7. Materials Technologies: Propulsion Materials

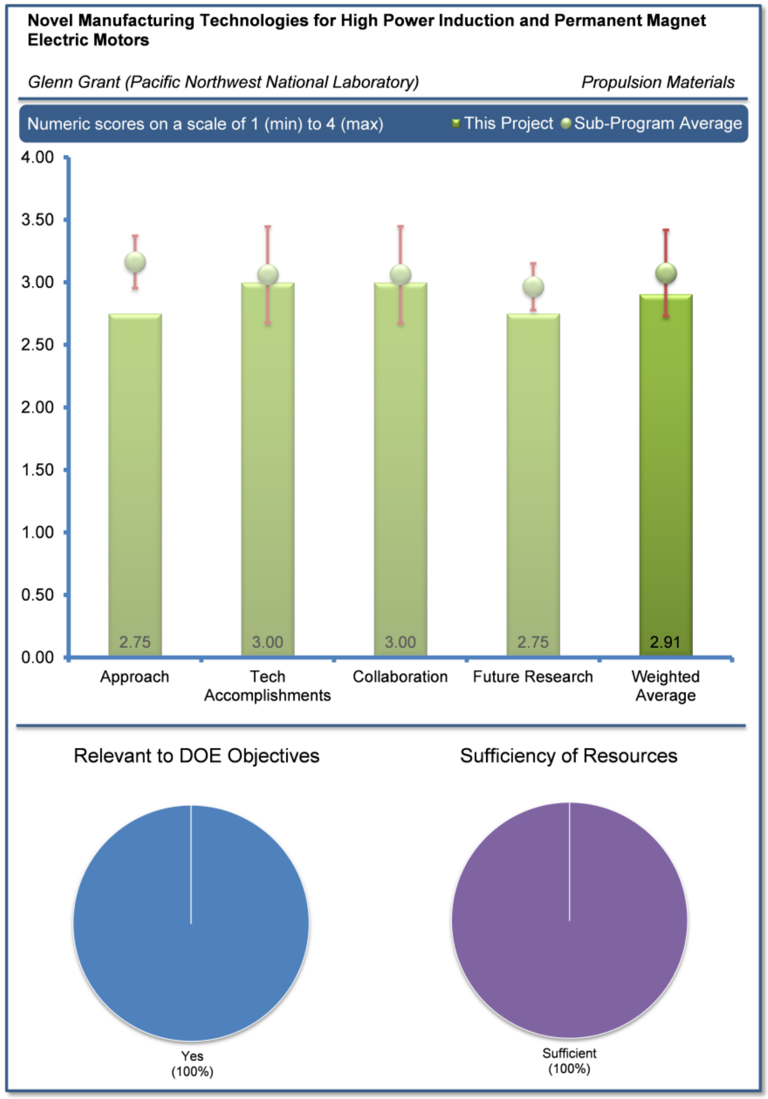
Propulsion materials research is critical to bringing advanced high-efficiency powertrains to the marketplace. The use of innovative materials in specialized applications throughout the powertrain can help to improve system efficiency and reduce emissions. Applications include engines, electrical drive systems, fuel systems, charge air systems, thermal management systems, exhaust aftertreatment systems (EATS), and engine accessories. U.S. Department of Energy (DOE) researchers and industry partners work together to identify the types of materials technologies required for advanced engines. These include material compositions and properties, as well as manufacturing processes, component cost, life prediction, and durability. In addition, propulsion materials research develops "enabling technologies" to ensure the success of new power electronics, advanced internal combustion engines, hybrid systems, and emission reduction technologies.

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
Novel Manufacturing Technologies for High Power Induction and Permanent Magnet Electric Motors	Glenn Grant (Pacific Northwest National Laboratory)	7-3	2.75	3.00	3.00	2.75	2.91
NOx Sensor Development	Robert Glass (Lawrence Livermore National Laboratory)	7-6	3.38	3.50	3.50	3.13	3.42
Materials Issues Associated with EGR Systems	Michael Lance (Oak Ridge National Laboratory)	7-9	3.50	4.00	4.00	3.00	3.75
Durability of Diesel Engine Particulate Filters	Thomas Watkins (Oak Ridge National Laboratory)	7-11	3.20	3.00	3.00	2.60	3.00
Thermoelectric Mechanical Reliability	Andrew Wereszczak (Oak Ridge National Laboratory)	7-13	3.20	3.20	3.20	2.80	3.15
Thermoelectrics Theory and Structure	David J. Singh (Oak Ridge National Laboratory)	7-15	3.25	3.50	3.50	3.00	3.38
Low-Cost Direct Bonded Aluminum (DBA) Substrates	Hua-Tay Lin (Oak Ridge National Laboratory)	7-17	3.00	2.50	2.50	3.25	2.72
Improved Organics for Power Electronics and Electric Motors	Andy Wereszczak (Oak Ridge National Laboratory)	7-19	3.40	2.80	2.80	3.20	3.00
Materials for Advanced Turbocharger Designs	Phil Maziasz (Oak Ridge National Laboratory)	7-22	3.00	3.00	3.00	3.00	3.00
Engine Materials Compatibility with Alternative Fuels	Steve Pawel (Oak Ridge National Laboratory)	7-25	3.33	3.17	3.17	3.17	3.21
Biofuels Impact on DPF Durability	Michael Lance (Oak Ridge National Laboratory)	7-28	3.00	2.83	2.83	2.83	2.88
Electrically-Assisted Diesel Particulate Filter Regeneration	Michael Lance (Oak Ridge National Laboratory)	7-31	3.00	3.00	3.00	3.00	3.00
Compact Potentiometric NOx Sensor	Dileep Singh (Argonne National Laboratory)	7-33	3.29	2.57	2.57	3.00	2.80

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High-Temperature Aluminum Alloys	Mark Smith (Pacific Northwest National Laboratory)	7-36	3.00	2.80	2.80	2.80	2.85
Overall Average			3.16	3.06	3.06	2.97	3.08

Novel Manufacturing Technologies for High Power Induction and Permanent Magnet Electric Motors: Glenn Grant (Pacific Northwest National Laboratory) – pm004



Reviewer Sample Size

This project was reviewed by four reviewers.

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

Comments for this question were generally positive. One reviewer stated that this project does indeed support the overall DOE objectives of petroleum displacement or reduction. The reviewer pointed out that the researchers hope to develop novel low temperature solid state joining strategies that should reduce distortion, improve the structural integrity, and increase the thermal and electrical conductivities of the components. The reviewer further noted that the presenter stated that all of these benefits should enable the fabrication of smaller, lighter, less costly and more reliable traction motors and other electrical components. The next commenter agreed that continuing and deepening electrification of the highway transportation sector is a generally agreed means of reducing the petroleum demand of this sector, which is currently based almost entirely on petroleum-derived energy, by increasing overall propulsion efficiency and by diversifying the primary energy sources supplying it. Another observer stated that electrification is one of the ways to improve the energy efficiency of vehicles and motors are integral to that part of the strategy. This reviewer continued that improving the production capability of motors will be beneficial by reducing the cost. Further, this reviewer stated that as this project is developing an enabling technology to improve the production, it contributes to the petroleum reduction. The final reviewer stated that multiple barriers had been clearly addressed by the project.

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 mixed comments on the approach to the work. One reviewer thought that the researchers employed a good approach, with a good coupling to barriers with measureable parameters. Another reviewer stated that task one and two are on the Friction Stir Welding (FSW) process and the third task is for magnetic material development, but was not sure how these two areas are related. This person asked if other issues were to be considered for electric motors, and noted that the research is aimed to develop linear FSW process for producing joints in copper rotors. The reviewer remarked that even though the idea is unique, the process may not be the suitable, as the geometry of the rotors may call for different joining techniques other than linear joints. This reviewer also wished to know how much of the joining is involved in the rotor production process. The next panel member agreed that the technical approach to this work is sharply focused on several important technical and cost barriers to the wider adoption of electrical propulsion systems and prime movers. This commenter pointed out that the focus of the work (electric motor fabrication and cost optimization), however, is fairly narrow. This reviewer remarked that significant in-kind participation of a major vehicle manufacturer is testimony to the importance the industry attaches to this work, but that other issues may be of greater ultimate importance to electrical propulsion systems, e.g., energy storage. Another panelist relayed that the researchers stated that they were going to work on copper-copper, copper-aluminum, and new materials using FSW, but the panelist did not feel that the presenter adequately described what they were going to do. Instead the presenter spent additional time on the relevance of the work and how it would reduce the size, weight and cost of motors if successful. The panelist realized that this is a very new project and the specifics of their work are probably still being developed, but next year the panelist would like to see specifics about what the research team is going to do and how it is going to join very small and/or complex shaped parts with very simple and bulky friction stir welding tools. The panelist would also be interested in what General Motors Corporation (GM) plans to do and how that will complement the Pacific Northwest National Laboratory (PNNL) work.

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

Reviews for this section were mixed. One panel member commented that the technical accomplishments were good for the short length of time since the project's inception. This person commented that the researchers have already investigated a variety of tool materials for both copper-copper (Cu-Cu) and copper-aluminum welds, and a number of process parameters including the spindle speed or revolutions per minute (RPM) of the tool and the travel speed of the tool across the component surface. This panelist looks forward to seeing what the researchers will be able to accomplish in a full year. Another reviewer observed that testing so far is leading to quantified results, but would like the researchers to show how successes tie back to the goals, and to show how close to target they are for areas of focused improvements in cost and weight. The next panel member thought that the project has surfaced some areas, e.g., FSW tool life, that clearly need attention, but that with less than one year's effort to date, it is difficult to assess the extent of progress. Accomplishments in the balance of fiscal year (FY) 2012 and up to the indicated go/no go gates will be critical to an evaluation of progress toward objectives. The final panelist relayed that FSW of Cu-Cu joints was investigated; the quality was assessed but not much was presented about the performance of the joints.

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

Comments to this question were mixed. One reviewer relayed that the researchers at PNNL have established collaboration with GM, who in turn have a large contract with the Power Electronics and Electric Machines Program to develop a new traction motor. This reviewer noted that the solid state joining technology being developed at PNNL will leverage and/or compliment the motor development at GM and, if successful, could be implemented in GM's new motor. Another observer thought that collaboration with one or more metal fabrication specialty companies would enhance this project. General Motors is likely to be a major beneficiary of the technology(ies) developed in this project, and it is to be hoped they would also be available to other vehicle builders. The second reviewer also thought that it seems unlikely that vehicle manufacturers would be major users of those technologies, as distinct from producers of electric motors and motor components. The next reviewer stated that PNNL developed a Cooperative Research and Development Agreement (CRADA) with GM for the project, but that the involvement of GM researchers is not shown in the presentation.

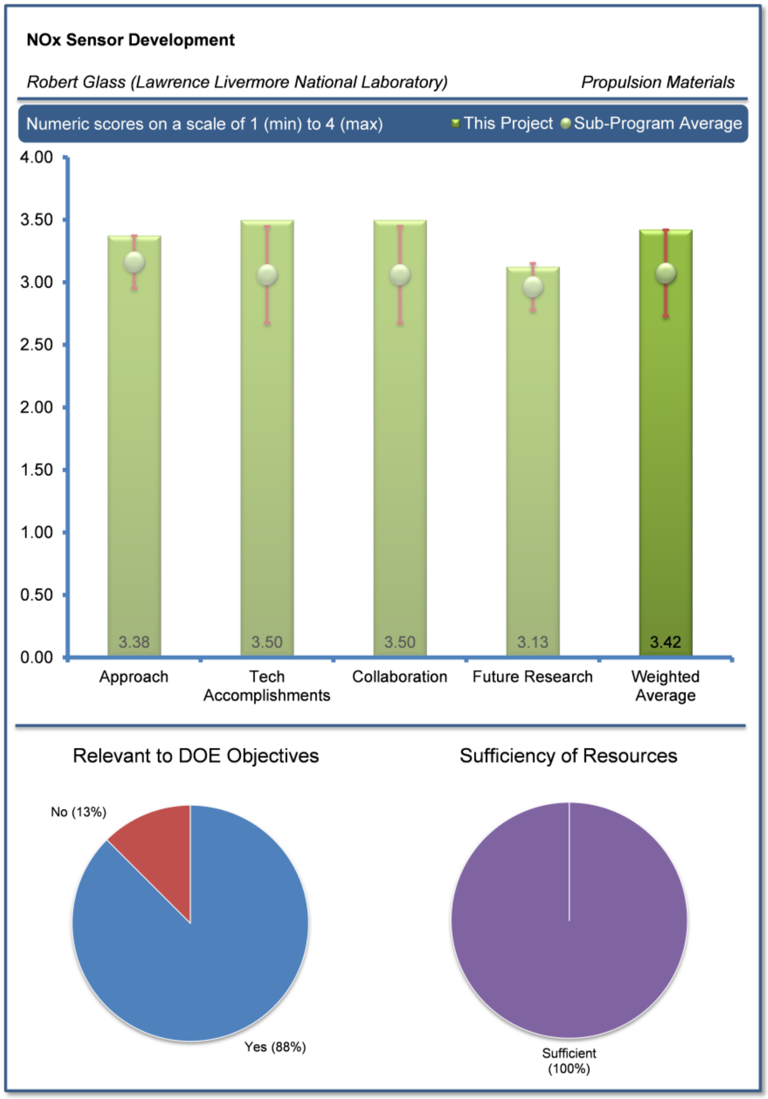
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Commenters gave mixed replies to this question. The first reviewer thought that even given the limited extent of past progress due to the recent inception of the project, it seemed clear that plans for the next 20 or so months of this project's future address the stated barriers and are sharply focused on overcoming them. An additional reviewer thought that the future work outlined by the researchers would build on the work that was started this year and will culminate with a very challenging go/no-go decision based on the mechanical performance criteria of welds of different geometries. The third reviewer said in reference to Slide 16 that future work planned is good, but that outputs should focus on delivery of barrier-reducing technology. The next commenter observed that the plan is to concentrate on the FSW joints, but there was no plan for the work on magnetic material development. The final observer believed that some innovative thinking would be required to figure out how to join the small and complex shaped components used in electric motors using conventional friction stir welding tools.

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

Four reviewers rated the resources sufficient. One qualified this rating by stating that this project will be receiving $445,000 during FY 2012, which is one of the highest totals for the Propulsion Materials Program. The reviewer believes that the funding is sufficient for this work.

NOx Sensor Development: Robert Glass (Lawrence Livermore National Laboratory) – pm005



Reviewer Sample Size

This project was reviewed by eight reviewers.

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

Reviews for this question were mostly positive. One commenter stated that accurate, responsive and above all cost-effective sensors for key emissions species are a key to long-term compliance with relevant emissions standards, without over-compliance, which is usually associated with larger-than-necessary fuel economy penalties. This commenter also stated that optimal control of oxides of nitrogen (NO_x) in particular is crucial for compression ignition (CI) engine vehicles, whose wider adoption would pay significant national dividends in petroleum conservation. Another reviewer thought that dieselization of a greater portion of the vehicle fleet would reduce petroleum consumption, and that development of a robust low cost NO_x sensor will assist in the implementation of diesel vehicles that are clean and efficient. The next reviewer pointed out that sensors are critical to development of fuel efficient and clean engine technology, and that they are the heart of the system; the level of technology in sensors is a critical component of future engine technologies. An additional panelist agreed that a NO_x sensor could be required for enabling diesel technologies, in turn contributing to reducing consumption by 1.5 million barrels per day through a 33% conversion to diesel. This panelist relayed that cost reduction of sensors as well as durability and accuracy will enable improved control. The panel member also asked what the targeted and estimated cost reductions are with the new technology, since diesels are in production with NO_x sensors today. A subsequent reviewer was not sure if the one-third driver conversion to diesel is realistic; however, the notion of higher fuel efficiency correlates to DOE's petroleum displacement goals. Another person commented that this project does indeed support the objective of reducing petroleum consumption. This person agreed that it is well known that diesel engines are more efficient than gasoline engines, but noted that their emissions, especially NO_x, have traditionally been higher than gasoline engines. This person further stated that to combat high NO_x emission levels, engines were de-tuned to minimize NO_x, and with the development of NO_x treatment strategies, measurement and control, engines can now be tuned for maximum efficiency. This person believes that the development of low-cost, rapid response NO_x sensors is therefore an enabling technology that will help optimize the efficiency of heavy duty (HD) engines used on trucks and will encourage the American public to purchase a higher fraction of more efficient diesel engines. The reviewer concluded with the thought that, with the price of diesel fuel being higher than gasoline, the American public is not likely to buy a lot more diesel automobiles. The next reviewer stated that material cost appeared to be too high, and that there exists long lead times for commercialization. A final reviewer observed that the project's aim is to develop low-cost, durable sensor technology for NO_x measurement and control to accelerate the introduction of clean, high-efficiency, light-duty diesel vehicles. This reviewer noted only one type of exhaust NO_x sensor available on the market, and that solid state electrochemical NO_x sensor technology is a proven robust technology.

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?

Remarks were mixed on the researchers' approach. The first panelist remarked that Ford Motor Company's significant contribution of in-kind support suggests both the importance the automotive industry attaches to development of practical NO_x sensors for light duty (LD) diesel vehicles and the industry's endorsement of the technical approach. An additional observer relayed that Lawrence Livermore National Laboratory (LLNL) developed a unique design and measurement strategy that leverages proven robust solid-state electrochemical technology using complex alternating current (AC) impedance (electrical response to low-amplitude AC signal) as opposed to direct current (DC) signals. This observer also noted that the researchers are developing a novel sensor with the potential to meet original equipment manufacturers' (OEM) cost and operational requirements. The next panelist thought the primary investigator (PI) showed that the project's research developed a solution that is possible, and has now to show low cost manufacturing. Another reviewer confirmed that for this year, researchers were testing prototypes to improve performance, including drift and sample-to-sample reproducibility. The next panel member commented that the technology being developed is challenging, although there seemed to be a reasonable approach to overcoming the barriers and obstacles as information is gained over time. The panelist thinks that there still seem to be many issues that need development before commercialization is imminent. A subsequent reviewer was of the opinion that the researchers' approach was valid and producing good results, but that the presented information on approach did not give detail on what the objectives are nor how those objectives shall be achieved. Another reviewer stated that although this project has been ongoing for a very long time, it was unclear whether the researchers have learned a lot and made great progress, especially in the last three or four years. The reviewer saw that the researchers have developed a novel technology that measures AC impedance instead of DC signals, thus offering better sensitivity for both nitric oxide (NO) and nitrogen dioxide (NO_2) better stability, and a simpler, less expensive technology. The reviewer also appreciated that the researchers have included engine testing in their work, which enables them to determine whether the sensor is robust and durable enough for successful commercialization. The final reviewer characterized the research as using an electrochemical sensor approach, using an alternating current sensing approach, working on testing and mass production fabrication strategies, and developing an electronic interface.

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

Impressions of the technical accomplishments and progress were mixed. One reviewer remarked that the researchers at LLNL and Ford have made good progress this year. The reviewer relayed that the researchers have investigated two different sensing materials (Au and LSM), recognized that Au was more stable, and that LSM had some drift because of the formation of microcracks due to a thermal expansion mismatch. The reviewer noted that the researchers were able to modify the substrate to change the thermal expansion of the substrate and that significantly reduced the number of microcracks and produced acceptable drift. This first reviewer also thought that the engine testing that was done showed that the sensors were robust and durable in the engine environment and the performance was at least as good as current amperometric NO_x sensors. Another panel member thought the accomplishments regarding sensor measurement advances were good. This panelist also pointed out that NO_x values can range to well over 1,000 parts per million (ppm) in real life, and suggested considering regeneration, etc. The panelist remarked that sensor performance over 100 ppm was undefined, and asked if this was for post NO_x reduction catalyst application only. This panelist went on to ask what the requirements for range, temperature, and other conditions were. The next reviewer thought that the review highlighted the progress in a broad overview with vague milestones, and that it seemed as though the OEM was driving the schedule to keep swift progress, which is fine so long as the development is not compromised. The reviewer thought the presenter did not give a sense of the impact of a swift project conclusion. The reviewer assumed that Ford will continue to work with EmiSense and adopt this technology, but wondered if there was any risk that Ford would not pursue it. Another observer stated the researchers were still developing information from research. This reviewer observed that the researchers' laboratory long-term aging (up to 1,000 hours) confirmed that previously measured minimal drift in Au prototype, but indicated variance in LSM prototype; demonstrated acceptable solution to optimize the tradeoff between micro-crack formation and drift in LSM prototype by modifying substrate composition; demonstrated excellent performance of Au prototype in both high (up to 100 ppm) and low (less than 20 ppm) NO concentrations alongside two commercial amperometric sensors (same design, two different suppliers); and additional advanced engine testing in real diesel exhaust and aggressive conditions continued to show good results including sensor durability and robustness. The final reviewer thought that significant progress had been made toward the project objectives, and listed the researchers' accomplishments as having demonstrated sensor prototypes in lab and in engine dynamometer testing; having demonstrated prototype electronics; having confirmed aging performance of one prototype and observed drift and sample-to-sample variability with another; having observed microcrack formation in the less stable design and improved performance by minimizing microcrack formation; and finally having demonstrated optimized design.

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

Comments on this section were generally positive. One person commented that the collaboration and coordination with other institutions has been outstanding in this project, and pointed out that the researchers have worked with Ford for many years and their guidance has steered the project in the right direction. The reviewer also thought that the additional collaboration with EmiSense (Coors Ceramics & Ceramatec) at this stage of the project has been a big plus because both Ford and EmiSense are pushing this technology toward commercialization. Another commenter thought that collaboration with current industry partners (EMISense and Ford) seems close and appropriate; a rating of Outstanding was therefore justified. However, this commenter thought it seemed likely that virtually all manufacturers of emissions controls and all light-duty vehicle builders will wish to employ the technology and its fruits if this project is ultimately successful. The commenter questioned if control of patents, etc. would allow the technology's universal adoption by OEMs, or if licensing fees, etc. would motivate them to duplicate this work and develop their own proprietary approaches to NO_x sensing. The next reviewer commented that collaboration between the adoption by EmiSense and the interest and direct collaboration with Ford lend commercial credibility to the project. The following reviewer saw significant collaboration with Ford and an established partnership with a patent licensee via a CRADA. The subsequent observer thought the researchers have the right collaborative partner from historical perspective, but that it was difficult to determine whether the partners are working sufficiently collaboratively on the project to match needs for continuing development. The next reviewer noted good collaboration with Ford and EmiSense, and a final panelist stated that there was collaboration with Ford and EmiSense.

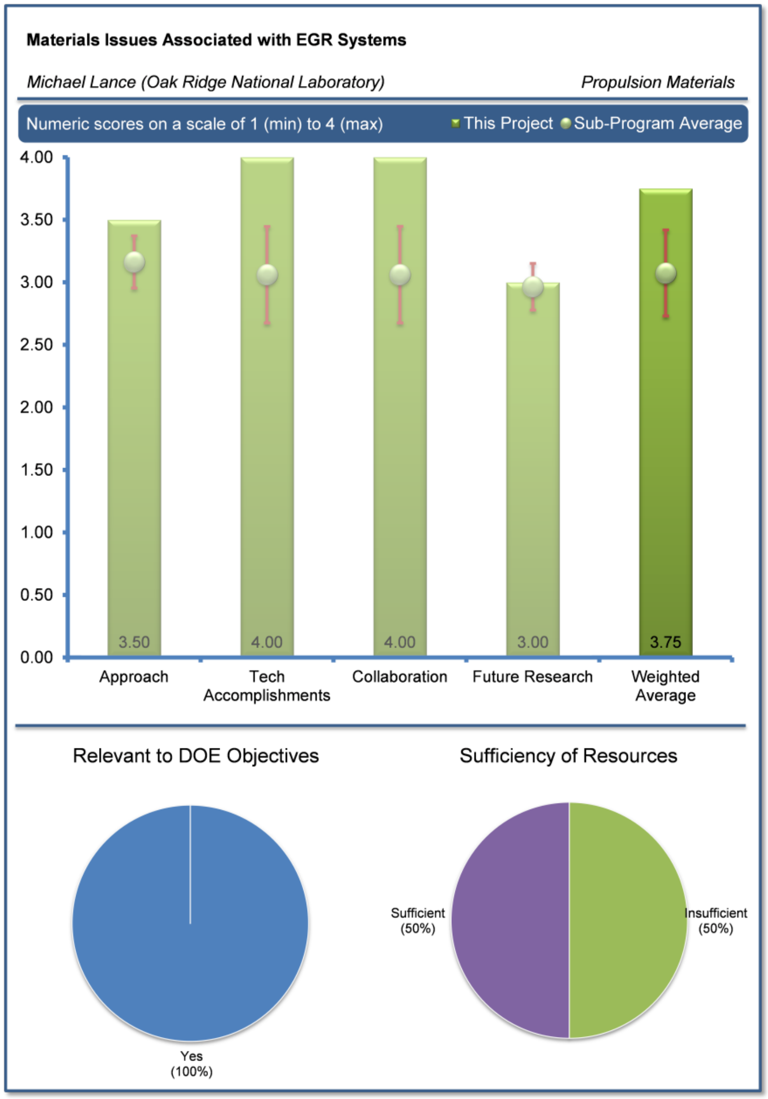
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Most comments on this section were positive. One panel member enthused that that the plans for future work were outstanding because partner EmiSense will be involved with the investigation of processing/fabrication techniques like tape casting, slurry painting, spin casting, and photolithography and sputtering. This panelist thought that there should not be any wasted effort because the partner planning commercialization will focus on the technologies that look most promising to them. The panel member also thought for similar reasons that it was very wise to include Ford and EmiSense in the work on sensing strategy and electronics; their participation will ensure that the best path for commercialization is chosen. Another reviewer found that the researchers had a good plan to work with EmiSense to refine fabrication/processing strategy and develop long-term and accelerated testing protocol. The next commenter thought that the researchers employed a logical approach, based on findings. Another observer stated that researchers will perform down-selection of fabrication methods and electronics design, and will validate engine/vehicle performance. The next panelist remarked that plans seemed clear for future testing, and that long term durability was key, but wondered if the testing should be done in an expected environment. A subsequent reviewer thought the presenter did not offer great insight into what appears to be a significant amount of work in the remaining period of the contract. The final panelist remarked that key decision points will be reached this year and next, and appear to have been adequately and logically prepared for. The final reviewer qualified his remark by noting that, on the other hand, this project's eggs are essentially all in one basket (i.e., impedance-based sensing, and should those key decisions be negative, no alternative pathway is apparent).

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

Eight reviewers found the resources to be sufficient. One reviewer thought that the project appears to have been adequately funded. Another noted that the project has adequate funding for FY 2012 ($400,000). The next confirmed that this project received $400,000 in FY 2012 and has been well funded since its inception. A further reviewer pointed out that no cost share was described other than roughly one-third in-kind support from Ford. The final observer provided that spending was in accordance with plan.

Materials Issues Associated with EGR Systems: Michael Lance (Oak Ridge National Laboratory) – pm009



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 found that this project addresses eliminating a 1-2% efficiency loss, which is aligned with DOE's petroleum displacement objectives. Another panelist stated that this project seeks to mitigate exhaust gas recirculation (EGR) cooler fouling, which reduces the fuel economy of combustion engines. This panel member further explained that EGR cooling is currently the primary approach to reducing NO_x emissions from lean burn engines such as diesel engines which tend to be higher NO_x producers than lower compression gasoline engines.

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 thought that this project employed excellent forensic analysis combined with controlled lab research and problem solving. The next observer noted that the approach was logical and well laid out, but could be improved if sufficient funding were available to enable more engine operating set points to be selected to better simulate the engine map operation in real world conditions. This observer also advised that increased attention should be given to the chemistry taking place within the EGR cooler as the formation of polycyclic aromatic hydrocarbons (PAHs) indicates that quite a bit of chemistry, as opposed to simple condensation, is taking place therein.

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

One reviewer remarked that with clear support and interest from OEM community, progress appears to be well monitored and task adjustments seem to be readily adopted. The second reviewer said that given the modest funding level, progress on meeting the milestones has been quite good. The reviewer recommended that increased emphasis should now be given to developing the refreshing protocol suggested by results showing that water vapor has a substantial positive effect on reducing fouling buildup.

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

One panel member thought that there was an ideal level of partnership and interest from industry OEMs. The panelist qualified this by pointing out that there was no mention of the loss of Army interest from 2011 activity. Post-presentation questions revealed that Army funding did not continue. This reviewer inquired about why Army engagement was not kept. The panelist also commented that the presentation did not describe why some OEMs did not contribute specimens for analysis. Another reviewer stated that while collaboration and coordination of this work with other institutions has been outstanding, perhaps even this could be enhanced by adding a few fuel providers to the mix. This reviewer believed that by so doing, more attention could be paid to the reaction conditions and the chemistry taking place within the ERG cooler.

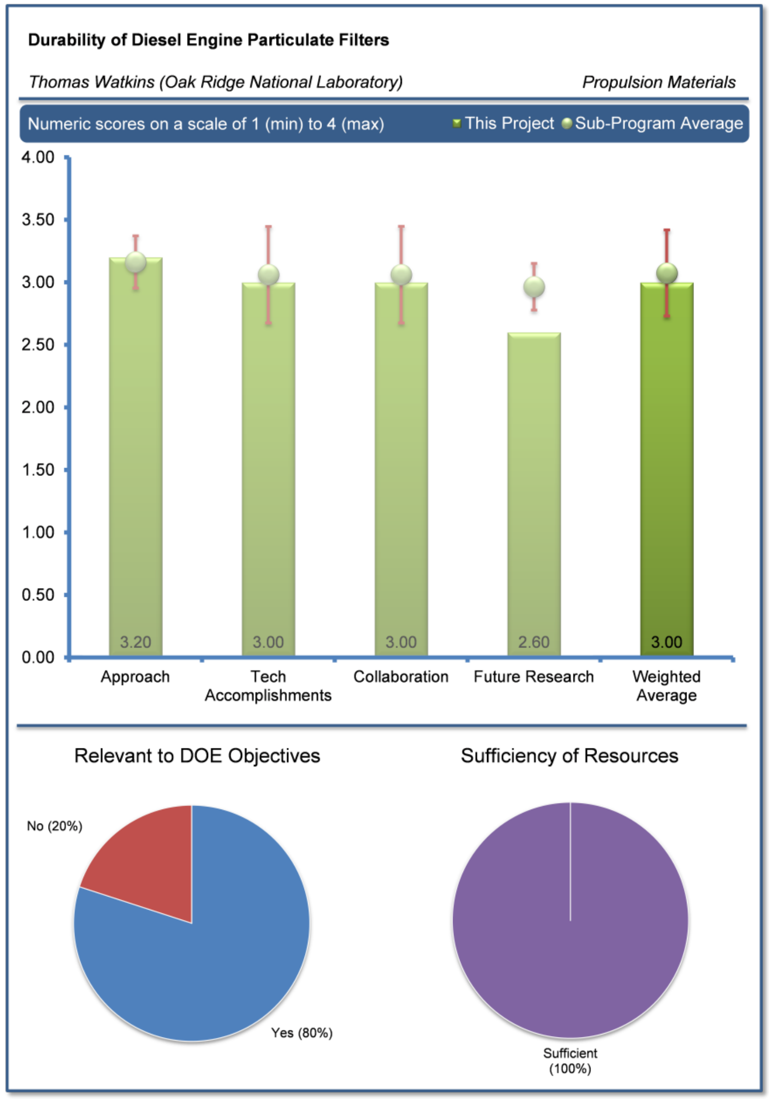
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer thought that the proposed future research directions are logical and build upon past progress, but also suggested that improvements could be made by investigating whether or not there are any material effects on the fouling build up, perhaps through a catalytic effect. The second observer wrote that while the review offered a rudimentary outline (two main topics) of future work, there was little information presented that described transition to industry adoption.

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

One reviewer rated the resources as sufficient, while the other found resources to be insufficient. The first reviewer noted that no cost share was described, while the other reviewer commented that the level of resources are adequate for the rather slow pace of progress achieved thus far; however, EGR cooler fouling is a serious impediment to achieving the full fuel efficiency of the U.S. heavy duty trucking fleet. This observer points out that EGR cooler failure constitutes a substantial cost penalty to truck operators who are already struggling with reduced profit margins, and that to increase the pace of progress, this project merits at least a 15-20% increase in resources.

Durability of Diesel Engine Particulate Filters: Thomas Watkins (Oak Ridge National Laboratory) – pm010



Reviewer Sample Size

This project was reviewed by five reviewers.

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

One observer believed that this project supports the DOE objective of petroleum displacement by both optimizing the diesel particulate filter (DPF) regeneration cycle, thereby reducing the quantity of fuel needed to regenerate the DPF, and also by cleaning emissions of particulate matter (PM), thereby making diesel technology more acceptable to the customer, especially the light duty vehicle customer. This observer pointed out that because diesel engines are about 25% more fuel efficient than comparable gasoline engines, enabling more clean diesel engines in U.S. vehicles may lead to substantial petroleum reduction. Another commenter thought that by improving DPF designs, the fuel penalty and durability of DPFs can be improved, enabling greater reliance on efficient, clean diesel technology, which will reduce petroleum consumption. The next reviewer relayed that the stated goal of the project includes material improvement for EATS durability and efficiency improvements, which may reduce fuel economy impact of regeneration by 25%. Another reviewer stated that the review presents correlation to Vehicle Technology Program (VTP) goals through improved component efficiency over existing systems, but that the vehicle system efficiency improvement is not clearly described in the review. The final reviewer commented that the effect on the internal combustion (IC) engine combustion regime and the high cost material content which needs to be used. Side projects need to be solved for this 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?

Comments for this question were generally positive. One reviewer thought that the approach was logical and well designed. In this reviewer's opinion it is a clear Federal role to assist U.S. industry to develop needed material properties data to enable cost-effective energy efficient technologies. The reviewer further stated that, moreover, partnering between industry and DOE National Laboratories to leverage the Federal investment in scientific tools (ceramic technology instrumentation) increases the probability of success. The reviewer further stipulated, however, that due to the lack of viscoelesticity in ceramic materials, it is difficult to assure reliability in life prediction models of ceramics because failure tends to be catastrophic and stochastic rather than deterministic. Another observer noted that this CRADA activity has generated DPF property data that allows accurate DPF behavior predictions, probabilistic design tools, non-destructive techniques and thermo-mechanical characterization to provide materials behavior and property data to model regeneration. This observer further stated that research focused on SiC substrates, and used Oak Ridge National Laboratory (ORNL) High Temperature Materials Laboratory (HTML) facilities. The next panel member thought the review identified the interest in employing Si-C material for its material properties and logically addresses technical issues, but that the review did not describe cost other than to identify that the material is more durable. The reviewer wondered about the return on investment. The final panelist inquired how the change in materials would reduce the fuel used in regeneration; why regeneration was any better with this material; and what were the regeneration characteristic that benefits the customer. This reviewer wanted to know if it is better in active regeneration, passive regeneration, both, or other. This reviewer inquired that if it is a matter of data provision for modeling of regenerations, how does this improve regeneration compared to simply improving the modeling of existing materials? This reviewer also was interested in knowing whether cracking is really a problem today, how many crack, and why.

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

Reviews were mixed for this question. One person said that progress toward the objectives has been good and improved materials properties data is being generated for the technical literature. However, this person remarked that the introduction of SiC as a potential DPF filter material is somewhat puzzling, as there does not seem to be an overriding rationale for investigating it as a potential DPF material in this project. Another reviewer remarked analysis of material strength done, and material development is good, but was unsure of the progress towards goals regarding cost reduction, efficiency improvement, or anything other than thermal shock resistance. A final observer relayed that the researchers developed a rig for high temperature fracture toughness testing, and characterized toughness and crack behavior.

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

One reviewer thought that collaboration and coordination with the industry partners appeared to be satisfactory but a stronger (quantitative) link to improvements in DPF performance, e.g., reduced fuel consumption penalty would strengthen the case for this work and indeed, help make the case for investigation of other potential higher performing/lower cost materials such as SiC. Another observer relayed that the review characterized the collaboration and support by Cummins as an active and important partner. The next reviewer reported the researchers have an active CRADA with Cummins. The last reviewer also noted that the researchers are working with Cummins.

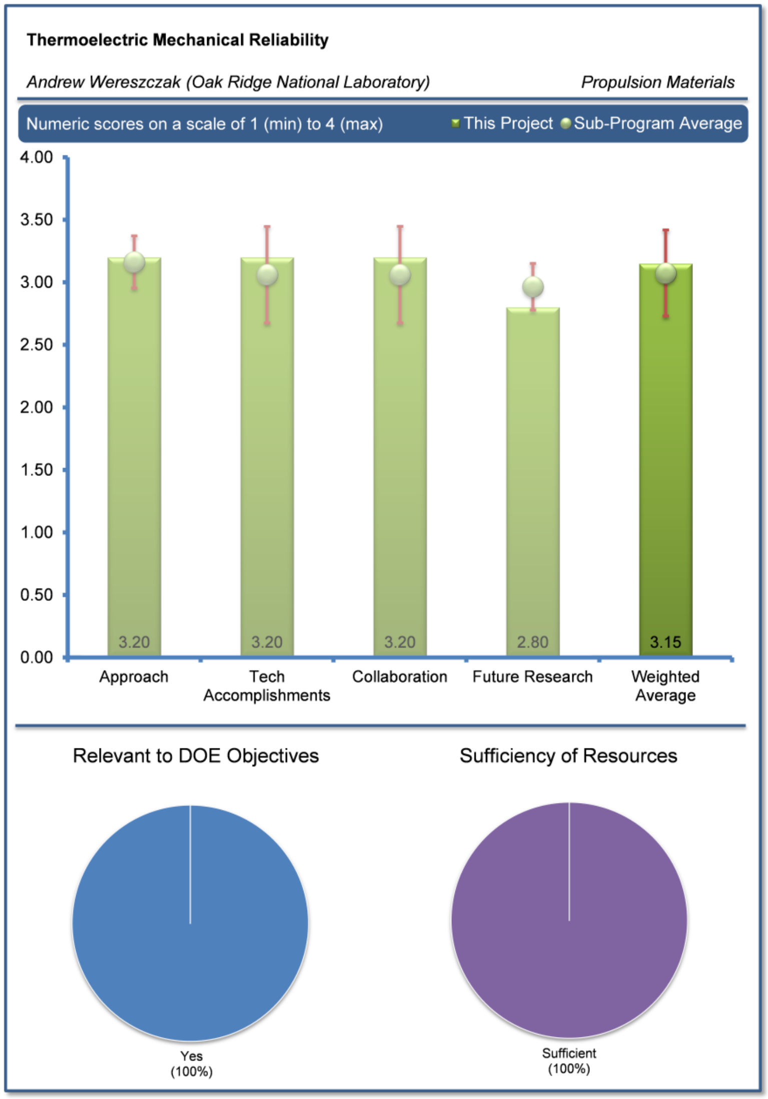
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer suggested that the researchers consider deeper analysis of what the user needs regarding efficiency of catalyst vs. temperature, ability to store and regenerate soot, and contamination due to fuel/lube/coolant components. Another panelist remarked that future research could focus totally on SiC or other potential DPF materials if a stronger rationale for so doing were articulated in the project objective. The next commenter said that while the review offered a rudimentary outline of future work, there was little information presented that described transition to industry adoption. The final panel member relayed that researchers will continue to perform characterization efforts and consider coated DPFs.

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

All five reviewers rated the resources to be sufficient. One clarified that resources appear to be sufficient to achieve the stated milestones in a timely fashion, although eliminating SiC as a part of this project could enable completion sooner and with less expenditure of funds. Another reviewer commented that funding appears adequate, and a last reviewer thought the project has an excellent 50/50 cost share.

Thermoelectric Mechanical Reliability: Andrew Wereszczak (Oak Ridge National Laboratory) – pm012



Reviewer Sample Size

This project was reviewed by five reviewers.

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

Comments for this section were positive. One observer stated that the possibility of using thermoelectric generators (TEGs) to capture waste heat from the exhaust to increase fuel efficiency of vehicles clearly does support the overall DOE objective of petroleum displacement, and that the question to be answered is whether or not this can be cost-effective. Another reviewer thought that thermoelectric materials have the potential for a lot of the waste heat in the vehicle to produce electrical power and cooling which should make the vehicle much more efficient. This reviewer said that increasing the mechanical strength of these materials is a key enabler to making these materials feasible in terms of surviving the large temperature gradients experienced in the vehicle. The next panelist rated waste heat recovery a high priority in reduction of fuel consumption, and material for thermoelectrics is the largest barrier in implementation. This panelist also suggested that advances in cooling may have secondary benefits. The final reviewer commented that the function is there, it is just a matter of how to measure and characterize.

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 were generally positive for this section. One commenter said that the approach seems to be reasonable and data driven, and that this systematic approach combines theoretical, analytical and experimental approaches. Another reviewer thought that there was good focus on material strength for application, but there was no focus on efficiency of material or cost of material, only strength. A final reviewer agreed that the approach is quite sound, as the measurement of physical and mechanical properties of these rather complex composition materials is not simple. This reviewer noted that databases of brittle material properties tend to be much less developed and statistically reliable than those of metals due to the essentially unavoidable incorporation of microflaws into the compact. The reviewer also stated that the use of a round robin to have multiple laboratories measure ostensibly the same material parameters from a single batch of material illustrates some of the difficulties inherent to making these measurements. According to this reviewer, it is interesting that one of the supposedly simplest parameters to measure, heat capacity, appeared to be one of the most difficult with which to gain consensus values. The reviewer posited that it might be interesting to compute the heat capacity from first principals to see if this could provide a clue as to the origin of the experimental measurement difficulties.

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

One panel member said that good work was done on stress analysis, but that thermal heat capacity measurement of course needs to be better understood, and test methods need to be developed for repeatable and reliable information. Another panelist remarked that progress toward objectives has been good. However, this panelist was concerned about the problem with the heat capacity measurements, and thought that it was not clear what measures were being proposed to resolve the problem. A third reviewer observed there has been a lot of test data, but the challenge was to draw general deterministic conclusions.

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

Reviews were mixed for this section. One reviewer commented that there was great work on round robin testing to generate industry agreement. Another thought that coordination with partners and collaboration with other institutions through the International Energy Agency (IEA) round robin has been excellent. This reviewer wondered why the National Institute of Standards and Technology (NIST) was not involved in the materials properties measurement round robin. The final reviewer remarked that most of the work is done at ORNL and the only collaboration is with Marlow Corporation, even though there were specimens from many other institutions that have been tested.

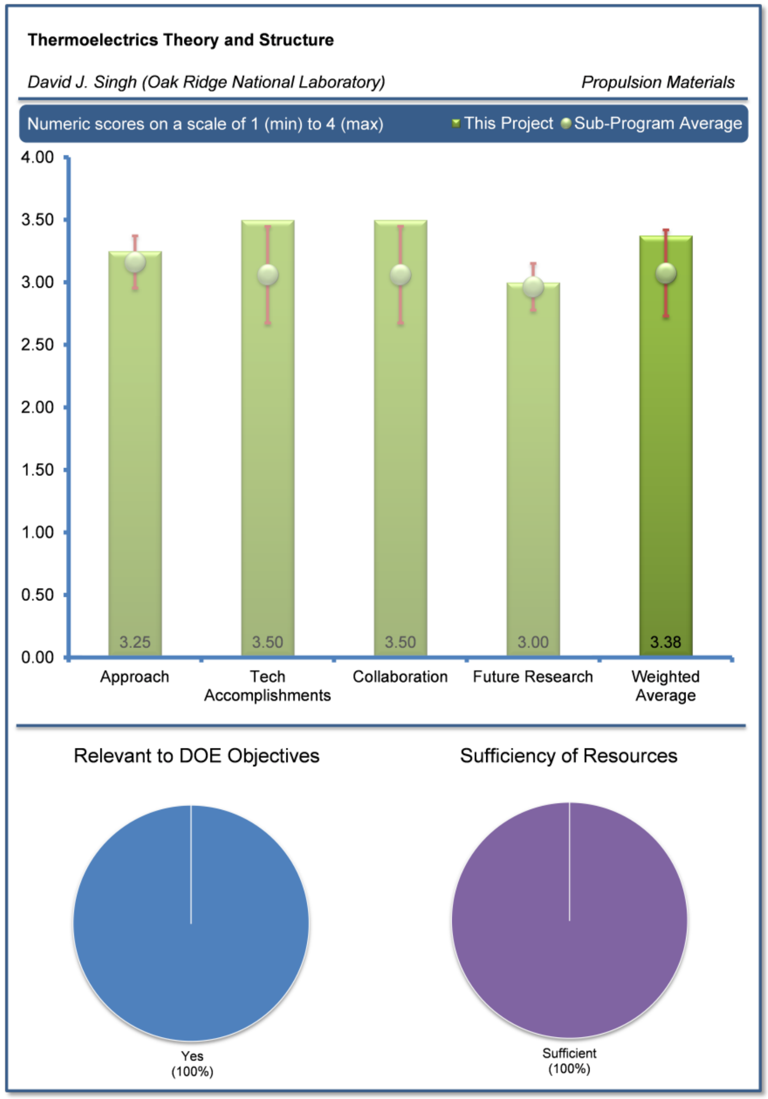
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Comments for this section were mixed. One reviewer thought that the proposed future work seems reasonable and there are plans on addressing identified gaps. Another observer stated that plans for future research to build upon past progress, but no solution to resolve discrepancies in the heat capacity measurements appears to have been proposed. The next panelist commented the researchers should define how the end result of this study will benefit the TEG unit technology development, addressing the reliability, cost, and efficiency of the units.

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

Four reviewers found resources to be sufficient. One reviewer commented that given the progress achieved to date the resources for the project appear to be adequate, and another thought that the resources seemed to be sufficient based on the scope of the work to be done.

Thermoelectrics Theory and Structure: David J. Singh (Oak Ridge National Laboratory) – pm013



Reviewer Sample Size

This project was reviewed by four reviewers.

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

Comments for this section were positive. One reviewer effused that this work is excellent and has the potential to enable the selection, synthesis and development of lower cost, less toxic materials for TEG devices in vehicles and other applications areas where waste heat is available. This reviewer also pointed out that enabling TEG waste heat utilization to become cost effective supports the overall DOE objective of petroleum displacement. Another reviewer commented that recovering as much waste heat as possible using thermoelectric materials can have a significant impact on fuel consumptions. A final observer wrote that coupled to fuel consumption, thermoelectric material is a known roadblock.

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?

Reviews in this area were mixed. One observer agreed that the researchers employed a systematic approach to scan through the various materials and doping processes to identify the most promising materials. Another explained that the use of theoretical computations to design material structures a priori, which may have promising properties for TEG devices, is a sound scientific approach. However, this reviewer thought that having identified several promising structures, it would make sense to seek to synthesize and experimentally measure relevant mechanical and physical properties to determine if these materials merit further development and corroborate predictions of the theoretical calculations. A final panel member inquired about the weighting values used in material matrix selection, and further queried whether cost, reliability, etc., were considered.

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

One observer considered progress to be excellent and that theoretical computations could be useful to pre-screen material compositions and structures prior to synthesis and material property determinations. However, this observer emphasized that experimental validation of the theoretical predictions is essential and should be pursued prior to extending further effort on other potential materials. Another reviewer saw good progress, with milestones of having established design guidelines and having established trends for thermoelectric materials. A final panelist remarked that it was good to see the model for PbSe directly impacted industry and the model seems valid.

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

Comments in this section were positive. One reviewer thought that there were a good group of collaborators, while another reviewer reported that the researchers had several external partners with a lot of diversity, including renowned universities, national labs and OEMs. The next reviewer remarked that collaboration and coordination with other institutions has been excellent. This reviewer noted that the materials design effort must now morph into a materials synthesis and properties measurement activity to confirm the theoretical or computed predictions prior to continuing to seek other compositions and structures. The reviewer also thought that upon experimental validation of these preliminary predictions, it would make sense to extend the approach to other potential material compositions and structures.

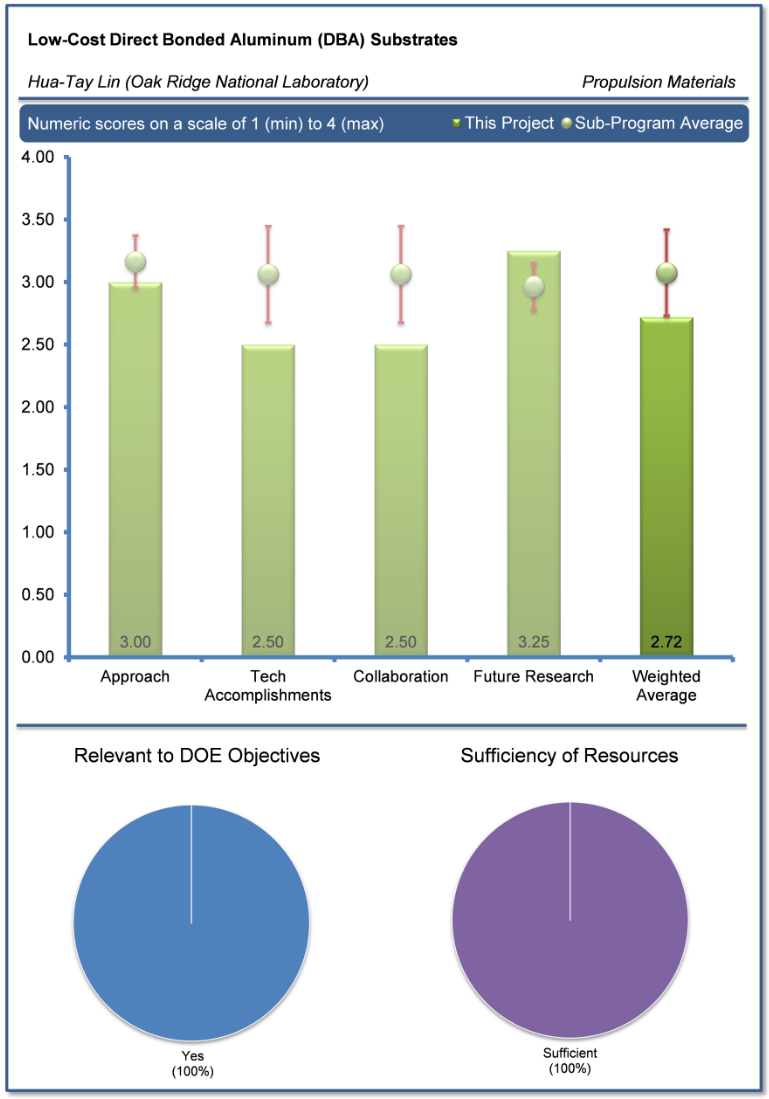
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers generally had positive feedback. One observer remarked that there was good proposed future work in trying to address the identified gaps. Another reviewer would like the researchers to please continue research and communicate a matrix of advantages and disadvantages of materials related to targets. The final reviewer relayed that future work is proposed on other potential compositions and structures. This reviewer noted that after some of the preliminary materials already identified have been synthesized, characterized and had their properties measured and validated with the predictions, it would then be appropriate to extend the investigation to other potentially even higher performing materials.

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

Four reviewers found resources to be sufficient. One reviewer said that resources for the project appear to be sufficient to achieve the milestones in a timely fashion, and another reported that the resources seem to be sufficient based on the proposed work.

Low-Cost Direct Bonded Aluminum (DBA) Substrates: Hua-Tay Lin (Oak Ridge National Laboratory) – pm036



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 agreed that developing low-cost high-performance direct-bonded aluminum (DBA) can be a key enabler to help semiconductor devices and inverters meet their very challenging cost and performance targets. Another observer also thought it appeared that the technology is focused to advance materials related to energy efficiency, such as weight reduction and cost reduction, but wished that the presenter had clarified the direct impact to the final application, as it was difficult to understand from the deeply technical material development presentation where this is used or how this can and will impact fuel efficiency. The next reviewer expressed concern that this project should focus more on a replacement for conventional substrates. This reviewer also pointed out that DBA is already relatively inexpensive, so cost reduction will not be significant area of progress, but that DBA with direct bonded copper (DBC) performance at the same or lower cost to current DBA would be significant. The final reviewer was of the opinion that Direct Bonded Alumina and Direct Bonded Copper substrates will be a likely location for failure as power electronics operating temperatures increase. This reviewer sees the development of better DBAs that can operate at higher temperatures as needed and therefore supporting the overall DOE objectives. The reviewer, however, thought that improved DBA substrates would likely have only a minimal effect on the size, weight, and cost of the electronics that are part of the vehicle, but that better DBA substrates would improve the reliability of those electronics.

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 commenter observed that the researchers employed a good approach, including benchmarking compared to the state of the art, as well as using ORNL capabilities to push the state of the art; in general, a systematic and well planned approach. Another reviewer remarked that the approach of selection and development seemed systematic and robust, but that it was difficult to foresee the final impact related to higher level barriers. The next observer relayed that the approach for this research project is to learn as much as possible about commercial direct bonded alumina substrates and benchmark their performance. With that understanding, this reviewer suggested to attempt to develop more reliable DBAs using the researchers' expertise in AlN and Si_3N_4 processing, since those materials reduce the thermal expansion mismatch between the substrates and the coatings.

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

One reviewer observed good progress and lots of analytical and experimental results that will help guide the research effort. Another panelist pointed out that this project was relatively new and was actually in the first full year of operation. This panelist thought that the researchers have made good progress with their literature search and the characterization and benchmarking of commercial DBAs; however, the researchers have not yet produced DBAs that are as good as the ones commercially available. A final observer asked how it was possible to measure the progress of this development versus the target reduction in cost or increase in energy density or lifetime.

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

Reviewers had mixed feedback on the level of collaborations. One reviewer believed that the collaboration and coordination with other institutions had been fair to the point of the presentation. This reviewer noted that Dr. Lin has collaborated with researchers at the National Transportation Research Center (NTRC), who are funded by the Power Electronics and Electric Machines Program, and who believe that DBAs are problematic at higher temperatures and need to be improved. This reviewer further observed, however, that it was not obvious from the presentation if there has been much collaboration with companies that produce DBCs or DBAs. Another observer thought that collaboration and coordination could be improved, as it seemed that the bulk of the work was done within ORNL. Another panelist recommended broadening commercial involvement. The last observer thought that it would be a good idea for the researchers to try and widen commercial involvement.

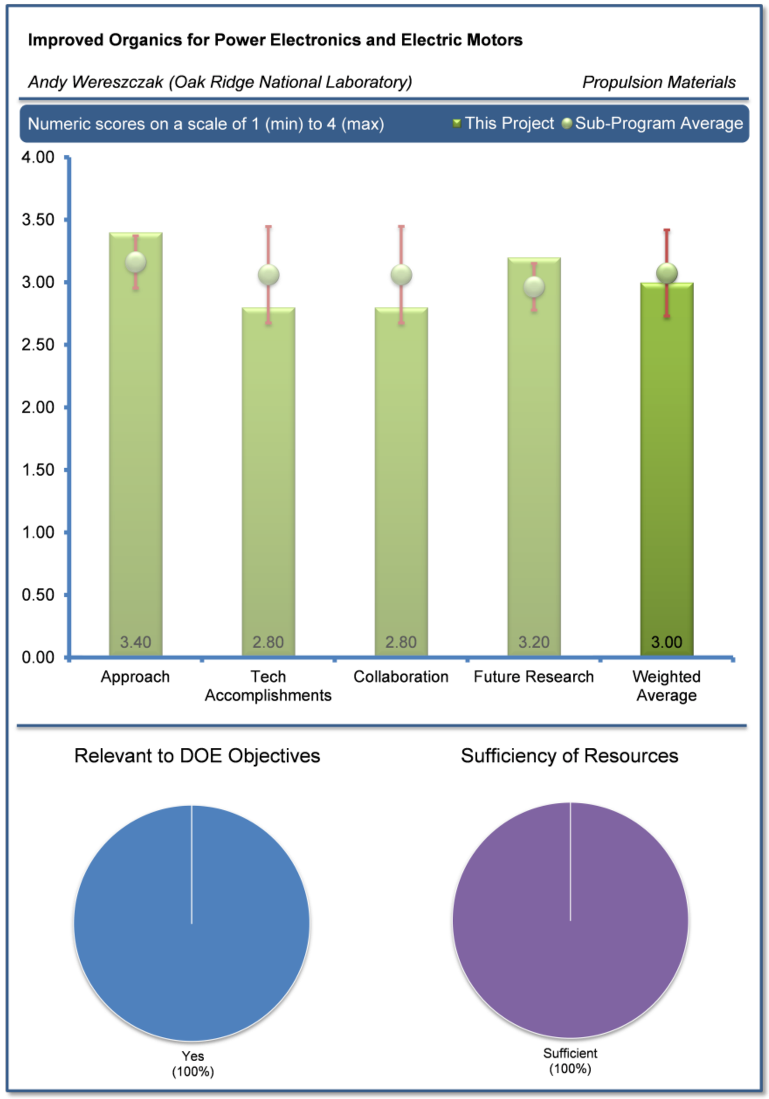
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Remarks were generally positive. One reviewer believed that the proposed future work is good, and that that the investigation of copper-clad Al ribbons and the use of reaction bonded silicon nitride substrates are good ideas that should reduce the thermal expansion mismatch and have the potential to produce better DBAs. Another remarked that there was good proposed future work that addresses the gaps and challenges. A final observer noted that the PI had not identified the exact benefits to users with estimates for total system savings in identified benefit areas.

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

Four reviewers found resources to be sufficient. One reviewer stated that resources are sufficient based on proposed work. Another observed that this project received $200,000 in FY 2011 and FY 2012, and believes that the project has been sufficiently funded for about 18 months of effort, because no funding was received until the last quarter of FY 2011. A final commenter thought that this is an important topic that is critical to meeting power electronics cost and performance targets, and that it might be good to consider growing the area of work.

Improved Organics for Power Electronics and Electric Motors: Andy Wereszczak (Oak Ridge National Laboratory) – pm037



Reviewer Sample Size

This project was reviewed by five reviewers.

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

One panel member commented that this project is very relevant to the goals of the Power Electronics and Electric Machines Program, which has goals of reducing the size, weight and cost of the electronic components and increasing their reliability. The panelist saw that this project addresses each of these goals; because improved epoxy molding compounds with higher thermal conductivities would reduce the size and decrease the operating temperature of film capacitors and motors, they therefore would reduce the cost and increase the reliability of power electronics. Another observer noted that reducing the size and weight of film capacitors used in inverters and traction motors would definitely reduce the weight of the vehicle and therefore reduce petroleum consumption. The next reviewer remarked that developing low cost high performance epoxy is a key enabler for low cost high-performance power electronics devices and motors. A subsequent reviewer pointed out that the PI was investigating improvement of power electronics in performance, reliability, and reduced cost, but would have liked the presenter to quantify the targeted savings and evaluate with a measureable parameter. A final panelist related that the researchers intend to develop power electronic devices (PEDs) that need less cooling, which can assist development of electric motors, PEDs and other components. This panelist saw that this could lead to volume and weight savings, and might enable vehicle systems operating with higher coolant temperatures and/or require less secondary cooling equipment, but the presentation did not make this link clear.

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 thought that the researchers employed a good systematic approach that included scanning and processing of various filler materials. Another found the approach for this project to be well organized with the lab researcher focusing on modeling and leaving the fabrication of sample epoxy molding compounds (EMCs) to the industry partners. This observer related that during the first year of the project, the PI developed a model that predicted the thermal conductivity of an epoxy molding compound when using a given particle size distribution and volume fraction of filler particles, and that later in the project, the PI developed models of different electronic components (motors or layered capacitors) that showed the effect of using epoxy molding compounds with different thermal conductivities on the size and operating temperature of the component. The observer concluded that once the models have identified the particle size distribution volume fraction, and composition of the filler particles, the industry partner can fabricate a number of samples of epoxy molding compounds. The next panelist characterized the research as having considered various filler materials to optimize particle size distribution and volume fraction, and having targeted goals of low environmental impact, low cost, and improved performance. The final reviewer asked how the researchers identified the candidate matrix of materials to be investigated, how many were considered and rejected, and if there was any consideration of manufacturability and availability of the material. This reviewer stated that in the meeting the presenter explained that the candidate matrix was identified by experience.

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

The first panel member stated that simulation showed that increases in thermal conductivity are beneficial for future thermal management. The second reviewer remarked that the PI has made good progress during the first full year of the project, by developing software to create two dimensional (2D) images of epoxy molding compounds when using different particle size distributions and volume fractions of fillers that enabled thermal conductivity modeling, and by also developing collaboration with SolEpoxy, who manufactures epoxy molding compounds for power electronic components for the automotive industry. This reviewer found that the first samples that were produced approximately doubled the thermal conductivity of the EMC but the electrical conductivity was too high, and also related that another round of samples would be produced using different filler with lower electrical conductivity. Another reviewer remarked that progress was good, but that it was not clear how the results compare to the current state of the art. The last reviewer relayed that the researchers had identified and simulated the materials requirements, particle size distribution (PSD) and volume percentage, and that models allowed the thermal conductivity to be simulated based on input properties, which allowed the most desirable characteristics to be defined. The reviewer wrote that researchers simulated practical devices, such as a film capacitor, motor components, and a power module, in order to explore the impact of thermal conductivity.

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

Reviewers had mixed comments on collaboration. The first reviewer thought that this project exhibited outstanding collaboration/ coordination with other institutions. This reviewer saw the most important collaborator as SolEpoxy, who manufactures conventional epoxy molding compounds that have low thermal conductivities, and this reviewer was very interested in the project because the reviewer believes that there is a realistic chance of fabricating epoxy molding compounds with included particulates that increase the thermal conductivity by a factor of 10 or more. The reviewer opined that the collaboration was very significant because SolEpoxy agreed to fabricate test samples using filler materials supplied by ORNL. The reviewer thinks that, should this concept prove to be very successful, SolEpoxy would be ready to commercialize the new material in a matter of months. The reviewer further stated that the project is collaborating with researchers funded by the Power Electronics and Electric Machines Program, and that these researchers provide guidance about the components that could benefit most from the use of epoxy molding compounds with higher thermal conductivities. The same reviewer concluded that this project is also collaborating with Ube, who supplies the filler particles that are incorporated into the epoxy compounds. Another panel member observed industrial collaborations, and potential for collaboration with NTRC and ORNL, but no university involvement. Another panelist thought the project needed industry power electronics and motor application partners. The final observer said that it seemed that all the work is done at ORNL.

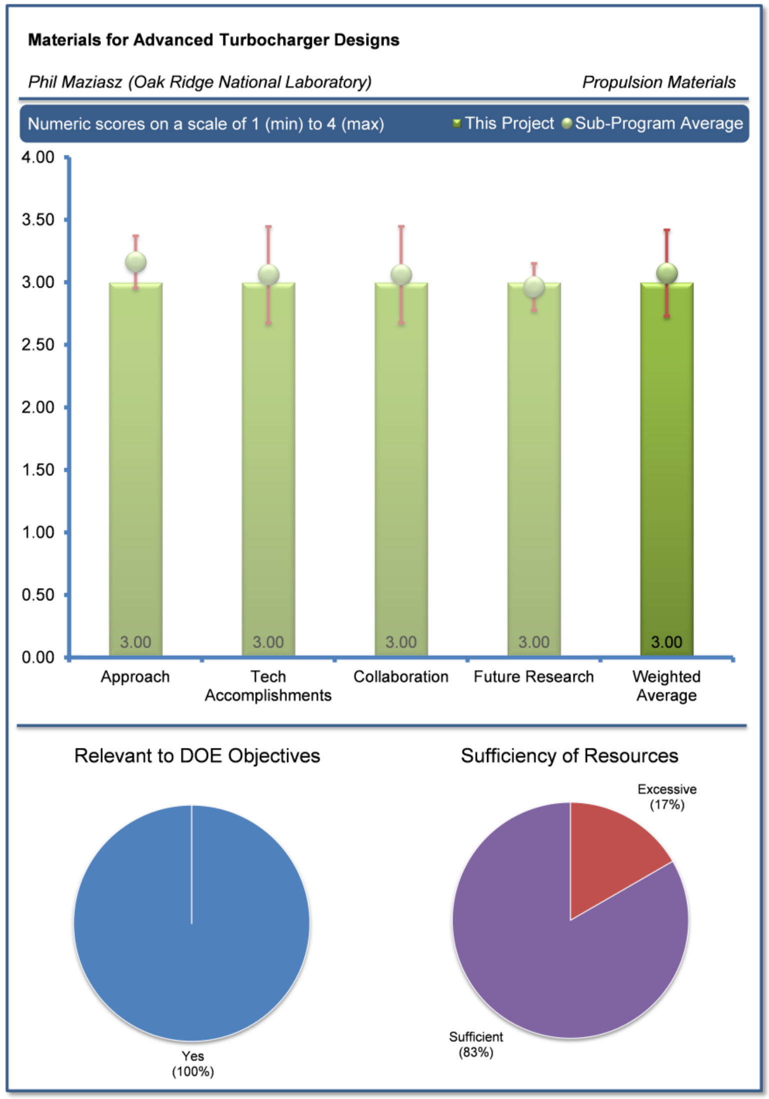
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer stated that the proposed work seemed outstanding, and that the use of low-cost MgO fillers with high thermal conductivities but lower electrical conductivities should produce very interesting results. The reviewer also noted that work was also planned to investigate the use of different epoxies that would be stable at the higher temperatures of today's electronics. Another reviewer thought that there was good proposed future work trying to address the identified challenges. The next panelist observed that the researchers will consider another generation of materials and its impact on thermal conductivity and will target getting to greater than 10 W/mk. The final reviewer hopes to see some results taking this selected material, seeing how it would be implemented, and what the benefit relative to DOE goals will be.

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

All five reviewers found resources to be sufficient. One reviewer observed sufficient resources based on proposed work, and another reviewer opined that the project seemed adequately funded. The third reviewer reported that funding for this project in FY 2012 is only $150,000, which is one of the least expensive projects funded by Propulsion Materials. This reviewer hoped the dollar value was sufficient because much of the fabrication was being done by the industry partner. The same reviewer further noted that the lab researcher had developed the models and was characterizing samples.

Materials for Advanced Turbocharger Designs: Phil Maziasz (Oak Ridge National Laboratory) – pm038



Reviewer Sample Size

This project was reviewed by six reviewers.

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

The first reviewer said that improving the powertrain efficiency will boost fuel economy and help in reducing the petroleum consumption, and that turbo chargers are used to enhance the efficiency and will therefore contribute to improved performance. The next reviewer agreed that the long term vision is increased exhaust gas for efficiency improvement of engines. The second panelist remarked that the research addresses the needs for advanced turbochargers, which are elements of higher efficiency engine designs (e.g., downsized boosted gasoline direct injection [GDI] engines), which directly displace or prevent petroleum consumption. The panelist qualified that high efficiency clean combustion places greater thermal demands on the turbochargers; therefore this is a key component of the 20% engine efficiency improvement targeted for commercial truck engines (e.g., the Supertruck program). Another observer noted this project addresses technical challenges in developing a material that can be used at higher temperatures, such as greater than 750°C diesel, or greater than 950°C gasoline, that exceed the strength and temperature capability of current materials, particularly cast-iron for turbocharger housings. This observer further commented that turbocharger housing and other components with more temperature capability and strength will enable higher, sustained operating temperatures, and that stainless steel turbo-housings will also reduce weight and retain exhaust heat relative to cast-irons. The next panel member observed that turbochargers are limited in peak temperature range and durability and this project covers technology which should be enabling for them to perform beyond the current temperature and environment limits. The final reviewer thought that the plan looked feasible in terms of material application and research.

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

Reviewers had mixed comments on the project's approach. One person remarked that the project appears to be highly successful for the application described, and that the alloy developed may have other applications for high temperature service. Another reviewer thought that the work approach discussed seemed valid, but the approach slide in the presentation did not seems to describe a clear method of steps or incremental developments to achieve the goals. The next panelist observed that the research addresses the strength and higher temperature needs for the turbocharger housing by considering new materials. This panelist suggested considering replacing cast iron housings with austenitic stainless steels, and examining residual stress between steel shafts and Nickel (Ni)-based alloy turbine wheels. A subsequent panel member relayed that ORNL and Honeywell identified two areas of focus: cast stainless steel housing, and electron-beam (EB) weld joint residual stress measurement of wheel and shaft. The final reviewer characterized the first task as measuring residual stress in a manufactured component, and the second task as creep testing of a new alloy composition; the client had identified a component for testing using this new composition. This reviewer noted that this was a good development and that the approach is good, but was unclear on how these two tasks were related and what the rationale was for combining these two tasks. The final reviewer concluded by asking whether this project is supporting one company for start-up trials.

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

The first panelist characterized the research as having completed neutron scattering examination of E-beam weld of steel shaft/Ni alloy joint, and having fabricated a turbo housing from cast stainless steel, which showed improved tensile strength and higher creep resistance at higher temperatures (permits thinner housings for the same strength). One reviewer commented that it was difficult to see what improvement was made for the CF8C-Plus cast austenitic stainless steel alloy in this project, but acknowledged that a new alloy has been developed and tested, and that possibly the industrial trials will lead into implementation of the development. This reviewer also said that during the presentation it was revealed that a larger component for another client was made using the same material. Another panel member asked how the solution options compare to current cost and weight and strength, etc. and asked if there was a comparison between the new options and present options. The final reviewer related that the accomplishments, thus far, are doing the following: addressing the concern of residual stresses in weld-joints between Ni-based alloy turbine wheels and steel shafts with neutron scattering experiments on wheel/shaft components at the HTML at ORNL; and acquiring long-term creep-rupture data that has shown that CF8C-Plus cast stainless steel has more performance than HK30-Nb stainless alloy as an upgrade for turbo-housings at 700-900°C.

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

Reviewers generally saw coordination with other institutions. The first reviewer saw close collaboration with Honeywell, and participation in the HTML user program. The next reviewer stated that the researchers worked closely with Honeywell in developing material for turbocharger components, identified an application in a Ford V-6 3.5L Ecoboost turbocharged gasoline engine used on light trucks, and utilized the HTML user program in doing residual stress measurements on joints. Another reviewer agreed that there was collaboration between Ford and ORNL. The next reviewer thought that the CRADA with Honeywell was a good vehicle for the collaboration, as Honeywell was seeking a manufacturing partner to produce castings and the technology transfer is well advanced with U.S. manufacturing base enhanced. The final reviewer thought that it was not clear from the report where commercial development is or has proceeded. This reviewer assumes that there is interest, but no specific commercial development appears to have been noted at this particular stage of the research.

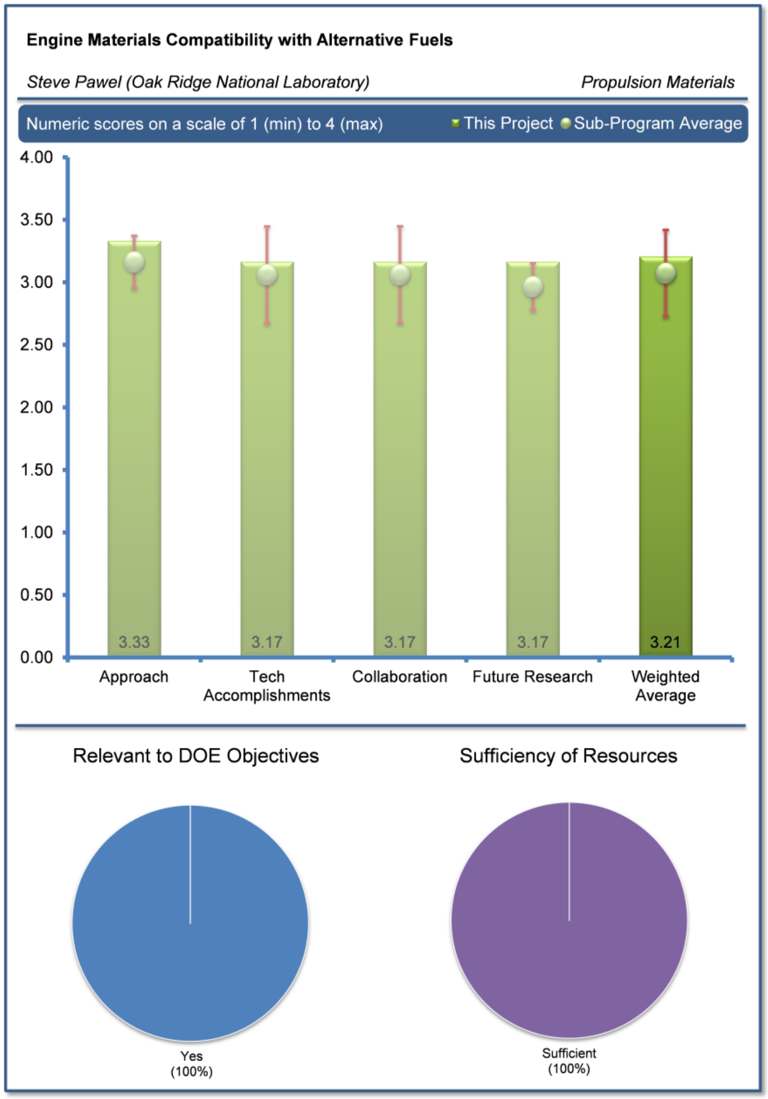
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One observer pointed out that most of the work appeared to have been completed or significantly demonstrated in actual components. Another agreed that the project had ended, but researchers were seeking an extension for the industrial trials to produce castings for further evaluation. This reviewer thought that it would be nice to see where the follow-on work might lead, and had hoped that the team had identified gaps and areas where improvements need to be made, because follow-up to this work was not presented. The next panel member relayed that researchers will continue working with Honeywell and a foundry to move this work toward production, and will consider additional materials development and testing, including oxidation and fatigue. Another reviewer would like quantification of the thermal advantage of the new housing compared to current housings, and what the new housing does to turbine out temperatures and turbine flow/pressure ratio (eff). The final observer related that Honeywell will work with a stainless steel foundry to produce turbocharger housings of CF8C-Plus steel; noted that future research will expand properties testing for turbine housing and wheel alloys to include oxidation and fatigue; and suggested studying the cast-ability of the stainless steel.

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

Five reviewers found resources to be sufficient, while one rated funds excessive. One reviewer considered the $300,000 in FY 2012 to be adequate, given that the project will be ending in September 2012. Another reviewer agreed that funding appeared to be adequate for this project. The last reviewer said that $300,000 can support more activities than just collecting creep testing and neutron scattering data, which is what the last year's work consisted of.

Engine Materials Compatibility with Alternative Fuels: Steve Pawel (Oak Ridge National Laboratory) – pm039



Reviewer Sample Size

This project was reviewed by six reviewers.

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

One reviewer thought this project clearly addresses the need for reliable alternative fuel sources over petroleum by evaluating the risk to engine durability, which is critical to the acceptance of using biofuels. Another panel member pointed out that enabling more effective and more efficient use of alternative fuels can lead to petroleum displacement, and that emphasis of ethanol based flex fuel impacts the corrosion of engine system components. The next person considered information on the use of alternate fuels with light weight engine materials to be directly useful and critical to development of durable and reliable, fuel efficient engines. A subsequent reviewer encouraged replacing petroleum products with fuels derived from bio-based materials, noting that this project is identifying potential issues that may arise due to the increased bio-fuel additives and will be an enabler for the process of petroleum replacement. The next panelist relayed that this project examines the impact of ethanol as an alternate fuel for displacement of petroleum fuels. The final panel member stated that this project utilizes laboratory exposures and forensic analysis of materials from field testing to assess aluminum corrosion rates/forms and mechanisms as a function of key fuel blend variables and alloy composition and to address a potential compatibility concern with use of alternate fuel, i.e., ethanol.

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 praised the researchers for producing excellent work and clear results. Another agreed that this was a well designed project that met task requirements and provided quantitative output. The next observer thought that there was a clear method of determining compatibility tests planned. A subsequent panel member said that for experiments, the team has used pure aluminum, which may not be a candidate material for the engines; and that the completely dry fuel mix may not be the actual environment in the engine. However, this panelist thinks that the work reveals the potential pitfalls if biofuels are used without consideration; that is, the corrosion effects will be different from that caused by current fuel blends. Another person classified the project as laboratory experiments and forensic studies of field components, with the focus on ethanol driven corrosion of aluminum components. This person also relayed that the researchers are looking for rapid protocols to study corrosion by comparing lab and field components. The final reviewer characterized the project as having an integrated approach to examine compatibility issues. The reviewer observed that task one is surface analysis of materials exposed in field and laboratory testing; task two is in-situ extraction of gas and/or fluid from operating engines; task three consists of laboratory corrosion exposures of coupon materials; and task four is development of test protocols for rapid evaluation of material/fuel combinations.

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

Most reviewers saw good progress. One reviewer thought the researchers had done excellent testing, producing usable results. This reviewer considered the work directly applicable for consideration in design of efficient engines using aluminum, in particular, as a light-weight engine component material. Another reviewer agreed that excellent progress was made by having identified the trigger to the corrosion and the mechanism that retards or delays the effect. This reviewer's only concern was that closer surface analysis was not done to the samples that did not exhibit corrosion; the 24 hour test with different water content and heat where the sample did not corrode maybe the result of the corrosion being slowed down but not eliminated, and over a significant time, say ten years, corrosion may be an issue. The next observer asked what the history of fuel for the samples shown in task one engine analysis was, and thought that the galvanic corrosion study was good information from task two. A subsequent observer related that researchers have tested various environments, i.e., ethanol content, and temperatures, and that the effect of the dry fuel on aluminum corrosion has been identified. Also, this observer stated that some possible mitigation techniques including coating had been identified. Another person commented that researchers have completed forensic analyses of field aged components, and observed that corrosion impacts can be masked or obscured by combustion products, which raised a question as to whether organics removal can be done to pre-treat samples prior to corrosion analysis. This person reported that researchers did not observe galvanic corrosion of aluminum components, but did see Aluminum 1100 corrosion increased with dry ethanol concentration in gasoline and duration of exposure. This reviewer concluded that the research showed that coatings can protect the aluminum alloys from corrosion. The final reviewer related that in collaboration with industry partners, corrosion of aluminum as a function of fuel blend exposure conditions was characterized, and that some progress was made in each specific task. The reviewer observed that for task one metallography indicates primarily pitting and some aggressive general attack; some hints that second phase is relatively resistant. For task two, sampling location #1 produced more than twice the condensate of sampling location #2 in both experiments. For task three, no galvanic corrosion of Al observed, Aluminum 1100 exhibited corrosion rates that increased with dry ethanol concentration, and modified surface film on aluminum alloys impacted corrosion susceptibility. Finally, this reviewer noted that for task four, electrochemical testing is not appropriate.

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

Reviewers saw collaboration with industry. One person noted that collaboration was sufficient as needed for the project. Another reviewer agreed, stating that all the major U.S. players were at the table. A subsequent reviewer elaborated that this was a CRADA project between ORNL and United States Council for Automotive Research (USCAR) that includes GM, Ford, and Chrysler. The following panelist observed that the project was a partnership with USCAR under a CRADA activity, and another reviewer stated that collaboration with industry partners exists. The final reviewer stated that the researchers have a collaboration agreement with the USCAR, and that the automakers have provided access to some engine testing and obtained combustion products from engine chambers. However, this reviewer notes that no other interactions have been documented.

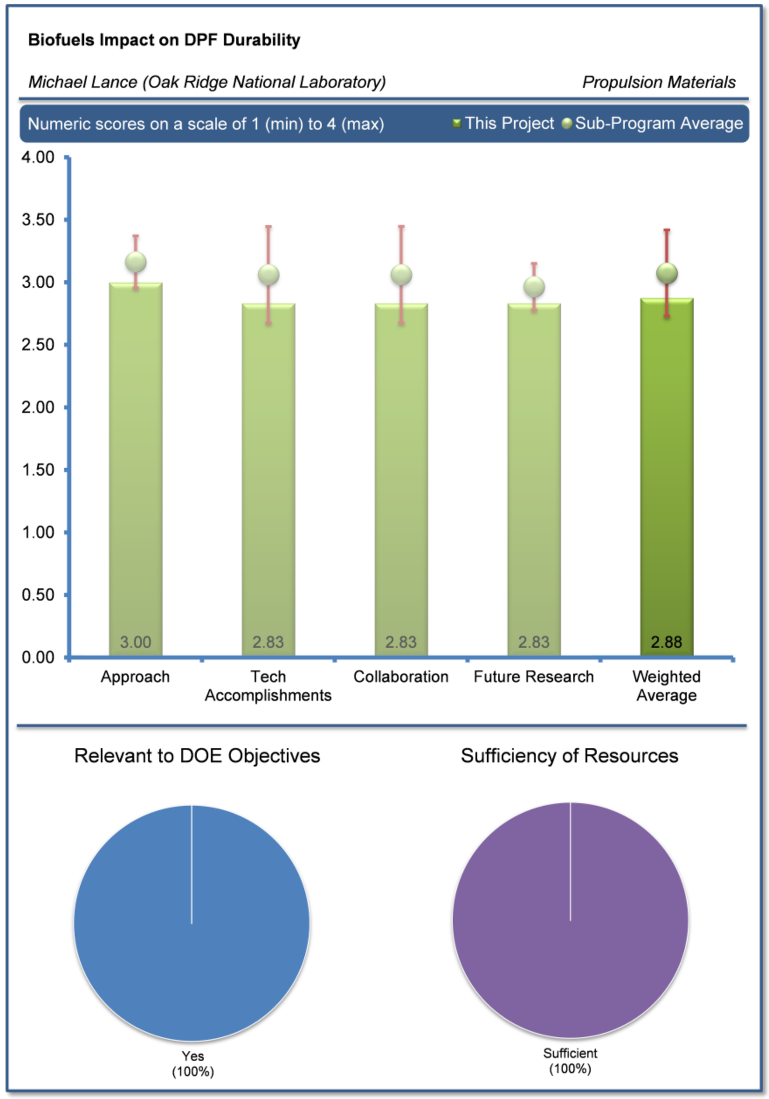
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers had mixed feedback on future research strategies. One reviewer pointed out that the project is wrapping up, but a follow-up plan has been formulated to explore characterization and mitigation. Another reviewer suggested that the team should focus on actual fuel blends and well simulated environments close to actual systems. Also, this reviewer suggested that a comparison should be made to what is being done in other jurisdictions such as Brazil, Europe and Canada, where biofuel is actively promoted. A subsequent reviewer thought that the proposed work to investigate possible fuel additives to mitigate damage from alternative fuel blends could be of benefit to the industry as a whole, and if it could be accomplished, would be of great importance. This reviewer pointed out that the development of coatings is also desirable, but from an engineering point of view, coatings always will hold greater risk due to the inevitable presence of defects or "holidays" in coatings. This reviewer finally suggested that alloy development is desirable, but may be a much longer term approach that may or may not be successful. Another reviewer suggests that researchers continue laboratory testing to expand blend variables, and to continue exploring various mitigation strategies, including fuel additives that would suppress corrosion reaction, surface modification strategies to protect underlying aluminum, and alloy development. This panel member stated that future work may consider surface treatment of aluminum alloys to minimize corrosion. The final observer thought that broadening the scope of this project may help address some of the following concerns: Ethanol is becoming one of the working fluid choices for Rankine Cycle waste heat recovery; and temperatures exceeding 300°C are possible, which could limit the cost effective use of aluminum for condenser, expander and fluid conveyance hardware.

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

Six reviewers rated resources to be sufficient. One reviewer noted that the funding level was $270,000 for FY 2012 and the project is expect to be completed in December 2012. Another reviewer agreed that funding seems to have been adequate. The last commenter thought that if some of the future goals of this project could be achieved, it would be of benefit in enabling the comfortable use of aluminum in products using alternative fuels. This commenter also said the project instead appears to be winding to a close, and that more work would be worth the effort if funds were available.

Biofuels Impact on DPF Durability: Michael Lance (Oak Ridge National Laboratory) – pm040



Reviewer Sample Size

This project was reviewed by six reviewers.

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

One panel member deduced that this project seeks to bolster the DOE petroleum displacement goals through improved biofuel adoption. Another reviewer remarked that, to the extent that biodiesel can supplement or replace ultra-low sulfur diesel (ULSD) petroleum-based diesel fuel, this project supports the overall DOE objective of petroleum displacement. The next panelist agreed that biofuels are considered a key option for reducing use of petroleum products and understanding the effects that biofuels may have on various parts of the engine system, including the diesel particulate filters, is important. This panelist pointed out that early understanding of what damage biofuels may do and how to prevent such damage is critical to industry and to the commercial use of biofuels. The panel member further reported that industry has already experienced warranty issues and problems with biofuels that were not expected and required unexpected research and product changes to avoid and fix, and that this research may be considered part of that work needed to understand what may happen, to avoid problems. The next reviewer stated that biofuel or alternative fuel impact on aftertreatment is not fully understood, and understanding of the impact of biofuel quantification is key to improvements. Another observer commented that there was inadequate data on the effects of fuel properties, and that the knowledge base was inadequate for determining the effect of fuel properties on the deterioration rates and durability of engine fuel system and emission control system devices and components. This observer asked if biodiesel would negatively impact DPF performance, and if this project is to characterize changes in the microstructure and material properties of DPFs in exhaust gas produced by biodiesel blends.

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 comments on the approach. One commenter thought that the approach to addressing adoption of biofuels with current DPF systems is well addressed in the review. Another observer found the approach to be logical and well laid out to address the technical barriers, and added that addressing the apparent degradation of a stored DPF first enabled the team to ascertain that the problem did not lie in the DPF material itself but rather in the binder used to hold the ceramic together. The next reviewer remarked that it would have been ideal to repeat the failure with an uncoated DPF. This reviewer inquired if, for example, there may be pre- or post- storage conditions such as temperature and humidity conditions that increase or decrease the risk of long term failure while exposed. This reviewer noted that root cause analysis was not done. A following observer said that the presentation did not make clear if catalyst accelerated aging testing was performed under conditions that entirely duplicate field service conditions to the greatest extent possible. This observer found that, in particular, for durability testing at low, medium and high temperatures with cycling between temperatures, the low temperature testing at 200°C would appear to be too hot for significant exhaust gas (water) condensation to have occurred. The observer added that it depends on where the temperature was measured, and where the sampling location is for sampling exhaust gas condensate, as to whether the DPF filters had experienced the type of heavier water condensation that occurs on initial engine start up. This observer thought the presentation provided some acknowledgement that liquid-form water condensate is damaging, but was not clear whether there was testing performed to verify whether the problem was overcome, or if researchers had allowed that condensation to occur as part of the durability cycle. In addition, the observer noted that the component surfaces must be cool enough for surface condensation to occur; bulk gas temperatures are not necessarily reflective of this. A final reviewer reported two approaches were taken by working with the National Renewable Energy Laboratory (NREL) and Ford, including Low-Temperature Corrosion, and Thermal Aging and Ash Accumulation.

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

One reviewer thought that good basic information was gathered that was helpful toward goals. Another agreed, saying that the progress in meeting technical milestones has been good, as has progress in developing a good database for use by the OEM's and DPF manufacturers. This reviewer commented that this project is quite appropriate for Federal support because there is as of yet not quite a well-established biodiesel fuel production industry. The next panelist asked how analysis of DPF failures will be performed, if the researchers could or would ensure that the test generator would have representative emission constituents compared to normal applications, and if the researchers would compare generator emissions to a standard accepted test to ensure that they are representative. A final observer reported that low temperature corrosion was likely caused by biodiesel attack of the polymeric binder holding the skin together; that finite element based approach whereby mechanical properties are determined by iteratively comparing experiment results with finite element analysis (FEA) properties was established; and that long-term low-cost testing of materials in real diesel engine exhaust was established at NTRC.

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

Reviewers had mixed responses about collaboration. One reviewer thought that the project exhibited good collaboration. A second reviewer commented that more than one partner was positive. The next panelist observed that there was excellent collaboration between NREL, Manufacturers of Emission Controls Association (MECA), National Biodiesel Board (NBB), and Corning. The next observer stated that collaboration to date had been only fair but it appears that with the addition of NREL, Ford and other collaborators, collaboration and coordination is improving. The final reviewer reported that the projects collaboration has transitioned to new partners. This reviewer inquired about how involved these partners are and what support they offered, and would like to know the reason GM discontinued its collaboration in this effort.

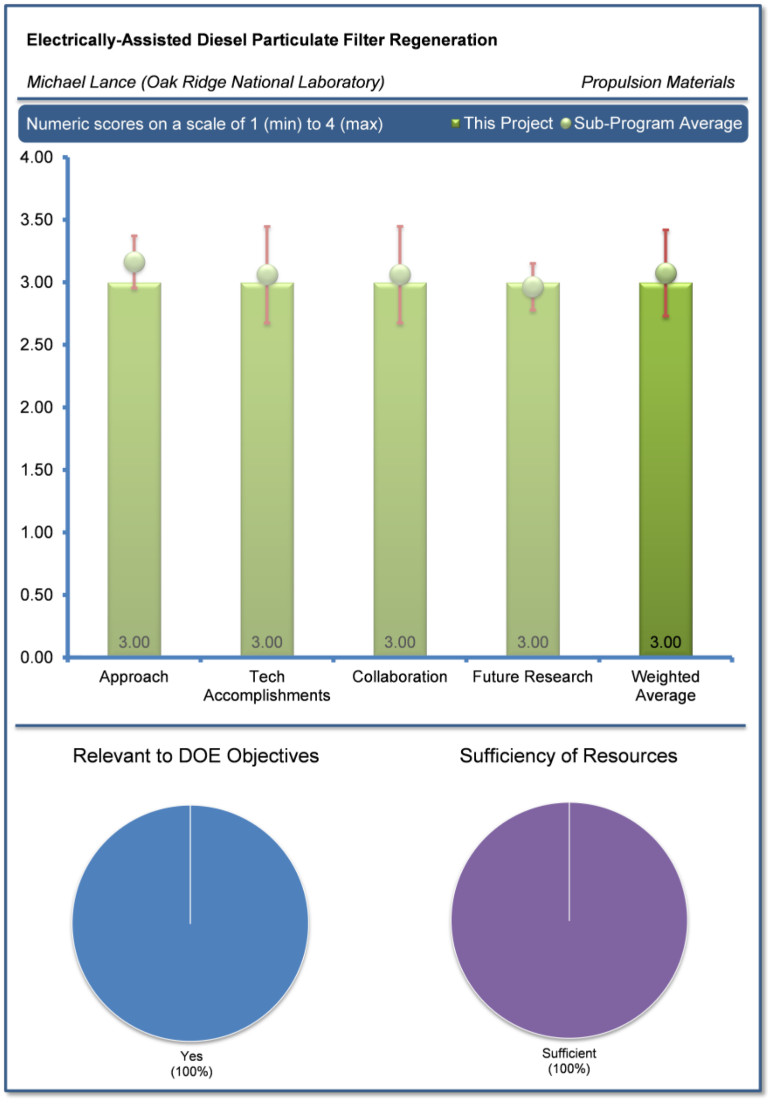
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One panelist thought that the approach for future work was good, as it built upon past progress and should see rapid progress now that all of the tools for carrying out the work are in place. This panelist hoped that the addition of other collaborators would accelerate results. Another reviewer felt that a study on lube oil and coolant contributions could be key for the next step study. The next observer pointed out that while the review offered a rudimentary outline of future work, no milestones were offered and the potential for strategic redirection, if any, from new partners was not addressed. Another reviewer suggested that the investigator may wish to also consider the possibility of investigating the effects of increased level of metallic corrosion deposits from upstream air handling systems, in addition to the changes in deposits solely from the biofuels themselves, if it is believed that the biodiesel fuels may effectively be more corrosive than straight fuel. A final panel member related that a generator set will be used to conduct accelerated biodiesel aging in order to determine the effect of metal additives on DPF material properties. The final reviewer also recommended considering engine testing at low load conditions.

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

All six reviewers found resources to be sufficient. One reviewer considered $300,000 in FY 2012 to be adequate, while another agreed that resources appear to be adequate to maintain the current rate of progress of the work. Another reviewer remarked that no cost share was described in the presentation.

Electrically-Assisted Diesel Particulate Filter Regeneration: Michael Lance (Oak Ridge National Laboratory) – pm041



Reviewer Sample Size

This project was reviewed by five reviewers.

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

One reviewer commented that fuel efficiency improvement is a clear interest in this project, and as such is well aligned with DOE's petroleum displacement goals. Another observer commented that this is a creative example of how energy may be shifted and utilized within the engine system more efficiently to get the desired effects of greater fuel efficiency and improved emissions. The next panelist stated that reduction in fuel consumption during regeneration is relevant. A subsequent reviewer remarked that injecting fuel to burn off accumulated soot from the DPF is one source of fuel economy penalty imposed on diesel engines by environmental emissions requirements, and that any approach which reduces or eliminates this extra fuel consumption will enhance the fuel economy advantage of diesel engines versus conventional gasoline engines. The final panel member reported that the goal of the project is to improve the technologies and strategies for PM filters to achieve reliable regeneration at low exhaust temperatures, and to reduce fuel economy penalty.

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 panel member thought the project had an excellent approach to evaluating the system. Another found that the work was providing very basic information to the participants on catalyst filters, and this information is essential for technical development. A subsequent observer saw good thermal and material analysis, but asked how this information could be used to reduce cost or weight of the DPF with new knowledge of failure modes. This observer further asked how the researchers quantified the cost of electricity, speculating that it must come from fuel, and asked what the cost and weight of the system was. Another panelist observed that three tasks were taken to evaluate the efficiency of the device developed by GM. This observer indicated that task one was Efficiency and Temperature Measurement; task two was DPF Mechanical Properties Measurement; and task three was Heater Alloy Selection. The final reviewer commented that the approach to performing the work is quite sophisticated and takes advantage of the Federal investment in ceramic technology research and development (R&D) over the past 20-30 years at ORNL. This reviewer also though that it was not clear that Federal involvement was really necessary to carry out this work. The reviewer concluded by asking if a ceramic manufacturer, e.g., Corning, could have done this work under a GM subcontract.

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

One reviewer thought that technical progress has been excellent, and appeared to affirm that the goals of the project are being achieved. This reviewer found cost-effectiveness of the approach remains to be demonstrated, however, and that resides in the commercial sector with GM. Another panelist felt there was good technical progress, but that progress should be tied to the consumer regarding true cost and feature benefit. The next panel member observed that the review presented a complete summary of the results in comparing an electrically-assisted DPF to a conventional DPF. The final observer characterized the project as having demonstrated an Electrically-Assisted Diesel Particulate Filter (EADPF) on a GM 1.9-liter engine at ORNL; having demonstrated fiber optic-based temperature measurement on bench scale in preparation for engine-based experiments; and having results consistently showing elastic modulus of DPF cordierite is lower than reported sonic-based-measured literature values while tensile failure stresses are equivalent.

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

One reviewer commented that since this work is a CRADA between ORNL and GM, collaboration and coordination has been good. Another thought that working directly with system designer would enable high project success. The next panelist pointed out the researchers had worked with GM at a 50/50 cost share. The final commenter felt that some of the basic results, e.g., modulus, would not be surprising if greater collaboration had occurred prior to work, or if individuals familiar with the composite/fibrous type structure were involved ahead in the measurement and modeling; however, the information gathered from testing should be useful.

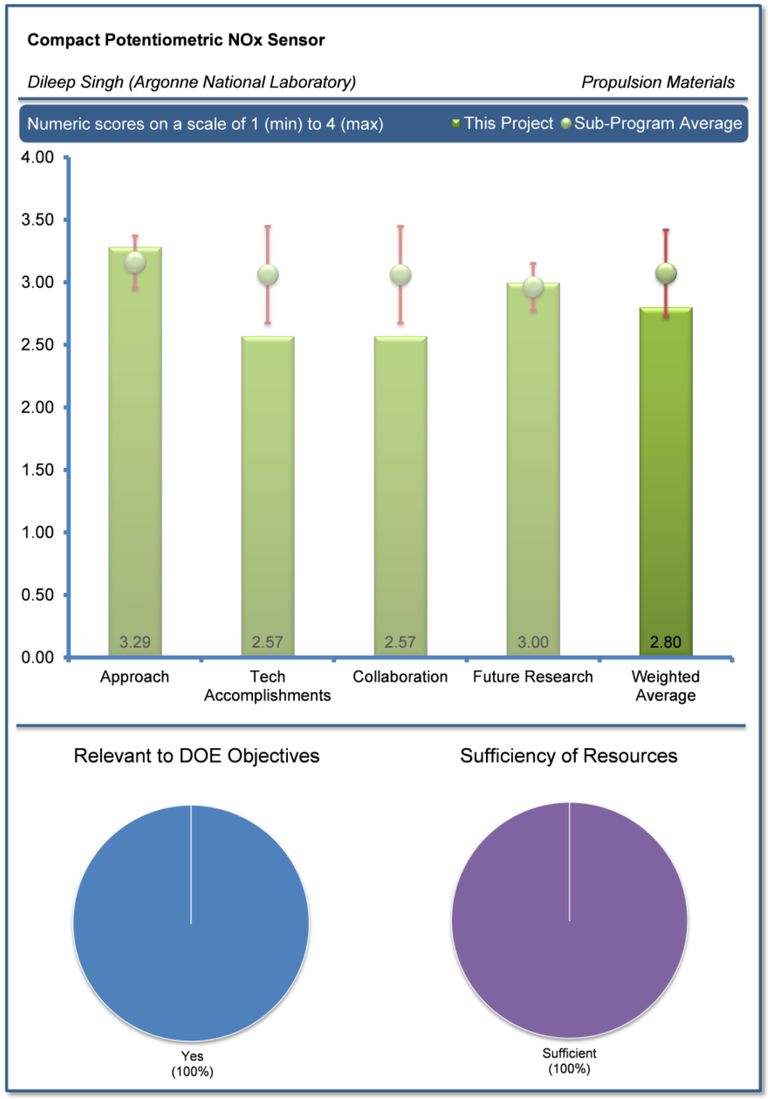
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The first reviewer commented that there was no future work planned, but said that presenting the thermal and structural analysis in more detail would be good. Another panel member stated that there does not appear to be significant work planned ahead on this project, as it is nearly completed. The third panelist thought that progress has been excellent such that this project appears to be successful and complete, and remarked that future work to establish cost-effectiveness of the approach is up to the commercial partner, GM. The final observer observed that task one completed measurements of DPF substrate temperature and task two developed rules of design for the heater and described test methods for standardization. The final observer commented that the researchers should also consider the cost of additional electricity needed to run the device.

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

The five reviewers found resources to be sufficient. One thought that because progress on the work toward achieving the stated objectives has been on target, the resources appear to have been sufficient. Another reviewer pointed out that the project has an excellent cost share arrangement, and the next reviewer relayed that the project has $250,000 in funding to be completed in September.

Compact Potentiometric NOx Sensor: Dileep Singh (Argonne National Laboratory) – pm043



Reviewer Sample Size

This project was reviewed by seven reviewers.

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

Reviewers generally found that the project supports DOE's objectives. One reviewer commented that this project absolutely supports the DOE objectives of petroleum displacement because emissions and fuel efficiency depend so highly on the sensors which are used for engine operations. This reviewer remarked that without them and without the information they provide, modern efficient engines would not be able to operate. Another panelist agreed that low cost high temperature sensors would enable more efficient and clean combustion processes, thereby reducing petroleum consumption. The next panel member concluded that this project does indeed support the objective of reducing petroleum consumption. This panel member stated that it is well known that diesel engines are more efficient than gasoline engines, but noted that their emissions, especially NO_x, have traditionally been higher than gasoline engines. This panel member further related that to combat high NO_x emission levels, engines were de-tuned to minimize NO_x, and with the development of NO_x treatment strategies, measurement and control, engines can now be tuned for maximum efficiency. The panel member therefore concluded that development of low-cost, rapid response NO_x sensors is an enabling technology that will help optimize the efficiency of HD engines used on trucks and will encourage the American public to purchase a larger fraction of more efficient diesel engines. However, this panel member observed that with the cost of diesel fuel being higher than gasoline, people will not flock to diesel engines. A following reviewer remarked that accurate, durable, and responsive exhaust gas composition sensors are key enablers to long-term compliance with vehicle emissions standards with minimal fuel economy penalty. This reviewer felt that the ability to combine sensing functions in a single sensor, oxygen and NO_x in this case, is a clear cost advantage in mass production. The subsequent observer remarked that more advanced sensors are truly needed in the Heavy Duty Vehicle industry, and that proving that such a sensor can function is critical; and that this work has demonstrated that such a sensor is feasible. This observer noted that the study would have been more complete if there was some description of the team's confidence that the sensor could be mass produced, and confidence that the sensor could continue to meet the application requirements. The observer also noted that petroleum displacement was not described in the briefing; the final report would do well to offers such description. Another panel member reported that the goal of the project was to address the need for a compact, reliable, robust, inexpensive bi-functional sensor technology that is amenable for mass production. The final reviewer relayed the project was focused on the ability to improve engine control and reduce cost through improvements in sensors and industrialization.

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 project appeared to be well laid out, planned and executed, and from the presentation it appeared to have been flawless. Another reviewer agreed that the project employed a good method of approach and clear high level objectives. The next panel member thought that the approach was able to demonstrate that the objectives were satisfied. Another panelist believed that the approach for performing this work has been good. This panelist said that over the years, the researchers have been able to resolve all of the materials and sensing issues that have come up and have produced a sensor that performs well in the laboratory environment. The panelist was concerned, however, that no engine testing has been performed to verify that the sensors are robust and durable enough to function accurately for 10 years or 150,000 miles. A subsequent panelist related that the approach for NO_x sensing was to develop a compact sensor with an internal reference, and suggested considering joining technology, electrode and sensing materials. This panelist relayed that sensor design was based on electrochemical materials. The final panel member commented that sensor design was based on relatively simple and well-known electrochemical principles, by employing a closed end device made from oxygen ion conducting partially stabilized zirconia ceramic (YSZ). This panel member further said that researchers used appropriate filters and sensing materials, modified the oxygen sensor such that NO_x concentrations are measured, and conducted extensive tests to validate the performance of the sensor.

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

Reviewers had mixed responses regarding technical progress. The first panel member thought that the technical accomplishments in this project have been outstanding, as evidenced by multiple patents and what appears to be lots of interest from companies to license and commercialize the sensors. Another reviewer commented that the project appears to have developed and proceeded successfully so far, and is ready for the current stage, which is finding commercial partners. Another panel member agreed that the review indicated some interest from industry, implying that this technology could satisfy a technical need. This panel member pointed out that the objectives did not describe the path to manufacturing, and the review did not comment on it either. The panel member also found that although there was interest, the review did not describe if there are defined manufacturing techniques that could bring the product to market. The panel member hoped that despite a lack of cost objective, that the final report on this project would offer some insight into a notional cost comparison between this solution and the current technology. This panel member concluded that if the current solution is more costly, market commercialization advantages should be addressed. The next reviewer noted that interest in licensing agreements expressed by three manufacturers of emissions controls suggested the significance of project accomplishments, which have been diverse, touching upon sensor performance, fabrication techniques and materials optimization. A subsequent observer wrote that the sensor materials and packaging were developed and demonstrated in previous years, and that the technologies developed have been patented. This observer saw that during the project, the sensor test apparatus was developed, sensitivity was demonstrated, and the project developed alternate (low cost) electrode material. However, this observer commented that it was unclear if the technologies were commercialize-able or could move to mass production. Another reviewer relayed that the researchers had built a sensor to measure oxygen and NO_x, and had run into barriers including durability of solution. This reviewer would like to know about the status of a plan for determining the durability of a solution, and thought the presentation did not make clear if the addition of Al to the ceramic catalyst was the solution to the defined thermal cycling robustness issue. The reviewer questioned how NO_x sensor development would improve efficiency, as sensors are currently on the market and are functioning in reasonable fashion in closed loop control of both engine out emissions and aftertreatment systems. This reviewer would like to see an approach and mechanism that would truly impact the DOE goals. The final reviewer characterized developments as having joined advanced materials by plastic deformation; creating a high temperature sensor with internal reference; achieving good sensor sensitivity to NO_x; having replaced platinum (Pt) with other electrode material (LSAM); having joined LSAM to yttria-stabilized polycrystalline tetragonal zirconia (YTZP); having been awarded an R&D 100 Award; and having several patents issued.

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

Reviewers had mixed input regarding the amount of collaboration. One reviewer noted that the collaboration appeared to be appropriate to the development, considering patentability issues. Another reviewer observed growing use of university for research and industry partnership. The next panel member reported that the project was working to establish commercial connections to migrate the technology toward commercialization, and noted the involvement with Ohio State University. A subsequent panelist said that collaboration only appeared to be with two Ph.D. students from Ohio State University, and that the General Electric collaboration was not well described in the presentation, as the charts only defined the interaction as being a supplier of O_2 sensor. This panelist thought that having an OEM or tier supplier would have offered more requirements driving guidance to ensure compliance with market needs. The following reviewer felt that project collaboration did not seem especially broad, and that the presentation did not make clear what the nature and extent of that collaboration was. This reviewer reported that three of the five collaborating institutions named were manufacturers potentially interested in licensing the technology, but that it was not clear that they collaborated in its development in any significant way. The reviewer found that the other two collaborators' roles were not described in sufficient detail to allow an assessment of how close or appropriate their collaboration was. The next observer relayed that the only collaboration that has taken place during the development phase of this project was with Ohio State. This observer has found that licensing and commercialization of a technology is much more difficult and time consuming that one anticipates, and therefore does not believe that waiting until the final year of a project to focus on licensing is the best strategy. The observer recommended in the future identifying industry partners early on to give them a chance to guide the research and to thoroughly buy into the technology well in advance of commercialization. The final panel member listed the collaborators as Ohio State University, General Electric, Marathon Sensors, Integrated Fuel Technology, and Howell International, which has shown interest.

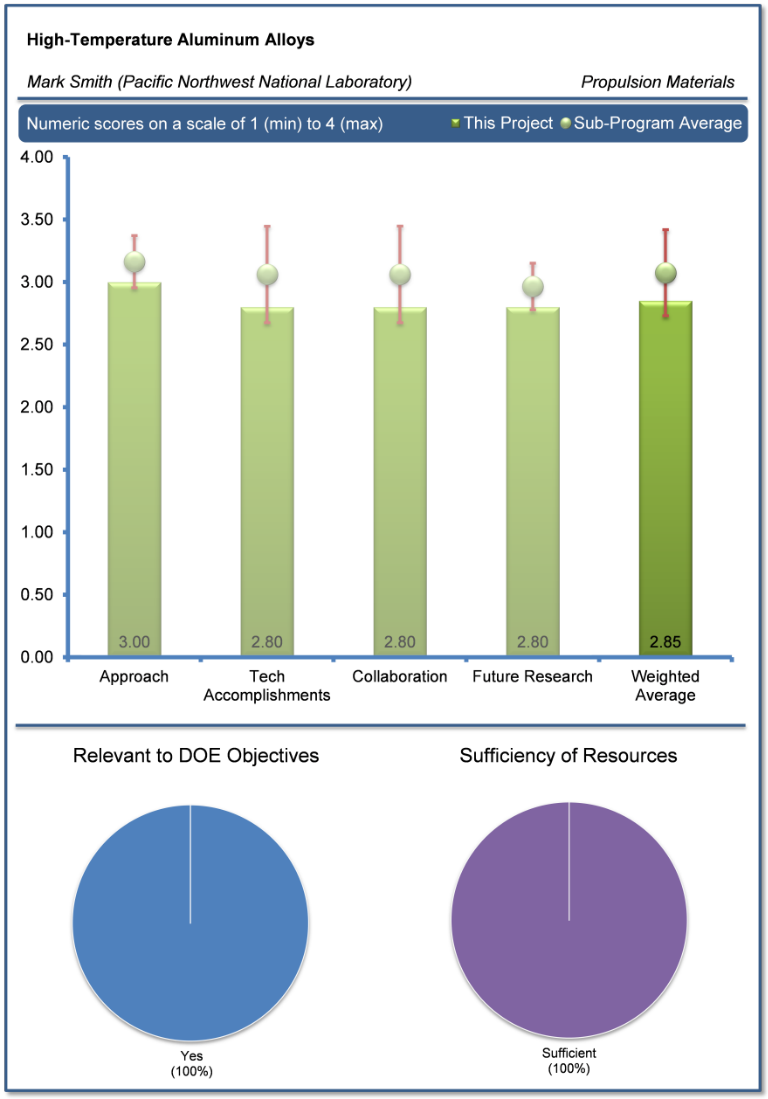
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Some reviewers noted that future work involves commercialization. One reviewer stated that FY 2012 is the final year of this project and all the research has been completed. Therefore, the only future work is trying to license the technology for commercialization. Another reviewer commented that with the project 95% complete, future work appears to be limited to exploring the possibility of licensing the developed technology for commercial production. This reviewer commented that this is a commendable and logical concluding step, but whether partnerships with licensees are necessary for demonstration of the technology is not clear. Demonstration could be left to licensees upon transfer of the technology to them. The next panelist remarked that although the project is complete, to capitalize on the work accomplished, the technology needs to be commercialized. A subsequent panel member thought that the project needed to do engine tests to demonstrate the performance of the sensor in real applications. Another observer related that future work involved defining a test plan for analysis and durability in industrial applications. The final reviewer thought that the proposed future work to bring commercial partners appears timely and according to a well laid-out plan.

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

Six reviewers rated the resources sufficient, while one found resources excessive. One reviewer believed that this appeared to be a significant project for a university, considering the project needed to spend so much in a short time. However, the results were excellent and timely and the findings in the project are critical to our nation’s ability to develop and maintain global competitiveness. The next panelist reported that there was $60,000 for FY 2012 to finish the project, and another panel member commented that funding appears to have been adequate. A subsequent reviewer noted that this project was allocated only $60,000 this FY, and noted that while this is a very small number, there was no technical research being performed, only technology transfer and licensing. Another observer indicated that DOE funds were being used for Business Development, which does not appear to be a project objective. The final reviewer explained that the FY 2012 funding of $60,000 may not be necessary to achieve remaining project goals. This reviewer referred back to whether partnerships were necessary for demonstration of the technology, or if demonstration could be left to licensees upon transfer of the technology to them.

High-Temperature Aluminum Alloys: Mark Smith (Pacific Northwest National Laboratory) – pm044



Reviewer Sample Size

This project was reviewed by five reviewers.

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

One reviewer stated that increasing the operating temperature of IC engines will improve the fuel efficiency, and that many efforts are being made to develop cost effective materials for engine applications; this project is one of them. This reviewer noted that if the materials' high temperature capability can be enhanced without increasing the cost significantly, then the engines could operate at higher temperatures consuming less fuel for the same power output. Another observer saw weight reduction as the most basic, straightforward and efficacious approach to improving vehicle fuel economy. This reviewer considered the application of aluminum to drivetrains, chassis, etc. in substitution for steel has long been a proven step toward reducing vehicle weight. The reviewer found that development of aluminum alloys with higher temperature tolerance was an obvious approach to broadening the range of vehicle applications of this lightweight family of alloys, particularly as HD engine technology development proceeds in the direction of higher brake mean effective pressures (BMEPs) and temperatures. The next observer commented that this project was to develop aluminum alloys with better mechanical properties at temperatures above 300°C, which this observer believed to be extremely important and very relevant to the DOE objectives of petroleum reduction. The observer pointed out that operating temperature continues to rise in light-duty and heavy-duty engines, and that the conventional aluminum alloys have reached their upper temperature limit. This observer remarked that the development of an improved Al alloy that can be used in both LD and HD engines would enable more Al to be used in engines and reduce their weight and increase the fuel efficiency. A subsequent reviewer found the project had a good approach in terms of processing technique. The final reviewer acknowledged the importance of high temperature aluminum alloys, but would like to know what DOE barriers were addressed and how the barriers tie to 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?

One reviewer believed that the approach identified by the researchers at PNNL is outstanding, emphasizing that the plan is to evaluate candidate Al alloys using cost-effective rapid solidification methods. This reviewer praised the researchers for recognizing that the mechanical properties need to exceed those of the traditional Al alloys used today and those properties must be retained throughout the entire process of consolidation and forming. Finally, the reviewer was glad that the investigators also recognized that the cost of the Al alloys are very important, and for comparing the cost and performance with the best Al alloys available today. Another panelist pointed out that aluminum-iron alloys have been tested in the past and this project is aimed to develop an alternate production route. However, it was not clear to this panelist whether all the barriers for the manufacturing have been addressed; specifically, the panelist questioned whether the rapid solidification route can reduce the segregation of iron the melting process carried out to obtain the liquid metal was the optimum process. The final observer thought that the task plan was well defined, but was unsure again what barriers are addressed and how barrier reduction will be ensured.

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

One panelist thought that the researchers had made excellent progress while working on four different Al alloy compositions, i.e., Al-8Fe, Al-12Fe, University of Connecticut, and AFM, and had also made some very good progress on the extrusion of rods and billets made from these materials. However, the microstructures are not sufficiently uniform. This panelist was very impressed with the work achieved in less than a year's time. Another reviewer felt that the generation of aluminum flakes and matrix of compositions showed progress, but wondered if any compositions were new to this project or if all were pre-existing. The last reviewer relayed that the structure of the rapidly solidified powder and the consolidated metal were analyzed; however, complete mixture of iron particles had not yet been confirmed. Also, this reviewer observed from the presentation that some areas were iron free and no explanation could be provided for the discrepancy.

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

Reviewers observed collaboration with other institutions. One observer stated the project identified collaboration with a processing company. Another panelist thought that collaboration with an established processor of RS alloys (Transmet) is a plus. The next panel member felt that involvement from a user (Cummins) and a commercial metal powder producer (Transmet) was good and could result in the development of a viable process, and that the involvement of a material producer (Kaiser Aluminum) made the partnership complete. The final reviewer agreed that the researchers have put together a very good team to investigate higher temperature and stronger Al alloys for HD applications. This reviewer thought that the folks from Cummins would be able to give the researchers the guidance they need as far as the operating temperatures and mechanical properties, and that fellow team member Transmet Corporation, who has a commercial melt spinning operation, may be able to process materials for Cummins. This reviewer felt it was not clear from the presentation whether Kaiser Aluminum was on the team or not as they were not mentioned on the overview slide at the beginning of their presentation, but were mentioned at the end.

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 panel member thought that the future work described in the list of FY 2012 milestones is very good and will build on all the work accomplished prior to the annual merit review. This panel member reported that it appears the investigators have a lot of work planned for FY 2012, including significant interaction with Cummins. Another panelist thought that the project exhibited good tracking of tasks past and future, insuring that DOE technical barriers are addressed. The next reviewer suggested that attention should be focused on identifying and correcting the anisotropy of the compacted and extruded rod samples. The final reviewer commented that the investigator should look at the distribution of iron in the aluminum matrix, and that the final content of the iron in the matrix need to be analyzed. This reviewer stated that adding iron to aluminum is quite difficult and beyond certain limits iron will precipitate from the melt, and therefore this process needs to be closely monitored.

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

Four reviewers found resources to be sufficient. One reviewer stated that the funding for FY 2012 will be $395,000, one of the larger amounts for all the Propulsion Materials projects, and therefore sufficient for the project.

Section Acronyms

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

Acronym	Definition
2D	Two Dimensional
AC	Alternating Current
AFM	Alumina, ferric oxide, monosulfate phase
Al-12Fe	High-temperature Aluminum Alloy Composition
Al-8Fe	High-temperature Aluminum Alloy Composition
Al	Aluminum
AlN	Aluminum Nitride
Au	Gold
BMEP	Brake Mean Effective Pressure
C	Degrees Celsius
CF8C-Plus	A type of cast austinitic stainless steel
CI	Compression Ignition
CRADA	Cooperative Research and Development Agreement
Cu	Copper
DBA	Direct Bonded Aluminum
DBC	Direct Bonded Copper
DC	Direct Current
DOE	Department of Energy
DPF	Diesel Particulate Filter
EADPF	Electrically-Assisted Diesel Particulate Filter
EATS	Exhaust Aftertreatment System
EB	Electron Beam
EGR	Exhaust Gas Recirculation
EMC	Epoxy Molding Compounds
FEA	Finite Element Analysis
FSW	Friction Stir Welding
FY	Fiscal Year
GDI	Gasoline Direct Injection
GM	General Motors Corporation
HK30-Nb	A type of stainless steel alloy
HD	Heavy-Duty
HTML	High Temperature Materials Laboratory
IC	Internal Combustion
IEA	International Energy Agency
LD	Light-Duty
LLNL	Lawrence Livermore National Laboratory
LSAM	Lanthanum-aluminate based oxides
LSM	Lanthanum Strontium Manganite

MECA	Manufacturers of Emissions Control Association
MgO	Magnesium oxide or Magnesia
NBB	National Biodiesel Board
NIST	National Institute of Standards and Technology
Ni	Nickel
NO	Nitric Oxide
NOx	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
NREL	National Renewable Energy Laboratory
NTRC	National Transportation Research Center
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PAH	Polycyclic Aromatic Hydrocarbon
PbSe	Lead selenide or lead(II) selenide
PED	Power Electronic Device
PI	Principal Investigator
PM	Particulate Matter
PNNL	Pacific Northwest National Laboratory
ppm	Parts per million
PSD	Particle Size Distribution
Pt	Platinum
R&D	Research and Development
RPM	Revolutions Per Minute
Si3N4	Silicon nitride
SiC	Silicon Carbide
TEG	Thermoelectric Generator
ULSD	Ultra-Low Sulfur Diesel
USCAR	United States Council for Automotive Research
VTP	Vehicle Technologies Program
YSZ	Yttria-Stabilized Zirconia
YTZP	Yttria-stabilized Polycrystalline Tetragonal Zirconia

THIS PAGE INTENTIONALLY LEFT BLANK