter technology in particular, but also for power electronics more generally. This cost-reduction potential will remain very important to understand, particularly for its sensitivity to: 1) economies of scale/volume production, 2) the increasing performance (power density, specific power and efficiency) possible with further improvements in the technology, 3) the increasing value of reducing dependence on petroleum as an automotive fuel, not only via energy efficiency improvements, but also via shifting energy usage from petroleum to U.S. energy sources, as well as the increasing value (which is largely unrecognized today, economically-speaking or otherwise, compared to what is needed to halt global warming before feedback effects send it completely beyond any reasonable possibility of our control), and 4) the consumer value of changes in fuel prices, up or down, and impact on demand and, thereby, sales/production volume available to manufacturers. This factor is particularly important for understanding the ability of the United States to attract investment for these advanced energy technologies, since the United States continues to heavily subsidize petroleum as an energy source, as it has been for decades, and U.S. incentives for alternatives to petroleum are at a relatively very low level compared to most of the nations where most of our global competitors are based.

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

Reactions to this question were mixed. One person commented that there is a strong approach to gather meaningful and useful data, while still addressing technical barriers to cost targets. Another person cautioned that the project is relying solely on other research and has not made any projections or recommendations yet; however, the reviewer acknowledged that the study is only 40% complete. One expert expressed that it is not easy to obtain the information that this work is based upon, since most of it is considered highly proprietary for the companies that can supply it. The reviewer added that these companies are also in business to make a profit, so are negatively motivated when it comes to revealing the true details of the lowest costs that are even known to be possible, let alone what might be possible with reasonable extrapolations from just today's technology, let alone totally different approaches. Another person had related comments, observing that the approach is very good but will be hampered by suppliers' reluctance to provide cost information as well as the issues identified in the presentation; however, even with these limitations the reviewer thought that the results will be viable. The last person to comment stated that the researchers seem to be looking everywhere for information, but the lack of a common vocabulary and different partitioning of hardware makes the comparisons difficult. The reviewer concluded by saying that they would like to see a format of how the final report will look.

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

Reactions to this question were mixed. One person simply stated that a methodical approach focused was used on the work statement. Another expert felt that the progress has been good for this project, but that they would like to have seen more information on the articles mentioned in the presentation but understand the time delay. The reviewer added that the description of where the data came from is insightful and allows one to judge the usefulness of the data for their purpose. One reviewer cautioned that as a reviewer, producing initial results and report findings over the next five months appears as a risk with meeting project end date. The reviewer suggested that effort should have been made to present an example of initial data and report, even at a preliminary level. The final reviewer commented that the information could be very useful if a common ground(s) for comparison can be found and understood. The reviewer asked how the researchers will know when they are done, also asked what the form of the final report, table or analysis looks like.

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

Reactions to this question were all positive. One person simply stated that the researcher seems to be looking everywhere. Another reviewer acknowledged the close collaboration with National Labs, universities, Tier 1 OEMs and other research publications. One commenter explained that the project commands diverse and wide band collaboration in order to collect and analyze the data. Another project evaluator commented on the outstanding review of the other studies that are being conducted, as well as the original survey work being attempted. The final reviewer praised that the results are impressive, but no mention was made as to the number of industry partners who responded was given so it is hard to judge how well these parties cooperated. This is going to be a difficult problem to address as most commercial entities are unwilling to provide cost information. The reviewer thought that researchers will be able to get enough information to enable trends to be seen.

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

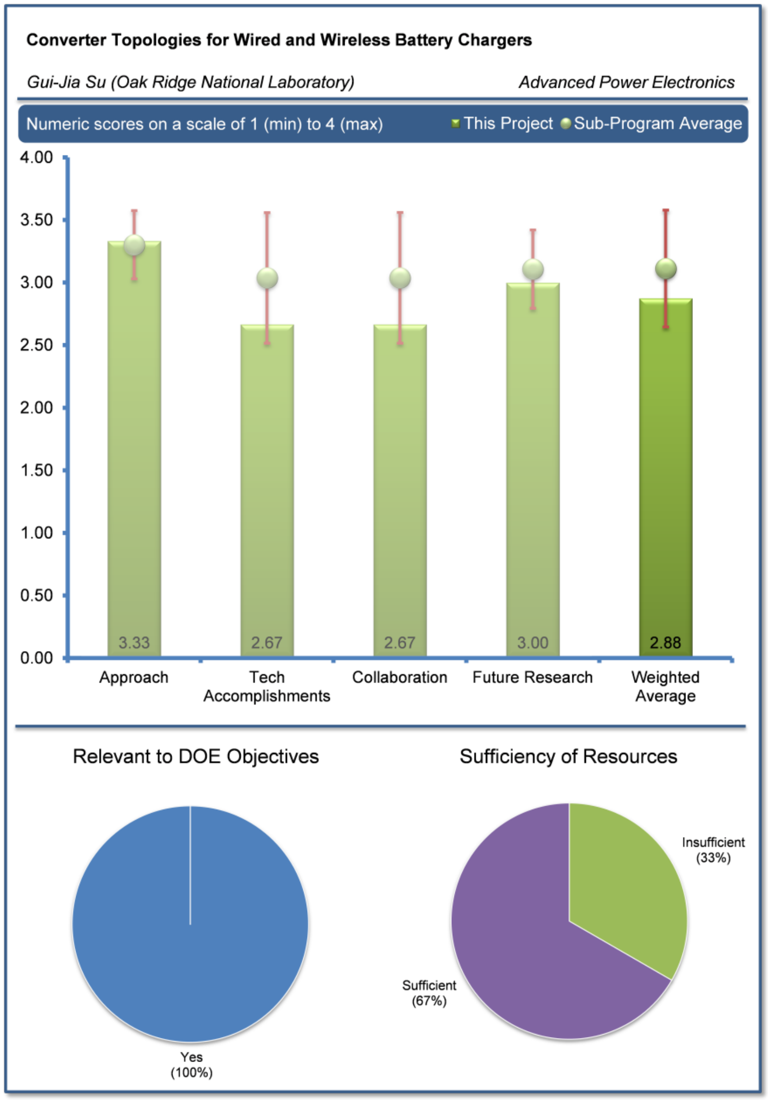
Reactions to this question were mixed. One expert described that the future work is still under development, but the ideas presented were interesting and could prove to be valuable if the databases are kept up to date. Another reviewer remarked that this was not clearly stated except for future discussions with DOE. A third person had similar comments, stating that future work needs to be better defined other than discussions with DOE. Another person expressed that they would like to see more efforts to go back to some of the other sources to uncover the difference between full costs versus incremental costs versus production volume (scale) versus actual and projected generations of technology improvements. The final reviewer had detailed comments, describing that detailed results are due later this year. The interim report does not address the form of the final report. If it is a wealth of information, the reviewer asked how does one go from a system to a module to a component or architecture or process to find the game changer technology, or understand cost. The reviewer felt that it would be interesting to know the value comparison of the

OEM patents by OEM. This reviewer cautioned that it is not how many you have, but what their value is, and which ones are the most valuable. To evaluate a patent's strength, or value, several companies have developed algorithms to measure a patent's strength (Innography is one of several companies). The algorithms use several criteria such as strength of claims, citations, (and other things the companies do not reveal) to make that determination. The reviewer concluded by noting that the real value of a patent is ultimately based on what the buyer is willing to pay for it.

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

Reactions to this question were mixed, with one person finding resources were insufficient, and four of five people finding them sufficient. One reviewer stated that even though they marked the resources as sufficient, the project probably needs more funding support to best accomplish its objectives. One person commented further that the project appears to have adequate resources to meet research milestones. Another person commented that the resources are sufficient since the project is not basic research, but rather primarily just compiling and analyzing existing data. The last reviewer to comment noted that the project is working to a schedule, and the researchers did not mention a need for additional resources.

Converter Topologies for Wired and Wireless Battery Chargers: Gui-Jia Su (Oak Ridge National Laboratory) – ape033



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person affirmed that the cost reduction opportunity for the Level 1 and Level 2 charger from using the power electronics already integral with the inverter seems very significant. The reviewer added that the ability to plug-in cost-effectively will enable a major displacement of petroleum, far beyond the petroleum reduction possible with even the highest efficiency non-plug-in hybrids. Another commenter remarked that reducing the cost, weight and size of the onboard battery charger helps to enable the market for EDVs; this will help to reduce our dependence on foreign oil. The final reviewer commented that this task addresses the need to charge the on-vehicle batteries in a cost-effective manner; by increasing the efficiency and reducing the mass of the vehicle this project could increase the miles per gallon equivalent (MPGe) and overall efficiency of the vehicle.

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

Only two reviewer provided comments. The first person noted that the project's goal is to design build and test an isolation converter for use in the on-board charger. The barriers are cost, weight and volume, but the reviewer asked if these can be quantified (not a percentage of metric) for the researchers' particular charger. The reviewer added that other barriers are high efficiency, but again asked if this can be quantified with respect to today's chargers, and inquiries how high is high. The reviewer concluded by noting that the simulations from 2011 look promising, but criticized that the isolation converter was not included. The reviewer explained that the isolation converter is under patent review and no details were disclosed. The other reviewer to comment had very detailed comments, stating that this approach is interesting and can potentially meet the desired goals. There are a couple of issues that need to be clarified because they will impact the cost of the system. The first relates to the motor(s): the diagram shows the neutral point being brought out; this is not normally done and will increase the cost for the motor. The second is related to the isolation method; the diagram indicates a separate isolation unit between the inverter and the battery that may have to support not the typical charging currents but the full motoring current which will have a large effect on cost and size of this component. Another area of concern is the thermal requirements during charging. The thermal needs of the vehicle need to be defined and the impact on the 12-volt load during charging has to be addressed. If the cooling system is required to be operational, the reviewer asked what the load is on the high-voltage system, since the load cannot be provided by just the 12-volt battery due to the extended time of the charge process. If the accessory loads require significant 12-volt power and/or high-voltage power then the overall impact may be that it is not feasible for a Level 1 charger. For instance, an air cooled battery requiring conditioned air may require most of the charge power just to operate the air-conditioning system.

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

Reactions to this question were mixed. This person mentioned that they could not comment on details of the concept since it is under patent review. This person acknowledged that a design exists, but there is not enough information to comment. Another commenter observed that the simulations show promise, but more information is required on the auxiliary loads and the connection scheme (the reviewer qualified this by stating that they realize that protection for the idea is required). The final person commented that the researchers need to learn more about the details of the approach, but it appears that this approach is yielding a major opportunity for reducing cost and size of the on-board power electronics needed for the Level 1 and 2 on-board chargers. The reviewer wondered if this might make possible a lower-cost approach for higher levels of charging as well, but details are lacking on this (perhaps due to the lack of IP protection).

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

One reviewer suggested that the researchers may want to involve a Tier One supplier to verify the results. They added that if it is practical working with a Tier One, or multiple Tier One suppliers, it could possibly get this into production faster. Another person had similar comments, suggesting that more industry involvement might be helpful (e.g., with Delphi) to consider system issues early-on in the design optimization. The final reviewer to comment felt that the high-level requirements have been successfully provided by the collaboration effort but some of the details are still required since they will have a large impact on the viability of this approach.

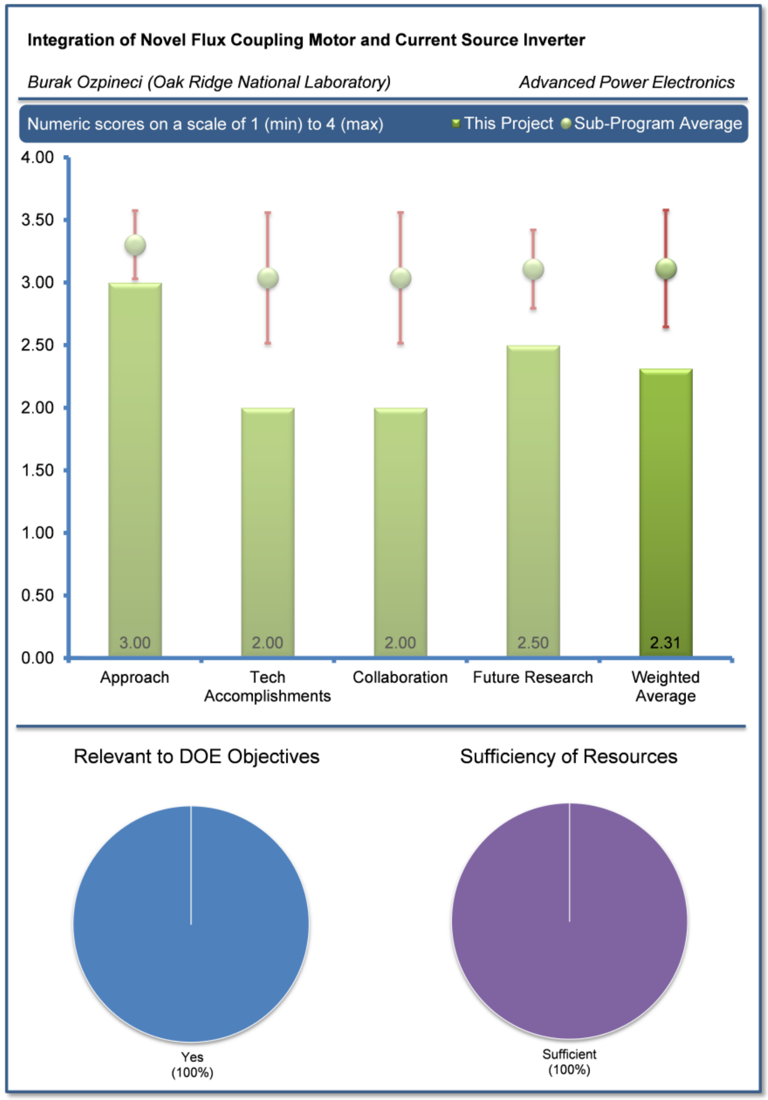
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer simply stated that the current design is an evolution of previous work. The other reviewer to comment acknowledged that progress is excellent if the assumptions are correct, but the reviewer cautioned that the risk is high that the assumptions are not correct. The reviewer added that if the 12-volt loads and high current paths are defined and do not impact the design then the plans are correct, otherwise the plans need to be modified to provide answers.

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

Reactions to this question were mixed with one person feeling that they were insufficient while two others felt they were sufficient. One person described that the resources appear sufficient for on-board wired charger, but not for including wireless charging as well (which is probably one reason that the project's scope has been reduced from wired and wireless charging to just wired charging). One reviewer suggested that the researchers may want to involve a Tier One supplier to verify the results. The final person commented that the direct resources are appropriate providing a significant change is not required once the questions from above are answered. The reviewer concluded by suggesting that the researchers might need some additional support from the vehicle team.

Integration of Novel Flux Coupling Motor and Current Source Inverter: Burak Ozpineci (Oak Ridge National Laboratory) – ape034



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person commented that the project supports the objective of petroleum displacement by developing a new inverter and motor concept. If successful this new concept would result in cost savings and performance improvement for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another evaluator described that the proposed motor has no rare earth magnets, no DC link capacitor, and no extra DC link inductor in current source inverter (CSI). These features offer the possibility of a lower total system cost without reduction in performance, which facilitate adoption of EVs and HEVs. One expert noted that meeting the DOE VTP 2015 cost targets and the VTP 2020 drive system targets will help to lower the cost of the power electronics for EDVs. They added that this lower cost will help to enable the market for EDVs and reduce our dependence on foreign oil. The final person pointed out that the project strives to address the technical (temperature) and cost problems associated with large conventional DC link capacitors by utilizing a current-source inverter. The reviewer added that the project also addresses the need for a series inductor by attempting to utilize the inductance of the propulsion motor, as well as addressing current rare earth magnet material availability problem by using a non-PM motor.

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

One evaluator noted that the program builds on earlier successful program for CSI inverter and marries it with development of a non-PM motor. Another person simply stated that the project had shown good use of FEA and system simulation to design core and inverter. The third reviewer had detailed comments explaining that the main goal of the project is the integration of a current source inverter with a new flux coupling machine without permanent magnets. They added that the flux coupling machine has a DC excitation coil and core. The high inductance in the motor will also be used as the inductor for the current source inverter. **This commenter asserted that t**he overall approach is generally well-designed and some of the technical barriers are identified, but many of the uncertainties about the viability of the concept remain at this point in time, which is acceptable for a research project in an early stage. **The final reviewer described that the concept depends on the ability to utilize the excitation coil in the motor to function in two roles. In addition to providing motor excitation it will also function as an inductor for the CSI. It has not been shown, yet, that the DC and AC flux can be separated.**

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

One reviewer commented that the CSI inverter was demonstrated with separate CSI inductor and with motor excitation coil. One expert explained that the researchers evaluated the system efficiency using separate CSI inductor and then NFC machine field coil as inductor. They also mentioned that the researchers developed a shorting ring concept to reduce effects of AC flux components in machine. Another commenter asserted that the Technical Accomplishments are only fair so far and the progress in overcoming the identified barriers is only modest. The reviewer felt that the achievements in the former project about the design of the flux coupling machine itself are not sufficient yet to fully prove the statement that it is on par with an IPM machine. Within the project here, so far it is only proven that the excitation coil and core can generally be used as the inductor for the current source inverter but with only very low efficiency. It seems that it is not fully understood at this point in time why the efficiency is low and how it can be improved. It is also unclear at this point in time how the operation of the flux coupling motor is effected by the AC flux in the excitation core. The final reviewer also had detailed comments, explaining that using the excitation coil in the motor as the inductor for the CSI has not been proven. The reviewer asked, from a system standpoint, if there will be a need for more electronics to separate the DC and AC flux components. The reviewer also asked what are the impacts of cost, weight, and complexity of those other components. Conversely, if the CSI inverters big inductor is ignored, and efforts are concentrated on the non-permanent magnet motor aspects, the reviewer asked how would that compare to the DOE VTP 2015 and 2020 motor targets, and also would like to know if the motor could stand on its own. If so, this reviewer would like to know if a CSI inverter would be needed for this motor, or are there other alternatives.

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

Reactions to this question were mixed. One person stated that there is no collaboration with other researchers outside ORNL at this point in time. The reviewer, however, felt that it would be beneficial if collaboration with drive system OEMs could be established in order to provide guidance for the project about what is of interest for the industry. Another person simply stated that the only non-ORNL collaborators are core material suppliers. The final reviewer to comment observed that the researchers are working with soft magnetic core vendor(s), but asked if the researchers have considered a motor supplier to evaluate if the NFC machine can be manufactured.

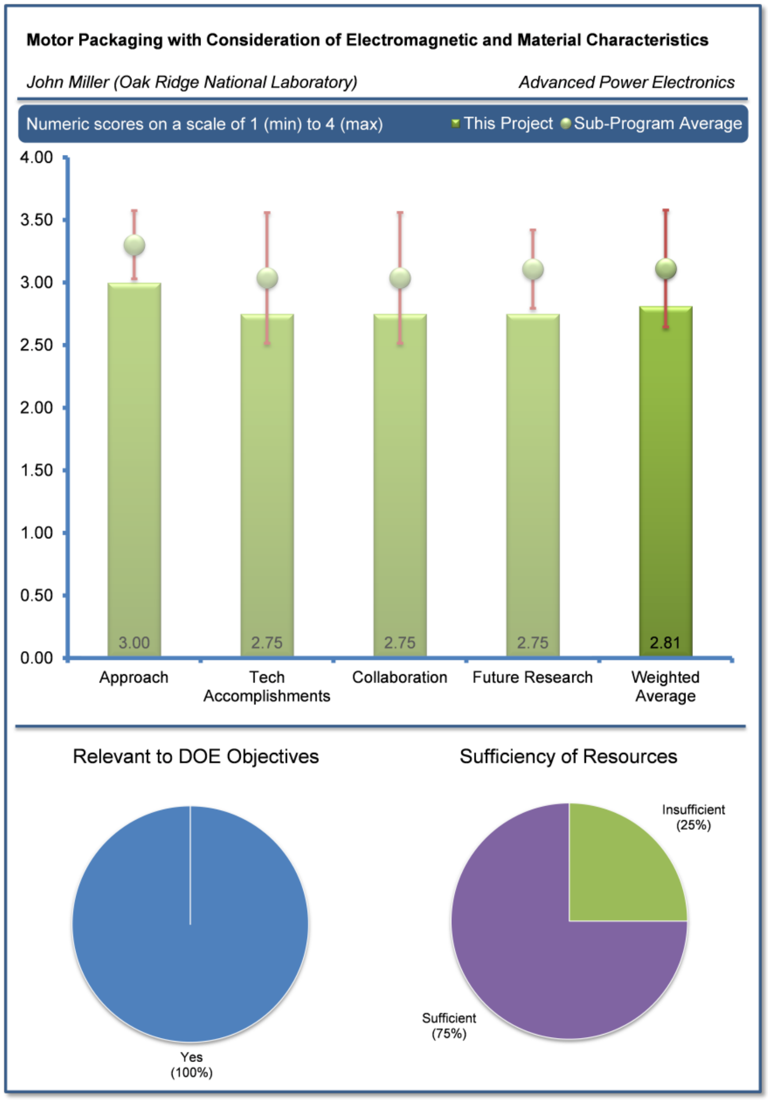
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer simply stated that the future research plans provide an appropriate emphasis on increasing efficiency. Another person simply stated that the plan appears adequate. Another commenter remarked that the milestone definition in the project is relatively vague. It was not obvious to the reviewer if the researchers have a concrete plan of how to overcome the identified barriers as, e.g., the very low efficiency. A lot of uncertainties remain in this project, which is acceptable for a research project, but the future research plan needs improvement. The final person commented that the researchers n**eed to focus on overcoming the ability to utilize the excitation coil in the motor to function in two roles. The reviewer concluded by stating that in addition to providing motor excitation it will also function as an inductor for the CSI.**

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

All four reviewers to comment felt that the resources were sufficient. One person provided additional detail, observing that the project has sufficient resources for the defined tasks; a milestone review in FY 2012 will determine if the concept has merit.

Motor Packaging with Consideration of Electromagnetic and Material Characteristics: John Miller (Oak Ridge National Laboratory) – ape035



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reactions to this question were all positive. One person commented that the project supports the objective of petroleum displacement by developing new motor packaging concepts and improved materials. If successful, these would result in cost savings and performance improvement for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another expert explained that efficiency improvement in PEV is essential to make the best use of battery, so working directly on the design of electrical machine to improve efficiency is working at the source. One person highlighted that improving motor efficiency improves EV range or reduces battery cost, and also improves continuous performance. The reviewer added that each of these helps improve market adoption of EVs and PHEVs. The final person to comment mentioned that improved materials and use of novel materials for higher efficiency directly relate to petroleum displacement.

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

One person explained that the main goal of the project is the development of more efficient electric machines by means of improving lamination material properties and improving cooling materials and processes. For a better understanding of the loss mechanisms in IPM machines, an example machine was analyzed regarding its loss distribution. This is a good approach as it helps to guide the work on improvements in the right direction. The reviewer explained that the overall approach is generally well-designed and some of the technical barriers are identified. They felt the milestones were well-defined and the manufacturing of prototype machines is coupled to Go/No-Go decisions-based on simulation results. Another commenter acknowledged the researchers' very good systematic approach to mapping core loss and then evaluating possible improvements by utilizing grain-oriented silicon steel. The final person explained that the project's focus on grain oriented silicon steel and the money/time investment required to optimize it for traditional motors is recognized as outside the scope of the program. Later in the presentation, however, items like potting compounds could become very useful and may be worth a closer look. The reviewer added that one important thing to note is that improved heat rejection at heavy loads can translate into smaller machines that have lower light-load losses, which the investigators note is the most important region for efficiency gains.

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

Reviewers generally noted good progress. One person described that the Technical Accomplishments are good so far and the progress in overcoming the identified barriers is adequate for the current status of the project. The reviewer added that for a better understanding of the loss mechanisms in IPM machines, an example machine was analyzed regarding its loss distribution. Guidelines for the development of optimized lamination steel were derived from the loss and magnetic flux analysis. The reviewer concluded by pointing out that the specific accomplishments in the investigation of the thermal material development for better heat transfer are somewhat unclear. The reviewer felt that it seems as if this part of the project is in a very early concept phase. Another reviewer commented that the researchers showed that significant improvement was possible by radial and circumferential aligned GOSS in the teeth and stator yoke, respectively. The researchers also evaluated steels and steel processing that could reduce loss at high frequency, allowing more efficient operation at higher speeds and power densities. The final person commented that substantial effort was spent on grain-oriented steel that will likely not proceed, but technologies that do not pan out (for whatever reason) do not mean they were not worth pursuing.

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

Reactions to this question were mixed. One person offered that collaborations with several divisions within ORNL and other National Labs have been set up. The reviewer said that it would be beneficial if collaboration with an electric machine OEM could be established in order to provide guidance for the project about what is of interest for the industry. The final reviewer asserted that partnering with industry is encouraged; vehicle and motor manufacturers will provide a slightly different view that may lead to new approaches.

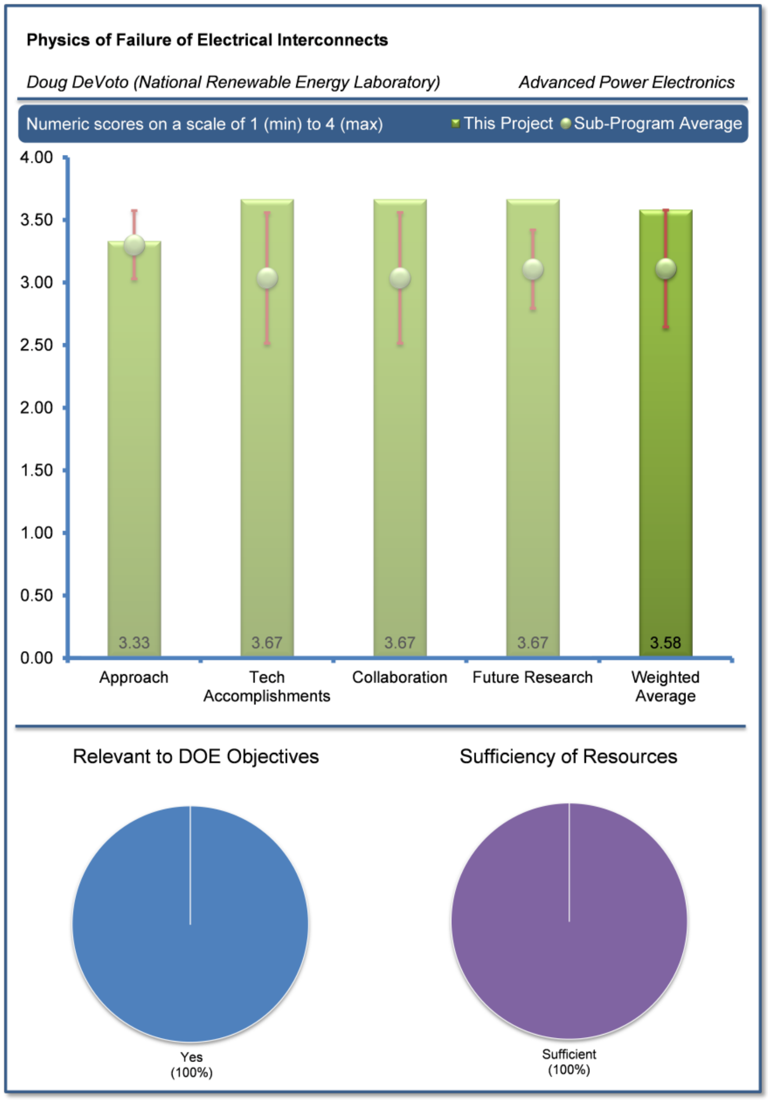
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewer feedback was mixed. One person said that the milestones in the project are generally well-defined. Surprisingly, the PI suggested that the project could be cancelled as a stand-alone project and could be combined with another project in which the same PI develops a new machine technology. The reviewer added that even though this suggestion makes sense from a technical point of view, it has to be asked, why the two projects were not been set up as only one project from the beginning; this might have given other rejected project proposals a better chance for receiving an approval. The second reviewer suggested looking at other winding types to improve ratio of continuous to peak power. The reviewer thinks that hairpin windings, for instance, already exceed the 58% target for the project, particularly when spray oil cooling is used. The final reviewer pointed out that it was said that this program will not move forward.

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

Reactions to this question were primarily positive, with one person commenting they were insufficient and three of four reviewers stating the resources were sufficient. One reviewer stated that it was said that this program will not move forward. Another person, however, felt that the project has sufficient resources for the defined tasks, but the suggested combination with another project by the PI requires a re-evaluation of the resource allocation.

Physics of Failure of Electrical Interconnects: Doug DeVoto (National Renewable Energy Laboratory) – ape036



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that the reliability of electrical interconnects is a core issue in automotive traction drives. Another reviewer noted that this project is focused on power electronics packaging reliability. The reviewer felt that poor reliability with a lack of understanding of the physics driving failure modes will lead to very poor market penetration and petroleum displacement, and as such, projects such as this will be key to wide spread adoption of the technology. The third reviewer stated that the project addresses the reliability of the power switch and thus directly impacts the cost of the system to the final customer. The reviewer also noted that a more reliable part will allow the warranty cost to be reduced and also provide the customer with a vehicle that is environmentally friendly but also reliable.

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

One reviewer stated that the project is organized with the proper focus on the study of the physics of failure for the interconnection wire bond fatigue and stress-strain characterization. Another reviewer liked the emphasis on increasing the understanding of internconnect models to de-risk and de-cost qualifying this essential and risky part of electronics packaging. The reviewer did note that they felt the project does had a hint of corporate welfare, specifically that the reviewer thought Orthodyne would be the subject matter experts on what this project is trying to do, but the presenter claimed otherwise. The third reviewer indicated that the project has identified a failure mode that is significant in today's devices and an alternative method of accomplishing the function. The project approach compared the two approaches using the appropriate testing methods to precipitate the failures. The reviewer felt that the only improvement would be to add some vibration testing during the process.

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

A reviewer noted that although this is a new project just getting started, the work appears to be progressing satisfactorily. Another reviewer felt that, though they expressed reservations about being able to provide a quality opinion, the results appeared to be on track with expectations. Another reviewer indicated that the approach has been determined and will provide the appropriate type of stress to accelerate the failure mode being addressed. The reviewer felt that using a common layout for both ribbon and wire bonding should eliminate any concerns that the testing was not performed correctly. The reviewer additionally stated that the simulations looked encouraging.

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

One reviewer indicated that the project had very good coordination with academia and Department of Defense (DOD). The second reviewer stated that the selection of industry leaders in this area is very good. The reviewer felt that using one supplier capable of providing both ribbon and wire bonding (sells both types of machines) was great. Additionally, the reviewer encourages a similar type of test for the PBA package from Oak Ridge National Laboratory (ORNL) either be added or planned for the future. Another reviewer felt that there was an excellent collaborative relationship with an industry leader (Orthodyne). The reviewer indicated that the presenter described Orthodyne as being fully behind the project. The reviewer noted one thing during questions: The presenter corrected statements multiple times following challenges by the reviewers. One specific example the reviewer cited was as follows: the failure mode of ribbon connects was described as catastrophic in contrast to multiple wire bonds which are graceful. It was noted that ribbon connection failure modes need not be all or nothing and the presenter agreed when this was pointed out. The reviewer attributed this issue to youth but recommended a more careful attention to detail in the future.

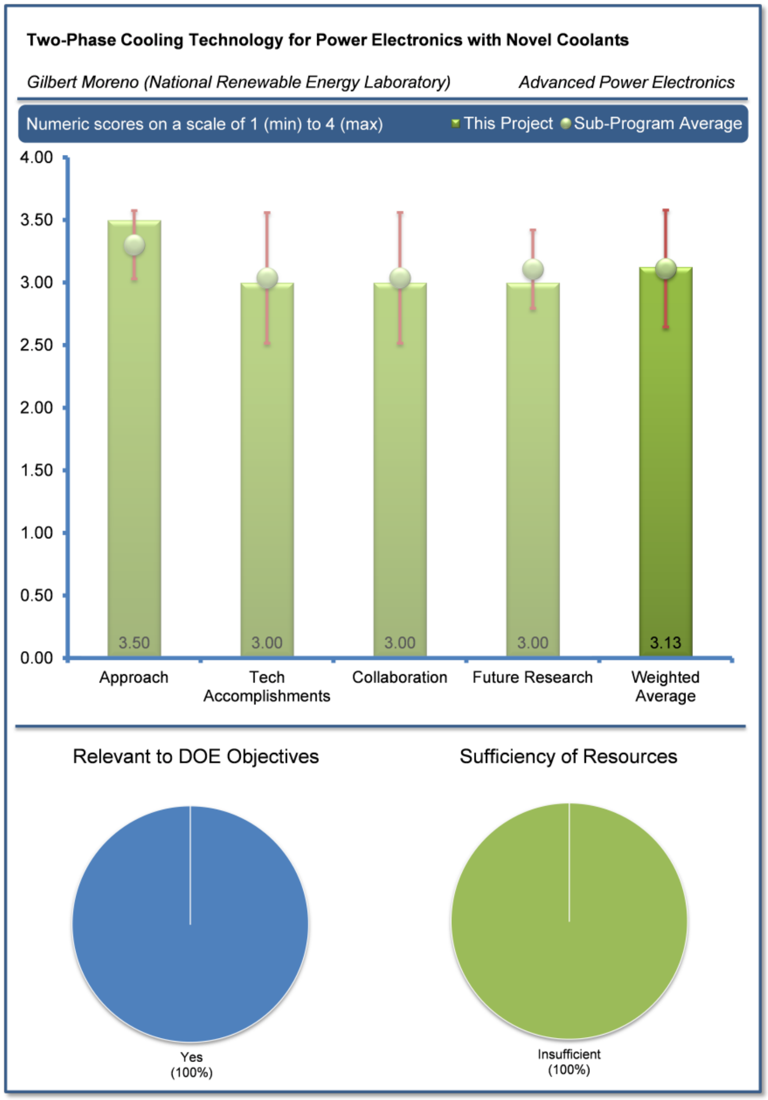
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the projects future research looks good, but they felt they were not fully qualified to provide the most effective critical review. Another reviewer noted that it was a very important aspect of traction drive and DC-DC converter power module reliability. The third reviewer noted that the future plans represent the logical next steps to this problem and include adding state of the art commercial methods.

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

All reviewers noted that the resources were sufficient.

Two-Phase Cooling Technology for Power Electronics with Novel Coolants: Gilbert Moreno (National Renewable Energy Laboratory) – ape037



Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer felt that the project met DOE's goals because advanced cooling for power electronics is an essential topic for the Vehicle Technology Program (VTP). The second reviewer noted that thermal system design and performance are required to achieve reliable and efficient electric traction system and can be complicated and relatively expensive. The reviewer indicated that this project addresses one approach to address this issue.

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

Reviewers had mixed responses to this question. One reviewer liked the project. The reviewer felt that it makes sense assuming the sizing of the components fall out in favor of the two-phase technique with available refrigerants. The reviewer also felt that the argument was compelling in that phase change represents a large advantage over non-phase change cooling, and the advantage can be used smartly in design trades to make a working system feasible in automotive applications (wide band gap semiconductors are similar in that respect). The reviewer noted that critical factors such as size and weight after the various parasitic losses of a real system are accounted for need to be addressed before one can really believe this is a disruptive technical approach. The reviewer also noted that reliability is, of course, also going to get close scrutiny by real-world automotive engineers. The first reviewer's main criticism was twofold, which they thought should be addressed in the future plans. First, the quantitative case is made using a scientific approach, rather than an engineering approach or measures of performance (i.e., graphs and charts of coefficients and normalized heat transfer calculations are used, rather than a point design of a working system) in which things like real-word heat exchangers and the need for filters and receivers and whatever else goes with a refrigerant-based system increase system size. The reviewer notes that these parasitic losses must be accounted for. Second, a collection of technologies of questionable relevance are amalgamated for no firm purpose into one project. The reviewer questioned why coating technologies were convolved with the core project. The reviewer wanted to know if they were needed and, if so, would have liked an explanation why and to have the presentation address whatever risk is added as a result; if the coating technologies were not needed, the reviewer recommended not including them in the project. The reviewer felt that including coating technologies detracts from the sense that the core technical approach is feasible. When pressed on this subject, the presenter agreed that the coatings were included because they were interesting new technologies, which the reviewer felt was the wrong answer. The reviewer indicated that in the real world of the automotive commercial market place, it is necessary to be clear and concise what you are doing and why it solves a problem or risk unnecessary delay potential adoption.

The second reviewer noted that, while the approach has shown the capability to provide excellent thermal performance at the device level, little has been done to address the system issues identified last year. While the use of this method has been shown on a power switch designed to be double side cooled, the reviewer wanted to know about switches designed for single sided cooling. The reviewer stated that the use of an intermediate coolant medium requires the addition of another interface to remove the heat from that medium. The reviewer granted that a simple liquid to liquid or potentially liquid to air exchanger may suffice, but that the cost of this must be investigated as well as its impact on the overall vehicle coolant system. The reviewer noted another area of concern with this approach in the interconnects required between each switch in the design shown; the reviewer wanted to know how will this be accomplished on the production line because of the significant number of connections to make and leak proof.

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

One reviewer felt that this must be a young project because most of the results seemed to be based on previous pre-proposal work. The reviewer did not feel that this lack of progress detracted from the overall project and noted that they liked the underlying concept and wished the project success. The second reviewer stated that the progress in demonstrating that the concept is valid has been very good but noted that practical implementations have not been demonstrated. The reviewer felt that the involvement of Delphi to assist in testing the design is a good next step but felt that a conventional module maker may also need to be involved.

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

The first reviewer stated that the use of new coolant fluids and surface treatments is very interesting. The reviewer wanted to know if these surface treatments can be used with today's coolants. The reviewer felt that, if the interface between this coolant system and either the air or vehicle coolant system can be economically and efficiency implemented, this may be a viable solution. The reviewer cautioned that the solution must provide cost benefits in terms of the overall system, i.e., either less switch area needed or a reduction in the load on the in vehicle coolant system for this to work. Another reviewer felt that they did not get a good sense at what collaboration was bringing to the project. The reviewer indicated that all of the activity related to coatings is an example of how collaboration sometimes needs to be better justified as core to the project. The reviewer recommended a more focused effort in which collaboration produces more than the sum of the parts. The reviewer noted an excellent example of collaboration was the two air-cooled projects that combine power electronics expertise and thermal engineering expertise to make a very effective project team.

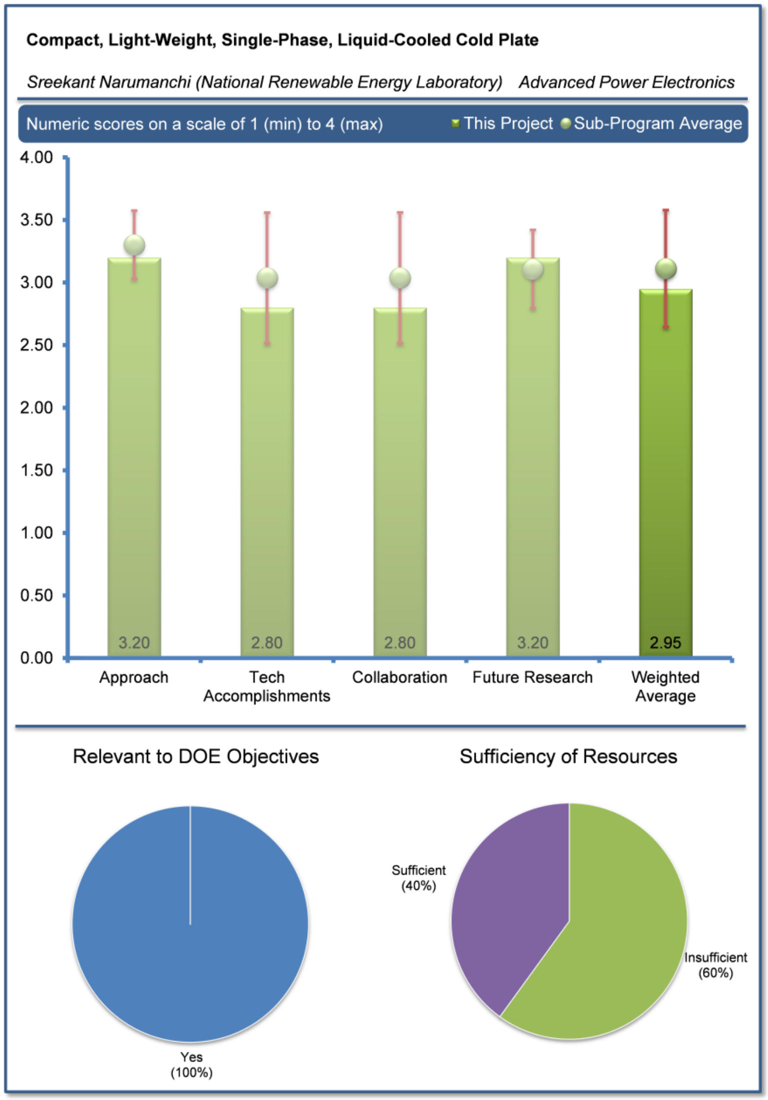
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the project is relatively new. The reviewer went on to state that this would be a good time to consider the issues raised in the technical approach critique so that the disruptive nature of the concept can be communicated while maintaining a focus on reducing to practice quickly so that we can all become believers. As previously indicated, the reviewer felt that the air-cooled projects have an excellent model for this project to follow. The second reviewer noted that the future plans as stated will support the development of this cooling approach at the switch level but not necessarily at the inverter level. The reviewer suggested getting some involvement from a vehicle integrator to assist in determining the impact at the vehicle level to assist in bringing this technology to the level required to actually implement at the vehicle level. This reviewer would also look at tying this coolant system into the on-vehicle air conditioning or perhaps the battery coolant system if there is one.

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

Both reviewers felt the project resources were insufficient. One reviewer indicated that they would like to see a larger project on the scale of the air-cooled projects. The other reviewer noted that vehicle level resources need to be added since this project has the potential to have a large impact at that level and it will create significant discussions.

Compact, Light-Weight, Single-Phase, Liquid-Cooled Cold Plate: Sreekant Narumanchi (National Renewable Energy Laboratory) – ape039



Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers had positive responses. One reviewer stated that integrating practical but advanced liquid cooling techniques in a production automotive traction inverter is highly relevant. Another reviewer stated that advanced thermal control technologies are critical to enabling higher power densities which are key to the success of Hybrid Electric Vehicles (HEV) and Electric Vehicles (EV) in the market place. The reviewer noted that good management system can reduce size, weight, and improve performance. These things lead the reviewer to conclude that the project is relevant to the Department of Energy (DOE) overall objectives of petroleum displacement. A third reviewer noted that the reduced power electronics thermal system weight and cost will help to provide a more attractive system for end-users. The use of plastic with glass fibers not only decreases the weight, but also offers more options for the manufacturability of the final product. Also, the increased thermal performance of this system will provide significant improvements to multiple private industry inverters, as well as potential other power electronics systems. A fourth reviewer indicated that this project addresses the need to improve the heat removal from the switches to allow smaller, lighter and more efficient inverters to be developed. This will lead to meeting the cost and size goals of the DOE leading to more electric vehicles on the roads.

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

Reviewers had mixed responses. One reviewer noted that the project is a good match between low cost materials and commercially available processes and components. Another reviewer indicated that the approach is generally through modeling and simulation, and that fabrication of prototype and testing of the prototype has been carried out. The reviewer also noted that discrepancies have been identified between modeling and prototype test results with a base line from a UQM inverter. The reviewer felt that the key is to reduce thermal resistance and increase heat transfer rates through the WEG jet. A third reviewer felt that the program is very short, and is being managed very well for the time frame allocated. Simulation is needed to increase efficiency of the program, and is now being compared to real-world experimentation. In addition, according to this reviewer, the corrosion and change in thermal characterization has been provided, starting at nearly the very beginning of the program. The reviewer remarked that it will be interesting to see if this changes over the remainder of the program and/or if there is a way to accelerate this life testing. The fourth reviewer said that the approach using spray cooling/jet impingement presented is a good approach but has several issues that need to be resolved before it is accepted by the vehicle manufacturers. While this project is presently defining the performance that can be achieved by this cooling approach, the reviewer felt that it is not addressing the issues from wide spread acceptance in the auto industry. The reviewer additionally noted that spray cooling can achieve improved thermal perforce at least in the controlled environment of the lab, but has not been proved to survive or be cost effective at the vehicle level.

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

Reviewers noted that the project has had good progress. One reviewer commented that the results are incremental in nature rather than transformative, but the results are positive and involve consideration and concern for economics which is essential. Another reviewer listed the project steps and noted the progress for each: the modeling was done, the prototype was fabricated, and preliminary testing was performed. A third reviewer noted that their comments were similar to the previous section in the project was utilizing the short timing very well. The reviewer felt that the accomplishments and progress were very easy to understand from the presentation and additionally commented that it was very nice work. A fourth reviewer stated that the progress to date has shown good results and has data to prove it along with simulations. The reviewer felt that the results indicate that there is high potential here but the performance and cost of the rest of the system need to have the same level of effort before it can be considered.

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

Reviewers had mixed input on the collaborations. One reviewer noted that the project has the right team. Another reviewer felt that the collaboration within the team was very good to excellent but system level involvement was required. The third reviewer noted that that there seems to be a good deal of collaboration with private industry, but other than providing the components, it seems that industry partners have not been actively involved in the simulation or management of the project direction. The reviewer was unsure if this was actually the case, but felt that this was not clear in the presentation. The reviewer would have liked to know if there were other things that UQM and Wolverine were doing. One reviewer felt that there is no true collaboration as UQM is providing the inverter and Wolverine Tube provides materials and components. The reviewer would like to see more collaboration with automotive Original Equipment Manufacturer (OEM)/supplier on the prototype and commercialization, connections with the real world applications, and possibly collaboration with academia institutions on the theories that support the technology.

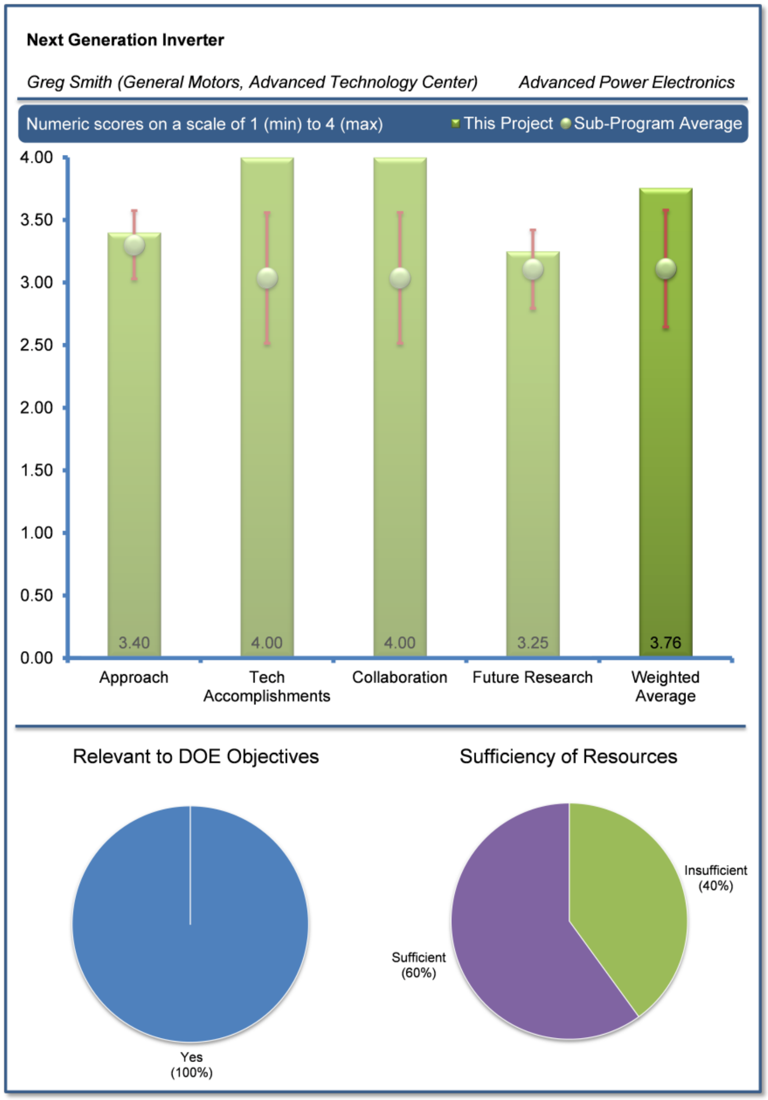
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

A reviewer commented that the initial results with respect to reliability and lifetime are good and that focus on this topic is essential for the work to transition to practical use. Another reviewer noted that the future plans appear to be well thought out and follow a natural progression of the technology and the project simulation and testing results. The reviewer felt that it would be helpful to get a better understanding of what accomplishments are expected from the planned second prototype build. The reviewer wanted to know if there were going to be other differences besides the micro-fins and if the testing performed on the second prototype would be different from the testing on the first prototype. A third reviewer indicated that the future plans need to specify what good results are in terms of device, unit, and system performance. The reviewer would have liked to see what the pressure drop and flow rate values are for the first prototype and if they are reasonable compared to today's vehicle coolant systems as well as the performance using the typical contaminated coolant fluid specifications for particle size. The reviewer noted that the nozzle size seemed adequate but felt that only data will provide a definitive indication of this impression. One reviewer noted that the project could use more risk mitigation regarding material selections (plastic creep, operating temp limits, etc.) Another reviewer noted that the projects will finish by the end of 2012. However, it was unclear to this reviewer whether all project objectives can be fulfilled by then, which raised questions for this reviewer. In particular, the reviewer wanted to know the following: the plan for commercialization; the advantage in comparison to the traditional heat exchanger, other than an increase in cooling efficiency and cooling uniformity; whether the new approach is able to compete in price/performance; and how the project plans to evaluate the success of the new approach.

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

Three reviewers felt there were insufficient resources. Two reviewers felt the resources were sufficient to complete the project. In particular, one reviewer commented that the results are promising but not transformative, that the path to commercial use is clear, but that risk remains in regards to long term reliability. Another reviewer stated that the program seems to be running very well with the resources provided. The reviewer did not see any area of needed improvement with regards to resources and felt that there was nice project management.

Next Generation Inverter: Greg Smith (General Motors) – ape040



Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers found that the project supports DOE objectives. One reviewer noted that the project was working with multiple suppliers and that the focus on low cost was positive as it is a key element for consumer acceptance. Another reviewer agreed, indicating that development of low-cost, high-performance inverters are key to the success of acceptance of electric vehicles. The reviewer stated that this program builds on the foundation of a previous successful inverter development program. Another reviewer noted that the technology is essential for electric and hybrid vehicles, which are critical for reducing petroleum usage. A fourth reviewer commented that this effort is to support electric or hybrid vehicles, which will reduce the dependence on petroleum products. The fifth reviewer stated that this project is directly related to develop next generation low-cost high performance power inverter for HEVs and EVs.

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

A reviewer noted that the approach to develop a comprehensive understanding of the inverter requirements and flow those down to the sub-component level was good. The reviewer also felt that the involvement of suppliers and General Motors' (GM) questioning of/understanding their cost drivers and impacts on performance/reliability was a very good approach. One reviewer noted that the project is working with a variety of supplies and has a co-development approach. The reviewer noted that the approach has a basis in conventional technology, and is considering modularity, scalability, volume, and mass. Another reviewer noted that GM is potentially one of the largest customers for the power inverters, and that they address the issue from the system level in this project. One reviewer commented that the technical requirements and barriers are extremely well understood and described; however, no specific technologies for overcoming the barriers were described. The reviewer noted that, it is not known if they have identified such technologies and are not describing them for proprietary purposes or if they have not identified promising technologies. The reviewer suspected the former to be the case but could not be sure. One reviewer expressed some concern that GM's desire to spec/develop a universal inverter that is adaptable to all vehicles, etc. is laudable, but may be too large an undertaking and take too much time. The reviewer was concerned that they may end up with something that does not meet the goals.

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

Several reviewers noted that the project is in its very early stage, with one indicating that it was only 2% complete, and two indicating that it was too early to make an assessment of accomplishments or progress. One reviewer felt that the team has made great progress to address the technical and market challenges. A reviewer noted that the team is considering cost reduction and performance, has a specification developed, has a test plan developed and has started testing, and had key suppliers identified. One reviewer felt that the descriptions of progress were vague, and suspected that this was probably for some of the same reasons the reviewer discussed when making comments on the previous question regarding overcoming of barriers to completion.

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

Several reviewers noted that the set of partners and suppliers for this project were well selected. One reviewer noted that the project is working with a good set of partners and suppliers. Another reviewer concluded that working with suppliers from multiple tiers, along with ORNL and the National Renewable Energy Laboratory (NREL), as the right thing to do. The third reviewer also noted the involvement of ORNL and NREL, and observed that an extensive group of potential suppliers are involved in the project. This reviewer noted that GM is providing strong leadership and coordination. The final reviewer observed that GM has been working with different vendors to develop the next generation inverter.

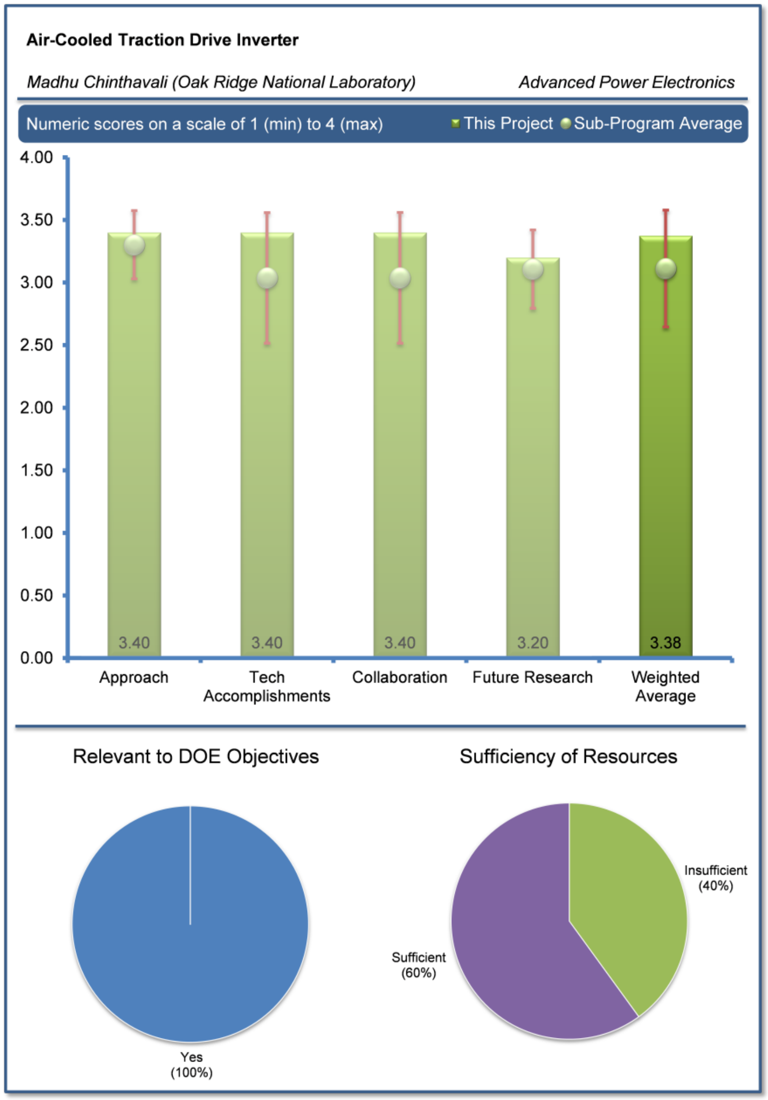
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer commented that the approach seem to be sound; another reviewer agreed, stating that the plan looks good. A third reviewer indicated that GM understands exactly what the customers are looking for in a next generation inverter.

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

Two reviewers felt the resources were insufficient. Three reviewers felt that the resources for the project were sufficient. The two reviewers who felt the funding was insufficient commented that GM's contribution to the project of $10 million is sufficient to supplement the smaller funding provided by DOE.

Air-Cooled Traction Drive Inverter: Madhu Chinthavali (Oak Ridge National Laboratory) – ape042



Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers found that the project supports DOE objectives. One reviewer commented that air cooled inverter for automotive traction drives is a definite option for future electric vehicles. Another reviewer agreed, indicating that that air cooling has the potential to reduce the cost of the power electronics and the overall system in the vehicle and is thus relevant to the DOE goals. A third reviewer indicated that highly efficient traction drive inverters will directly impact the amount of petroleum being consumed by the vehicle and/or increase range and reduced recharge frequency. The fourth reviewer stated that the project targets VTP 2015 targets which help to enable the market for Electric-Drive Vehicles (EDVs); this, in turn, lowers the United States' dependence on foreign oil. The fifth reviewer noted that the project's work supports innovative design of EV inverters to determine if DOE volume/weight/thermal/cost targets can be met.

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

One reviewer felt that the multidisciplinary design approach implementing a practical integrated thermal and electrical prototype, including capacitor issues, is the correct approach. The reviewer really liked what they saw. Another reviewer found that the inverter topologies are innovative. This reviewer asked about the number of discrete devices, whether the Printed Circuit Boards (PCBs) used are conventional or polyimide, and what are the estimated heat transfer coefficients of the finned structures for each case. The reviewer did not see any aspect of the project that looked at thermal cycle testing of the components or the complete inverter. The reviewer felt that this kind of analysis will be crucial for PCBs especially when temperatures of the die approach 250°C and beyond. A third reviewer noted that meeting 2015 VTP targets are being addressed. This reviewer indicated it was not clear what the allowable temp rise is for this inverter using Wide Band Gap (WBG) materials. In particular, the reviewer wanted to know if, for the air cooled inverter the θ_{ja} target can be quantified and what it is based on; the reviewer indicated drive cycle or 55kW for 18 seconds or some other criteria should be explicitly stated. The reviewer indicated that it is also not clear how 50°C ambient air was chosen as the test case in Slide 10 and requested an explanation of the selection process, and how does the selected temperature effects vehicle mounting locations. The reviewer indicated that those assumptions can have an impact on size and weight of the inverter. In addition, the reviewer noted that acquiring high temperature devices was discussed in the presentation but acquiring high temperature passives was not discussed. The fourth reviewer noted that the axial concept accommodates use of an annular capacitor and its low internal inductance/Equivalent Series Resistance (ESR) capabilities and that the capacitor appears to be cooled by the same air as the Insulated Gate Bipolar Transistors (IGBTs). The reviewer also noted that the rectangular approach is fairly conventional but that details of how the capacitor is cooled were not obvious. The reviewer felt that both designs are strongly focused on the barriers. The fifth reviewer indicated that the approach taken addresses the issues related to designing an air cooled inverter. The reviewer felt that the postponement while waiting for thermal advances was smart but they were not sure why there was a need to look at package inductance unless there are plans to change the design of the package. The reviewer also felt that the other items investigated were appropriate. While the reviewer felt that performing analysis on two different form factors very useful, they felt that there was a need to include impact of connectors on the design as well as where the inverter is located relative to motor. The reviewer noted that if the inverter is connected to the motor with very short leads then the inverter can act as a local heat sink for the motor thermal load which is more heat than is typically assumed for the motor leads from an inverter.

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

One reviewer noted good progress and that reported data seems reasonable. A second reviewer felt that there were innovative designs compared in a simulated environment. This reviewer would like to have seen the boundary conditions listed for the simulations (thermal). However, according to this reviewer effort appears to be progressing appropriately. One reviewer noted that the results of the thermal modeling for the axial design indicate that the design is not feasible due to the high IGBT junction temperature. Also, the reviewer noted that there was no mention of how effectively it will cool the capacitor. In addition, the reviewer noted that the results of thermal modeling for the rectangular design indicate that it is feasible, but, again, there was no mention of cooling the capacitor. A fourth reviewer noted that the analysis results indicate that it is possible to air cool an inverter based on the conditions stated. The reviewer felt that measurements related to the noise level generated by the blower and the effects of less than clean air being used, such as blockage of the heat exchanger as a function of life, were missing. The reviewer wanted to know where the ambient air temperature comes from. The reviewer was curious to know if transient conditions such as heat soak analyzed. The reviewer believed that this information should not be too hard to get given the quality of the analysis performed to date. One reviewer noted that 2010 simulations look interesting, but would like to know what assumptions being used in 2012 relating to ambient air coming into the power stage. These assumptions could have an impact on the design. The reviewer wonders if the PI can comment on what happens when the inverter goes through the dew point, and would like to know whether are all of the high-voltage/current connections are sealed. The reviewer wonders if the PI can comment on the ratings of the capacitors and other passive components. Furthermore, the reviewer would like to know where the 50°C ambient air comes from, and what happens to the power stage at 85°C. The reviewer inquires if it has been considered what are target noise levels of the power stage and fan, specifically how it was measured and was the current level acceptable. The reviewer would like to know are the new 200 ampere SiC switches packaged in a TOxx package or is it custom. Finally, this reviewer asked whether the packaging can handle the current and temperature cycles.

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

One reviewer indicated that the collaboration with NREL for thermal modeling was good, and a second reviewer commented that collaboration with suppliers for parts and NREL for thermal seems sufficient. This reviewer suggests working with the task team to define ambient air conditions in the vehicle as it could be helpful. A third reviewer noted that collaboration between NREL and ORNL to date has been great. This reviewer would like to see additional ambient conditions simulated and some effort made to simulate the fowling of the heat exchangers due to dirt, etc. The fourth reviewer referred to the work division as one of the few projects where the decisions made were intelligent. In particular, one reviewer noted that the decision to delay the ORNL work in fiscal year (FY) 2011 to allow a well-qualified thermal engineering team from NREL to contribute has been reflected in the outcomes. The reviewer remarked engineering that is more than the sum of the collaborators.

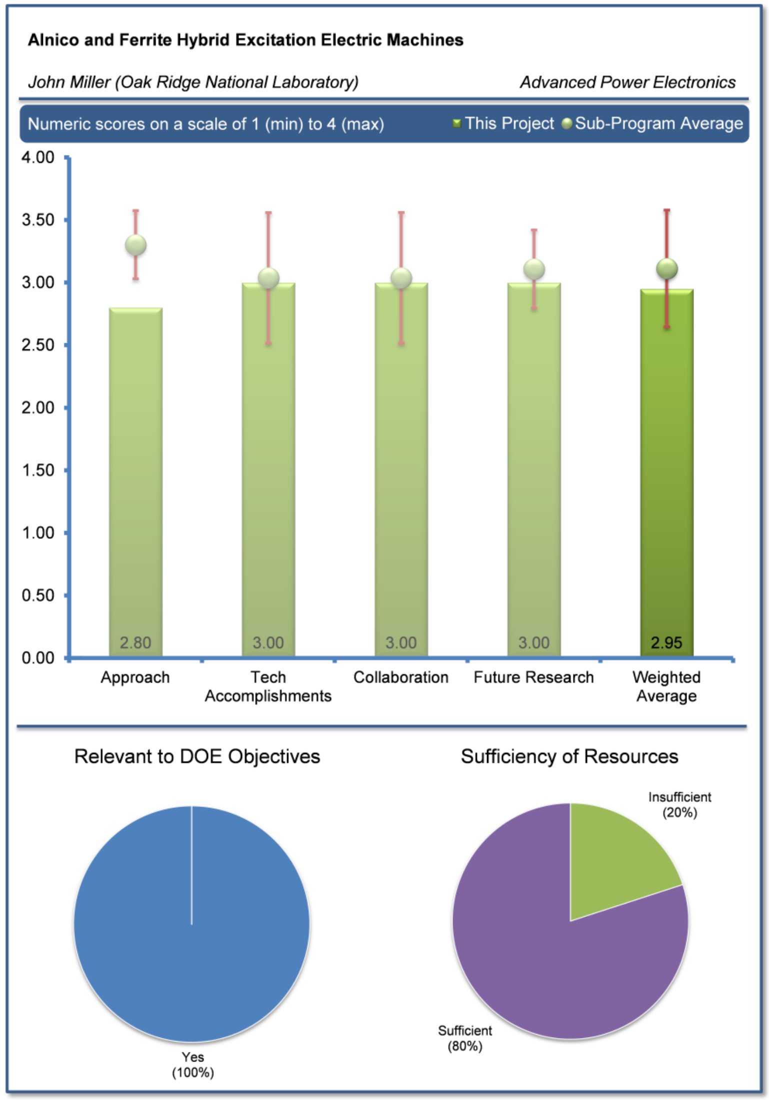
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers provided mixed feedback and some offered suggestions. One reviewer felt that the plans would advance the knowledge of what needs to be performed to accomplish an air cooled inverter. A second reviewer remarked that plan and milestones for future work are okay. A third reviewer did not see the intent to focus on the highly relevant thermal cycle reliability evaluation. The reviewer felt that second law thermal analysis should be considered for the modeling/simulation portion of the effort. A fourth reviewer thought that plans were good, but wanted to know why the project was not using the lowest specific on-resistance technology (i.e., smallest SiC area per unit ampere) because lowering losses for a given total semiconductor area is especially important for air cooling. Additionally, the reviewer noted that cost is king with automotive applications and felt that the feasibility is ultimately better served by using the SiC Junction-gate Field Effect Transistor (JFET) than the Metal Oxide Semiconductor Field Effect Transistor (MOSFET). The final reviewer noted that updating simulations and models based on the current concept was a good thing to plan to do. The reviewer indicated that the project team may want to reexamine the ambient environment and test case conditions.

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

Two felt that the resources were insufficient, and three reviewers felt that the resources were sufficient. One of the reviewers who felt the resources were insufficient commented that funding for FY 2013 will have to be increased for system build and test phase. Two reviewers who noted resource sufficiency reiterated this in their comments. Another reviewer felt that the resources that the project had relating to design and simulation studies were adequate.

Alnico and Ferrite Hybrid Excitation Electric Machines: John Miller (Oak Ridge National Laboratory) – ape043



Reviewer Sample Size

This project was reviewed by five reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

All four reviewers indicated that this project would either reduce the dependence on petroleum or facilitate adoption of HEVs and EVs. One reviewer commented that the project supports the objective of petroleum displacement by developing new motor concepts without the use of expensive rare earth magnet materials. The reviewer felt that, if successful, these new motor concepts would result in cost savings for electric drive systems. Another reviewer concurred, stating the elimination of rare earth elements from magnets would provide the high efficiency of Interior Permanent Magnet (IPM) motors at lower cost and in sustainable supply. The third reviewer indicated that motors and generators without using rare earth magnets would potentially reduce cost for electrical machines, which will in turn reduce the dependence on petroleum. A fourth reviewer stated that out-of-the-box thinking with regard to rare earth elimination is appropriate and supports vehicle electrification.

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

One reviewer noted that the project is in its early stage. Another reviewer indicated that there was good evaluation of flux switching machines. The reviewer was unclear on the reason for the dismissal of the transverse flux machine simply because of 3-dimensional flux path and use of SMC. The third reviewer stated that the main goal of the project is now the development of novel flux switching electric machines without the use of rare earth magnets. The initial broader range of the machine types to be investigated in the project has now been focused, which the reviewer felt was generally a good approach. The reviewer cautioned that, the flux switching machine topology may not be the right choice at this point in time as this machine topology is known for its relatively low magnetic utilization. Additionally, the reviewer noted that the research in the area of high speed machines requires an evaluation of the complete drive system including gear box and inverter. Overall the reviewer indicated that the approach is generally well designed and some of the technical barriers are identified. The milestones are also well defined and the manufacturing of prototype machines is coupled to go/no-go decisions based on simulation results. The fourth reviewer stated that the use of different magnet technologies inside the motor, taking advantage of their respective strengths, is worth a close look. The reviewer felt that high speed gearing and transmissions are challenging, and the reviewer cautioned the project team not to develop such a high speed motor concept without engaging a gearing/transmission resource.

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

Reviewers had mixed comments on technical accomplishments. One reviewer felt that the presenter provided a good explanation for why flux switching machines are not a competitive solution. Another reviewer commented that the technical accomplishments are acceptable so far and the progress in overcoming the identified barriers is adequate for the current status of this new project. Additionally, the reviewer noted that the transverse flux machine has been dismissed as a candidate but the described reasons are very vague and based on subjective evaluations of the work of others. The reviewer continued that the same can be said for the selection of the flux switching topology as candidate, which seemed to also be a subjective decision to the reviewer at this point in time and not really based on comparative simulation results to other machine types. The researchers claim that initial simulation results for the flux switching machine are promising but the presented information did not allow an evaluation of this statement. The third reviewer noted that the progress is difficult to gauge at this point, since this is a new program and the flux switching machine architecture has not been disclosed.

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

One reviewer indicated that the partnerships appear to be appropriate. Another reviewer noted that the collaborations with several divisions within ORNL and other national labs are set up. The reviewer felt that the collaboration with Ames Lab and their work on AlNiCo magnets is a very good choice. Additionally, the reviewer indicated that it would be beneficial if collaboration with an electric machine OEM could be established in order to provide guidance for the project about what is of interest for the industry.

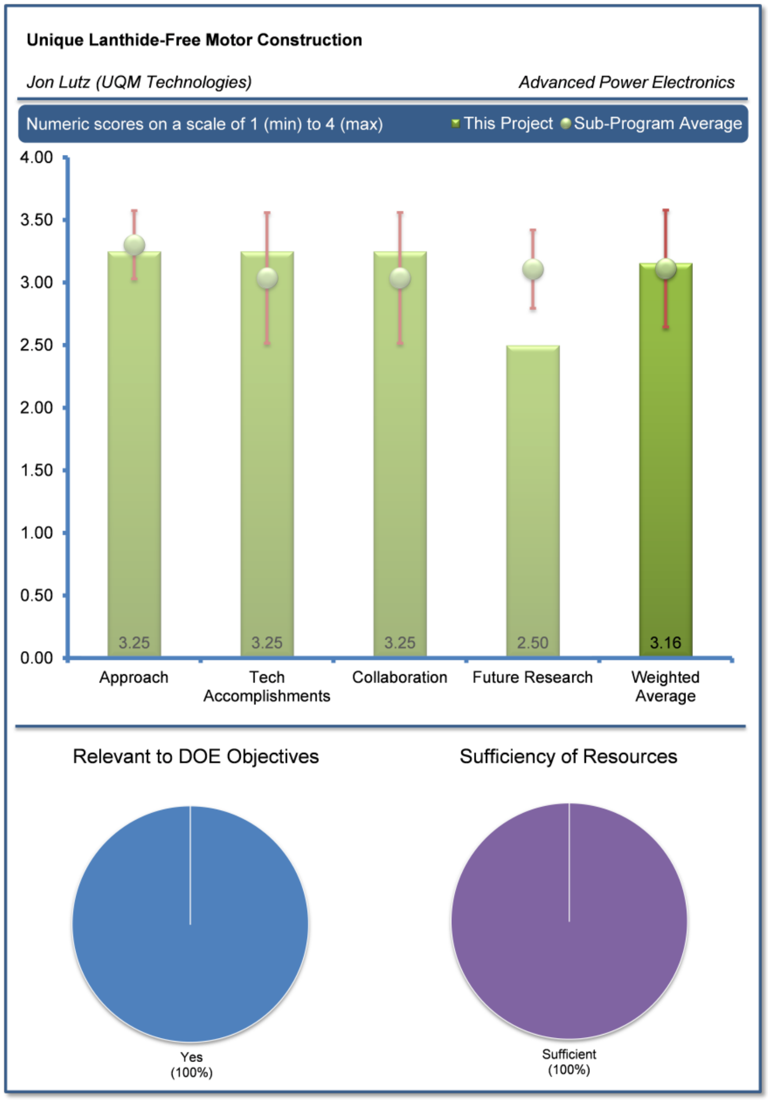
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer indicated that the milestones in the project are generally well defined. Another reviewer noted that if this program continues, the approach of year one modeling, year two proof-of-concept, and year three refinements is a good formula. Another reviewer was in agreement with the presenter that existing non-rare earth magnet materials are unlikely to provide solution, and that project should be merged with efforts to enhance magnetic materials. A reviewer indicated that the initial machine design with currently available magnet and lamination materials will be refined if better materials like AlNiCo with higher coercivity become available, which is a good plan. The reviewer cautioned that in case that the simulation shows that the flux switching machine concept cannot reach the goal of at least 80% of the performance of a conventional IPM machine, the researchers should set up a plan B, e.g., investigate other machine topologies. The reviewer encouraged the team to include an alternate course of action in the future plans.

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

One reviewer felt the resources were insufficient. Four reviewers felt the resources were sufficient. One reviewer commented that the suggested combination with another project by the principal investigator would require a reevaluation of the resource allocation if it occurred.

Unique Lanthanide-Free Motor Construction: Jon Lutz (UQM Technologies, Inc.) – ape044



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer commented that the project supports the objective of petroleum displacement by developing a new motor concept without the use of expensive rare earth magnet materials. The reviewer noted that, if successful, these would result in cost savings for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another reviewer commented that elimination of rare earth elements from magnets would provide the high efficiency of permanent magnet motors at lower cost and in sustainable supply. These all facilitate market adoption of HEVs and EVs.

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

One reviewer noted that the main goal of the project is the development of a new electric machine concept with AlNiCo magnets instead of rare earth magnets. The reviewer felt that the researchers have specific ideas from the very beginning of the project of how to solve the known issues with AlNiCo magnets in electric machines, which is rare because many projects an initial study phase is needed to determine what the actual scope of the work should be. This reviewer felt that the overall approach is generally well designed and the technical barriers are identified. The reviewer also felt that the milestones are well defined and the manufacturing of prototype machines is coupled to go/no-go decisions based on simulation results. Another reviewer felt that not much detail was given on approach, so the reviewer is giving the project team the benefit of the doubt. The reviewer noted that the premise of increasing the permeance coefficient and reducing the demagnetizing field is sound, as is pursuing enhanced coercivity AlNiCo magnets.

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

One reviewer indicated that the technical accomplishments were good considering that this is a new project. The reviewer noted that the requirements for the machine design have been defined and the collaboration with Ames Lab for the development of improved AlNiCo magnets is set-up, and initial finite element analysis simulations have been conducted and the results are claimed to be promising. The reviewer lamented that the researchers can not reveal any details about the new machine concept at this point in time as patent applications are pending. The reviewer found this acceptable because the project is in an early stage. Another reviewer found it difficult to judge the projects accomplishments without more detail. The reviewer noted that the structural integrity of the rotor will probably require sleeving, which will, if nonmagnetic, increase magnetic air gap and decrease the permeance coefficient, or, if magnetic, increase iron loss.

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

Reviewers noted good collaboration, especially with national labs. One reviewer commented that the use of national labs for support on thermal management and magnet material improvement was good. Another reviewer noted that collaborations with several national labs are set up. The reviewer felt that the collaboration with Ames Lab and their work on AlNiCo magnets is an excellent choice. The reviewer also felt that the other collaborations with NREL and ORNL will support the progress of the project.

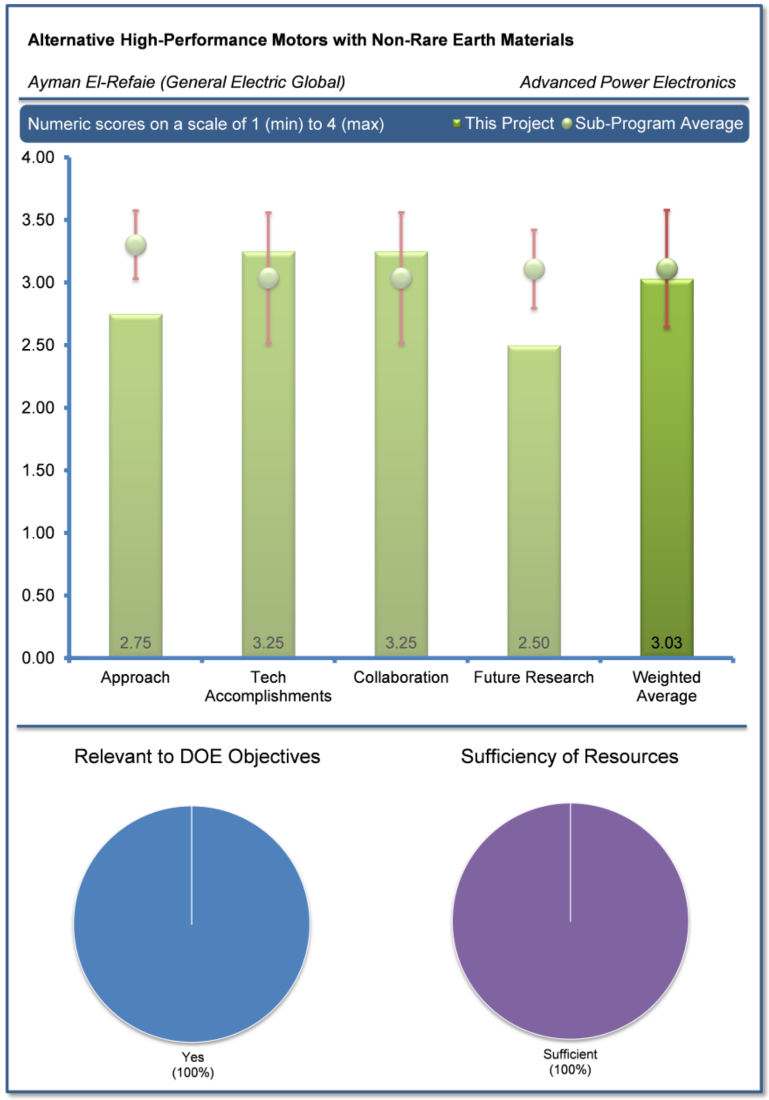
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the milestones in the project are well defined for FY 2012 progress and the barriers are identified as good as possible. The reviewer continued, stating that a milestone review in June 2012 with a go/no-go decision will determine the concepts potential based on simulation. The reviewer felt that the initial machine design with currently available AlNiCo magnet materials could be refined if AlNiCo with higher coercivity becomes available, which is based on the results in other projects. One reviewer suggested adding structural analysis for the rotor.

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

All four reviewers felt the resources for the project were sufficient. One reviewer remarked that the project has sufficient resources for the defined tasks.

Alternative High-Performance Motors with Non-Rare Earth Materials: Ayman El-Refaie (General Electric Global) – ape045



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that the project supports the objective of petroleum displacement by developing new motor concepts without the use of expensive rare earth magnet materials. If successful these would result in cost savings for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another reviewer commented that the objective was very attractive but that the program was ambitious. A third reviewer stated that the elimination of rare earth magnets would provide a significantly lower cost motor, and therefore facilitate market adoption of HEVs and EVs. A fourth reviewer indicated that the project supports DOE objectives by reducing the cost and supply chain risk for motors, which can be used in electrical or hybrid vehicles.

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

A reviewer stated that the main goal of the project is the development of new electric machine concepts with non-rare-earth magnets or with no magnets at all. The approach is to investigate ten different motor topologies and to identify promising new materials. The reviewer noted that, even though the researchers surely have a project plan, there is absolutely no information provided about the ten topologies or materials at this point in time. The reviewer felt that this makes it basically impossible to evaluate the approach at this point in time. Another reviewer noted that the description of the approach was pretty generic, but it makes sense to evaluate multiple topologies and also improve basic building block materials at the same time.

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

The first reviewer stated that there was not enough detail given to evaluate the project. The reviewer stated that it seemed like a long delay to get legal contracts signed with collaborators, noting that it was now seven months after the project award date, and only two contracts were about to be signed. Another reviewer noted that it was basically impossible to evaluate the accomplishments and the progress at this point in time. The reviewer cited that the principal investigator stated that the selection of the ten motor topologies has been finalized and the initial design work on some of the topologies has started but there are no details provided about the motor topologies or preliminary results. The reviewer also noted that the selection of promising materials for development in this project contained a similar lack of details or preliminary results.

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

One reviewer commented that the combination of collaborators was great, but that lack of legal contracts has prevented collaboration so far. Another reviewer noted that a number of collaborations with universities are set up for the motor development. The reviewer felt that, in particular, the collaboration with Ames Lab and Arnold Magnetics and their work on alternative magnet materials is a good choice. The reviewer did indicate that the project team must insure that the design of different motor topologies at different universities is well coordinated in order to facilitate an apples-to-apples comparison of the results. The reviewer also noted that all modeling assumptions have to be the same for all of the different motor designs.

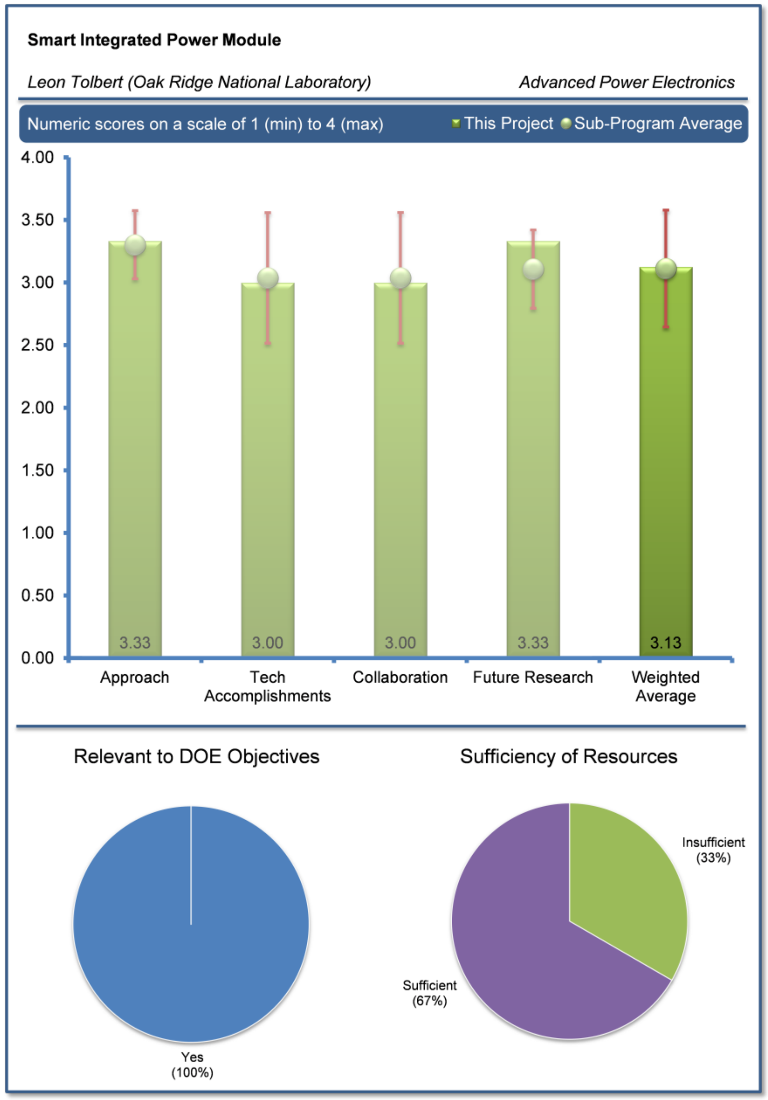
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer commented that the milestone and future plan definition is relatively vague at this point in time. The reviewer understands that the project is in a very early stage; nevertheless, the reviewer felt that the definition of milestones and future plans could be more detailed even with only a small amount of data or information available at this point in time. Another reviewer indicated that it was difficult to judge the proposed future research since the approach is very generic.

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

All four reviewers indicated that the resources were sufficient. One reviewer noted that it was difficult to evaluate this point as no details about the project content were revealed.

Smart Integrated Power Module: Leon Tolbert (Oak Ridge National Laboratory) – ape046



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer noted that the final goal is to produce a 55 kW inverter phase leg modules that can work at high temperatures and meet 2020 targets of 14 kW/l, 14 kW/kg, and 2015 targets of 5$/kW, and 98% efficiency. The reviewer felt that meeting the VTP targets helps to enable the market for EDVs which reduce our dependence on foreign oil. Another reviewer commented that this work supports the development of a power module with integrated gate drive and current sensing for incorporation in an EV inverter system to reduce size, weight and possibly cost of the invert while potentially improving the reliability. A third reviewer felt that this is an important area of work because it is necessary to increase integration and the use of WBG devices.

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

One reviewer commented that this project has several parallel objectives, all of which are important and seem to be well coordinated and complementary. The reviewer cautioned that integrating all of the developments together in one module will be a considerable challenge. Another reviewer felt that, by up integrating more functions into the IPM, cost size and weight will be reduced and WBG materials are proposed to address the high temperature capability. The reviewer noted that the details of how using WBG materials will reduce cost needs to be documented.

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

One reviewer noted that progress on the current measurement activity and gate drive activity appear to be okay and roughly on schedule but no mention was made about the temperature measurement progress or the high temperature packaging portions of the program. Another reviewer indicated that the development of the current and temperature sensor Application Specific Integrated Circuit (ASIC) could have wider applications for other power electronics applications. The reviewer felt that a comparison of accuracy and repeatability over temperature when properly shielded, of the hall sensor versus the traditional LEM sensor would be helpful. Also, the reviewer felt that packaging this part as a Small Outline Integrated Circuit (SOIC) for circuit board applications and evaluation would also be helpful. The reviewer commented that buffer and isolation circuits that work at higher temperature are a challenge and wanted to know the temperature rating the project team is targeting for the module.

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

One reviewer suggested that the team may want to consider collaboration with industrial power module suppliers, gate driver suppliers or current measurement probe suppliers. Another reviewer felt that finding a partner to assess and or commercialize this ASIC could be useful.

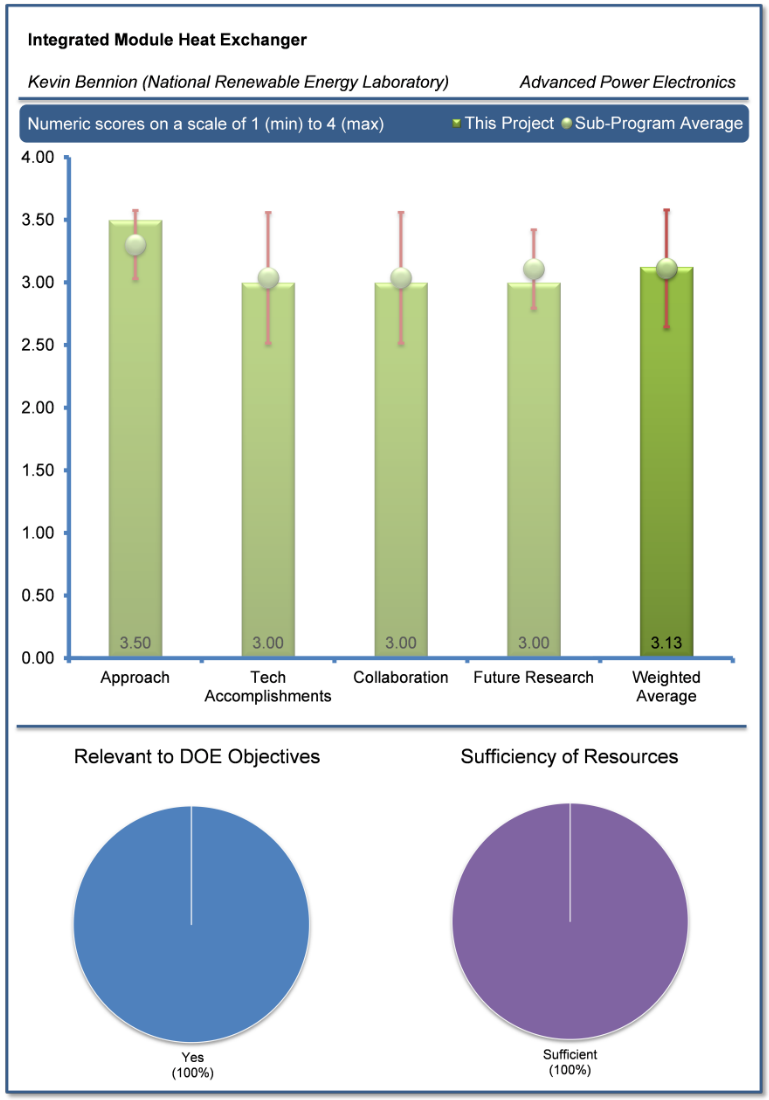
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer felt that the program plans and milestones appear adequate. The reviewer noted that the primary focus is currently on gate driver and current measurement tasks. Another reviewer noted that although this is a new project it is evolving previous work. The reviewer felt that the cost tradeoffs of using WBG materials needed to be addressed in the future.

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

One reviewer indicated the resources were insufficient. Two reviewers indicated the resources were sufficient. One reviewer noted that finding a partner to assess and or commercialize this ASIC could be useful as part of the ASIC development.

Integrated Module Heat Exchanger: Kevin Bennion (National Renewable Energy Laboratory) – ape047



Reviewer Sample Size

This project was reviewed by two reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers agreed that the project meets DOE objectives. One reviewer commented that increased heat dissipation is necessary to reduce power semiconductor cost, weight, and volume. Reducing cost, weight and increasing performance helps to meet the DOE VTP 2015 and 2020 targets. Additionally, this lower cost helps to enable the market for EDVs which reduces our dependence on foreign oil. Another reviewer indicated that the approach of solving the thermal issue at the power module is a good approach as it has the potential to have the biggest impact on cost and size of the unit. The reviewer felt that this is directly applicable to the DOE goals.

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

Reviewers provided suggestions on the approach. The first reviewer commented that the approach is logical and following a documented path that provides insight into the path to the expected results. The reviewer noted that the decision points are identified which will enable discussion on the results to be clarified based on the path taken, the performance is compared to today's standard design along with the different approaches taken and the strategy used to select the design. The reviewer did take time to indicate that the use of device simulator (heater) is good but care needs to be taken to duplicate the thermal density of a power module. Another reviewer felt that the approach was excellent, but did not understand why the project team was stopping at doubling heat flux improvement. The reviewer suggested that another project may be needed to determine what the maximum heat flux capabilities of the die and its package. The suggested new project could focus on a thermal system and package that is capable of 100% die utilization. A simple example of this idea is a die soldered to a substrate that is attached to a heat rail using a thermal interface material that is capable of 100W of heat dissipation. Next, make the same die and attach to two heat rails, one on top of the die and one on the bottom of the die using the same bonding materials. This dual cooled system is capable of approximately 200W of heat dissipation. If you continue this example out with more aggressive cooling strategies, the reviewer felt it was important to ask if you get to the point that the die, not the thermal system, needs improvement.

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

One reviewer stated that the results of the modeled approaches look promising. The reviewer liked that cost was a potentially deciding factor in the project. The reviewer felt that the iterative approach was also very good and was supportive of a project that makes decisions based on results. Finally, the reviewer felt that the approach in developing the model was very good. Another reviewer noted that the presented results look encouraging but the details are under patent review and not presented.

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

One reviewer indicated that the information flow between team members looked good as well as the plan to get an industry partner for module work. The second reviewer commented that it might be possible for the project team to find a partner in the semiconductor area or the national labs that could help answer the die utilization question.

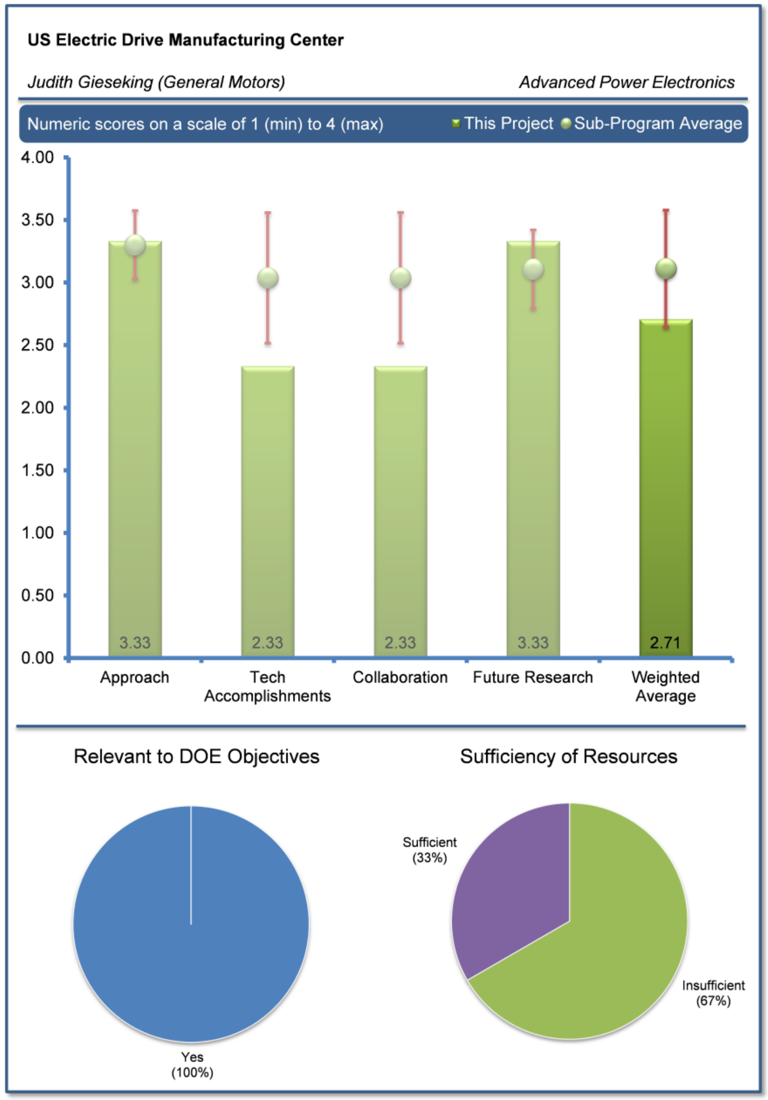
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer noted that the plans appear relevant to expected results. The reviewer indicated a need to review results to verify that the appropriate path is selected. The reviewer cautioned that the approach may be driven by selected industry partner if the project team is not careful. Another reviewer indicated that the proposed future work is consistent with the current work that is ongoing but reiterated that, since it is under patent review, it is difficult to understand the details.

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

Both reviewers felt that the resources were sufficient. One reviewer commented that adding resources to answer the die utilization question might be helpful. The second reviewer noted that the results indicate that the team has the appropriate resources.

US Electric Drive Manufacturing Center: Judith Gieseking (General Motors) – arravt021



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers agreed that the project meets DOE objectives. One reviewer indicated that this project establishes a manufacturing facility for traction motors for both hybrid as well as pure electrical vehicles in the United States. The reviewer felt that this will have a significant impact on establishing a domestic motor supply chain and hence reduce cost. Another reviewer noted that the project involves construction of a facility to manufacture motors for electric and hybrid vehicles, which will use much less gasoline than conventional internal combustion engine vehicles. The third reviewer stated that the project provides motor manufacturing capacity to enable economies-of-scale price reductions for EVs and HEVs.

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

One reviewer commented that the phased approach to establish the plant was good. Another reviewer noted that the quality of the approach is reflected in the record of progress as documented in the following question. Another reviewer noted that the project had manufacturing flexibility through use of robotics, induction and permanent magnet rotor flexibility, and potential for capacity expansion.

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

Reviewers indicated that the project is on schedule. The first reviewer noted that the project passed product and process development criteria on time. A second reviewer observed good progress according to plan and production is expected as scheduled. A third reviewer indicated that the project is on schedule, and it employs more than 200 people.

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

The first reviewer commented that an award was only given to GM. A second reviewer noted that the collaboration was limited, basically only including suppliers. Another reviewer noted that the only collaboration was with DOE, but that this was appropriate for the project. The reviewer did not feel other collaboration was required.

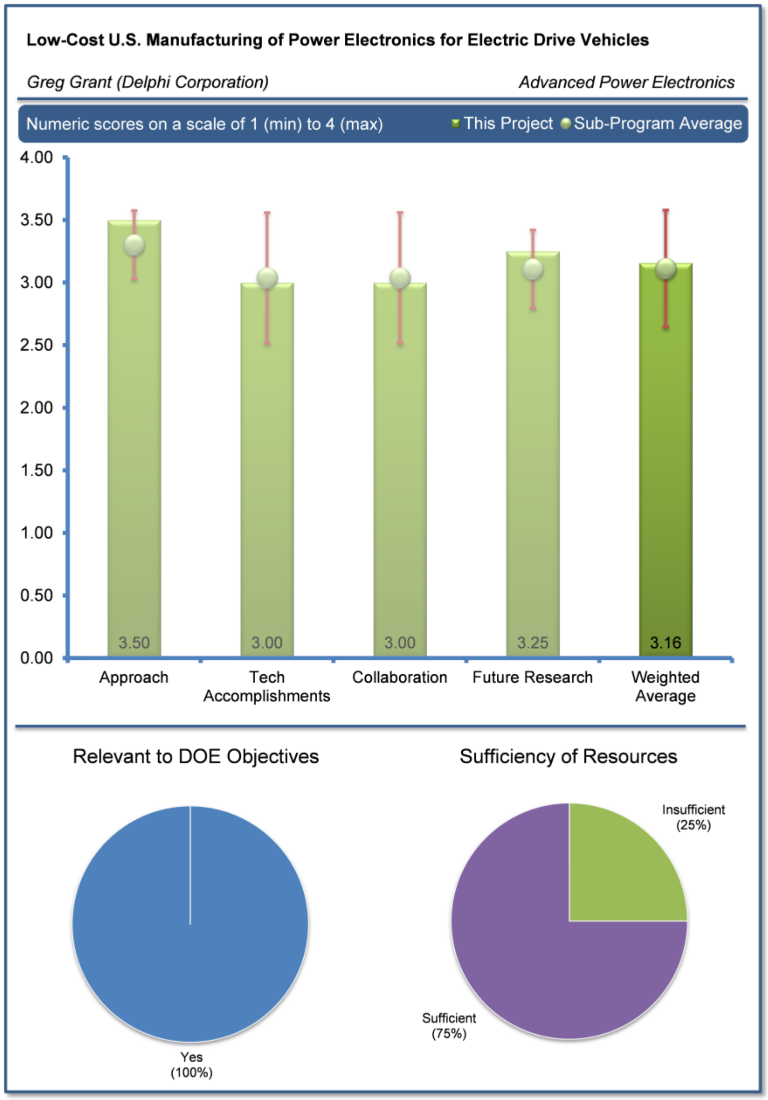
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that the manufacturing plans have been made and explained thoroughly. Another reviewer indicated that the plan to finish the plant on time was good.

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

Two reviewers felt that the resources for the project were insufficient. One reviewer felt the resources for the project were sufficient. One reviewer noted that despite the insufficient resources, the project is on schedule.

Low-Cost U.S. Manufacturing of Power Electronics for Electric Drive Vehicles: Greg Grant (Delphi Automotive Systems, LLC) – arravt022



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers found that the project supports DOE objectives. One reviewer noted that the project is focusing on technology that will reduce the overall cost of EDVs and create U.S. jobs. Another reviewer indicated that the project involves construction of a facility for manufacturing power electronics for EVs and HEVs, which use much less gasoline than conventional internal combustion engine vehicles. A third reviewer stated that the project promotes EV and HEV economies-of-scale, and therefore market adoption. The reviewer indicated that there is a broad range of vehicle and industrial applications as well for the inverter.

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

One reviewer noted that the project is leveraging the depth and breadth of Delphi resources and experience in automotive technology. The reviewer felt that this was a good use of supplier and customer strengths. Another reviewer commented that the suitability of the approach is reflected in the quality of the results. A third reviewer noted that the project is addressing needs on a component basis first, then system level. The reviewer felt that that the project team was leveraging supplier strengths, and taking a modular building-block approach.

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

Three reviewers noted that the project was on schedule, with one reviewer remarking on target to date, a second commenting that the project is on schedule, and a third noting that the project is on track with design validation testing. One reviewer felt that there was a lack of development of technical talent necessary for desired growth.

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

Reviewers observed collaboration. One reviewer noted that the project has a good mix of OEM customers, suppliers and government. Another reviewer indicated that Delphi has in place the customer base, strategic partnerships, and supplier foundation necessary to achieve the goals of this project. A third reviewer noted that the project was leveraging a large supplier base.

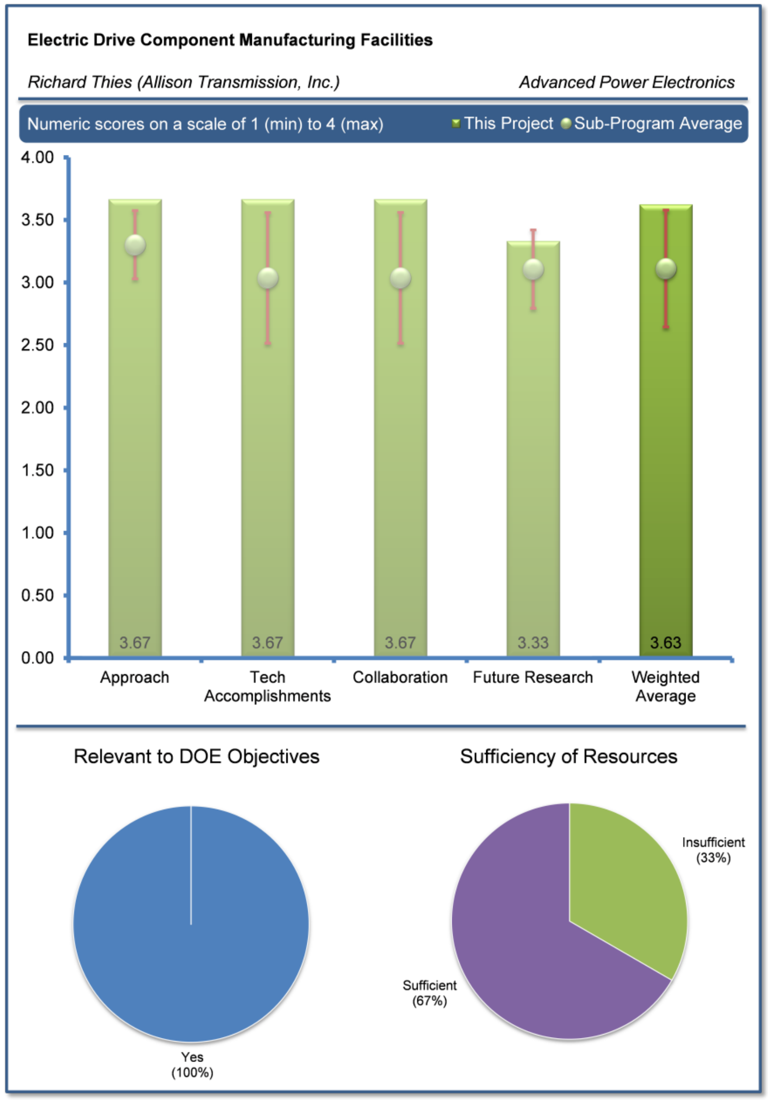
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two reviewers commented that the future plans are good, with one reviewer finding that there like a good plan moving forward, and a second reviewer commenting that future plans are well formed.

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

One reviewer felt the resources were insufficient. Three reviewers felt that the resources were sufficient. One reviewer noted that the project had the right mix of resources. Another reviewer commented that the project is on schedule.

Electric Drive Component Manufacturing Facilities: Richard Thies (Allison Transmission, Inc.) – arravt023



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer commented that this project establishes a manufacturing facility for electric drive trains for large trucks as well as buses and delivery trucks in the United States. This reviewer felt that the project will have a significant impact on establishing a domestic motor supply chain and hence reduce cost. Another reviewer noted that the project involves converting a building to make it suitable for manufacturing powertrains for hybrid trucks, which use less diesel fuel than conventional trucks. The third reviewer responded with a hybrid powertrain that has widespread applicability in commercial vehicles.

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

One reviewer commented that the approach to establishing the plant was good. Another reviewer indicated that the adequacy of the approach is reflected in the progress and success of the project. The third reviewer noted that the project demonstrated high sense of urgency upfront in overcoming technical problems and it is now reaping the benefits of that, with relatively few quality or durability problems with system. The reviewer indicated that the design was built on established automatic transmission platform with wide acceptance in industry.

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

One reviewer noted that all desired accomplishments have been realized. Another reviewer agreed indicating that there was good progress according to the plan and production was expected as scheduled. The third reviewer felt that the project was on track with timing and that there were no substantial quality or durability problems.

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

A reviewer indicated that the battery and inverter were from Delphi and that the motor was from Remy. Another reviewer also highlighted these collaborations in addition to collaborations with potential customers. The third reviewer also noted that the project was leveraging inverter and motor manufacturer expertise.

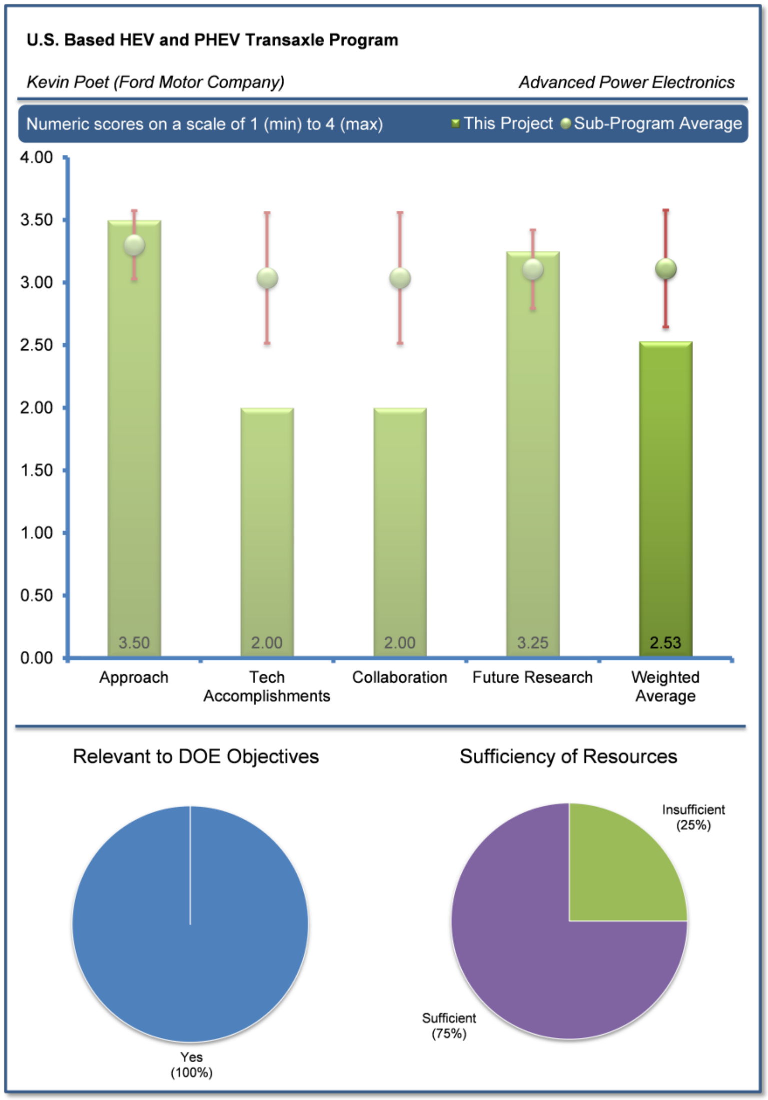
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the plan to finish the plant on time was good. Another reviewer indicated that the future activities have been established.

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

One reviewer felt the project resources were insufficient, and two reviewers felt that the project resources were sufficient. One reviewer observed sufficient resources. Another reviewer noted the project was on schedule.

U.S. Based HEV and PHEV Transaxle Program: Kevin Poet (Ford Motor Company) – arravt024



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer commented that this project establishes a manufacturing facility for transaxles for both HEVs as well as PHEVs in the United States. This will have a significant impact on establishing a domestic motor supply chain and hence reduce cost. Another reviewer felt that the project was pushing the technology envelope of HEV and PHEV. A third reviewer noted that the project provides economies-of-scale to reduce the cost of a hybrid powertrain.

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

One reviewer felt that the phased approach to establishing the plant was good. Another reviewer noted that the project based the manufacturing line on a dual path with conventional and hybrid transmission concept, utilizing 70% common manufacturing processes for the two products. The reviewer feels that this allows the manufacturing to flex with the market demand.

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

One reviewer indicated that the project completed product validation on time. Another reviewer indicated that the progress according to plan was good and production was expected as scheduled.

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

One reviewer felt that the project leveraged supplier expertise well. Another reviewer noted that an award was only given to Ford Motor Company. One reviewer wanted to see more formal partners.

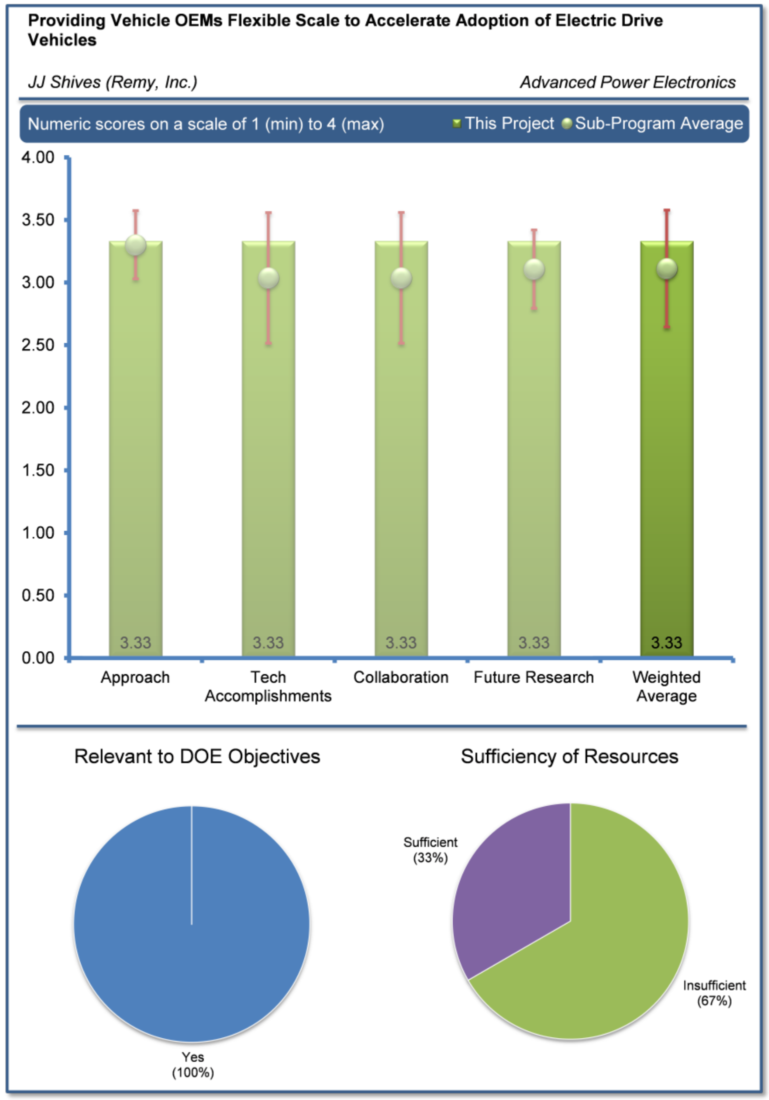
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two reviewers felt the plan was good. One reviewer noted that the only item left to complete the project was a complete run-at-rate.

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

One reviewer indicated that the resources were insufficient. Three reviewers indicated that the resources were sufficient.

Providing Vehicle OEMs Flexible Scale to Accelerate Adoption of Electric Drive Vehicles: JJ Shives (Remy, Inc.) – arravt025



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers found that the project supports DOE objectives. A reviewer commented that the project supports the objective of petroleum displacement by developing a standardized platform for the production of lower cost electric motors and inverters. If successful these would result in cost savings for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another reviewer noted that this project establishes a manufacturing facility for traction motors and drives. This will have a significant impact on establishing a domestic motor supply chain and hence reduce cost. The third reviewer stated that the project involves refurbishing some existing properties to enable manufacturing components for EVs and HEVs, which use less petroleum fuel than conventional vehicles.

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

One reviewer indicated that this was a good phased approach to establish the plant. Another reviewer agreed, stating that the approach had resulted in successfully meeting project goals. The third reviewer observed that the inverter products are based on existing designs and processes which should ensure the technical feasibility. In a first phase existing facilities are refurbished for initial production volumes while a second phase includes the addition of production capacity for high volume production. Moreover, the approach focuses on the abilities to deliver a commercial ready product and to accurately estimate the manufacturing costs. Finally, the development of recycling processes will be based on experience with recycling of conventional low voltage automotive motors and generators.

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

One reviewer remarked that all of the desired accomplishments have been realized. Another reviewer commented that there was good progress according to the plan and production was expected as scheduled. The third reviewer noted that the technical accomplishments are very good for the first phase of the project, which is the implementation of the initial smaller volume production environment. Two motor designs with different diameter and thus output power and torque are ready for production. The reviewer felt that scalability is ensured with possible variation in motor length, cooling technology and winding patterns. Validation of the motors and performance and durability testing is claimed to be complete. Two different inverter sample hardware will be released for production in August and October 2012.

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

Reviewers noted the collaboration with Phoenix International. One reviewer felt that the collaboration with Phoenix Electronics was good. Another reviewer noted this collaboration, commenting that, for the development and production of the inverters, collaboration was set up with Phoenix International, a division of John Deere. The reviewer felt that the project must ensure that the overall system optimization of inverter and motor together has a high priority in the collaboration. The third reviewer indicated that Remy has collaborated with Phoenix International as a sub-awardee to this grant and that the inverters will be developed and produced by Phoenix in Fargo, North Dakota.

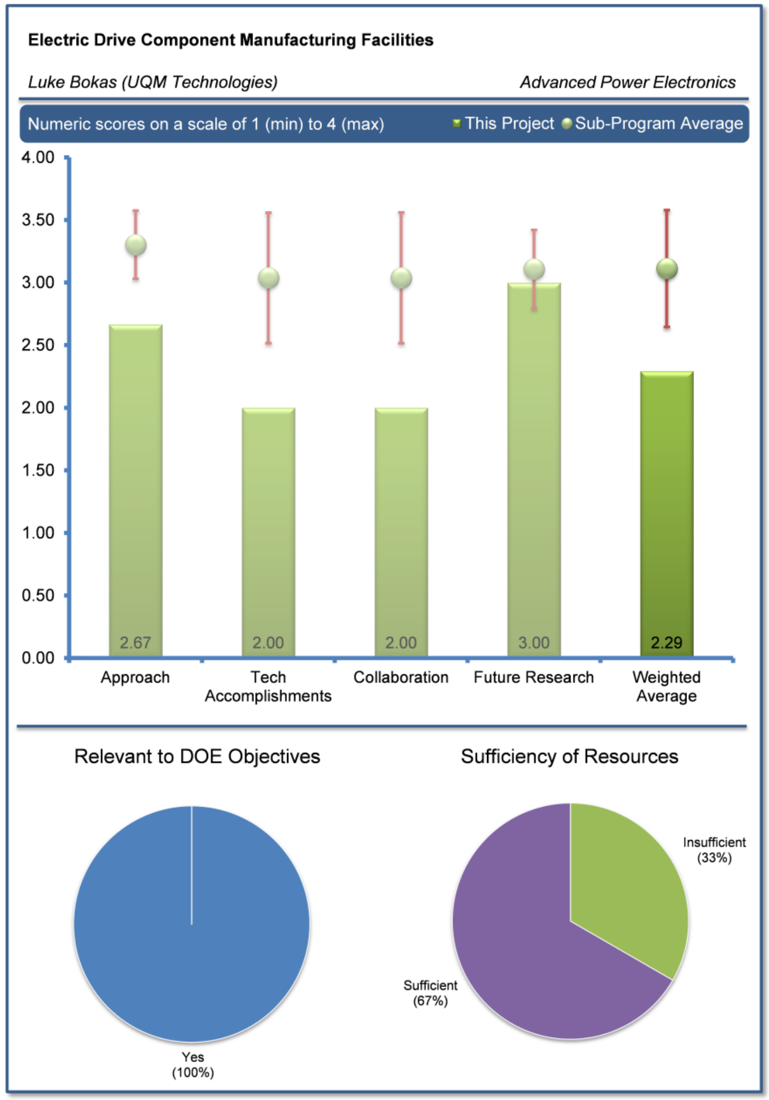
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the plan to finish the plant on time was good. Another reviewer agreed, noting that the future activities have been well defined. The third reviewer indicated that the milestones in the project are well defined for FY 2012 and FY 2013, which are the start of production at the Phase 1 facility and the selection of a Phase 2 site for production based on the estimated market demand. A milestone review in June 2012 with a go/no-go decision will determine the estimated production capacity increase for the Phase 2.

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

Two reviewers felt the resources were insufficient. One reviewer felt that the resources were sufficient. One reviewer remarked that the project was on schedule, and a +second reviewer commented that the project has sufficient resources.

Electric Drive Component Manufacturing Facilities: Luke Bokas (UQM Technologies, Inc.) – arravt026



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

A reviewer commented that the project supports the objective of petroleum displacement by making manufacturing investments for the production of lower cost electric motors and inverters. If successful these would result in cost savings for electric drive systems, which would enable a faster market introduction of HEVs and EVs. Another reviewer noted that this project establishes a manufacturing facility for traction motors and drives. This will have a significant impact on establishing a domestic motor supply chain and hence reduce cost. The third reviewer indicated that the project provides capacity for economies-of-scale production of EV powertrains.

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

One reviewer noted that the project has a good phased approach to establish the plant. Another reviewer felt that the overall approach and the milestones are both well defined. The reviewer indicated that the new motor and inverter products are based on existing designs and the principles of design for manufacturing and design for assembly are applied. In addition, manufacturing facilities for initial production volumes have been created and suppliers for key components have been established. The third reviewer noted that there was not much detail in the poster regarding technical barriers, but that there was no presenter at the poster to explain these to the reviewer.

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

One reviewer noted that the progress according to the plan was good and that production was expected as scheduled. Two reviewers noted that the project had completed the Production Part Approval Process (PPAP) of automotive (100 kW) motor and controller. The second of these reviewers indicated that the technical accomplishments are very good for the first phase of the project which is the implementation of the production lines for motor and inverter for the initial volume. The reviewer also noted that the initial production work on a higher power system with 220kW has been started, that the automotive production system is complete, and the products are supplied to customers.

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

One reviewer indicated that UQM established the production of the motor and inverter without the collaboration with another company which is generally a good approach because this should ensure that the overall system optimization of inverter and motor together for both design and production has a high priority. The reviewer noted that that multiple suppliers for key components have been established. Another reviewer noted that the award was only given to UQM.

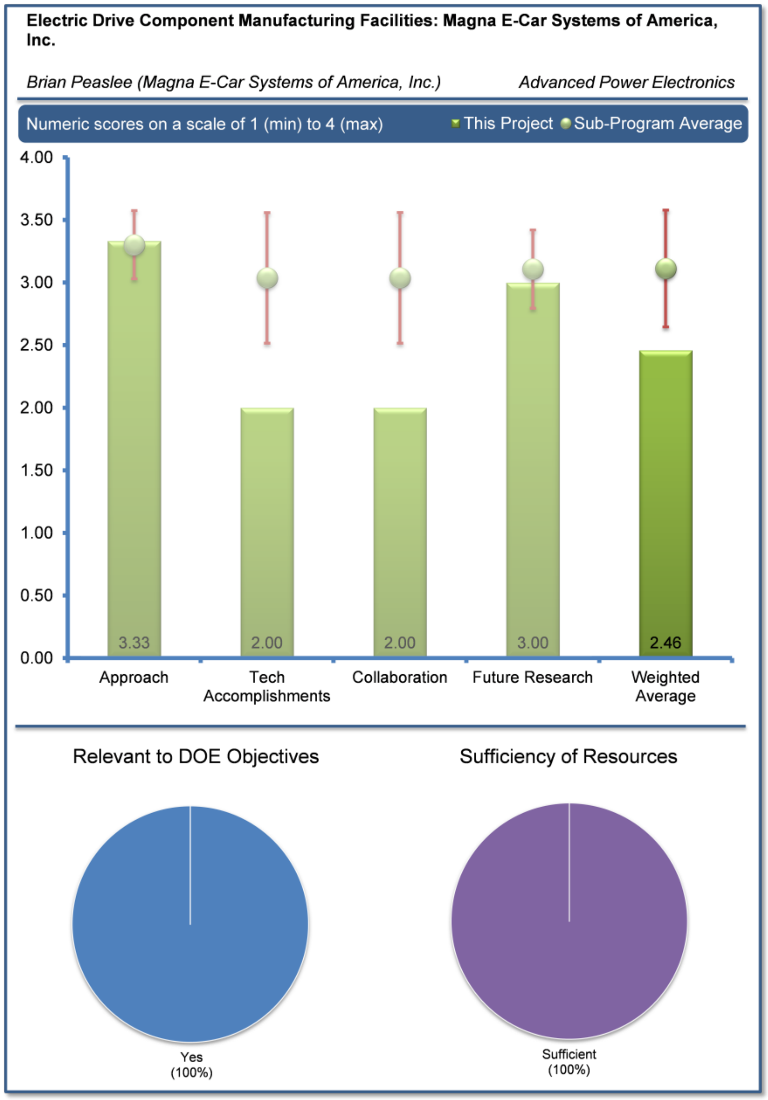
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer commented that the plan to finish the plant on time was good. Another reviewer indicated that the project ends in FY 2012 with the production line for the automotive product in place and the completion of the implementation of the production line for the truck/bus system. A milestone review in June 2012 with a go/no-go decision will determine if enough customer interest supports the investment for the truck/bus system production.

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

One reviewer felt that the resources were insufficient. Two reviewers felt that the resources were sufficient. One of the reviewers noted that the resources for the project were not mentioned in the project, and the reviewer assumed that they were sufficient.

Electric Drive Component Manufacturing: Magna E-Car Systems of America, Inc.: Brian Peaslee (Magna E-Car Systems of America, Inc.) – arravt027



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer noted that any petroleum displacement will include using hybrid components as part of the drive train. Those components will also require control modules, software, and calibrations. This project enhances industry readiness to produce those components and controls. A second reviewer commented that the project provides economies-of-scale for EV power plant and supporting electronics modules.

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

One reviewer indicated that the project takes a system wide approach, developing not only components, but the controllers, and includes integrating the hybrid system into a vehicle. The reviewer felt that the system level approach allows appropriate levels of optimization to occur. Another reviewer commented that there was no clear sign of development of the technical talent necessary to support an expansion of the product market.

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

One reviewer commented that preparing PPAP ready components is a difficult task; preparing several is extremely difficult. The reviewer noted that the tasks are complete, and that it is not possible to eliminate the barriers of OEM schedule changes.

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

One reviewer noted that all of the collaboration is within Magna divisions. Another reviewer felt that significantly reduced collaboration opportunities was part of the nature of preparing products for production in the marketplace.

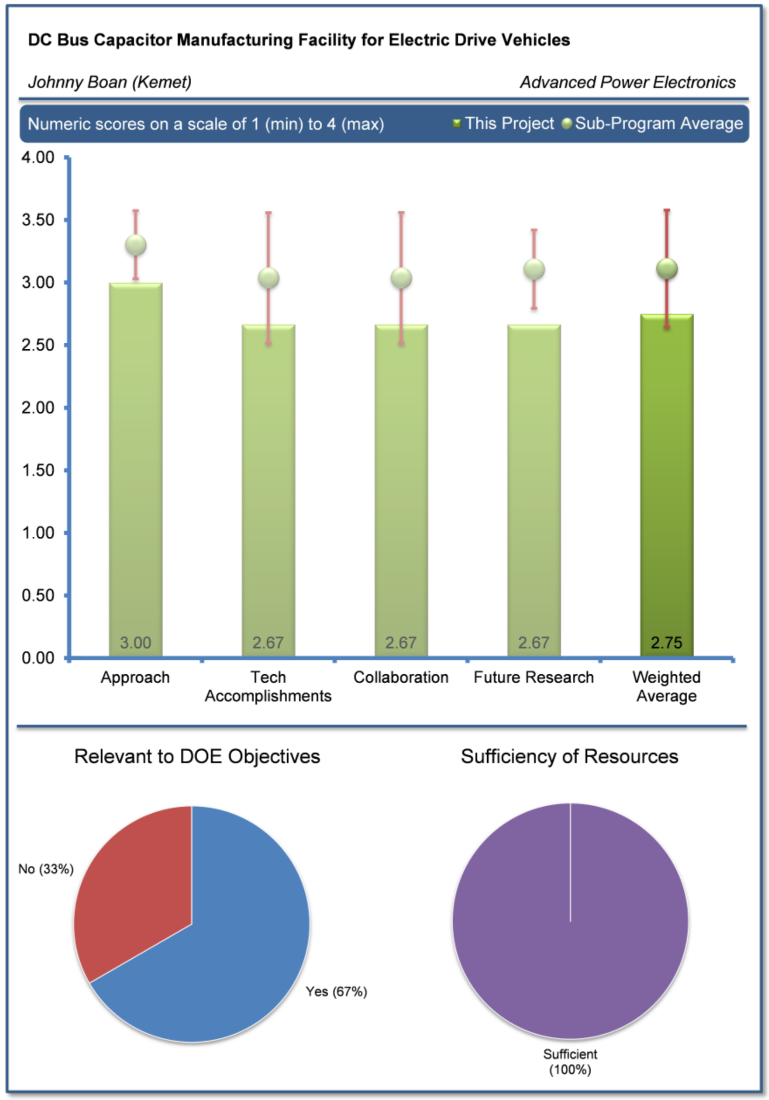
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt that these are the appropriate tasks that would take the components to real production.

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

All four reviewers felt that the resources for the project were sufficient. One reviewer commented that the tasks are all either fully complete or nearly complete.

DC Bus Capacitor Manufacturing Facility for Electric Drive Vehicles: Johnny Boan (KEMET Corporation) – arravt028



Reviewer Sample Size

This project was reviewed by four reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

One reviewer felt that development of components for electric vehicles will reduce the dependence on petroleum products. Another reviewer commented that any petroleum displacement will include using hybrid components as part of the drive train. Those components include inverters, which typically require large Direct Current (DC) bus capacitors. Having ready access to DC bus capacitors is an enabling technology for inverter design. This project addresses the issue by preparing a facility to provide those capacitors. One reviewer was not sure that the project supported the overall DOE objectives. The reviewer felt that the emphasis of the project seems to be on increased manufacturing capacity for DC capacitors in the United States. The reviewer was unsure what the global capacity already is in this area, or if additional capacity would really drive down global price substantially.

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

One reviewer provided a suggestion. This reviewer felt that the approach of first determining which type of capacitor is most likely to be needed by hybrid component designers, then preparing the factory is correct. The reviewer additionally commented that the presentation could be improved by expanding the technical barrier section. It is true that market acceptance of HEV and EV technology is a significant risk, as is mentioned. However, the reviewer felt that a description of the barriers that this project addresses would be a welcome addition. The reviewer suggested a statement along the lines of: Ready access to HV DC bus capacitors can be a barrier to hybrid component development. The project addresses that barrier by preparing a facility to produce a variety of DC bus capacitors in the volume needed. The ready availability of a production facility will speed the development of new designs. This reviewer noted that the suggested statement is true of this project, and suggests that the presentation could take credit for addressing this important barrier.

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

One reviewer felt that there were no real technical barriers to progress. The reviewer felt that the challenge in the project is investing and creating flexible capacity and jobs without large market demand. Another reviewer noted that the project is meeting goals, and on schedule. The reviewer felt that the plan of creating capacity in incremental volumes is correct, as there is risk that the volumes might not materialize. The reviewer found it impressive that the plant has produced some production level capacitors in a relatively short time frame.

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

One reviewer commented that the nature of preparing products for production in the marketplace significantly reduces the opportunity for collaboration between independent companies. Despite these barriers, the reviewer felt that the degree of cooperation between federal and local governments is impressive.

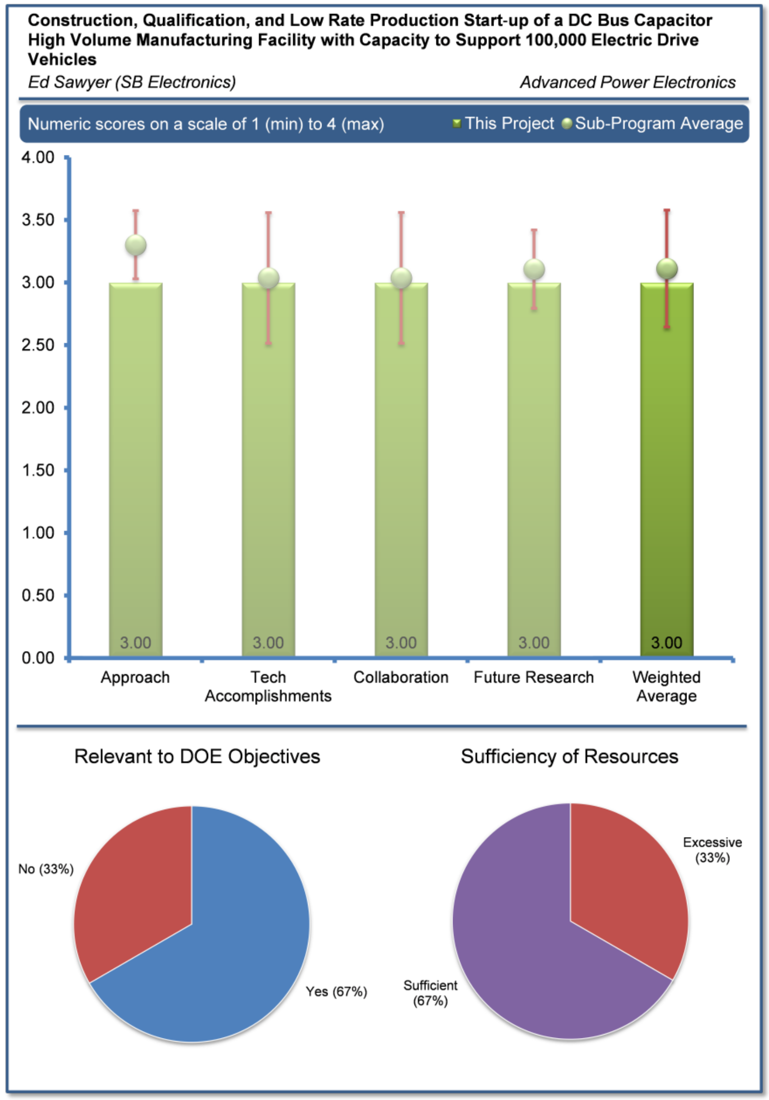
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer noted that the future work is properly planned, starting with a flexible product line capable of producing a variety of components, followed by a series of high volume lines once a few designs have been chosen. Another reviewer commented that this is a manufacturing facility and not a research project which made it difficult to rate the proposed future research.

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

All four reviewers felt that the resources for this project were sufficient.

Construction, Qualification, and Low Rate Production Start-up of a DC Bus Capacitor High Volume Manufacturing Facility with Capacity to Support 100,000 Electric Drive Vehicles: Ed Sawyer (SBE, Inc.) – arravt029



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers had mixed responses. One reviewer commented that any petroleum displacement will include using hybrid components as part of the drive train. Those components include inverters, which typically require large DC bus capacitors. Having ready access to DC bus capacitors is an enabling technology for inverter design. This project addresses the issue by preparing a facility to provide those capacitors. A second reviewer indicated that the project was to perform a build out of production capacity for the Polypropylene based DC Link Bus capacitor for use in inverters for HEVs and to provide added technical support to aid customers to develop solutions to mate the capacitor into the inverter. A third reviewer was not sure that the project supported the overall DOE objectives. The reviewer felt that the emphasis of the project seems to be on increased manufacturing capacity for DC capacitors in United States. The reviewer was unsure what the global capacity already is in this area, or if additional capacity would really drive down global price substantially.

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

One reviewer indicated that the project is nearly complete with factory built out. The reviewer felt that there were questions about how the industry will fully utilize the production capacity since it is centered on Power Ring architecture. Another reviewer commented that the approach is appropriate to addressing the technical barrier (need for high voltage DC bus capacitor production capability). The reviewer felt that the objective and targets addressed were clearly stated. Additionally, the reviewer noted that the target of achieving TS16949 is critical to completing the production ready objective. The third reviewer commented that a low Equivalent Series Inductance (ESL) capacitor design, providing packaging advantage. The reviewer also noted that the project leveraged some common processes and resources with conventional capacitor manufacturing to reduce costs. This reviewer felt that the presentation could be enhanced by describing more fully the types of DC bus capacitors that will be produced in the plant.

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

Reviewers had mixed feedback on technical accomplishments. One reviewer noted that the project is 90% complete with only major remaining milestone being TS16949 certification. The second reviewer noted that the technical accomplishments and progress are appropriate for this phase of the program. The reviewer felt that the presentation could have been enhanced by more detailed breakdown of timeline for FY 2012 approaches and challenges. The reviewer thought that showing three bars spanning an entire year (Slide 16) did not provide as much ability to judge progress as the reviewer had hoped. The third reviewer felt that there was some question remaining regarding how quickly the market will develop to utilize the production capacity now online.

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

One reviewer noted that there were collaborations ranging from contractors and suppliers (EF Wall, API and Steiner) to ORNL. The reviewer noted that the customer collaborator, Azure, went bankrupt. Another reviewer commented that the nature of preparing products for production in the marketplace significantly reduces the opportunity for collaboration. Including ORNL in the process provided a valuable second set of eyes on the project to insure that the capacitors are appropriate for the hybrid market.

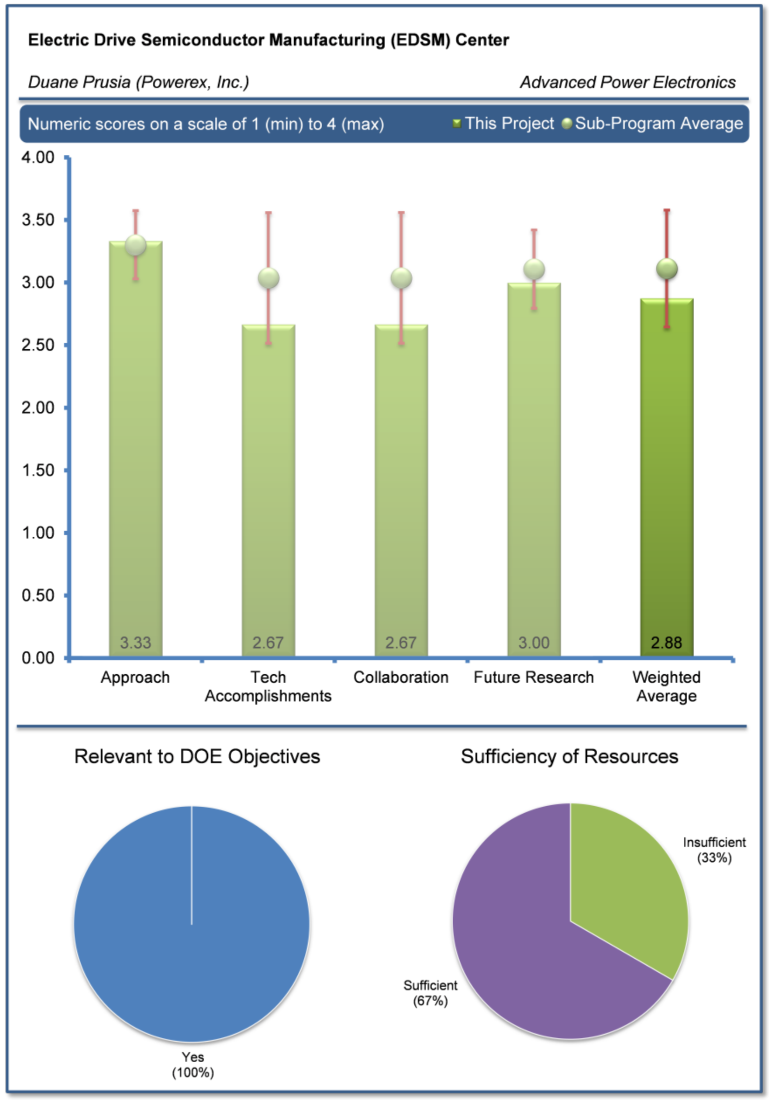
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer stated that there was the potential for further expansion of capacity, TS16949 certification, and customer development. Another reviewer felt that the plan to complete the factory and obtain certification is realistic and aggressive, yet achievable.

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

Two reviewers felt that the resources were sufficient. One reviewer felt that the resources were excessive. The reviewer who felt the resources were excessive noted that SBE put in place the capacity before market adoption so the capacity will be underutilized for some time.

Electric Drive Semiconductor Manufacturing (EDSM) Center: Duane Prusia (Powerex, Inc.) – arravt030



Reviewer Sample Size

This project was reviewed by three reviewers.

Question 1: Does this project support the overall DOE objectives? Why or why not?

Reviewers found that the project supports DOE objectives. One reviewer noted that power electronics are critical to vehicle electrification and support the objective of petroleum displacement. Another reviewer commented that the project promotes economies-of-scale in an area of high cost for EV and HEV applications. A third reviewer indicated that any petroleum displacement will include using hybrid components as part of the drive train. Those components include inverters, which require high voltage power semiconductor devices. The reviewer felt that having ready access to power semiconductor devices is an enabling technology for inverter design and that the project addresses the issue by preparing a facility to provide those devices.

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

One reviewer commented that it was good to see a prototype center and reliability center in addition to the manufacturing center. The reviewer noted that for the reliability center specifically, it will be important to publish test results and help guide inverter manufacturers. A second reviewer indicated that the planned approach demonstrates knowledge of the steps required to complete the task. The reviewer felt that the approach reflects the fact that simply building a power electronics manufacturing area is not enough. Supporting areas including the reliability center and the prototyping center are required for a fully viable facility.

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

One reviewer indicated that the program has moved quickly and is on track for near-term completion. Another reviewer stated that the technical accomplishments for this program were on track to complete the project on time and within budget.

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

One reviewer indicated that this type of project does not lend itself to collaboration. The second reviewer agreed, stating that collaboration is not a requirement of this type of grant. The reviewer felt that it would be useful to report on how the prototype and reliability center work will involve users and researchers.

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

One reviewer commented that the project has moved quickly toward completion. The second reviewer felt that the proposal appropriately describes the tasks required to finish the project and that they must be completed.

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

One reviewer felt the resources were insufficient. Two reviewers felt the resources were sufficient.

Section Acronyms

The following list of Acronyms cited within this section is provided as a reference for readers.

Acronym	Definition
AC	Alternating Current
AMR	Annual Merit Review
ANL	Argonne National Laboratory
APE	Advanced Power Electronics
APEEM	Advanced Power Electronics and Electric Machines Program
API	American Petroleum Institute
ARRA	American Recovery and Reinvestment Act
ASIC	Application-Specific Integrated Circuit
AVX	AVX Corporation
AWG	American Wire Gauge
BOPP	Bi-axially Oriented Polypropylene (film)
CA	Commercially Available
CALCE	Center for Advanced Life Cycle Engineering (UMD)
CSI	Current Source Inverter
CVD	Chemical Vapor Deposition
DC	Direct Current
DOD	Department of Defense
DOE	Department of Energy
EDV	Electric-Drive Vehicle
EMI	Electromagnetic Interference
ESL	Equivalent Series Inductance
ESR	Equivalent Series Resistance
ETM	Electro-Thermo-Mechanical
EV	Electric Vehicle
FEA	Finite Element Analysis
FCHEV	Fuel Cell Hybrid Electric Vehicle
FOM	Figure of Merit
FY	Fiscal Year
GM	General Motors Corporation
GOSS	Grain-Oriented Silicon Steel
HEV	Hybrid Electric Vehicle
HSG	Hybrid Starter Generator
HV	High Voltage
IGBT	Insulated-Gate Bipolar Transistor
IPM	Interior Permanent Magnet
IP	Intellectual Property
IR	Infrared
JFET	Junction Gate Field-Effective Transistor

Acronym	Definition
KEMET	KEMET Electronics Corporation
Kg	Kilogram
KW	Kilowatt
LCD	Liquid Crystal Display
LEM	LEM, Inc.
LHFZ	Laser Heated Floating Zone
LTC	Large Tapered Crystal
MLCC	Multilayered Ceramic Capacitor
MOSFET	Metal-Oxide-Semiconductor Field-Effective Transistor
MPGe	Miles Per Gallon equivalent
NASA	National Aeronautics and Space Administration
NEG	Nippon Electric Glass Co., Ltd.
NFC	Novel Flux Coupling
NIST	National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PBA	Planar Bond All
PCB	Printed Circuit Boards
PEEM	Power Electronics and Electrical Machines
PEV	Plug-in Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
PI	Principal Investigator
PLZT	Pb1-xLaxZryTi1-yO3
PM	Permanent Magnet
PP	Polypropylene
PPAP	Production Part Approval Process
PWB	Printed Wiring Board
RE	Rare Earth
RF	Radio Frequency
ROMP	Ring Opening Metathesis Polymerization
SMC	Soft Magnetic Composites
SNL	Sandia National Laboratory
SOA	State Of the Art
SOIC	Small Outline Integrated Circuit
SPS	Strategic Polymer Sciences, Inc.
UQM	UQM Technologies, Inc.
V	Volts
VTP	Vehicle Technologies Program
W	Watts
WBG	Wide Bandgap

Acronym	Definition
WEG	Water Ethylene Glycol

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