7. MATERIALS TECHNOLOGIES: PROPULSION MATERIALS

Advanced materials, including metals, polymers, composites, and intermetallic compounds, can play an important role in improving the efficiency of transportation engines and vehicles. Weight reduction is one of the most effective ways to increase the fuel economy of vehicles while reducing exhaust emissions. The development of propulsion materials and enabling technologies will help reduce costs while improving the durability, efficiency, and performance of advanced internal combustion, diesel, hybrid, and fuel-cell-powered vehicles. The advanced materials research conducted under the direction of the U.S. Department of Energy and the Vehicle Technologies Program will help ensure the nation's transportation energy and environmental future by making affordable full-function cars and trucks that use less oil and produce fewer harmful emissions.

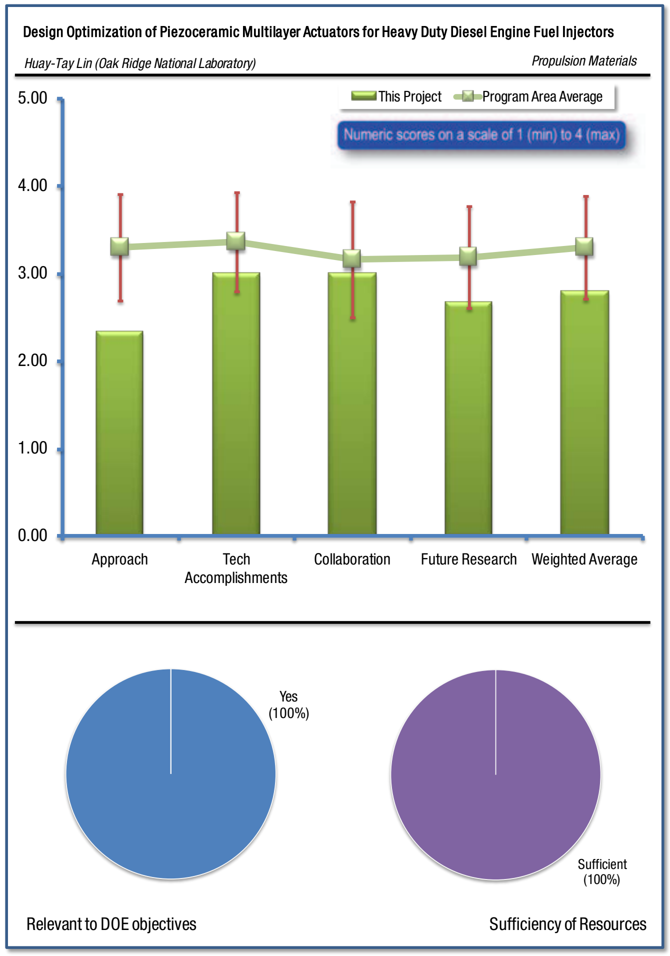
In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses *(on a scale of 1 to 4)*. In the pages that follow, the reviewer responses to each question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

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Design Optimization of Piezoceramic Multilayer Actuators for Heavy Duty Diesel Engine Fuel Injectors	Huay-Tay Lin (Oak Ridge National Laboratory)	7-3	2.33	3.00	3.00	2.67	2.79
Fatigue Enhancements by Shock Peening	Curt Lavender (Pacific Northwest National Laboratory)	7-5	3.33	3.33	3.33	3.67	3.38
Fuel Injector Holes (Fabrication of Micro-Orifices for Fuel Injectors)	George Fenske (Argonne National Laboratory)	7-7	4.00	4.00	3.67	3.33	3.88
Tailored Materials for Advanced CIDI Engines	Glenn Grant (Pacific Northwest National Laboratory)	7-9	3.00	3.67	3.00	3.67	3.42
NOx Sensor Development	Robert Glass (Lawrence Livermore National Laboratory)	7-11	3.33	3.00	3.33	3.67	3.21
Low Cost Titanium – Propulsion Applications	Curt Lavender (Pacific Northwest National Laboratory)	7-13	3.00	3.00	3.67	3.00	3.08
Friction and Wear Enhancement of Titanium Alloy Engine Components	Peter Blau (Oak Ridge National Laboratory)	7-15	3.67	3.67	3.33	3.00	3.54
Erosion of Radiator Materials by Nanofluids	Jules Routbort (Argonne National Laboratory)	7-17	3.67	3.33	3.67	3.00	3.42
Materials Issues Associated with EGR Systems	Michael Lance (Oak Ridge National Laboratory)	7-19	4.00	4.00	4.00	4.00	4.00
Durability of Diesel Engine Particulate Filters	Thomas Watkins (Oak Ridge National Laboratory)	7-20	3.00	3.50	3.00	3.00	3.25
Catalysts via First Principles	Chaitanya K. Narula (Oak Ridge National Laboratory)	7-22	3.67	3.33	2.67	3.33	3.33
Thermoelectric Mechanical Reliability	Andrew Wereszczak (Oak Ridge National Laboratory)	7-24	3.00	3.00	3.00	3.00	3.00
Thermoelectrics Theory and Structure	David J. Singh (Oak Ridge National Laboratory)	7-26	3.33	3.33	3.33	3.33	3.33
Proactive Strategies for Designing Thermoelectric Materials for Power Generation	Terry Hendricks (Pacific Northwest National Laboratory)	7-28	3.00	3.33	3.00	3.33	3.21

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Solder Joints of Power Electronics	*Govindarajan Muralidharan (Oak Ridge National Laboratory)*	*7-30*	*3.50*	*3.00*	*3.50*	*3.50*	*3.25*
Materials Compatibility of Power Electronics	*Beth Armstrong (Oak Ridge National Laboratory)*	*7-32*	*2.67*	*3.00*	*2.00*	*2.67*	*2.75*
Environmental Effects on Power Electronic Devices	*Andrew Wereszczak (Oak Ridge National Laboratory)*	*7-34*	*3.33*	*3.33*	*2.67*	*3.00*	*3.21*
Materials for HCCI Engines	*Govindarajan Muralidharan (Oak Ridge National Laboratory)*	*7-36*	*3.50*	*3.50*	*2.50*	*3.50*	*3.38*
Hydrogen Materials Compatibility for the H-ICE	*Stan Pitman (Pacific Northwest National Laboratory)*	*7-38*	*3.33*	*3.33*	*3.33*	*3.33*	*3.33*
Materials-Enabled High-Efficiency Diesel Engines	*Michael Kass (Oak Ridge National Laboratory)*	*7-40*	*2.67*	*2.67*	*3.33*	*3.00*	*2.79*
Materials for High Pressure Fuel Injection Systems	*Peter Blau (Oak Ridge National Laboratory)*	*7-42*	*3.50*	*3.50*	*3.50*	*3.50*	*3.50*
Materials for Advanced Engine Valve Train	*Phil Maziasz (Oak Ridge National Laboratory)*	*7-44*	*3.67*	*4.00*	*3.67*	*3.33*	*3.79*
Compact Potentiometric NOx Sensor	*Dileep Singh (Argonne National Laboratory)*	*7-46*	*3.33*	*3.67*	*3.33*	*3.00*	*3.46*
NDE Development for ACERT Engine Components	*Jiangang Sun (Oak Ridge National Laboratory)*	*7-48*	*3.50*	*3.00*	*3.50*	*3.50*	*3.25*
Surface Texturing for Friction Control	*George Fenske (Argonne National Laboratory)*	*7-50*	*3.33*	*3.67*	*3.00*	*3.33*	*3.46*
Friction Modeling for Lubricated Engine and Drivetrain Components	*George Fenske (Argonne National Laboratory)*	*7-52*	*3.50*	*2.50*	*3.00*	*3.00*	*2.88*
Ultra-Fast Chemical Conversion Surfaces	*George Fenske (Argonne National Laboratory)*	*7-54*	*3.50*	*3.50*	*3.50*	*3.50*	*3.50*
Catalyst Characterization	*Thomas Watkins (Oak Ridge National Laboratory)*	*7-56*	*3.00*	*3.50*	*3.50*	*3.50*	*3.38*
Ultra-High Resolution Electron Microscopy for Catalyst Characterization	*Larry Allard (Oak Ridge National Laboratory)*	*7-58*	*3.33*	*3.00*	*3.33*	*2.67*	*3.08*
Low-Friction Hard Coatings	*Ali Erdemir (Argonne National Laboratory)*	*7-60*	*3.50*	*4.00*	*3.50*	*3.50*	*3.75*
Residual Stress Measurements in Thin Coatings	*Dileep Singh (Argonne National Laboratory)*	*7-62*	*3.33*	*3.33*	*2.33*	*3.00*	*3.17*
Diamond Based TE Materials	*Dieter Gruen (Argonne National Laboratory)*	*7-64*	*4.00*	*4.00*	*4.00*	*3.00*	*3.88*
Durability of ACERT Engine Components	*Hua-Tay Lin (Oak Ridge National Laboratory)*	*7-66*	*3.00*	*3.67*	*3.33*	*3.00*	*3.38*
Life Cycle Modeling of Propulsion Materials	*Sujit Das (Oak Ridge National Laboratory)*	*7-68*	*3.33*	*3.33*	*2.00*	*2.33*	*3.04*
OVERALL AVERAGE			**3.30**	**3.36**	**3.16**	**3.18**	**3.30**

NOTE: Italics denote poster presentations.

Design Optimization of Piezoceramic Multilayer Actuators for Heavy Duty Diesel Engine Fuel Injectors: Huay-Tay Lin (Oak Ridge National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

A reviewer observed that the project was initiated in FY09 with an annual budget of $300K, and project goals are consistent with the program. The PI has done a good job in articulating them (in a sort of boilerplate list that could be applicable to any of the other programs being supported). The second was unsure, saying the presentation didn't directly or indirectly indicate the project would lead to any consumer application. The third reviewer noted that the intent is to increase energy efficiency of heavy duty vehicles. One comment is that there should be clarity of the stage of research and development these projects are (see OMB circular A-11). This is basic research.

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

A reviewer noted that this project aims to attack the problem of efficiency by development of a piezoelectric fuel injector for heavy-duty diesel engines. It was not clear how the link between the injector and engine performance was made. The design was simply presented along with its technical aspects, but precisely what needed to be designed to achieve performance enhancements was not evident. The PI should endeavor to make a stronger link between injector parameters and engine performance metrics. The presentation suffered somewhat from inadequately setting the stage for the approach (experiments done, conditions imposed, etc.) A reviewer said that there was some disconnect between the research presented and the goal of increasing efficiency. Individual experiments and testing were not roadmapped into a cohesive story of how these elements fit into the overall goal. The final reviewer expressed the belief that the project research schedule could potentially be compressed, terming the milestone schedule very generous.

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

Review comments were mixed for this aspect of the research. A reviewer observed that the PI seems to have done a lot of work to outline performance (e.g., electric field effects). The methodology he has brought to bear on his experiments is impressive. The PI needs to set the stage better for the various tasks, rather than jumping into a presentation of the technical results. (The reviewer pointed out that on one of the PI's often used figures, the x- axis had the symbol "m" that was not defined until questions were asked about it.) It was often very difficult to follow the thread of discussions of the various figures that were presented. The reviewer rated the research progress as "good" because the PI has done a lot of work, but would rate the clarity of presentation, relevance and rationale as "poor." The essential question of "why" an approach was taken was not answered.

Given this rating scheme it appears this program will reach the stated goals and objectives. However, the relevancy to improved fuel efficiency and economy were not evident. The reviewer's overall impression is a scientific project that is increasing the science knowledge base but is lacking direct industrial application. The reader definitely needed a broad background in this field to understand any direct consumer relevancy. However, there is no indication of any follow-on research using alternative fuels. At best this appears to support continuation of diesel engine technology. At worst, this appears to be a scientific investigation program resulting in a technical report and nothing further. There is no indication of any producibility or reliability data or direct or in-direct (supporting) manufacturing base.

Some questions were raised on the state of the ultimate design for fuel injector actuators for which Cummins is responsible. Individual experiments and data did not lead to an understanding of the overall objective of this effort. This reviewer also had comments about the presentation, noting that acronyms and abbreviations should be clear, and some of the charts were not clear.

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

One reviewer praised project collaboration with industrial partners – Cummins, Inc. and materials suppliers. A second, conversely, felt there seemed to be little collaboration with industry, and noted that the PI is awaiting a final design from Cummins and that interaction between the PI and the team should be more descriptive. A reviewer restated the list of partners (Cummins, Kinetic Ceramics, EPCOS, and ORNL) and noted there appeared to be no other co-developers: the reviewer also observed there is an existing industrial base and a readily-available consumer market.

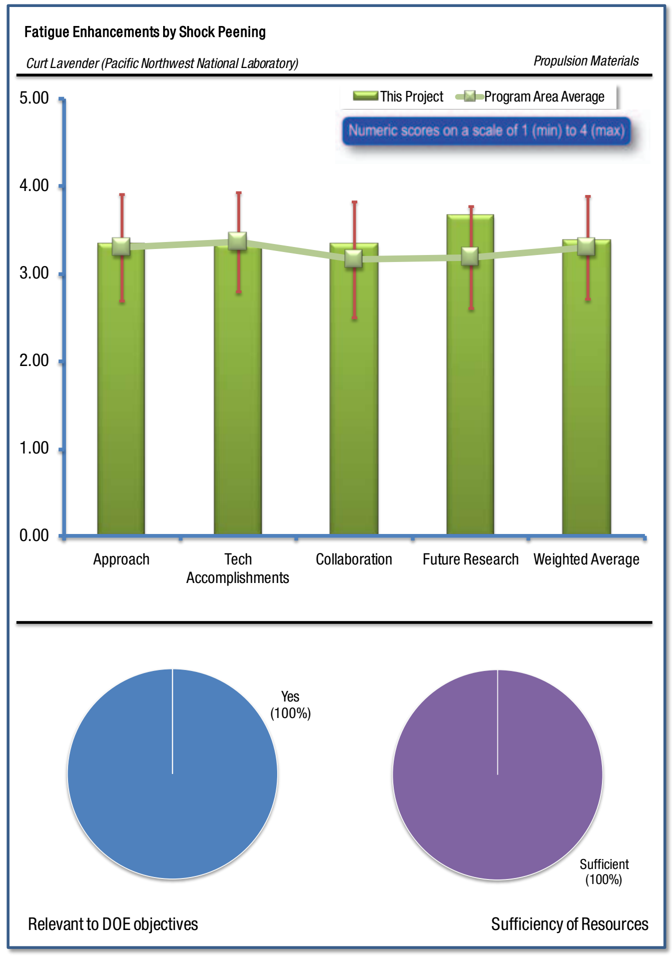
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt the proposed follow-on work was reasonable, but called for a stronger connection to be made between injection pressure and fuel spray characteristics, noting that elements such as droplet size, velocity, and number density really are the crucial parameters that will influence performance. This reviewer expressed the hope that the major industrial partner could work with the PI to forge a stronger link between injector piezoactuation and engine performance. The second reviewer felt the post-presentation Q&A more effectively explained the thrust of this project than the presentation itself. In particular, he questioned whether the project can be concluded and results transitioned to mass production and, if they could, whether service personnel could, with current training and instrumentation, service and maintain the mass-produced equipment (or is this too specialized for the current average diesel mechanic). If the objective is to improve fuel economy, the potential drawback is a requirement for additional training with associated advanced diagnostic equipment for the servicing mechanic. It is furthermore questionable whether this technology will be cost effective for the purchasing truck company/driver and whether this project will make an overall impact on a trucking industry potentially moving from petroleum based fuels to other fuels. To the final reviewer, the narrative fails to fully describe the proposed work and its implementation. This reviewer suggested a roadmap be developed to show how the individual elements progress towards the ultimate goal.

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

Two reviewers commented on this question. One felt the resources were adequate for the tasks performed. The other suggested accelerating the project to curtail the final research year, increasing final project year funding to cover production of a final report and terminate the project.

Fatigue Enhancements by Shock Peening: Curt Lavender (Pacific Northwest National Laboratory)



REVIEWER SAMPLE SIZE

This project had a total of 3 reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVE OF PETROLEUM DISPLACEMENT? WHY OR WHY NOT?

The first reviewer said this research may result in improved engine efficiencies by increasing injection pressures and the overall durability of reciprocating parts. Another had positive comments on the relevance, stating the work is directly related to turbo-charged engine technology in turbine body and component failure analysis resulting in better producibility and component reliability.

The final reviewer observed that this project began in 2007 on the problem of "shock peening" (i.e., water peening). The PI is approaching the end of this project (2010) at a level of $300K per year. The project is focused on increasing the operating stresses of materials through enhancement of fatigue life. Three methods examined are laser shock peening, water jet peening, and friction stir processing. Only LJP results were presented. The goal has been to demonstrate fatigue enhancements and to prototype a component enhanced by surface modification for full scale evaluation (this latter is an effort with Cummins).

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

A reviewer stated that the approach investigated fatigue enhancements and technology deployment: the latter perhaps is still in a state of development (e.g., adoption of LJP for materials processing in industry). A reviewer observed the team is pursuing multiple avenues of investigation (laser shock peening and waterjet) along with friction stir: this enhances opportunities for success. The final reviewer said that LSP or WSP both have potential for a new method of shock and reliability testing. These are potentially cheaper in application with more consistent results, thus improving the overall safety of the material. This suggests the need for a comprehensive test standard if this technology is accepted as the industry standard, and addresses the question of quality assurance during manufacturing. For DOD, such a test may be required during quality assurance or acceptance testing. The team used commercially available components for testing.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

A reviewer felt progress was shown in developing residual stresses with the waterjet and laser peening processes. Technology transfer of the laser process is proceeding along with prototype development. Progress was shown in developing and enhancing the friction stir process. Further comments highlighted that the briefing suggests industry applicability, and there is a readily-available manufacturing base. There is potential for a follow-on project, but any follow-on project should be carefully evaluated for direct improvements to industrial applications versus increasing the knowledge database.

The final reviewer said that this past year, the effort concerned LSP and WJP tests. The PI did a nice job of presenting the physics of the peening processes investigated. The peening process seems somewhat complicated, and it is quite interesting that an element of control exists. The residual stress enhancement with LSP is impressive. The WJP process was stated to produce longer fatigue life, but results for WJP were not shown.

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

One reviewer deemed interaction among project collaborators to be effective and the collaborators as good. The others observed that collaboration included several participating companies and the South Dakota School of Mines, and that collaboration includes Cummins as well.

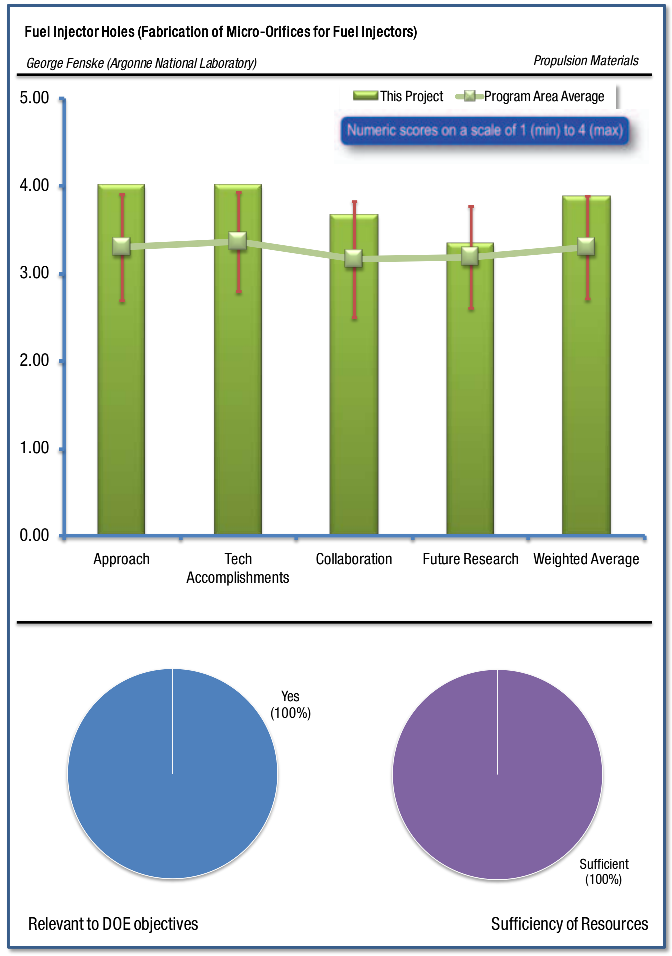
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer expressed the view that the project appears to be completed. He found the results interesting and was hopeful that industry would adopt these processing techniques. The second reviewer noted that the project will terminate in FY 2010 and a final report is expected. The reviewer did not suggest any future work and, based on the presentation, believed the techniques would then transition into industrial application(s). This reviewer suggested the team consider a test standard discussion with DOT, DOC, NTSB, and non-government organizations like ASTM. According to the final reviewer, testing is proposed for real components enhanced by the laser process, and rolling bearing tests with waterjet peened components are also to be conducted. Work will continue to further development of the friction stir processing technology.

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

Of the two reviewers offering relevant comments on this question, one termed the cost-sharing arrangement excellent. The other believed the resources to have been adequate for the work performed. The third merely noted the project’s probable termination in FY 2010.

Fuel Injector Holes (Fabrication of Micro-Orifices for Fuel Injectors): George Fenske (Argonne National Laboratory)



REVIEWER SAMPLE SIZE

This project had a total of 3 reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVE OF PETROLEUM DISPLACEMENT? WHY OR WHY NOT?

All three reviewers commenting agreed that this project is relevant to DOE's goal of reducing petroleum consumption and cited specific mechanisms by which improved fuel injector design would contribute to meeting this goal. The first reviewer said the project is to develop fuel injector manufacturing technology to reduce diesel emissions by reducing in cylinder production of particulates: this project also improves fuel efficiency. Another noted that the basic philosophy of this topic is fuel injector design to reduce engine-out PM. Reducing PM reduces regeneration frequency, which is especially important for medium to light duty vehicles. These vehicles will require an active PM regeneration, which is a high fuel consuming cycle. By better control of emissions, the engine manufacturers have more flexibility in calibrating their engine, leading to improved fuel efficiency.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

The three reviewers concurred in their positive evaluation of the project approach. The focus was sharply tailored to evaluating the plating techniques uniformity and robustness. Uniformity is critical to meet required injector to injector variation metrics used by the engine OEMs. Evaluating the plating robustness is also a critical aspect of meeting full operating life of this component. At the beginning of the project, a great number of alternative technologies have been evaluated. This gives good confidence that the chosen process is near optimum. There was good translation of the requirements in the final application to the upfront material testing. The final reviewer noted several specific aspects of the work: use of an electroless nickel process that is mature and can be used in mass productions; treat prototype component for technology transfer to industrial platers; spray visualization study by EPA; use of NDE technique to assist evaluation; and incorporation of engine testing in plan.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer called progress excellent and said it was highly likely the plating process would be amenable to mass production. The second reviewer considered the objectives of this project to be excellent. It is well understood in the combustion community that fuel vaporization is critical to meet low engine-out particulates: however, the barrier is lower engine-out emissions. The only weakness the reviewer identified in this project is the absence of any emission data to validate that this particular approach is going to meet the desired objective of lower PM. The reviewer did think the team was on the right track. The final reviewer listed a series of accomplishments: addressed coating adhesion issue; transferred concept to industrial platers; demonstrated feasibility of 3-D X-Ray imaging technique to examine the uniformity of coating; made excellent use of NDA tools; and evaluated application of high frequency vibrator to simulate cavitation erosion.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

All three reviewers praised the collaboration evident in this project. One noted "great collaboration with many cross-functional entities," citing four project partners and their contributions (imaging technique with EPA, EDM supplier, Extrude Honing company, Electoless Plating Company, and a fuel injector OEM). Another pointed out the collaborators' "solid interest." The third cited the participation of the EPA as having improved the project and noted the beginning of cooperation with industry.

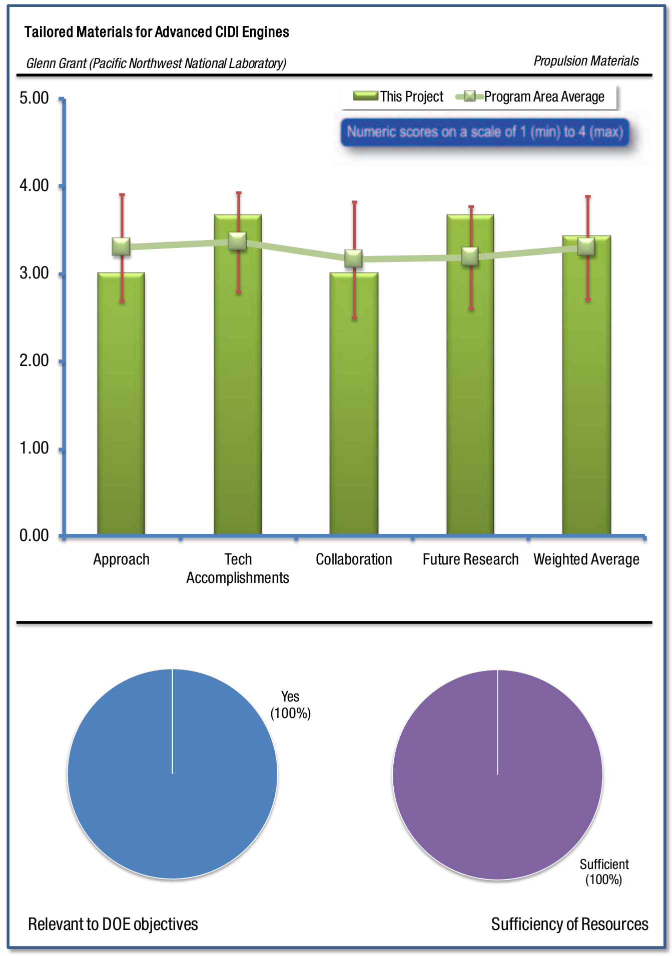
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer said the planned future component testing "look[ed] good." He suggested moving the scheduled engine testing forward, expressing the view that injector design was far enough along to warrant engine and emissions testing. A second reviewer felt that future plans were based on progress made to date and urged close attention to cavitation erosion test results, feeling they could lead to increase manufacturer interest if positive, but could constitute "show stoppers" if results were poor. The third reviewer noted four items of proposed future work: flow visualization study by EPA; prepare second generation multi-sized orifice nozzle for OEM; conduct cavitation erosion study; and develop 3-D X-ray imaging.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

A reviewer considered the project's rate of expenditure and its results to be in balance. The other comment was that progress on injector design looks good, and the only missing data is engine emission results.

Tailored Materials for Advanced CIDI Engines: Glenn Grant (Pacific Northwest National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

Reviewers generally agreed that this project supports DOE's goal of displacing petroleum. This project displaces petroleum by making the required fuel efficient technology at a lower cost. This is done by processing low cost materials to improve in-cylinder peak pressures. This piston processing technique enables technology that allows the engine to operate more efficiently. Other higher cost materials accomplish the same goal, but by lowering the overall cost the technology is easier to implement in the marketplace. Allowing for higher pressures when using aluminum pistons will lead to reduction of fuel consumption, according to the second reviewer. The final reviewer listed several aspects of the work that are relevant: improve fuel efficiency; increase peak brake thermal efficiency and durability; and reduce powertrain cost.

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

A reviewer observed the project is focused on improving the strength of the materials in the piston bowl. Friction stirring is promising for this application as well as for adding mixing materials for improved strength. The fundamental target is improved strength with a lower cost material. However, this project is ending this year, and there is no engine validation in the plan. The key objective should be demonstrating fuel efficiency. A solid approach is chosen, according to the second reviewer, who said that certain material properties should have been under investigation somewhat earlier in the project to allow for corrective action (as an example thermal conductivity of friction stirred nanotubes in the aluminum.) The final reviewer listed several activities: develop surface modification; investigate FSP; and maintain primary focus on aluminum piston coupons.

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

Two reviewers felt technical progress in this project was good to excellent. The first urged that the project report compare the modified aluminum piston being investigated to the current steel piston for high cylinder pressures. He pointed out that a wider operating window for the former would result in a reduction of overall fuel consumption. The second reviewer deemed that theoretically, the initial goals seem to be met. This program shows good technical work to meet a desired goal. To this reviewer, the program is missing the key objective of evaluating the technique in an engine: sufficient progress towards meeting this objective has been produced, and it is time to evaluate this technique on an engine. The third reviewer cited three technical accomplishments of the project: stirred in carbon nanotube and nanofiber to reduce CTE; studies of FSP mixing process; development of prototype piston blank.

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

A reviewer observed that collaboration with the partners in the project is good: an involvement of a piston manufacturer would improve the consortium. The second comment was that the interaction with other partners looks very good. Since this project is concluding soon, demonstrating the DOE objective should be the highest priority. Engine results that demonstrate the effectiveness of the techniques should be highest priority at this time. The third reviewer said the team had worked closely with Missouri S&T, Cat, and BYU, and is in the process of working with piston suppliers.

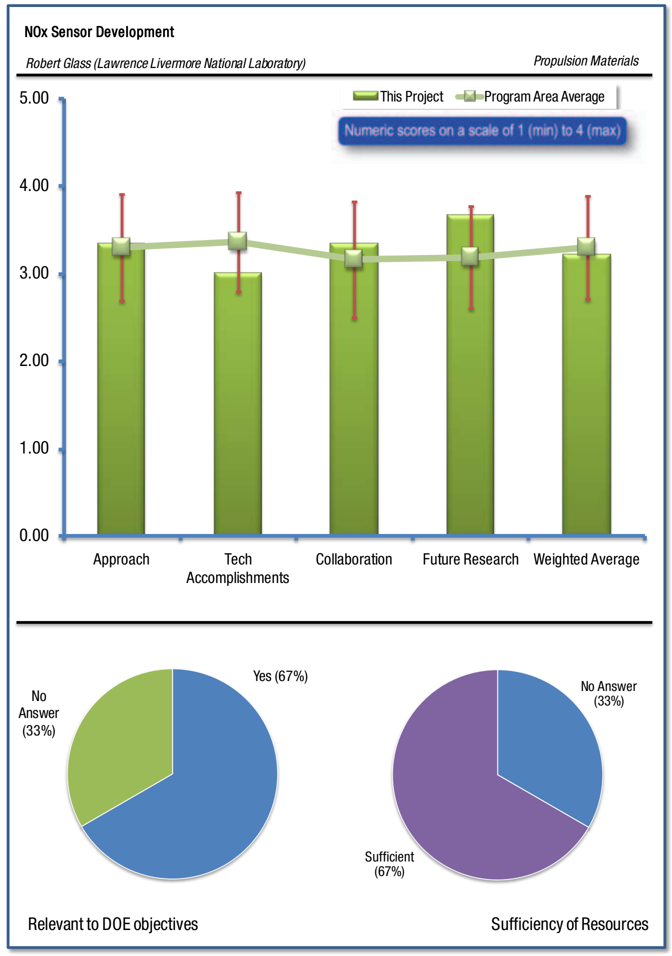
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer termed the proposed work in line with the previous findings, and noted it is in its final stage. The second said future work continues the theme of improving overall material strength using other mixing materials. The third reviewer cited three items of future work (thermal and mechanical tests are planned; FSP trials for thermal property control, maybe using MMCs; and complete trial in steel) and urged that consideration be given to constrained thermal fatigue tests of FSP samples and eventually producing pistons with FSP bowl rims for rig and engine testing.

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

One reviewer deemed the project budget in balance with the mentioned activities. The other comments were that the material work is generally meeting objectives, and a suggestion that the team consider doing constrained thermal fatigue test of FSP samples and then component testing and engine testing.

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



Reviewer Sample Size

This project had a total of 3 reviewers.

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

All reviewers agreed that this project supports DOE's overall fuel consumption reduction goal, directly and indirectly. Reliable, accurate, responsive and economical NOx sensors could greatly facilitate the wider adoption of diesel engines in the light-duty vehicle sector by simplifying the task of bringing them into compliance with the more stringent tier of emissions regulations. The wider adoption of diesels would reduce LDV fuel consumption both directly, through per-vehicle fuel consumption reduction and indirectly, through less severe fuel processing at the refinery. Increasing the efficiency of engines can facilitate the reduction in fuel consumption; NOx control is paramount in designing efficient engines, according to the second reviewer. This project indirectly supports DOE petroleum displacement objectives by enabling low temperature combustion, PCCI, and other type of near-homogeneous type combustion strategies that theoretically could improve the part load efficient of advanced compression ignition 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?

Two reviewers commented favorably on the project approach. Using well-established and proven oxygen sensor technology as a point of departure in the design of less expensive NOx sensors is a key advantage of the project approach. To the second reviewer, the overall approach is logical and very good. The only suggestion is that the PI considers more cyclic testing to assess long term drift on the LSM sensor; presentation material suggests that LSM sensor may not predict NOx accurately enough given the 100% error once the NH_3 concentration began to increase. The third reviewer praised the clear explanation of the approach and challenges given in the presentation but felt the project duration to be excessive; over five years or more, he felt, focus may be lost and progress become incremental.

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

This project has made much progress in addressing certain sensing issues, including oxygen concentration and temperature sensitivities; the group should be commended for their efforts. Nevertheless, this reviewer observed there is still much work in front of the PI in producing an end product that precisely measures NOx while correcting for oxygen and NH_3 concentrations and temperature, and can withstand the long term duty cycle of a light-duty engine warming up and cooling down. The second reviewer stated that the evolution of the technology was described and the importance of various parameters was explained. However, more explanation would have provided clarity on the following issues: What had happened over the past seven years? Did the research only concentrate on the same material during this time period? What is being used in Europe?

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

All three reviewers felt this project exhibited good to very good collaboration and coordination. One observed that working with a major LD engine/vehicle producer is appropriate and commendable, and called the choice of Ford as the LDV builder partner particularly apt, citing Ford's patent on the sole currently available electrochemical NO_x sensor. The second agreed, noting there was very good collaboration between LLNL and Ford Motor Company; it is critical that the vehicle OEM will be assisting in testing these sensors under real world conditions. Also, the PI has taken the initiative to seek a commercialization partner. The third reviewer mentioned that an automotive OEM is involved, but participation from a Tier 1 supplier is yet to be identified; as the technology has been developed over more than a decade, it is necessary to have some manufacturer involved.

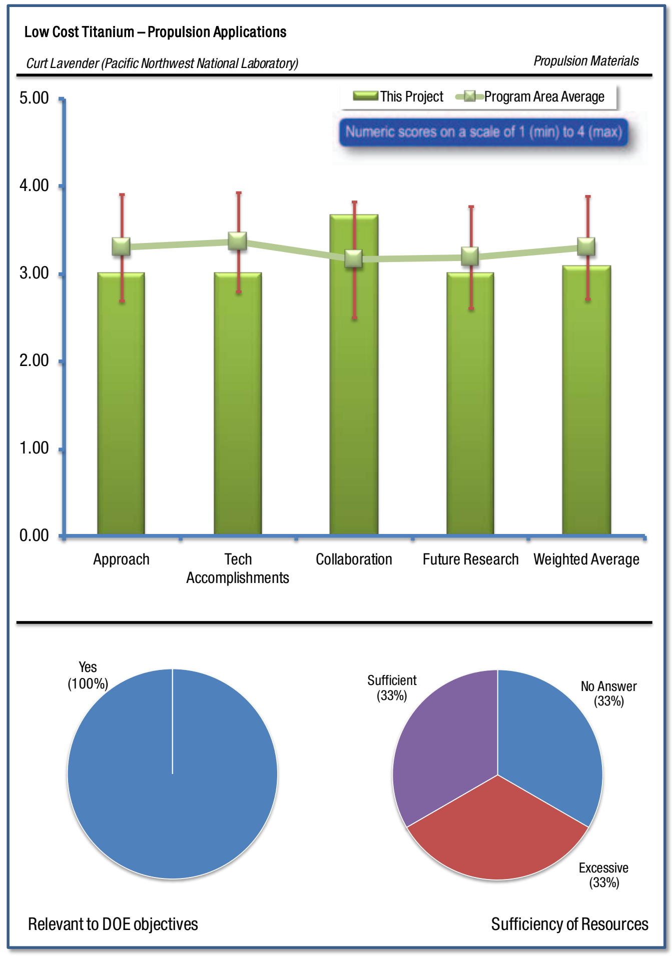
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two reviewers commented. One said simply "none" in response to future work, and the other said that while the pathway for the next two years was outlined, no commercialization plan was proposed.

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

None of the reviewers commented on this question.

Low Cost Titanium – Propulsion Applications: Curt Lavender (Pacific Northwest National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

Two reviewers felt this project to be potentially relevant to DOE's principal goal, but agreed such relevance had not been expressly claimed or explained. One said that while the magnitude of potential engine efficiency improvements (if any) due to use of high strength-to-weight-ratio titanium alloys in piston engines has not been assessed yet in this project, it is generally accepted that reducing the mass of reciprocating assemblies is beneficial to engine mechanical efficiency. This could reduce fuel consumption, at least indirectly, perhaps by permitting reduction of engine displacement for a given power output. The other agreed that there is some potential relevance for this project to meet DOE fuel petroleum displacement, but the PI didn't seem to understand how this would occur from an engine thermodynamic view point. The third reviewer's comment centered on reduced weight, increased durability, and improved manufacturing and producibility of Ti-containing parts.

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

The two reviewers voicing concern at the absence of an explicit justification for the project in terms of fuel conservation potential reiterated those concerns in responding to this question. A reviewer has some concern regarding the extent of alloy identification, characterization and processing work to date, in view of the fact that no explicit assessment has yet been made of the potential benefits of incorporating titanium alloy reciprocating parts in engines. Another comment was that the project approach is good in the sense of looking at material properties, cost, and fatigue of the low cost titanium, but it is poor from the perspective of understanding how using this material will improve engine thermal efficiency. The latter question should be answered prior to the former material property assessment assuming that fuel efficiency is driving this project. The last reviewer observed this is a new start effort: modify current end items (turbine fan) by using Ti replacement total assembly or Ti parts, and determine feasibility of using Ti in lieu of current materials. There are potential cost savings in improved durability, manufacturing, durability, and maintainability.

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

Good progress seems to have been made in the materials processing areas noted in the approach, but this work, promising as its results have been, may be premature, given that the potential benefits of this technology to engine performance have not yet been quantified. A second reviewer observed that this is a new project, but the PI has shown some initial material property measurements and so initially progress is good. Nevertheless, it would be helpful to look at improving fuel efficiency as the first step in this project versus as a later step based on its justification for existence. The final comment was that this is a new start effort that leverages the DOE GIPP effort. It does not appear to involve any significant technology issues in producing or testing Ti containing components.

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

All three reviewers considered this project to be exhibiting good collaboration and coordination among the participants. One called the international collaboration commendable, one deemed the partnership among the principal investigator, an engine OEM and a material producer to be very good, and the third noted the involvement of private industry, academia and potential international partners, including Cummins (who has the manufacturing base to produce these titanium items).

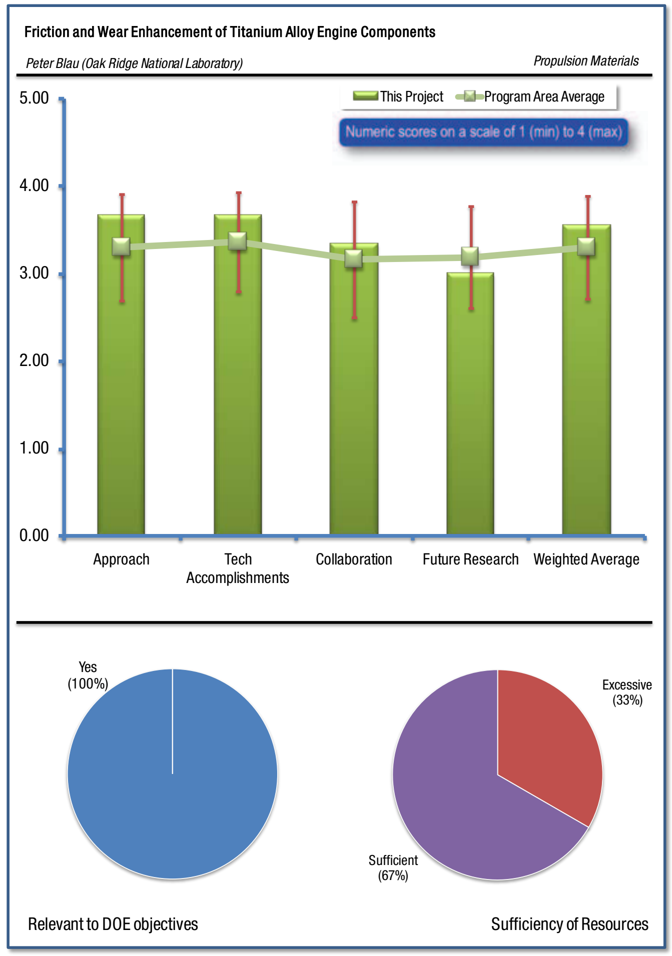
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer termed planned future research as good overall, but suggested that engine efficiency effects receive priority attention. A second reviewer concurred, saying "Modeling of efficiency effects of titanium engine parts can't happen too soon." While the trend has been strongest in Europe to date, it can be expected that U.S. vehicle manufacturers, too, will come under increasing pressure to assume "cradle-to-grave" responsibility for their products. This will include disposal and recycling of vehicles at the end of their lives. It might therefore be prudent to assess the implications of introducing a wholly new family of alloys into engine construction. Titanium is neither iron/steel nor aluminum, which account for the great majority of current engine construction materials. How will Ti parts be separated and recycled? The third reviewer said there is no indication of weight reduction if titanium is substituted for steel and the tradeoff is durability vs. weight and cost. The reviewer did believe the work addresses current industry requirements, and is married to near-term industry requirements. Future work is to pick existing steel engine system, substitute Ti components, and test, determining feasibility of substituting Ti for steel. The limiting factor is the availability of Ti ores. If Ti ore is available in the continental U.S., this may be feasible. However, if Ti is subject to interdiction, supply shortfalls, or is just unavailable, then this is a questionable project.

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

Only one reviewer commented: "In view of possible 'cart-before-the-horse' weakness identified above [i.e., much material processing work; no quantification of fuel economy improvement potential], expenditures on Ti alloy processing may prove to have been excessive."

Friction and Wear Enhancement of Titanium Alloy Engine Components: Peter Blau (Oak Ridge National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

Two reviewers felt this project relevant to DOE's principal goal. One said so explicitly and both mentioned the potential advantages of lightweight materials for engine part construction. A reviewer further added that the overall strategy is to develop lighter materials using titanium alloys for engine components such as connecting rods, valves, bushings, pistons, etc. A reviewer observed that the goal is to reduce weight, but lightweight alloys have friction and wear issues. Engine efficiency would increase if standard alloys could be replaced with Ti alloys. The final commenter simply noted that one can reduce overall weight of materials using Ti versus steel.

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

The focus on titanium is relevant to the first reviewer. Generally, titanium components in engines will drive up cost because of the expense of the material. However, this issue seems to have been addressed by a companion project, so cost may in fact not be an issue. The specific objective includes a focus on the connecting rod and the requirements for engineering bearing surfaces. Additional tasks include bench scale testing, construction of a loading test rig, and selection of candidate surface treatments and coatings. The methodology to be used seems to be somewhat standard (e.g., ASTM testing) and, in that regard, the forthcoming data should be less subject to uncertainties (i.e., no new diagnostics are developed and known and proven instrumentation is used). The second reviewer noted that work this year is on the system definition to select connecting rods, and the work seeks to expand aerospace pallatives to reduce fretting and look at other tribologic issues. Approach is a logical progression of tasks building upon the results of preceding tasks, and the phases are well defined to depict the yearly funding cycles. The final reviewer felt that essentially this work is integration of existing technologies with Ti material, which uses aerospace technology for vehicle applications. This is one of those projects that could be accelerated with additional funding. Using existing technologies also suggests the prototyping milestone could be accomplished faster, depending upon the availability of Ti component, manufacturing capability, and component part testing. DOE should consider some additional funding with acceleration of this project.

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

Two reviewers acknowledged the accomplishments in early stages of this new project. The project is relatively new, according to the first reviewer. What was presented concerned mainly results from literature studies to advocate titanium, some of the issues involved with it, and results from an effort to measure the friction coefficient. Some results on tomographic imaging measurements were also presented that document wear on bare materials. Overall, the PI has done a lot in a relatively short time. The issue here is what has been learned and/or how he will process the information he has obtained to allow more generalizations of the results. A second reviewer thought there was good progress made with literature review, testing protocols determined, baseline tests and planning for other alloys and surfaces to be investigated. Results of initial wear tests well depicted and explained.

The third reviewer expressed the work objective as substituting Ti components in an existing steel-based test engine. Essentially, how fast could candidate test items be demonstrated? This appears to be a traditional project timeline–literature review, initial lab testing, down-select candidates, etc. Could this project be run in parallel–multiple similar design items with different coatings and surface treatment samples and test. There appears to be an unstated modeling and simulation component inherent to this project. If so, that needs to be explained. If not, then what are the most likely surface treatment/coatings and could a test of candidate items be accelerated?

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

All three reviewers recognized the participation in this project of academic and industrial partners as well as that of NASA. The PI has endeavored to create a dynamic team, in the view of the first reviewer, who said the main concern is an apparent lack of commitment (e.g., CRADA or equivalent) for the collaborators. The PI indicated this as an advantage, but the virtue of formal commitments is that the collaborators will then have a vested interest in the results obtained here and not simply be casual observers with no real intent to use the results that would be obtained. The second review comment was that the team is partnering with private industry and academia, as well as NASA. They are reacting to current industry requirements. The work supports existing industry manufacturing capability. The final reviewer said that collaboration involves 100% DOE funding, informal collaboration with Cummins, Greenleaf and NASA. The presentation charts were dated, as the team now has Virginia Commonwealth University. This reviewer also noted the claims of the PI about how informal non-CRADA agreements make progress easier. There is a good mix of industry/ academia and other government agencies.

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?

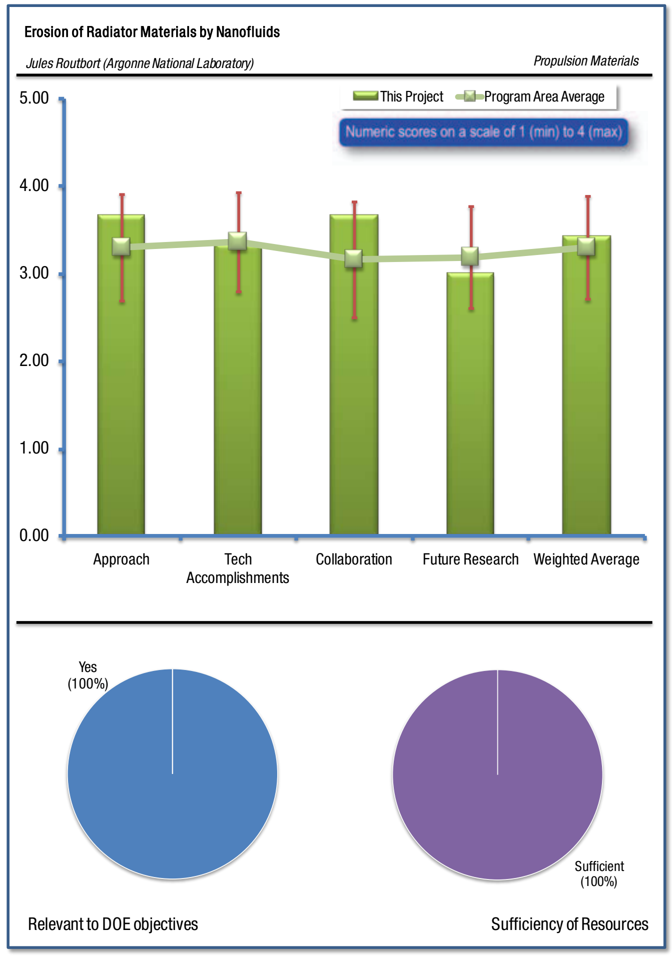
One reviewer referred to his comments under Question 3 (above) in which he speculated that project efforts could be "run in parallel" and the testing of candidate surface treatments thereby accelerated. The second reviewer's viewpoint was that the project just started in October 2009, and limited progress has been made to date. More work on bench-scale friction and wear tests and design, build, and testing a spectrum loading wear test system remains for FY10. FY11 will build upon this basis and flow into full concept validation in the last year. The test rig fabrication will greatly aid future progress on this and other efforts.

The detailed comments from the third reviewer discussed the continuing work that will include bench scale testing and confirm plans for scale-up and validation phase. The PI believes that if friction wear can be improved, new applications will be opened. The piston rod is a sort of paradigm for this. Some mechanism should be investigated to get the PNNL team of the Low Cost Titanium – Propulsion Applications project folded into this effort, or vice versa. For all of the testing and measurement that has been done and which is apparently to be done in the coming year, the PI should endeavor to look more closely at his future data to attempt to understand mechanisms for the effects his team finds. Modeling work will help here. To be most effective, the experiments should provide specific data that can be modeled, and where there are disagreements the model should be improved or the experimental hardware refined. There appears to be little of such an approach here. It is not clear that results will be forthcoming that might be generalized. The PI should guard against merely obtaining data without scrutinizing them to attempt to extract basic mechanisms for the effects involved.

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

One reviewer deemed the resources to be adequate. A second commented "New project." The third reviewer felt the project funding was reasonable at $300-400,000. However, he noted the similarity of this project (and its rationale) to the PNNL Low Cost Titanium project and questioned whether, in view of the $700,000 funding of the latter, the investment in titanium may be excessive. (The PI here thanked Curt Lavender of PNNL in his introduction, the reviewer noted.) He recommended consideration be given to combining them or, if it's deemed advisable to continue both, that the two at least be coordinated.

Erosion of Radiator Materials by Nanofluids: Jules Routbort (Argonne National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

All three reviewers agreed that the project is relevant to DOE petroleum conservation goals. Two cited the possibility of the work leading to smaller radiators, reduced vehicle frontal area and attendant aero drag reduction. One mentioned reduced pumping energy requirements. One reviewer, however, noted that nanoparticles in heat transfer fluids might *increase* viscosity (and pumping energy requirement) and could possibly clog liquid lines, although they have been shown to enhance heat transfer with higher thermal conductivity (according to the PI). This reviewer also suggested that a more quantitative link should be established between research in nanofluids and petroleum displacement.

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

Three reviewers all expressed some reservations regarding the approach to accomplishing the work. The premise that nanofluids exhibit enhanced thermal conductivity was questioned by one reviewer. The reviewer observed that the presentation states "Nanofluids have enhanced thermal properties..." The enhancement is most likely not anomalously high, which has been a big selling point in past nanofluids research. A lot has been made of the ability of nanofluids to enhance conductivity beyond Maxwell's expression. One must be skeptical of such results. The reviewer continued by stating that the PI cites some data that show enhancements in thermal conductivity (e.g., the alumna composites, etc.). At the same time, a large round robin study (i.e., J. Phys D, Appl. Phys, 43,165501 (2010)) concluded that, in fact, "...no anomalous enhancement of thermal conductivity was observed in the limited set of nanofluids tested in this exercise." The fluids in that study are not the same as here, but the point is that a balanced and guarded approach should be taken. The data that show enhanced heat transfer coefficients are interesting but it was unclear how they were obtained.

A second reviewer questioned whether the subject nanofluids could withstand lengthy periods of quiescence in a vehicle cooling system, be usable on demand, and still perform as specified, and if such fluids could withstand environmental temperature extremes (-40^o to 135^{o}F). The reviewer noted this is for a military-related vehicle application. This reviewer also wondered if the project could be accelerated, given that the nanofluids were provided by industry and that no erosion had been detected. He also inquired about the extent of the industrial base for nanofluid production. The third reviewer noted this was part of a larger program to develop nanofluids for heat transfer applications, and spoke of a straightforward approach analyzing pumping power (due to increased viscosity) and erosion.

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

A reviewer said progress has been good, with ongoing planning for full scale/ real environment testing using automotive components. An innovative test apparatus was developed to investigate alternative nanofluids. The second reviewer noted that the technology involves no critical or strategic ores or materials: the source of nanofluid components appears readily available. The briefing did not specify the availability of nanofluid components, discussion revealed a very available industrial base with readily available nanofluid component supplies. The third reviewer observed that a range of data was reported. This reviewer thought the erosion measurements are important, as they show no effect over prolonged impingement onto a rotating impeller, which is quite interesting. However, there seemed to have been little effort to identify the mechanisms for this quite interesting result. One would have thought that prolonged impingement would have had an effect, but it seems not to be the case here. Pumping power versus flow rate shows significant increase over fluids without nanoparticles. The data appear to be well correlated.

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

All three reviewers praised the collaboration of multiple research partners. The collaboration with other institutions and agencies appears to be substantial regarding financial investment. It is good that Valvoline is supplying the nanofluids. A reviewer highlighted the multiple private industry, academia, and government participants. The last reviewer noted these aspects: good teaming, multiple work for others, and in kind and multiple material suppliers with the Tank Automotive Command, Michelin, Saint Gobain, Nanoscale, other DOE laboratories and Valvoline.

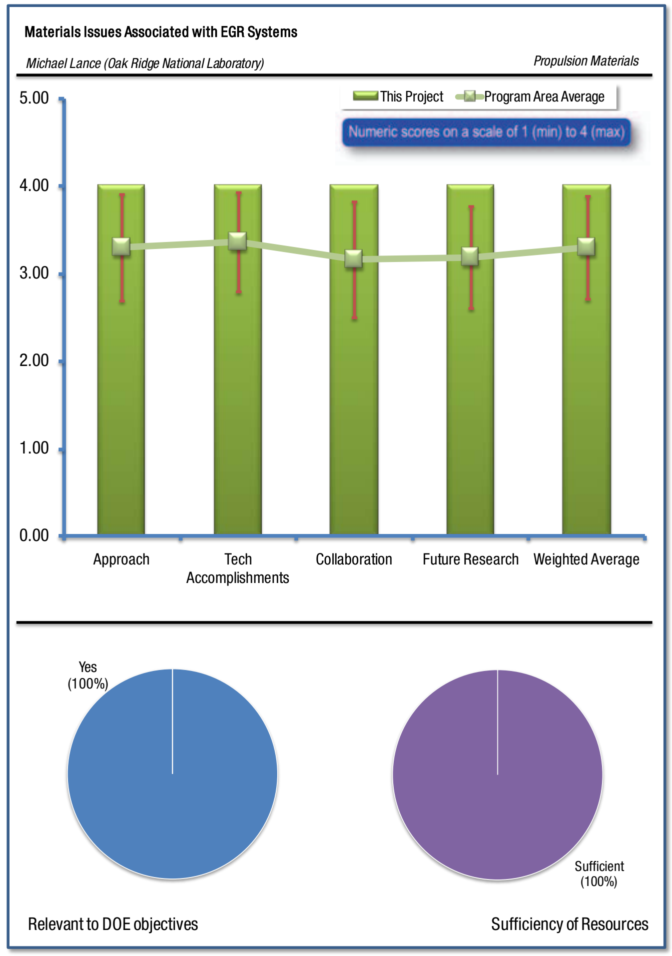
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers discussed several suggestions and observations regarding future work. The first reviewer wondered if this work could be accelerated with availability of additional nanofluid candidates. When could this be commercially available? Will this new fluid be cost effective to the consumer while being environmentally safe and easily disposed? The second reviewer commented about the team making a logical progression to a full scale engine and automotive pumps. Work will include measurement of erosion rates, power consumption, efficiencies and long term performance. This reviewer is unsure if resources are to be available for tests in a full scale radiator facility. The final reviewer stated that the PI will continue the erosion tests, imposing a range of flow rates and a modified erosion apparatus using a higher volume percent of nanofluids, as well as graphitic nanofluids. CFD modeling is also proposed, but the description of it is vague. Property measurements of a fluid before and after a fluid has been used will also be performed. This reviewer also observed that the PI intends to test results in a full-scale radiator configuration. In future presentations, it would help to say a few words about the methodology and uncertainty of the data to be reported. Furthermore, nanofluids will only be industrially viable if they can be produced in large quantities: it is not evident to this reviewer that is the case. Finally, there should be a strong effort to understand the data, not merely to show enhancements or degradations, etc.

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

A reviewer thought the team has made good progress with smaller than usual levels of funding, and it also seems to get major in-kind investments. The team may want to determine what resources would be needed for full scale radiator testing. There appears to be a significant contribution from other agencies and industrial partners (e.g., TARDEC, Michelin, etc.) who appear to be contributing significant costs and fluids, observed the second reviewer. The final reviewer noted only that the work is funded through FY 10.

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



Reviewer Sample Size

This project had a total of 1 reviewer.

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

A single reviewer commented on this project. He observed that improved EGR cooling assists in producing lower engine-out NOx. Typically when engine-out NOx emissions are high, the catalyst efficiencies must be raised to meet the regulated standards. Typically NOx efficiencies are improved with higher SCR temperatures. Therefore, de-tuning the engine will increase exhaust temperatures so that the NOx emissions are met. However this inefficiency sacrifices fuel economy.

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

The reviewer described the project as having been set up to integrate all the issues associated with EGR fouling and to truly understand the EGR fouling problem. All the diesel engine suppliers are contributing EGR coolers and an advisory board was created to evaluate the work.

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

The reviewer said "The objectives of the program are on target." This approach is initially concentrated on characterizing the PM morphology that creates the cooler inefficiencies. The next phase targets solutions to the problem. An important aspect of the program is that it includes bio fuels.

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

The reviewer noted the involvement of virtually all U.S. heavy-duty diesel engine builders in this project, and noted that it is industry-focused.

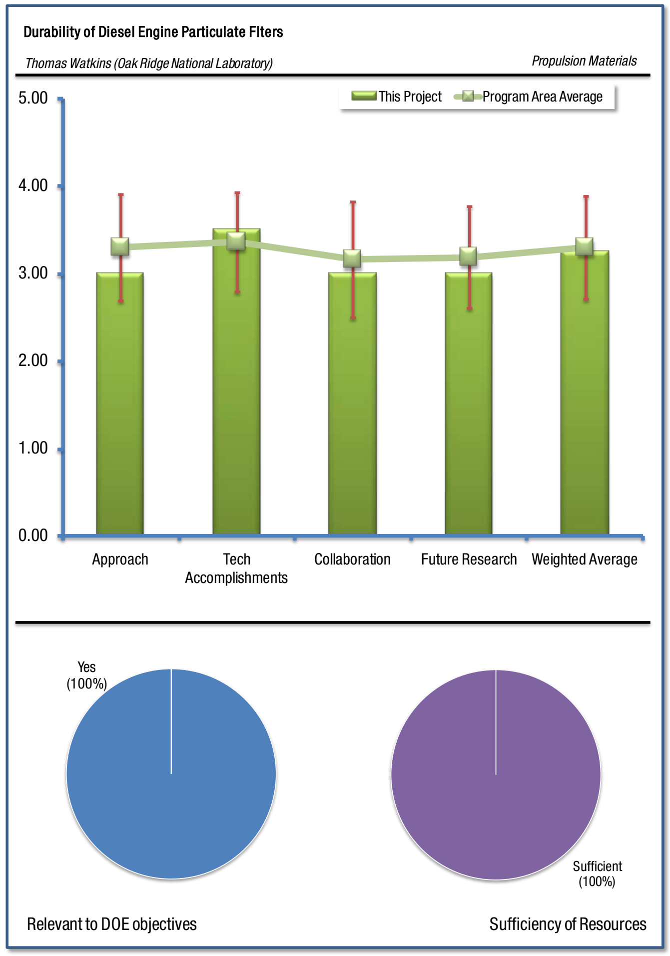
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The reviewer noted that the objective is to use the EGR PM morphology to generate potential mitigation solutions.

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

The reviewer said only that the project seems to be staffed properly and designed to leverage outside OEMs as well as biofuel work from another program.

Durability of Diesel Engine Particulate Flters: Thomas Watkins (Oak Ridge National Laboratory)



Reviewer Sample Size

This project had a total of 2 reviewers.

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

Two reviewers commented on this project. They agreed it is relevant to DOE's petroleum conservation goal, but one called the relation indirect: this is clearly a supportive project. The other said DPF durability is still a concern within the automotive industry. The program may improve the regeneration strategy that will theoretically reduce fuel consumption.

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

The first reviewer observed that DPF regeneration is a process that requires significant improvement throughout the industry. Therefore the data generated may be very important in improving the overall fuel consumption. However, there is no evidence that the data is producing those results. Some concrete measures of fuel efficiency gains must be included in future reviews. The second reviewer thought that looking at the porosity strength relation is a good approach. Durability is also determined by the number of regenerations, which in themselves have a relation with the pore sizes. When the last relationship was also taken into consideration, a better definition for the optimum could have come out of this project.

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

Progress is in accordance with plans, one reviewer said. The other reviewer said that the objective is to characterize the physical and mechanical properties of DPFs, and the fundamental results are targeted to that objective. However, the objective further states the team is developing tools to assess their reliability and durability: this area is weak, as there are no data showing how results improved DPF durability. Better coordination with the model or vehicle results would help this project.

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

One reviewer called collaboration good, but recommended strengthened sharing of DPF durability results. The other wanted better collaboration with project partner Corning and said combinations with the activities going on in DOE's catalyst programs could enrich the outcome of the project.

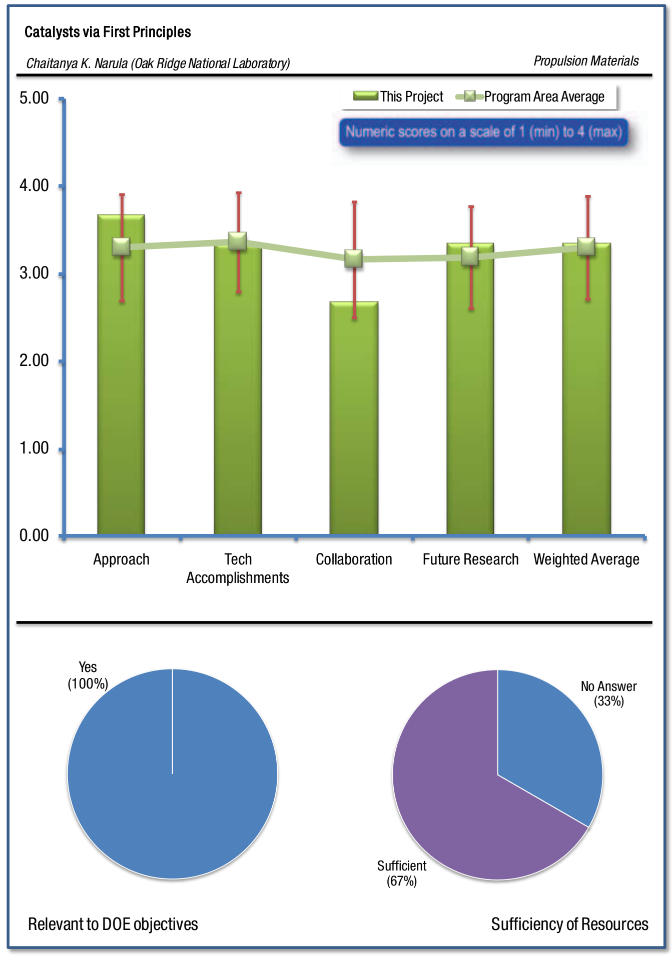
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said, "Future plans look good." He also called for correlation of material data with DPF durability. The other reviewer said only, "Project is nearly finished."

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Good data generation on the different DPF materials, stated the only review comment.

Catalysts via First Principles: Chaitanya K. Narula (Oak Ridge National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

All three reviewers agreed this project is relevant to DOE's petroleum conservation goal, although one said its relevance was very indirect, in that it could enable development of NO_x aftertreatment devices that in turn could enable advanced combustion approaches offering higher engine thermal efficiencies. Another characterized this as a very basic study of characterization and understanding of mechanisms involved in catalytic action of materials; improving the performance will enhance the efficiency of catalytic action. This reviewer observed that all projects which try to understand the mechanisms can be shown to contribute to the fuel conservation; however, more fundamental studies like this will have impact in long term but cannot be measured directly. The final reviewer commented that exhaust aftertreatment catalysts are universally employed to permit both SI and CI engines to meet current emissions standards, a trend that began in the mid-1970s and that can be expected to continue indefinitely. The importance of catalyst performance to vehicle fuel efficiency can hardly be overstated. Catalyst design, however, has depended heavily on trial-and-error evaluation. The ability to identify potential catalyst formulations and predict their performance based on first principles of catalysis would clearly represent a significant step forward.

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?

Two reviewers commented. The first characterized this as a project involving characterization of material and developing theory on operation; the approach is well defined. The second stated that this is a very good, financially low cost, fundamental materials discovery R&D effort that has great potential to add engine OEMs in developing future NOx aftertreatment devices.

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

"Significant understanding has been achieved and explained well," one reviewer said. The other felt the project is leading to very fundamental understanding on how to locate platinum on a catalytic surface with improved reactivity. This reviewer thought it would be interesting eventually to develop a design of a bench-scale catalyst and compare its performance to the performance of a current state-of-the-art item.

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

One reviewer simply noted that this is basic characterization work and no industrial partners are involved. The other credited the Principal Investigator with gaining the support of John Deere, noting the project has been the victim of the downturn in the automobile business. This reviewer thought it would beneficial if the PI could find other partners such as GM or DDC.

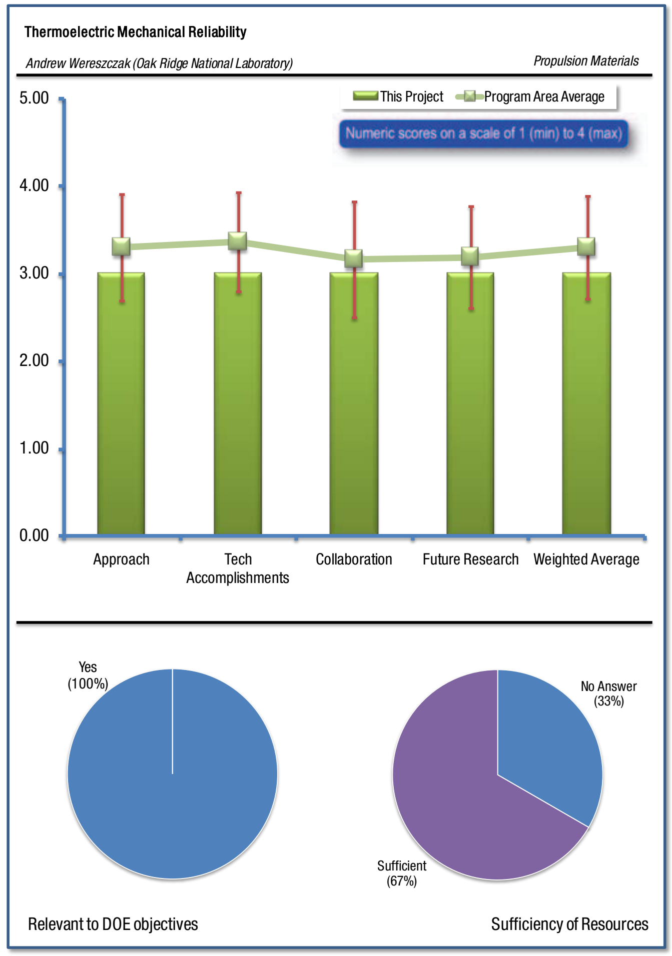
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

There were no comments on this question from any of the three reviewers.

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

There were no comments on this question from any of the three reviewers.

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



Reviewer Sample Size

This project had a total of 3 reviewers.

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

Thermoelectric materials are enablers in improving the thermal efficiency of vehicles, according to the first reviewer. The second felt that this project is indirectly tied to DOE petroleum displacement goals by addressing real world engineering reliability and durability issues with thermoelectric materials that could enable the use of waste energy recovery devices which can improve vehicle level fuel consumption. The third said that thermoelectric materials could enable the use of energy rejected to the atmosphere as heat by internal combustion engines. Electrical energy produced by practical (i.e., economic, reliable and effective) TE devices could result in reduction of engine accessory loads (alternator, PS pump, A/C, etc.) and contribute to improving fuel efficiency.

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

A reviewer noted that the approach shows clear appreciation of current TE material limits and a logical approach to extending them. Other comments were that the lack of test procedures is a barrier for the development of materials. Using regular characterization methods, the project is developing newer test procedures; data base generation is critical for future material development. The final reviewer said that the approach is targeted at addressing the obvious key thermomechanical properties of the candidate thermoelectric material. It is apparent that a major property is missing from their targeted list. Does the PI believe that the 3 point tensile test is the best approach for simulating tensile stress seen in the real TEM application? Does a historical two point tensile test make sense? Also, based on the various measured thermophysical properties, what type of efficiency improvement does the PI expect for a waste energy recovery system?

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

According to the first reviewer, this project has generated some interesting and useful data on certain potential material candidates that is valuable in assessing the potential for improving overall waste energy conversion system efficiency. It would be useful if the PI could extrapolate these findings toward the impact of the performance of a waste energy recovery system. The second comment was that a significant amount of data had been generated; this includes the development of new test process; standard test development is an easy way of disseminating and benchmark the progress.

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

Review comments were generally positive, including a note that one supplier of material and one user is involved. A reviewer termed the collaboration with a high-volume vehicle manufacturer as commendable, but the presentation did not make it clear what General Motors' role/contribution has been, or what GM will contribute in future work. The final comment was that it appears a material supplier is supporting this project and also GM in some capacity; it is not clear what level of participation GM has invested in this effort.

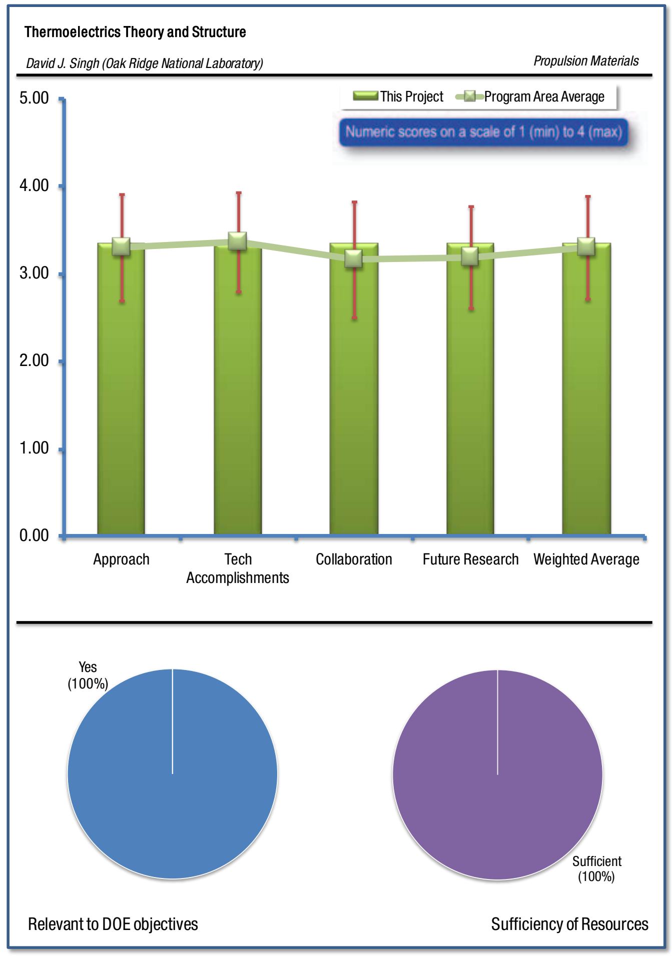
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Overall, there is a good approach for measuring various candidate material thermophysical properties; it would be helpful if the PI could extrapolate any such measurements toward waste recovery system performance improvement. A second reviewer reiterated the question of what role GM will play in this project. The third reviewer listed these activities: test process development is expected to be completed; characterization of the material; and interaction with industry for production.

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

No comments were provided for the resource sufficiency.

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



REVIEWER SAMPLE SIZE

This project had a total of 3 reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVE OF PETROLEUM DISPLACEMENT? WHY OR WHY NOT?

All three reviewers agreed this project is relevant to DOE's petroleum conservation goal. To the first reviewer, this project is broadly relevant to DOE's interest for enhanced efficiency. In this project, this objective is being addressed by the perceived need for high ZT materials for various waste heat recovery applications. The targeted goal of $1/W down to $0.20/W is relevant (though it is not clear that it will actually be achievable). The motivation articulates the standard points of relevance for thermoelectrics. The second reviewer also agreed with the relevance and said that the goal is to recover waste heat from exhaust gases to recover energy. This would increase automotive efficiency and reduce use of petroleum. The final reviewer said the project was relevant, based on supply problems of rare earth availability. The effort seeks substitutes to rare earths. However, the title is misleading suggesting no relevancy: this reviewer recommended the title be changed to indicate some specific end use.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

The three reviewers appear to agree that the approach is basically sound. One reviewer said the project uses standard, established technologies. Another said the project is good basic research leading to selection of materials, noting that the focus is on transport theory, looking at materials and design tools. Use of go/no go gates is useful (if indeed they are making impartial decisions along the way). The third reviewer noted that the project emphasizes a theoretical approach to materials development to achieve high ZT. The emphasis is almost exclusively on materials development (theoretically) with a view to finding new materials and design rules using first principles calculations to identify favorable compositions for thermoelectric materials. The PI shows fine insight to recognize the supply issue for TE and other materials. The approach emphasizes skutterudite materials.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The first reviewer noted that the PI carried out first-principles computations on a variety of crystal structures (of calcium and strontium plus others). Very favorable results for thermoelectrics were observed at a level of existing skutterudites, but at lower cost. The PI also carried out "transport" calculations (though he did not elaborate on what he meant by "transport"). The reviewer further noted that when compared to more standard materials like Bi_2Te_3 and other widely considered TE materials, Ca and Sr compounds were found to be cheaper, safer and with performance equal if not superior. The second reviewer approved of conducting a project that addresses material supply availability and cost. The final reviewer observed that heavy band / light band mixture studies for high ZT were completed, thermal conductivity of filled skutterudites was investigated, and virtual crystal calculations were conducted for new materials.

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

Two reviewers commented positively on collaboration, one terming the collaborations with Caltech and others "very good," and noting that the PI is doing computations to complement the experiments done there. This work is similar to other universities that the PI is collaborating with, including an Energy Frontier Research Center. Another observed good collaboration with academia, industry and other government agencies, including General Motors, Naval Research Laboratory, Massachusetts Institute of Technology, Oregon State, Corning and California Institute of Technology. The third noted the absence of a CRADA, but nevertheless noted "extensive private industry, academia and Federal Government agency participants."

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?

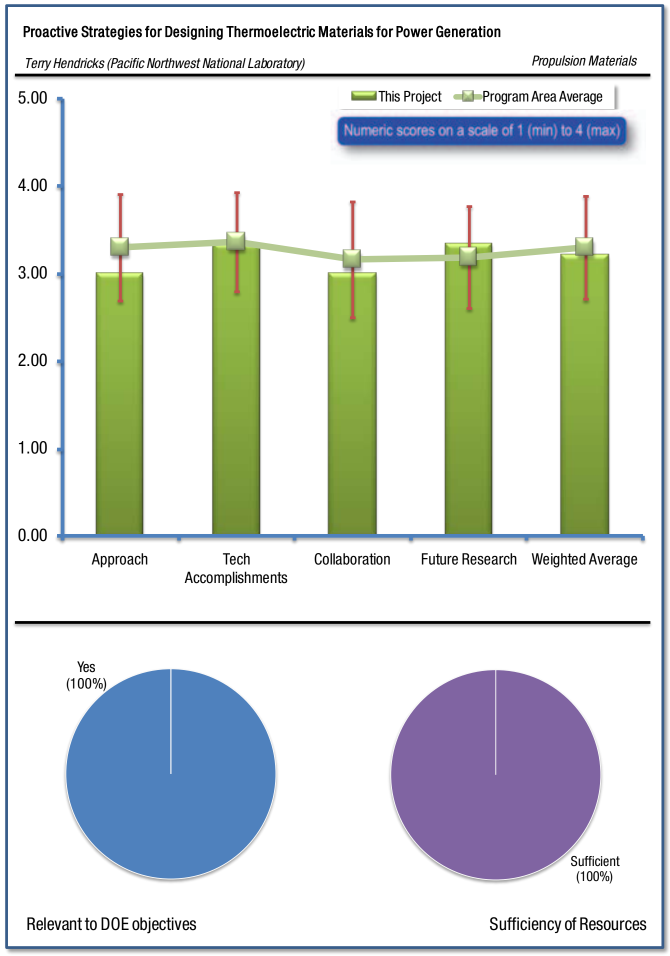
Initial comments about the future work include its high potential for waste heat recovery, and its focus on completion of theoretical work to optimize selection of good performing thermoelectic compounds. The latter reviewer also stated the goal is to develop high performance/ low cost components.

To the third reviewer, the future work includes virtually no discussion of precisely how the materials would be used nor of the packages that would house them. The PI should know that unless efficient packages can be developed to house the materials he will develop, the potential benefits of high ZT materials will not be realized in practice. While this is a materials development effort, the larger picture must be kept in mind, since after all, DOE is an applications program. In future work the PI should give the audience an appreciation for some of the theory involved (e.g., equations, computational power brought to bear, etc.)

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

Resources were characterized as being adequate for what is being pursued, and sufficient to continue work. The final comment was that the project ends in FY11, and more research is required for the new material. Applications of this technology await better materials. Also, this technology is applicable to only high temperature environments. It is probably not suitable for battery operated vehicles, but has applications potential for gas/diesel and H type vehicles.

Proactive Strategies for Designing Thermoelectric Materials for Power Generation: Terry Hendricks (Pacific Northwest National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

Reviewers were generally positive about the support of DOE objectives, with one reviewer stating that the objective is to improve commercial and heavy truck efficiency by recovering exhaust heat, directly supporting DOE goals. The second reviewer termed this as being "standard DOE vehicle objectives." The third reviewer commented more extensively, stating that this work concerns materials relevant to waste heat recovery. The project also deals with skutterudites and their design for power generation. The stated motivation appears to be somewhat boilerplate for the VTP program (hybrids, significant waste from exhaust, passenger climate control, reduced load on engine, etc.). The commenter observed that the PI is developing new n and p type thermoelectric materials that can withstand temperatures of 800 and 900 K. A targeted goal is a ZT of 1.6 or higher, achieved in a relevant temperature range.

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

All reviewers approved of the technical approach employed in this project. A reviewer termed the project a good basic investigation with third-party validation, noting that the team is also investigating structural properties as any compound selected would be operating in a harsh environment. Another comment was that the work uses In and Co (both higher cost minerals) and other rare earth minerals: available supply may not meet demand if this technology progresses. The technical approach appears sound to meet project objectives. However, the skutterudite materials derived from this research may make any product too expensive to incorporate into a vehicle. The final comment was that the organization of the project is very good and proceeds in a logical fashion. A combination of thermmoelectric development and materials characterization is being pursued. The approach to material enhancement is to fill the voids in skutterudites to reduce the black body phonon radiation that passes through the crystal structure, thereby lowering the thermal conductivity and enhancing ZT. A rather wide range of indium and serium based materials are being examined in a systematic approach that seeks to include measurements of Seebeck coefficient, electrical and thermal conductivity.

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

Two reviewers mentioned several accomplishments with apparent approval, observing extensive testing and characterization of over a dozen materials and seeing no indications of any technical barriers. Other accomplishments noted included the measurement of structural properties and elastic moduli, and development of innovative test equipment (high temperature measurement system) for n and p type thermoelectric compounds. The third and final commenter was more descriptive in his comments: the PI noted that module packaging is as important as materials development, which is very good. Measurements that have been made include CTE, Seebeck coefficient and electrical resistivity. A resonant ultrasound system is used to measure Young's modulus and Poisson's ratio. A high temperature chamber was developed to make these measurements. Impressive as this effort is, it was not immediately clear what the relevance of these measurements was to using thermoelectrics for waste heat recovery. Data on Seebeck coefficient and electrical resistivity were reported. The results showed a ZT between 1.5 and 1.6 at about 470K, which is impressive.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Reviewers also generally lauded this aspect of the project. One noted the development of an effective working relationship with Oregon State University, who apparently does thermal property measurements: more details of the OSU experimental capabilities would enhance the work performed. A second reviewer cited an adequate team of academia, industry and other government agencies (Oregon State University, Oak Ridge National Laboratory, Tellurex Corporation, BSST LLC, ZT Plus) and coordination with another waste heat recovery and utilization project. The third reviewer simply noted that there are eight agencies involved in this project.

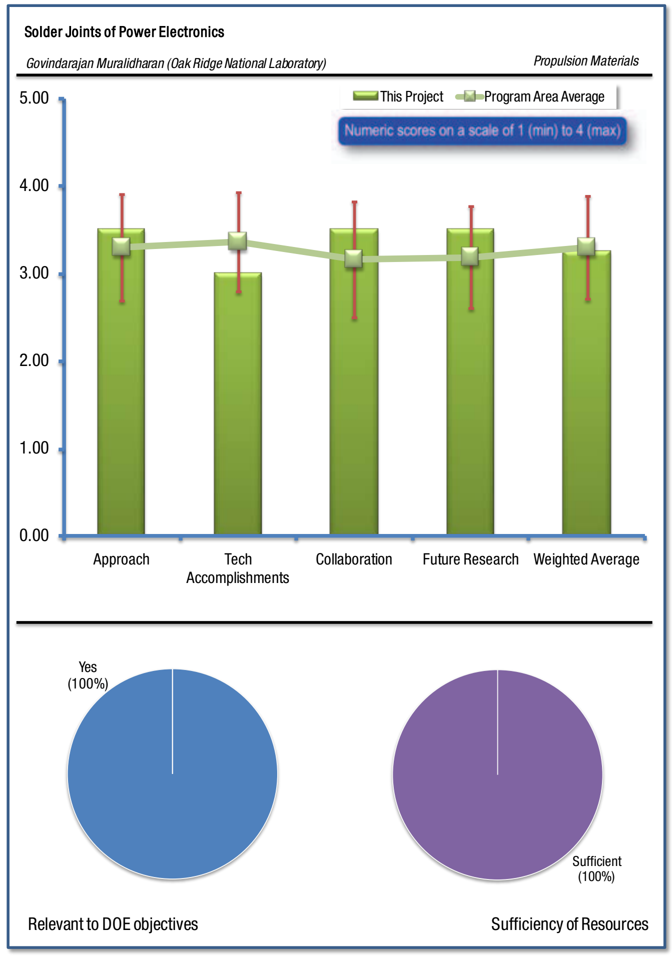
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

A reviewer said that future work would optimize synthesis procedures, fabricate compounds and include third party testing to validate performance. Structural properties would continue to be a key parameter to investigate. Another said the future work characterizes the new materials, focusing on the n-type In, Cs, At materials. The final comment was that future work includes similar measurements as reported this year (e.g., Young's modulus, Poisson's ratio, CTE, etc.), introducing “rattlers” in a range of rare Earth materials, and characterizing TE properties with ORNL. It would help to have some cross-referencing of the data to be obtained with other groups.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers called the project resources adequate for the work to be done and sufficient through FY 10,with program completion in FY 10. One noted the similarity of this project’s goals with those of PM013 and asked if the two could be combined. The third praised excellent use of resources but was not sure of any cost sharing.

Solder Joints of Power Electronics: Govindarajan Muralidharan (Oak Ridge National Laboratory)



REVIEWER SAMPLE SIZE

This project had a total of 2 reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVE OF PETROLEUM DISPLACEMENT? WHY OR WHY NOT?

One reviewer said the project indirectly supports high-efficiency energy and electronics by providing for higher-temperature solder joints that are more reliable. The other reviewers' comments appeared to reflect some misgivings, however. One said the project is relevant in computer controls for advanced vehicle power systems, etc. The third reviewer was openly skeptical, conceding that the integrity of solder joints is certainly important for long-term reliability of electronic packages, which are pervasive in many vehicle control systems, but stating that the thread of connection of enhancements and improvements in this area with "petroleum displacement" is tenuous and a stretch at best. The work plan sets the stage for this problem in the context of electronic reliability; a stronger connection with petroleum displacement needs to be made.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

The first reviewer observed that the project reaches completion in FY10. The reviewer offered several comments on the presentation, noting that he had to read the entire briefing to discover this was related to future electric vehicles. If this reviewer had been a congressional staffer he would be asking some tough questions about the applicability of this project. Given staffers do not have considerable time to completely review each project, as written this project would have been a candidate for termination. This reviewer suggested either changing the title for more relevancy or moving the application closer to the front of the presentation.

Another reviewer said the structures analyzed in the project experiments appear to be somewhat standard, consisting of layered materials with solder joints. The approach to measure the time dependence of joint strength may be important in general, but it is unclear why this information is important for the targeted application unless the packages analyzed are expected to experience cycling in application. No discussion of this point was included. The third reviewer said this was a straightforward approach for the project objective: joints are to be studied with regarding the effect of steady-state exposure to of high temperature on microstructure and the strength of the joint over time investigated. Thermal cycling of solder candidates will be tracked to develop knowledge on degradation.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

The PI has done a good job developing a range of experimental data, has fabricated a number of gold/tin joints, and collaborated with Powerex, according to one reviewer, but despite the fact that the thermal cycling data reported appears to have been carefully done, it was unclear what the significance of the 30 minutes of uninterrupted operation and what it was intended to simulate. This reviewer noted that some of the observations were qualitative in nature, making generalizations difficult: for example, the damage accumulation over repeated thermal cycling. He said the modeling effort was interesting. Thermal diffusivity data were reported, and interesting as they may be, it was unclear what these data were used for and how they contributed to the objectives of the project. The second reviewer was unable to comment on project accomplishments since there is just no individual slide marked "accomplishments": what was accomplished? The third commended investigation of lead-free solder joints, but wondered if nickel would become an issue under domestic or international environmental regulations. He also approved the use of finite element modeling to investigate failure modes.

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

One reviewer said collaboration with Powerex is good but was left unsure of the precise nature of the Ford and NREL interactions and hat they were providing to the project. Another called the collaboration with industry (Ford, Powerex) adequate, noted the discussions with NREL, and speculated that collaboration might have been constrained by project funding levels which are lower than other projects. The third reviewer simply noted the participation of one major motor company and one apparent supplier.

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?

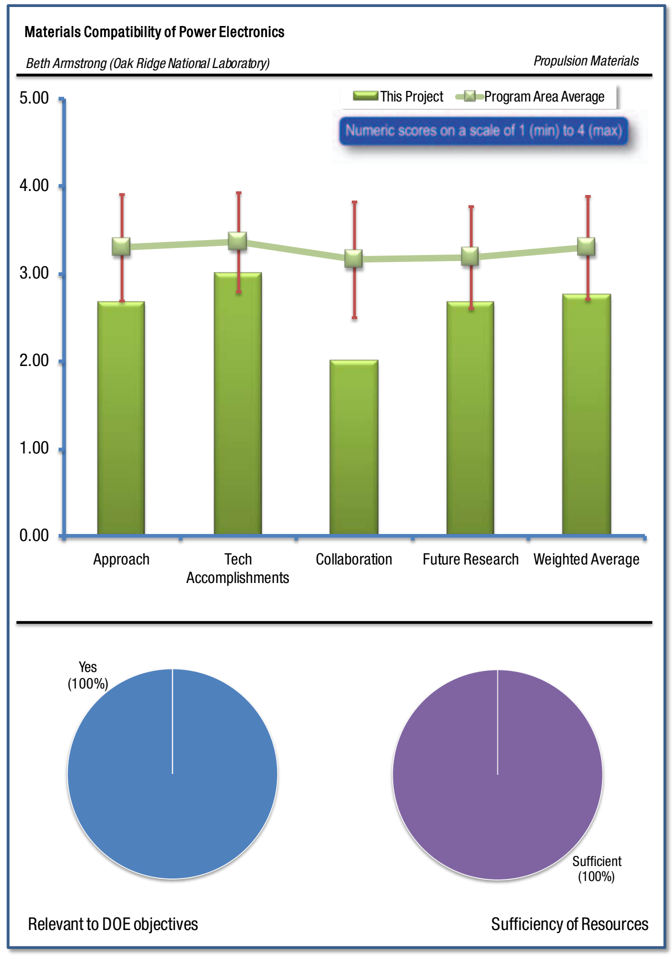
One reviewer termed the proposed future work a logical extension of current work efforts, further noting that work will continue on thermal diffusivity and degradation of joints over time and that multiple thermal cycles are planned on three candidates. The second appeared to agree, noting a sequential progress in testing the solder joints. The third reviewer, however, called for a stronger case to be made for the thermal diffusivity data which the PI is proposing for follow-on work. He also desired better justification for the 3000 thermal cycles that are to be imposed. He considered shear measurements to be important, but as with the other data, precisely how it all fits together and where the PI is going with the information he has obtained and proposes to develop for the future needs to be clearer.

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

The project resources appear to be adequate for the research carried out, according to one reviewer. A second called them smaller than for a typical project, but seems to be making excellent use of funding. The third reviewer noted that the project completes in FY10 and needs a written report. Also, when will the results from this project transition to industry?

This reviewer noted here (perhaps misplaced) that he totally disagreed with the previous year evaluation comment. The temperature in northern North Dakota can plunge to -70F, the high in Arizona is over 110F, and the salt contamination in New England is almost as bad as Hawaii. As we design vehicles as one vehicle is suitable for all climatic and environmental extremes the thermal cycling range should include the extremes. This reviewer suggests -40C to 115C as the range. If this is accepted, then what in your opinion will be the effect on your solder joints?

Materials Compatibility of Power Electronics: Beth Armstrong (Oak Ridge National Laboratory)



REVIEWER SAMPLE SIZE

This project had a total of 3 reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVE OF PETROLEUM DISPLACEMENT? WHY OR WHY NOT?

One reviewer noted that better packaging of power electronics into hybrid vehicles makes them more viable. More hybrids correlates with better fleet fuel efficiency. This reviewer also stated that since his perspective is from the vehicle side, packaging and increasing electrical power enables the opportunity to increase fuel efficiency. PHEV vehicles benefit from this type of research. Another considered this to be an enabling project to have more efficient power electronic systems. The third reviewer's comment stated the project objective to overcome the barriers on cost of high temperature integrated power electronic (HTIPE) systems and abuse tolerance and ruggedness of HTIPE systems.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

The project test plan is sound, according to one reviewer, but the unknown effect of the final coolant material is a setback to overall project. The project continues to evaluate potential cooling requirements. A second reviewer felt the approach is focusing more on characterizing the aluminum conductors and less on the actual cooling optimization. The third reviewer's comments offered no evaluation of the technical approach, restating the activity of developing and validating a laboratory methodology to evaluate the degradation of power electronics materials/components by evaporative cooling liquids.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer enumerated three project accomplishments directly from the presentation: developed methodology to evaluate the interaction of the power electronic components with the fluids used in the evaporative cooling systems and initiate testing of methodology; validated the proposed methodology for examining the interaction of the electrical components with evaporative coolant; and initiated mapping of materials compatibility space of power electronics with appropriate evaporative coolant. The second reviewer also cited one of these accomplishments, noting that the result so far is a methodology for testing electric conductors in a coolant. Since it is highly likely that the coolant chosen in this project will be replaced it is important that an insight is given in the robustness of the methodology in case of an alternative coolant. The final reviewer said that the project focuses on the fundamental objectives of material durability with external cooling.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Two reviewers said no collaboration had been mentioned in the presentation; the third desired to see more interest from industry, noting that few final users are involved in this project.

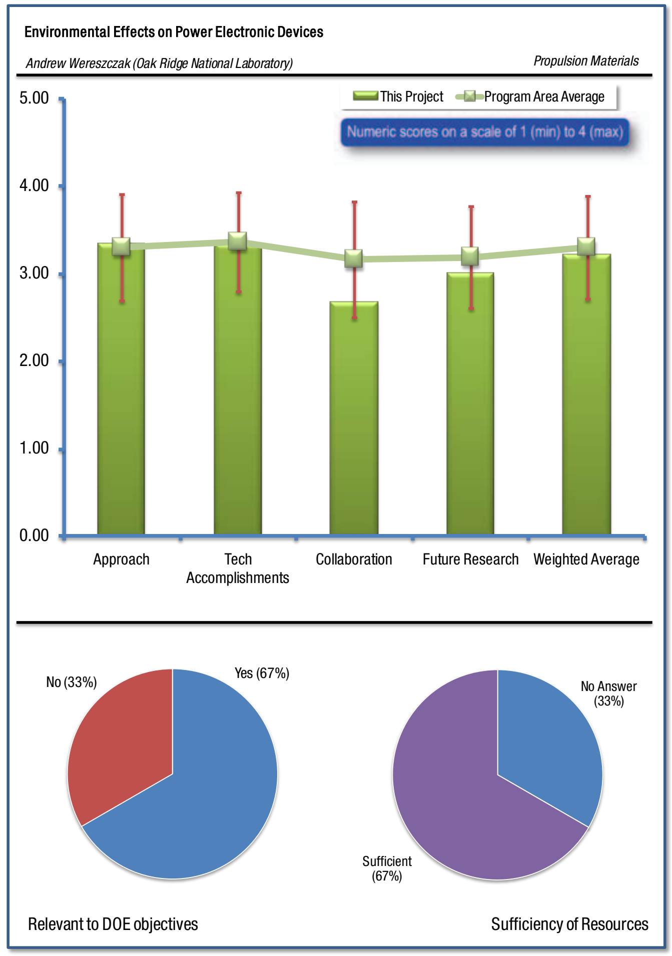
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Noting that the project is winding down, one reviewer urged that effort be devoted to defining test methods so as to make them usable with alternative coolants. Another simply reiterated the proposed research from the presentation: use more prototypic boards; and develop minimum test data that allows for a meaningful dialogue with system designers. The third reviewer said the project finishes by developing test plans that would be used by an end user.

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

The only comment on this question was “Tasks meeting time requirements.”

Environmental Effects on Power Electronic Devices: Andrew Wereszczak (Oak Ridge National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

Two reviewers noted that power electronic devices (PEDs) are a key enabling technology for hybrid-electric vehicles, which offer significant petroleum displacement potential. One stated that power electronics are key to practical, mass-producible electric and hybrid-electric vehicles which offer significant petroleum displacement potential. Another said that this project supports the use of power electronics in HEVs which are one vehicle propulsion technology that could improve specific vehicle application fuel consumption over a given duty cycle. The final reviewer observed the presentation did not elaborate on barriers and significance, but developing cooling methods can contribute to improved performance of PEDs.

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?

Two reviewers addressed comments to this question. One said the problem is well defined, but wanted a clearer explanation of where these devices are used and how it contributes to the vehicle. The other said the approach is addressing the key shortcomings of PEDs – thermal management and reliability issues.

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

One reviewer cited a patent application that arose from the project work. A second reviewer, noting that the mechanical analysis and thermophysical portions of the project yielded data for the poster, was left wondering what the end state was for the maximum allowable coolant inlet temperature and how it compared to the DOE target of 105°C. The third reviewer noted that effective cooling is crucial to the practicality of power electronic devices. The ability to reject heat without complex ancillary cooling systems is important to the economics of high-power electronic components and their ability to withstand the temperatures and mechanical stresses of the automotive environment will determine their operating lifetimes.

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

Two reviewers did not comment; one said the project appears to be a single-investigator effort and it isn't clear if the PI has been collaborating with industry or non-DOE government agencies.

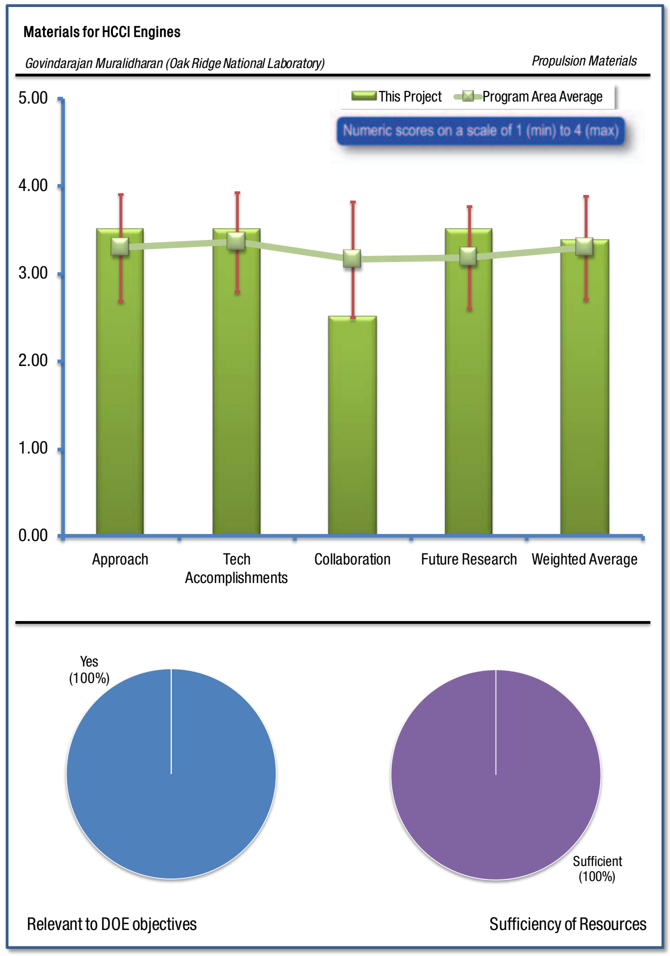
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

All three reviewers either noted that the project is slated to end in FY 2010, that no future research was proposed in the presentation or that there had been no request for further funding.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

There were no comments on this question.

Materials for HCCI Engines: Govindarajan Muralidharan (Oak Ridge National Laboratory)



Reviewer Sample Size

This project had a total of 2 reviewers.

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

Two reviewers responded to this question with germane comments. One said the project had "*de facto*" relevance to DOE's goals, as with any project to reduce material weight and derive benefits of fuel economy. However, he continued, the targeted goal of 25 to 40% improvement of fuel efficiency is very aggressive. The second reviewer observed investigation on improved engine valve materials that operate at higher temperatures for advanced, high-efficiency engine concepts. The third comment simply noted the improved exhaust valve material.

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?

Two reviewers praised the use of computational approaches in this project, one saying the integration of computational approaches to materials development is useful, and the other citing good use of thermodynamic/kinetic computational models to predict performance before testing. The first of these reviewers, however, commented that little was presented to more fully understand this component of the project. The PI noted the potential for "...rapid identification of new alloys with desired microstructure..." through modeling. However, the discussion of this point was sparse as it was presented only in block diagram form. More details need to be described. He also said the efficacy of the approach for achieving project goals is uncertain given a lack of a direct, quantifiable link between right material having been found or developed and improvement in fuel economy. Future presentations, this reviewer continued, should include a discussion of fuel economy and materials, not just "statements (rather like hand waving)". The third reviewer merely noted that the project appears to be on schedule for completion.

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

One reviewer, citing nice progression from modeling to practice, noted that the modeling had led to selection of an alloy with desired microstructure and properties and that small quantities have been made and larger heats subjected to fatigue testing. A second noted accomplishment of "a lot," and mentioned hardness testing, stress measurements, identification of structural features, etc. However, he was left wondering where this testing and measurement leads. Finally, the third reviewer posed a question: "There is no indication of any combination of Ni and Co at concentrations lower than about 50%. Was there some analysis that suggested this concentration, or could the mixture percentage be lowered further?"

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

Project collaborations were deemed reasonable by one reviewer, but considered to be a bit vague, including as they do 'discussions' and 'guidance' as with Eaton and Carpenter Industries. He called for better quantification to determine what these 'discussions' and 'guidance' have led to. Feeling it unclear that there was a commitment to work together, this reviewer urged collaborations be solidified through agreements, cost share, personnel exchanges, equipment donations, etc. and that the benefit of these interactions be made explicit. The PI notes that they are having extensive discussions with Eaton on an "on-going" basis. What does this mean? Similarly, the interaction with Carpenter ("discussions") is vague. These collaborations should be more substantive, or if they are then evidence to that effect should be provided.

This reviewer also noted that Eaton and Carpenter were the only project participants identified, that there was no indication of any manufacturing potential after project completion and no indication of commercial interest. The other reviewer noted that collaboration had been primarily with industry and speculated that smaller resources may have limited a broader participation by academia and other government agencies.

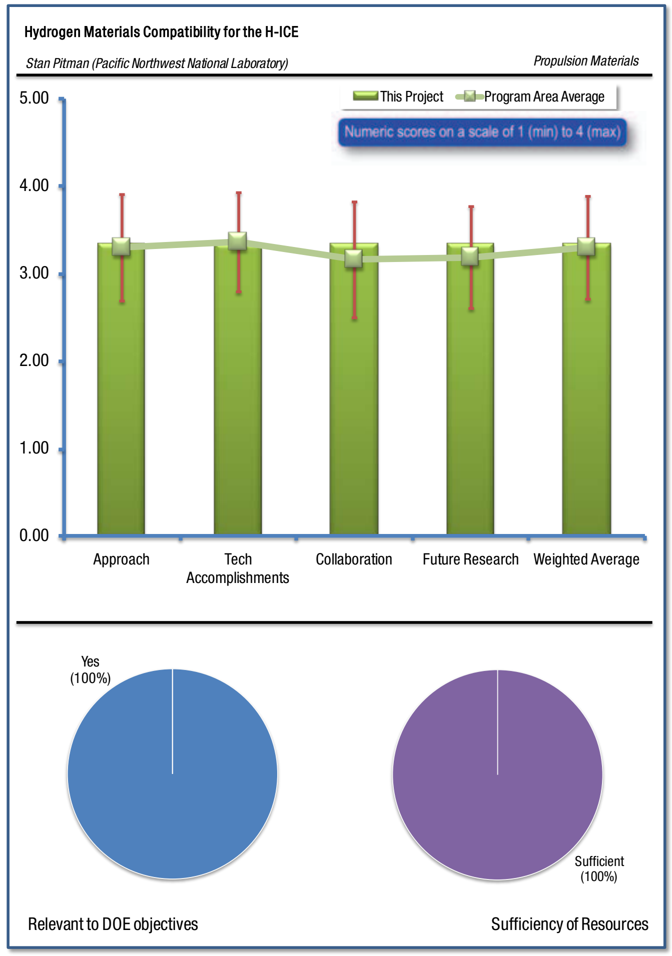
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two reviewers simply noted the project's planned completion in FY 2010, one noting the expectation of one or more patent applications and observing the project will investigate long term exposure, rotating beam fatigue and other characterizations. The third urged that the PIs should scrutinize their results more closely to develop a rationale for the future: the way forward seems to be more of the same from the past. Their itemized list of "future work" provides little in the way of a roadmap to their ultimate end state. In developing a roadmap, it would help to draw the reader through the rationale so that it can be better understood how the proposed tasks for the future would fit into the ultimate goals.

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

Two reviewers said, respectively, that project funding seems reasonable for the tasks carried out, and that the funding profile was typical with no cost sharing evident. The third asked if any follow-on work was planned.

Hydrogen Materials Compatibility for the H-ICE: Stan Pitman (Pacific Northwest National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

One reviewer implicitly characterized this project as relevant to DOE's petroleum conservation goal by noting that hydrogen is not petroleum dependent. The second reviewer's comment was similar: he said the project is focused on a technology that will enable the introduction of hydrogen as fuel for vehicles. The third reviewer was reiterating project objectives: this project tries to improve the durability and performance of fuel injectors for use in direct-injection hydrogen internal combustion engines by evaluating failure modes of piezoelectric materials, coatings, and connectors in high-pressure hydrogen gas; characterize actuator performance in hydrogen and developing new experimental methods for evaluating performance; and measure the friction and wear characteristics of injector materials and coatings in hydrogen gas in order to develop better injector designs.

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

A reviewer noted that the program is targeted at the technical barrier of a robust hydrogen injector: the two topics are the effects of hydrogen poisoning on the piezoelectric material, and increased injector wear due to hydrogen's lack of lubricity. The program targets injector designs issues related to hydrogen fuel. Another stated that the chosen approach for the development of hard coatings to avoid wear in a hydrogen rich environment is a good combination of coating design and experimental validation: this reviewer felt that the approach on characterizing of the adsorption of hydrogen is good, but how to create a barrier coating is still not well described. The final reviewer reiterated several aspects of the approach: evaluate kinetics and mechanism for deterioration of piezoelectric materials by hydrogen and examine potential remedies; and develop and evaluate novel coating methods for improved actuator reliability.

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

One reviewer, noting that the project is nearing completion, said a lot of work still has to be done. This reviewer wondered whether a project extension had been requested, since a presentation slide suggested proposed future work would take place in FY2011 as well as in FY2010, when the project is slated to end. He nonetheless considered that understanding of hydrogen ingress in piezo materials shows good progress. If the multi-layers approach is successfully validated, this reviewer said, this would also be a significant improvement. The second reviewer concurred, saying the nanolaminates look promising for reduction in injector wear caused by hydrogen, and felt tools like ion scattering and quasi-elastic neutron scattering should improve basic understanding of hydrogen poisoning as well as new solutions to stop it. The final reviewer listed technical accomplishments: H_2 charged samples show surface blistering except $BaTiO_3$; PZT/Pd H_2 charged surface shows Pd/Pb mixing (confirmed with RBS); fits of ERDA spectra give hydrogen depth profiling and compared with control (uncharged sample) for residual hydrogen; neutron scattering was used to study

H_2 in piezoelectrics; two tribometers are being used to evaluate lubricity and wear characteristics of Cr/N and B/N nanolaminates; and nanolaminates had superior tribological properties relative to the individual monolayers.

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

One reviewer called project collaboration with industrial partners and national labs good; the other two cited the project collaborators by name (Westport International, Ford Motor Company, National Laboratories).

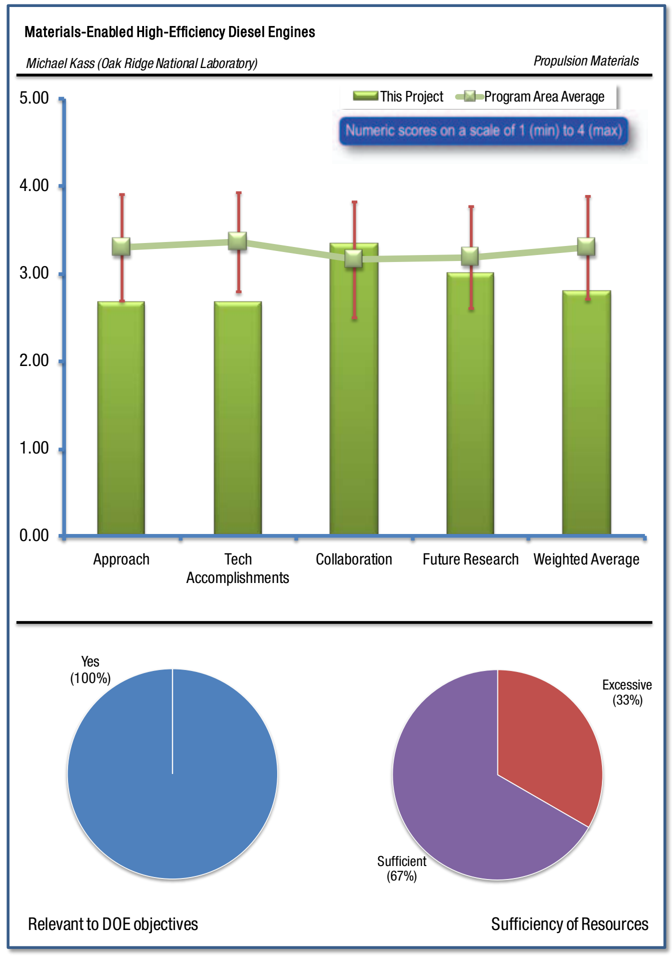
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Two reviewers commented. One said the future plan is a logical progression, and involves trying to better understand and model the hydrogen deposition within the injector. The other said that plans are in line with outcomes of the project to date but that it would be a challenge to finish within timeframe of 2010. A third reviewer did offer inputs, but only by listing future work: complete evaluation of hydrogen damage in PZT, and recommend potential remediation methods; and complete statistically-designed experiments of Cr/N and B/N coatings in argon and in hydrogen.

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

Of the two reviewers offering comments, one said the project had sufficient support for the described task and the other said that with only 10% left to accomplish, the resources should be sufficient.

Materials-Enabled High-Efficiency Diesel Engines: Michael Kass (Oak Ridge National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

Two reviewers deemed this project relevant to DOE's petroleum displacement goal. One said understanding the performance of materials used in diesel engines will help to improve efficiency and reduce fuel consumption. The other agreed that material improvements in these areas are directionally better for fuel economy and emissions, but also noted that industry partners limit the amount of information presented. This reviewer said that the project seems to target better lightweight materials for turbochargers and other powertrain components. The third reviewer observed that the presentation associated with this project (which is recognized to be in its early stages) provides little detail on a) precisely what advanced materials will be examined and b) how this project differs from/overlaps with Project PM033. However, use of biofuels would appear to be relevant to petroleum displacement and high-performance materials (other than the TBCs that are the subject of PM033) are also presumptively relevant to improved HDD engine performance.

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

A reviewer cited the paucity of specifically relevant information in the presentation in explaining the rating he gave the project in this category. A second reviewer called fundamental power train material improvements a good goal, but very broad. He suggested that more focused experiments would help analyze the overall result. The third reviewer mentioned the commissioning of a full-scale test cell with engine and looked forward to subsequent progress, noting that once this setup is available it will be possible to evaluate various technologies and materials and bench mark the process.

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

The first reviewer said basic research into the Second Law analysis is a good starting point but that sparse data limits the amount of feedback. The second reviewer observed that so far only the infrastructure has been set up; in the future, testing can benchmark various products including fuel mixes, new materials and exhaust control systems. The last reviewer, acknowledging the project's early stages, said it is unrealistic to expect 'significant' or 'excellent' progress to be evident.

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

"Collaboration with industry is very strong," one reviewer said. The second agreed, calling Caterpillar an excellent choice for an industrial partner. The third also noted this collaboration, terming the partnership with Caterpillar well-coordinated. But this reviewer said the ways in which other material suppliers are involved in the project is not explained. In this reviewer's view, a key question is "Who will be keeper of knowledge?" If the complete process chain is involved, he continued, then the knowledge is well disseminated. That isn't apt to be the case, in this reviewer's opinion, if Caterpillar is the sole industrial repository of knowledge gained from this project.

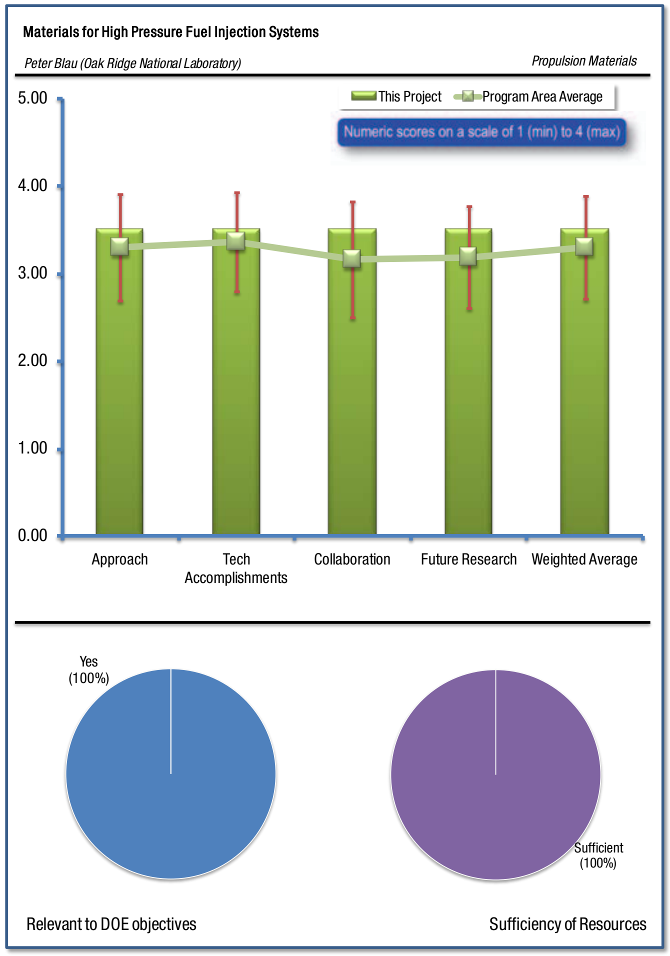
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Reviewers seemed implicitly to recognize that proposed future research was most significant in this relatively new project. Only two commented. One called future work "most critical" and anticipated that efficiency and material durability information would emerge from it. The second simply observed that the plan for testing is in progress.

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

"Resources are very strong," in the words of one of the two reviewers who commented. The second said funding for this project appears excessive relative to its likely payoff over and above that of the (apparently) closely related Project PM033, the small contribution that diesel-type biofuels are likely to make to petroleum displacement in the foreseeable future, and the project's brief duration.

Materials for High Pressure Fuel Injection Systems: Peter Blau (Oak Ridge National Laboratory)



REVIEWER SAMPLE SIZE

This project had a total of 2 reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVE OF PETROLEUM DISPLACEMENT? WHY OR WHY NOT?

Two reviewers acknowledged the connection between advanced diesel fuel injection systems and high-efficiency engines and, by extension, this project's relevance to DOE's petroleum conservation goal. One of these reviewers mentioned the need for new materials for increased fuel injection design pressures in high-efficiency engines. The other reviewer noted that the premise here seems to be that materials surrounding nozzle spray holes have to resist high pressure fatigue. And if materials are developed such that nozzles will not fail by fatigue (or clogging, shape changes, etc.), then fuel efficiency will be improved by 20%. The connection is tenuous (especially the 20% figure).[1] Certainly, if nozzles don't fail engines can continue to operate. If dimensional tolerances on holes are maintained, fuel can continue to be injected and engines continue to operate. However, the PIs need to do a better job to connect the lack of maintaining nozzle performance characteristics (which evidently is the key here) with petroleum displacement. The relevance they cite is all true (nozzles must resist changes in shape.) The issue here is the connection with petroleum displacement. This reviewer continued by saying that to give the PI the benefit of the doubt, certainly novel materials that would maintain injector parameters represents an enabling technology. So in that sense the project is relevant. Nonetheless, the PIs should make a stronger link to "petroleum displacement." The third reviewer's comment was simply that this is a continuing effort scheduled for completion in FY11.

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 characterized the approach as analytical, looking at looking at microstructures, residual stress, and fatigue studies for materials for fuel injector nozzles, and results were compared to current alloys. This reviewer deemed that a logical progression of research was depicted. Another stated that the approach taken is one of characterizing dimensional tolerances and microstructure of alloys, determining residual stresses, and carrying out fatigue studies. Again, the relevance of these activities to petroleum displacement should be better made. The indirect connection is understood but it should be the responsibility of the PI to make that connection. What was perhaps curious is that for all of the effort on materials testing and characterization of structural features, no effort is included to study the quality of the spray that is produced, and in particular how it might degrade by mechanisms that influence failure modes of the material. In the end it is the droplet parameters that control performance and this should be included in this study as well. It is hard to envision how a study of nozzles and associated materials issues can be separated from performance of sprays. The final comment was that the project appears to be on schedule and there are no apparent research barriers.

[1] DOE Note: This appears to be a misunderstanding on the reviewer's part. The 20% engine efficiency improvement goal is an overall goal of the Advanced Combustion Engine program; no single project is expected to achieve it. PM021 is one of several projects that support the goal of raising heavy-duty diesel engine efficiency from 42 to 50%.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer observed steady progress being shown on the work plan and noted the development by the project team of novel tools for sample preparation and testing approaches. Another said the quality of the work performed is good and the characterization of microstructural features is nicely done. What's lacking is how it all fits together, according to this reviewer. The PI was intent on showing all of the nice things that were done. In the end, one may still wonder "so what?" The connection to performance improvements should be strengthened, in particular showing how the fatigue testing will lead to petroleum reductions. The final review comment was that from the information provided in the briefing the project appears to be on schedule with no expected barriers to completion.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

"The collaboration with Caterpillar is very good," one reviewer said, and the emerging collaboration with CARTECH is also good. This reviewer recommended that collaboration be initiated with a manufacturer of atomizers (e.g., Parker-Hannefin, DeLaval, etc.). A second reviewer described a suitable team of government agencies, a large equipment manufacturer (Caterpillar) and a materials developer (Carpenter Technology Corporation). The last reviewer listed Caterpillar and ORNL as collaborators.

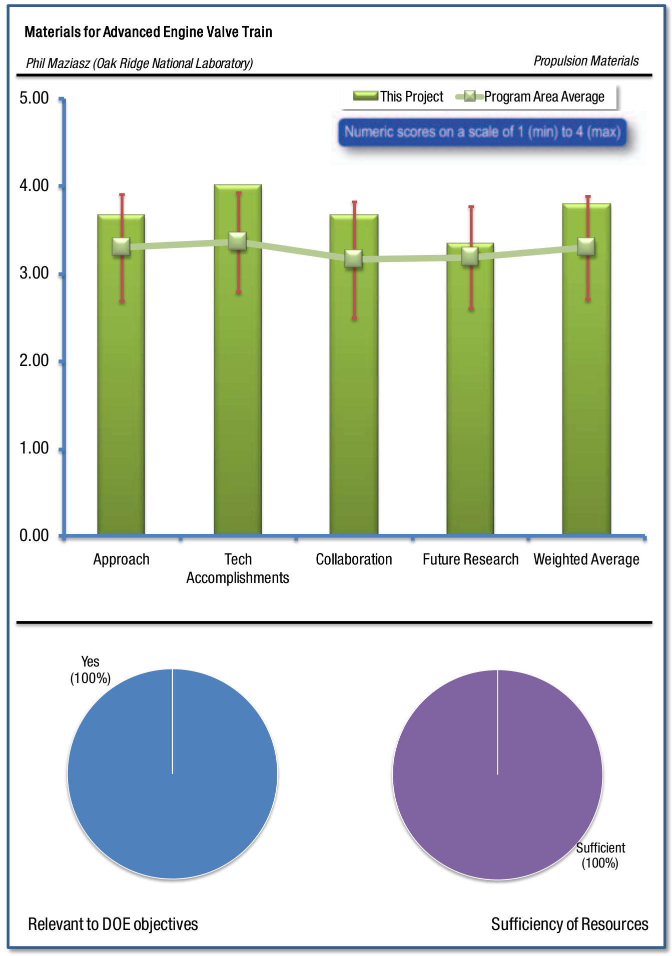
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

A reviewer termed the planned future work (extend the fatigue testing and include studies of crack nucleation) a logical expansion of the present work, also noting that some work remains in FY10 (fracture toughness and fatigue tests). A second suggested a path involving these items: "Continue through FY11, get the report, transition the research to CAT, and terminate the project." The future work may be summed up in the following way by the third reviewer: more of the same. It would be good for the PI to tell us why he thinks the proposed path of more fatigue testing and fracture measurements should be continued. Also, it would be appropriate to inform the reader what end point he is shooting for and how the proposed path of more testing will get him there.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Resources were deemed sufficient with excellent in-kind contributions by one reviewer. A second called resources adequate.

Materials for Advanced Engine Valve Train: Phil Maziasz (Oak Ridge National Laboratory)



REVIEWER SAMPLE SIZE

This project had a total of 3 reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVE OF PETROLEUM DISPLACEMENT? WHY OR WHY NOT?

All three reviewers seemed to agree on the relevance of this project to DOE's petroleum conservation goal. One said materials allowing higher combustion chamber temperatures will lead to reduced fuel consumption. Another noted that high-efficiency combustion creates challenges for existing valve materials, and the third observed that the project supports 2015 commercial engine goal (improve efficiency by 20% over 2009 baseline engine) in an apparent reference to the ACE program.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

Two of the three reviewers expressed opinions on the technical approach employed in this research. One said the approach is solid and the chosen direction is quite logical. He added that one factor not touched on in the presentation was the matter of valve material thermal conductivity. "Poor heat conductivity," he noted, "can in itself lead to higher temperatures. This can [counter any] gain in thermal resistance." The second reviewer said the program has implemented a sound technical approach to understanding the root cause of valve wear. This reviewer also noted that the approach should entail first identifying the cause of the failure and working with component suppliers, then formulating solutions to the problem. The third reviewer listed several aspects of the approach: characterized the root-causes of high temperature wear on engine and wear-rig tested standard valves and seats; worked with seat-insert supplier to modify and test seats with more wear resistance; identified Ni-based superalloys with more temperature capability than standard 31V alloy used for exhaust valves; and worked with valve supplier to obtain prototype valves and test specimens made from new superalloys with better high-temperature capability

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer said, "The program has identified the root cause of valve failure. They implemented a corrective action and validated their work on a test stand." He called the project well managed and noted it is working very closely with its industry partner. Another said results so far indicate that the goal will be met. Implementation on the market has a high probability. The third reviewer listed a series of accomplishments: addressed critical high-temperature wear issue between seat inserts and exhaust valves for diesel engines; identified root-cause microscopic nature of wear attack for both seat-inserts and exhaust valves; used pre-oxidation to mitigate wear on seat-inserts, and solution is ready for commercialization; and used critical knowledge to select and test Ni-based superalloys with more performance at higher temperatures to further mitigate wear

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

"The whole value chain is involved," said one reviewer. However, he went on, "there is not much evidence of interaction provided. Suppliers are involved as suppliers and not so much as partners." A second reviewer cited strong collaborations with the team's industry partner. The third reviewer said the project lead is working closely with Caterpillar, their valve seat supplier, and valve suppliers throughout the project.

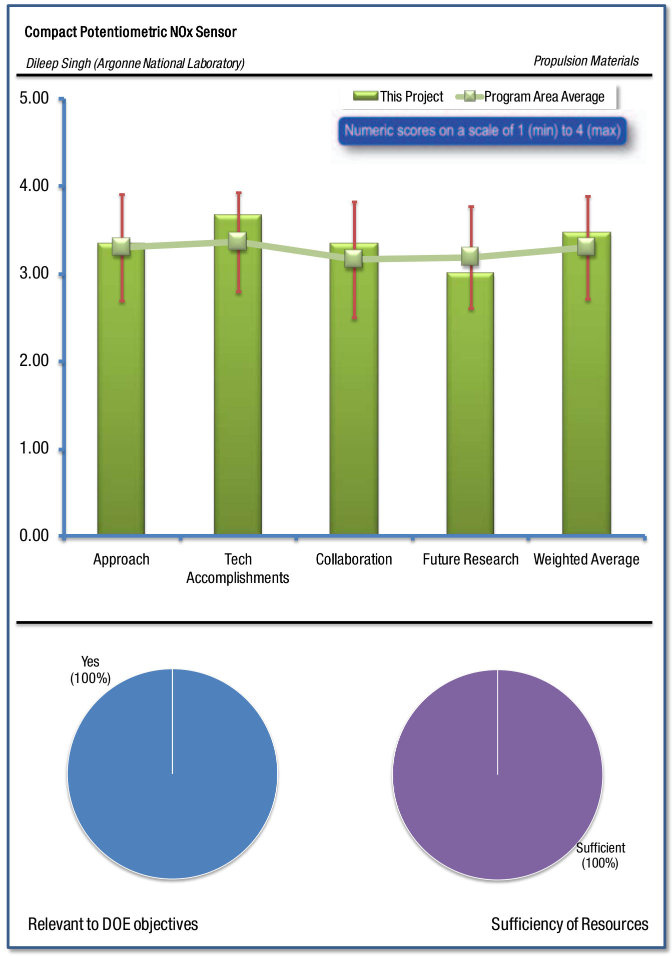
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

"This program seems to be set for a handoff to the industry partners," according to one reviewer, who noted that more materials are to be analyzed. Another noted its sharp focus in its final phase, and the likelihood that it would most likely finish successfully. The third reviewer reiterated the proposed future work from the presentation: Caterpillar will continue to rig-test new prototype valves, while ORNL will continue creep-test specimens of new Ni-based superalloys; tested prototype valves and creep specimens will then be characterized and analyzed at ORNL; and engine-tests of the durability of modified seat-inserts and upgraded exhaust valves will then lead to commercial production.

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

Comments included that the budget and results are in balance, and all deliverables met.

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



REVIEWER SAMPLE SIZE

This project had a total of 3 reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVE OF PETROLEUM DISPLACEMENT? WHY OR WHY NOT?

All three reviewers agreed on the relevance of this project to DOE's petroleum conservation goal. One called NO_x sensors "critical in emission control in diesel engines; without the sensors the energy efficient benefits of the diesel engines cannot be realized fully." A second, describing the goal of the project as development of a compact, reliable, inexpensive NO_x sensor that is amenable to mass production, said this will enable efficient combustion. The reviewer also said that the final goal is to optimize operation of vehicle combustion system that will increase fuel efficiency and reduce emissions. The third, using very similar words, said accurate, durable and economic exhaust gas composition sensors can enable close control of combustion, which can improve both engine fuel efficiency and environmental compliance. NO_x sensors, he went on, would be especially valuable in this regard, as NO_x is a key indicator of combustion behavior, a criteria pollutant and a key contributor to photochemical smog.

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 said basing the NO_x sensor on an oxygen sensor has an enhanced payoff. In this case, O_2 sensing is key to control of three-way catalyst emission control systems and NO_x sensing is also broadly applicable. Another reviewer was interested in technology(ies) in use for this purpose in Europe for NOx sensing and would have liked to have seen this topic addressed: this reviewer noted that the work is modifying the current sensor to measure NOx. The third reviewer quoted the approach description from the presentation: first develop a high-temperature oxygen sensor and subsequently modify it to sense NOx concurrently; sensor design is based on relatively simple and well-known electrochemical principles; develop high temperature plastic joining technology to join the YSZ sensor components to produce a leak–proof package; using appropriate filter(s) and sensing materials, modify the oxygen sensor such that NOx concentrations are measured; and conduct 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.

A reviewer listed the technical accomplishments as demonstrating the feasibility of the sensor technology and testing the sensor for performance. The other also listed accomplishments, highlighting these: based on YSZ ceramic, a basic sensor package design developed; using the sensor package design, an oxygen sensor with an internal reference developed and demonstrated; modifications made to the basic oxygen sensor design to sense NOx; modified oxygen sensor design has been demonstrated to sense NOx; and performance of NOx sensing has shown excellent sensitivity, resolution and long-term performance

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

"Various participants in the supply chain are involved," said one reviewer. A second reviewer cited "excellent collaborations" with three industry partners (Marathon Sensors, McDaniel Ceramics, and Integrated Fuel Technology).

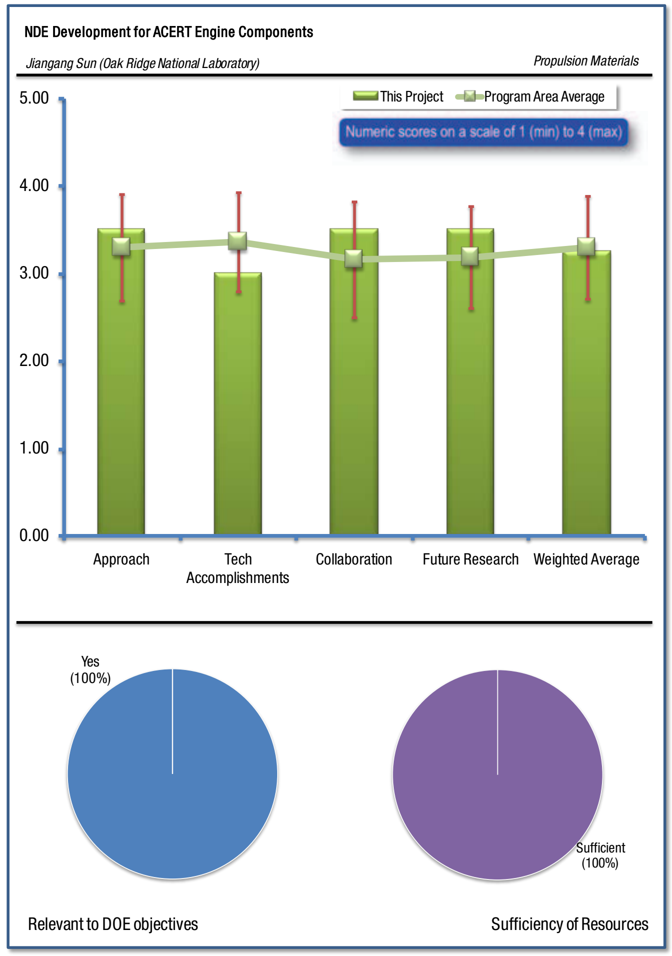
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

"Follow-on work on sensor development for other exhaust gas species is ambitious and potentially very valuable. Multi-species sensors could have specific applicability to unconventional combustion systems, particularly low-temperature combustion regimes," according to one reviewer. Another asked, "How long will it take to develop a new, electrically conducting ceramic? What is available in the market now?" The third reviewer listed future work: develop electrically conducting ceramics electrode and evaluate its electrical properties and joining characteristics with zirconia; include the ceramic electrode in the sensor package design and fabricate sensor; develop strategies to include CO and CO_2 sensing on the current sensor platform; initiate discussions with OEMs for technology demonstration and eventual transfer of technology; and need to study long-term durability of the sensor under field or engine operation conditions.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

No reviewer offered a comment on this question.

NDE Development for ACERT Engine Components: Jiangang Sun (Oak Ridge National Laboratory)



Reviewer Sample Size

This project had a total of 2 reviewers.

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

Two reviewers agreed that this project was at least indirectly relevant to the fuel conservation goal established by DOE. One said the work indirectly supports objective via development of rapid, nondestructive evaluations of surface properties of engine components. The other felt that the relevance here is one of being more of an enabling technology than a direct link to a process that can materially improve engine efficiency. NDE methods will always be valuable, provided they are accurate and easy to use. The focus here on developing NDE methods applicable to thermal management components, structural components, etc. is well placed. But the PIs should establish a greater link with petroleum displacement, and how much of a displacement, in their future work. The third reviewer pronounced himself unsure of the project's relevance. The reviewer read the entire briefing twice, coming to two different opinions on what the presenter intended to convey: 1) the project thrust is NDE development for Thermal Barrier Coatings or, the reviewer believes, paint for vehicle exhaust systems; or 2) the NDE is for a TBC internal to the exhaust system. The presentation needs to clearly indicate what a TBC is and what NDE is being considered to test that TBC.

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

The first reviewer stated that the team investigated current methods of nondestructive evaluations focusing on thermal barrier coatings. Efforts covered as-processed, thermally-cycled and engine-tested components. A variety of substrates and test methods were investigated. The second reviewer noted that they cannot argue the technical approach. Their confusion is probably in the definition of TBC. Technically, what TBC? Or will the NDE be so generic that it could be used to test any TBC? The final reviewer said that the PI includes this statement in his presentation: "By 2015, develop supporting materials technologies to improve heavy-duty engine efficiency to 50% while meeting emission standards (Goals from Multi-Year Program Plan)." However, this seems to be just a boilerplate statement lifted from another source. Precisely how the present study ties into this statement is not clearly developed in the proposal. In future presentations, the PIs should endeavor to draw connections with broader goals in a more logical way, showing how what they propose fit intimately with these broader goals. The approach based on thermal imaging and optical scanning methods is appropriate. The list of methods under development is impressive (applications for TBC damage evaluation, thermal property measurement, inspection). The methods include a laser backscattering system, optical coherence tomography, and thermal imaging. This is a lot. To assist evaluation, it would be preferable to focus on one in the presentation and provide details. As it stands, there is a lot of testing but where it leads is not clear. The rationale for the methodology is lost in the range of approaches being pursued simultaneously. The PI gives us a snapshot but the rationale is lost, and the reviewer is left with the thought of "what have we learned and how can the results be generalized?"

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer noted the development of test stands and fixtures, the thermal cycling of thermal barrier coatings and the optical and thermal imaging. The second stated he was able to offer no input, from the briefing. The third observed that a lot of testing is reported. However, interpretation of results was somewhat lacking. The PIs should step back and evaluate their own work. They should endeavor to extract cross-cutting principles from their observations. In the absence of doing this, what results from the approach is as collection of data that leads to uncertain conclusions, or no conclusions at all. Since 2007 when this project began, we have to evaluate what has been learned. The answer is elusive. Yet, the PIs have done some good work (e.g., a patent was issued in 2009 so there is substance to their work). They should also be encouraged to publish their work in journals as contrasted to conference proceedings where the latter is often of a lower standard and will not require as much thought in preparation. This effort will force them to scrutinize and critique their own work in greater detail.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

One reviewer said that the collaboration among ORNL, Cat and ANL is good, bringing together a range of relevant expertise. Collaborations with SUNY, Harvard and NASA, however, he felt are not described in detail: the PI mentions efforts in these collaborations to "evaluate and validate thermal imaging technologies for TBC characterizations and NDE," but where this would be done among those listed, who would do it and how the work would be paid for are not discussed. The substance is lacking. A second reviewer noted Caterpillar and ORNL as collaborators, as the technology is appropriate for only diesel engines at this time. They suggested another diesel engine builder (Cummins) as a possible collaborator, although he recognized that, as one of Caterpillar's competitors, it might not be an appropriate choice of industry collaborator. The reviewer asked if this is a test, could it be used industry-wide? And, should it be considered as a standard NDE test method by ASTM, etc.? The third reviewer deemed there to be a suitable team of partners and technology transfer collaborations. Partners include Caterpillar (industry) and Oak Ridge National Laboratory. Technology transfer is being assisted by Stony Brook, Harvard, and NASA to assist in evaluation of thermal imaging technologies for the barrier coatings.

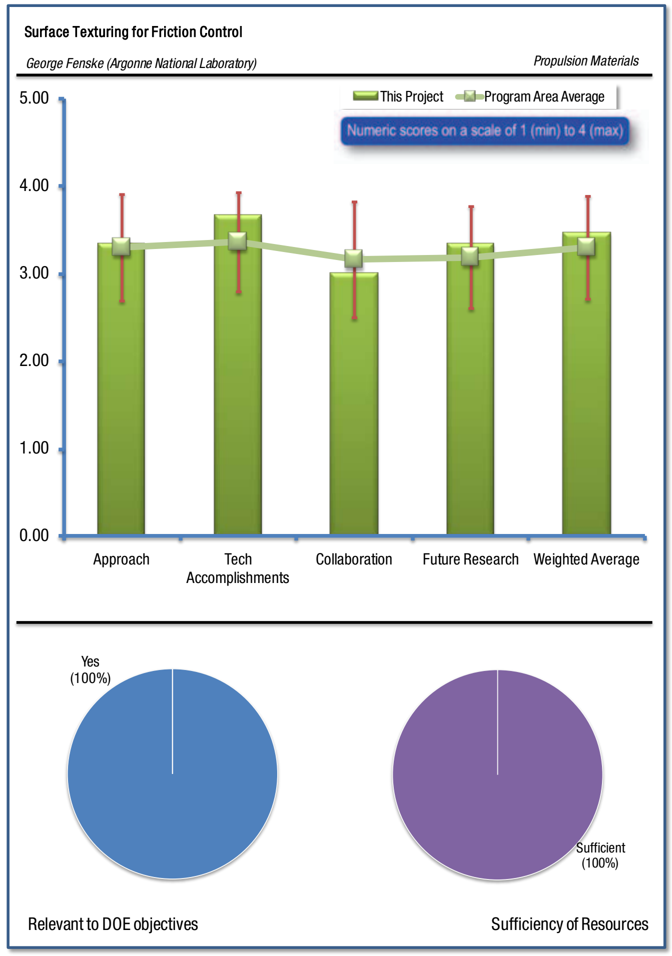
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The project plan, said one reviewer, suggests successful completion in FY2011. The second reviewer spoke about work that will continue with the thermal imaging methods and plans that are to develop X-ray and ultrasonic techniques to complement the thermal imaging. The third reviewer summed up the future work as "more of the same" (i.e., "Continue development of thermal imaging methods..."). The plan for the future is not well developed in terms of what it is going to lead to. The reviewer did not get a sense that much thought has been put into the future plan. For example, the PIs state they will "Investigate NDE methods for thermal recovery materials": are not they doing that already? If they want to "Develop x-ray and ultrasonic imaging methods for inspection of joint components," it seems that is what they have been doing for the past three years.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

Two reviewers essentially agreed that "the budget of $200,000 seems reasonable," as one put it, although he would have liked to see a financial contribution from the industry partners. The other reviewer regarded the funding as sufficient, and he, too, noted a lack of indicated cost sharing.

Surface Texturing for Friction Control: George Fenske (Argonne National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

All three reviewers stated their belief that the project is relevant to petroleum conservation, succinctly and in very similar language. One said: “Basic friction reduction improves vehicle and power train efficiencies.” The second said that basic friction reduction improves vehicle and powertrain efficiencies. The third observed that friction reduction will improve efficiency and translate to fuel savings and emission reduction.

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

The first reviewer observed that the set up offers a fundamental understanding of lubrication: the approach is logical for fundamental friction analysis. The second observed that the chosen approach is based on evaluating various surface texturing methods for given application. Since surface texturing is already in use, a more elaborate literature study should be integrated in the project to be able to build on already achieved results. It would also be an opportunity to take oil viscosity as a variable in this project. If a low viscosity oil provides sufficient lubrication, this in itself would lead to improved fuel efficiency without a reduction in frictional forces. The third reviewer listed several aspects of the approach: mechanistic study of the impact of surface texture will be studied by measuring lubricant fluid film thickness and friction under different lubrication regimes; application specific evaluation will be evaluated initially with appropriate bench top test rig. Eventually, component testing will be conducted on optimized textured surfaces; and the impact of surface texturing on basic tribological failure mechanisms will be evaluated using appropriate testing, surface and subsurface analysis and characterization.

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

One reviewer felt it was difficult to assess accomplishments and progress as the project is in its early stages. The second reviewer observed that the initial accomplishments are understanding where and why this surface preparation will reduce friction. The tests being conducted will help define the appropriate use of this surface preparation. The third reviewer listed a number of technical accomplishments: lubricant fluid film thickness measurement with optical interferometry; comparison of fluid film thickness for dimpled and undimpled surfaces; application specific journal bearing benchtop testing to assess application for engine main bearing; used a conformal block-on-ring contact configuration to measure friction for dimpled and undimpled steel ring sliding against conformal steel block; and surface texture (dimples) did showed reduced friction in conformal journal bearing contact configuration test.

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

Two reviewers each said the only collaboration was with Northwestern University (one noting specifically that the work is on vibro-mechanical method of surface texturing with dimple) and both urged wider collaboration be sought, one suggesting industries for potential real-world applications. The third reviewer said that this program is fundamental science and the collaborators are mostly universities.

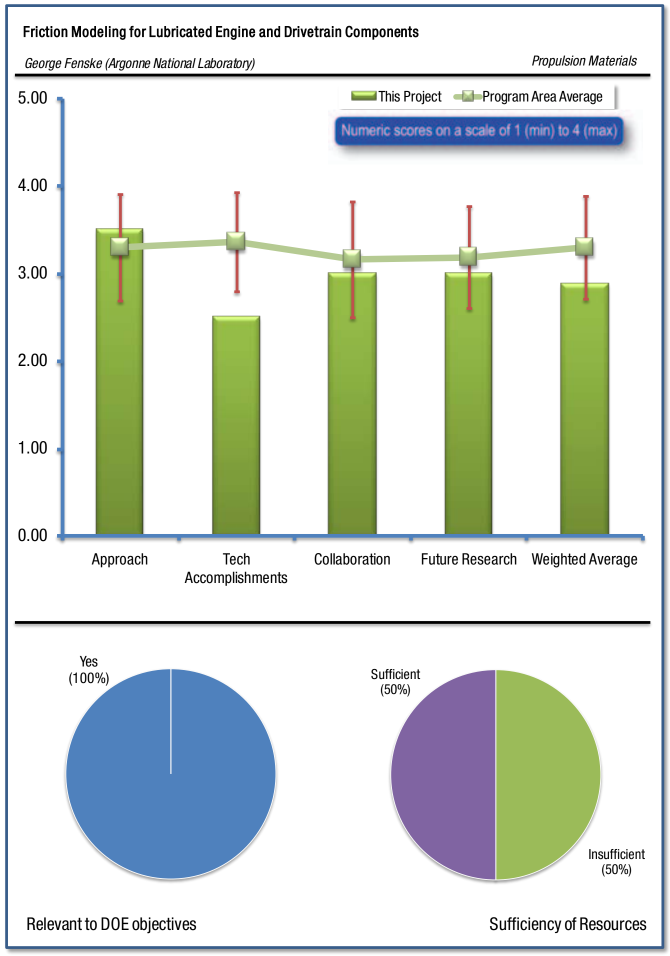
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said proposed future work would be outstanding when a clear picture of the state of the art was given. The second said the future work will identify technology optimization and its limitations. The third listed aspects of the future work: continue application specific tribological performance testing of textured surfaces; evaluate the impact of surface texturing on the various tribological failure mechanisms (scuffing, wear, contact fatigue, etc); evaluate the impact of surface texturing on the actions of lubricant additives in formation of tribochemical boundary films; and explore various methods and forms of surface texturing for tribological performance enhancement. This reviewer suggested that the team needs to explore potential applications in industries.

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

Two reviewers said the budget, respectively, was appropriate and, given that it was a new project, the initial funding of $200,000 should be adequate. The other reviewer's comment was that most goals were met.

Friction Modeling for Lubricated Engine and Drivetrain Components: George Fenske (Argonne National Laboratory)



Reviewer Sample Size

This project had a total of 2 reviewers.

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

The reviewers generally agreed on the support of this work to DOE objectives. Engine and drivetrain friction is a major (and poorly understood) contributor to energy losses and hence a potentially lucrative area for mechanical efficiency improvement. This would have direct benefits in fuel consumption reduction. Heretofore, driveline friction reduction has depended on straightforward manipulation of hydrodynamic lubrication conditions (e.g., reduced-viscosity engine oils). Understanding of boundary and mixed-film lubrication has lagged behind. The second reviewer said that friction is one of the major contributors to the reduced efficiency (others being drag and low temperature operation); understanding the friction will benefit by providing pathways to overcome this problem.

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 called the project goal ambitious, but said the approach was excellent. The other said the significance of the project goal is well explained. He went on, however, to inquire about the current state of knowledge. Friction has been studied for a long time and many theories and models exist; what is the significance of this particular approach?

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

One reviewer felt it would be unrealistic to expect significant technical accomplishments, given that the project was in its early stages at the time the presentation was made. The other reviewer, acknowledging the difficulty of modeling a mixed mode since data is not available to validate predictions, felt it would be beneficial if efforts are made to confirm the model.

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

The first reviewer could not find fault with the choice of Castrol as an industrial partner in this project. However, driveline tribology has received significant attention in the past decade or two. There must be firms with the specialized background experience and analytical capability to assist this project. Have any been sought out and their interest in collaborating solicited? The second reviewer noted that a material supplier and university are involved.

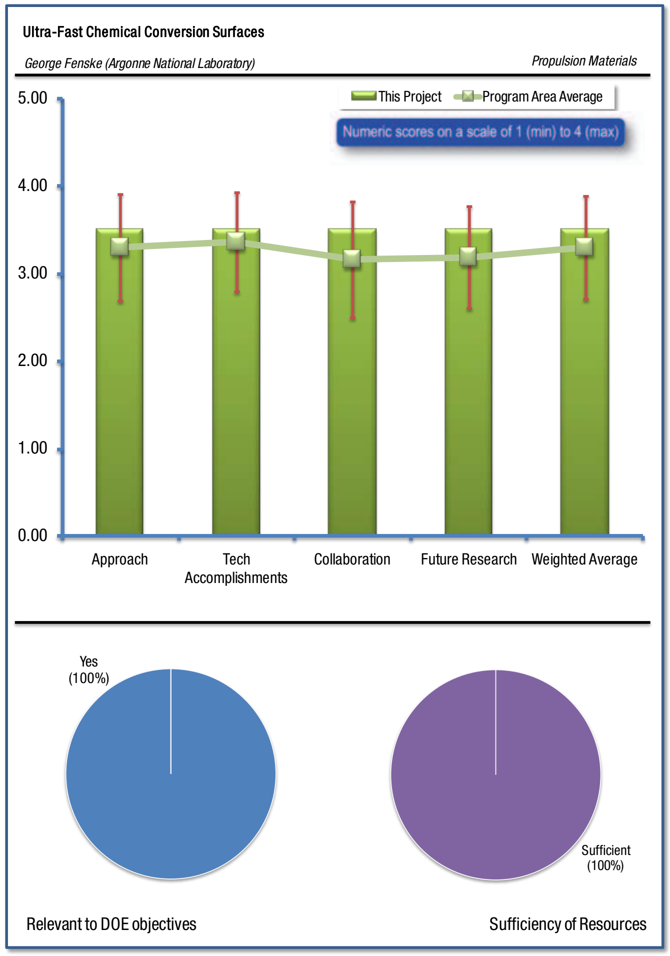
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

Only one reviewer offered an opinion on this question, saying development of test protocols is a good idea.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

In this review category, too, a single reviewer commented, to the effect that “This appears to be a rather modestly funded project in view of its potential payoff.”

Ultra-Fast Chemical Conversion Surfaces: George Fenske (Argonne National Laboratory)



REVIEWER SAMPLE SIZE

This project had a total of 2 reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVE OF PETROLEUM DISPLACEMENT? WHY OR WHY NOT?

Only one of this project's two reviewers commented, saying the project indirectly supports objective by developing higher-durability and lubricity components that can operate under severe operating conditions.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

"The approach includes go/no go decision points, which is an excellent idea," according to one reviewer. He added, "Approach is a step-wise progression of process optimization/lab studies." The other reviewer said that if the work is successful, this may have direct applicability to an end item and the consumer market. From purely a business viewpoint, any increase in durability results in a corresponding increase in the item service life and an indirect increase in overall cost of the end item. The recommendation is to focus on one or several specific items that could benefit from such a process. The concept is to improve specific item durability while holding costs.

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

One reviewer noted that the researchers were able to boride complex geometry parts with coatings twice as hard as carburized/nitride surfaces. Excellent wear test results were achieved versus uncoated specimens. This is good precursor work. The second reviewer wondered if the boriding process could be scaled up for mass item production, noting that no information was included in the presentation on this subject. The reviewer also noted that the collaboration slide indicates boriding examples for engine parts. Could the boriding process be used for other vehicle applications; i.e., brake pistons, brake shoes, or brake drums? The question is intended to increase brake service life.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

The project partners were characterized by one reviewer as a "quality team that includes Bodycote North America, Burgess-Norton, Mahle and NASA." The other reviewer mentioned several private industry organizations and NASA participating in this effort.

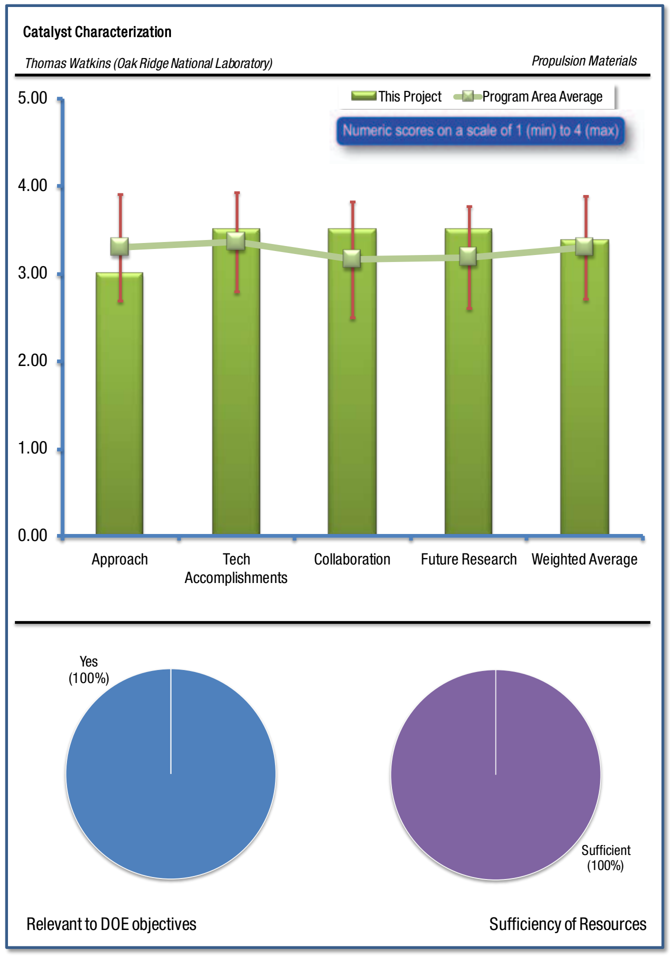
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

The project demonstrated very thick and hard borided layers on test engine parts, according to the first reviewer. The project is currently on a five year timeline. Due to early boriding successes, there is potential for project acceleration. This commenter suggests a project review with the intent of accelerating this effort. The second reviewer anticipates initiating boriding of actual engine components – a good next step. Also, the focus on developing quality control will aid in deployment of the technology.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

A reviewer felt the project funding appears sufficient for the project milestones. If the project is accelerated, there could be a project savings in the last research year. The other reviewer noted the 25% contractor cost share and said the project looks on target.

Catalyst Characterization: Thomas Watkins (Oak Ridge National Laboratory)



Reviewer Sample Size

This project had a total of 2 reviewers.

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

The two reviewers commenting on this aspect of the project seemed to believe it relevant, at least indirectly, and with some qualifications. One said that more efficient catalysts can lead to improved efficiency. At the beginning of this project in 2002, this was certainly true. After eight years this may not be so clear anymore. A reflection on this is needed. This reviewer also said, however, that the project focus was on ammonia slip and that efficient ammonia decomposition would allow for a higher urea dosing level, making the SCR more efficient. The reviewer noted that for the operator, urea is also a part of the cost of ownership; this should also be considered. The second reviewer observed that lean burn engines generally will require the use of an SCR and perhaps a DPF. Some control processes such as DPF regeneration may cause the stored ammonia on the SCR to prematurely release. At this time ammonia is not regulated, but ammonia release would certainly be regulated if widespread slip was encountered.

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?

In the first commenter's view, this program is set up to provide the material understanding associated with ammonia slip catalysts: this basic knowledge will be critical in designing these catalysts in the future. The second reviewer said that the study of the AMOX material in various stages of degeneration is a good approach to define a life prediction model, but how to come to an improvement is not well described.

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

One reviewer, acknowledging the delay in materials deliveries through 2009 (due to the 2010 heavy-duty engine product launch), said "progress this year is good." The other said that X-ray photoelectron spectroscopy seems to be a good tool to analyze the ammonia slip catalysts. Analyzing the catalyst coatings will help identify changes associated with aging. Ultimately this should lead to a better understanding of the catalyst formulations.

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

"Collaboration with partners seems strong," said one reviewer. The other agreed, saying there is a close cooperation with industry.

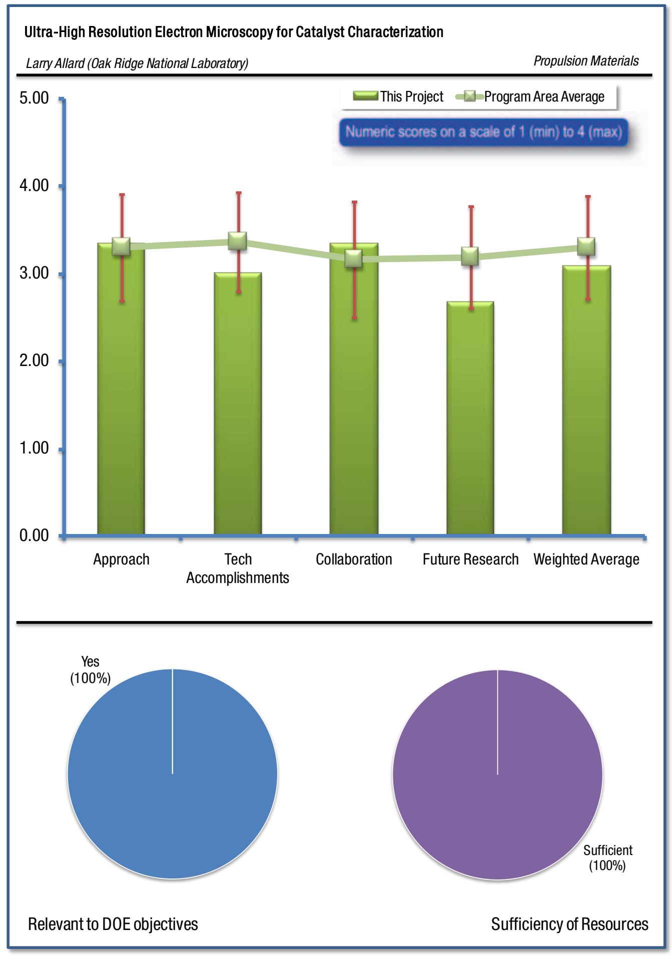
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

One reviewer said, "The focus looks appropriate," and called future work toward understanding catalyst aging mechanisms "critical." Proposed future research builds on past work, the other said, but a clearer statement on the way toward improved performance of the materials is lacking.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The first reviewer stated the project is meeting goals: the second offered that the mentioned budget must be sufficient for the mentioned deliverables in 2010.

Ultra-High Resolution Electron Microscopy for Catalyst Characterization: Larry Allard (Oak Ridge National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

The first reviewer said that catalysis is helpful in reducing the harmful emissions in diesel engines; understanding the reaction will help in developing new materials for catalytic converters. The second noted that catalysts are in universal use for engine exhaust aftertreatment and their advent is critical to permitting engine calibrations that optimize fuel consumption. Catalysts are also crucial to the practicality of fuel cells and to fuel processing and refinement. All these attributes contribute strongly to making catalysts crucial to petroleum displacement. The third offered a tentative yes to supporting of objectives, but PI should be clear on the applicability of this research to the stated goal. Assume new high efficiency engines operate in a regime harsher than current catalysts.

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

The approach was termed outstanding by one reviewer, referring to the use of electron microscopy to elucidate catalytic processes that take place at the atomic level. The second reviewer said, "This is a characterization project and the approach is good." This reviewer also highlighted the fact that new test methods and infrastructure are being developed to study catalytic reaction in-situ. The third reviewer, noting the equipment acquisitions of the lead organization, said the approach struck him as "a solution set looking for a problem via analysis of catalysts. The PI should be clearer in his methodology and rationale."

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

Two reviewers commented. One cited the building and commissioning of instruments to study the reactions and various additions to the microscope and their readiness for use. The other reviewer said the team has made progress in holder and other apparatus developments.

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

Slate of academic, institutional and industrial collaborators is extensive, according to the first reviewer, suggesting that collaboration and coordination are good to outstanding. Presentation, however, provides insufficient information on breakdown of project responsibilities among collaborators to permit an "outstanding" rating. The second comment was that there was a wide stable of academic, industry and other government agencies in the collaborations. The final review comment was that basic researchers from universities, federal labs as well as applied personal from industries are involved in the project.

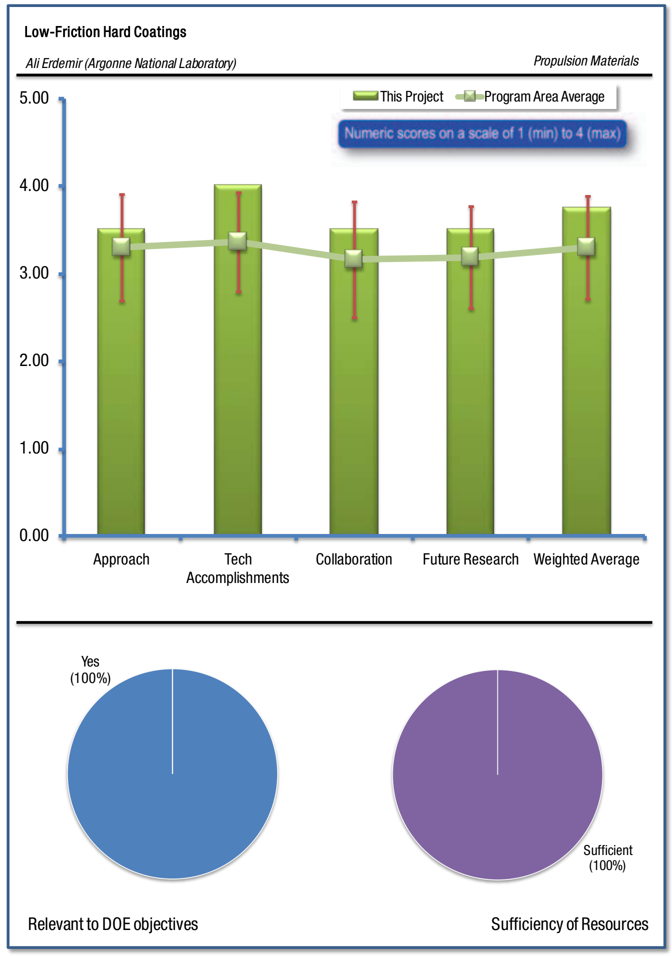
QUESTION 5: HAS THE PROJECT EFFECTIVELY PLANNED ITS FUTURE WORK IN A LOGICAL MANNER BY INCORPORATING APPROPRIATE DECISION POINTS, CONSIDERING BARRIERS TO THE REALIZATION OF THE PROPOSED TECHNOLOGY, AND, WHEN SENSIBLE, MITIGATING RISK BY PROVIDING ALTERNATE DEVELOPMENT PATHWAYS?

Only one reviewer commented on this question. The program will continue with its development of in situ gas reaction and double-tilt heating capabilities for catalyst reaction studies. The team will initiate work with some more industry partners, which is advisable.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

The sole comment was that there was some cost sharing, but the reviewer did not know if the equipment budget is sufficiently large on this effort to displace scientific and technical lab personnel.

Low-Friction Hard Coatings: Ali Erdemir (Argonne National Laboratory)



Reviewer Sample Size

This project had a total of 2 reviewers.

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

The two reviewers agreed the project is relevant to DOE goals, but one termed it "a continuing project with direct industry and DOE relevance "and the other felt it "indirectly supports objective by increasing durability and performance of high-efficiency engines." The latter commenter said that the PI should be clearer in stating how this project supports the goal.

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

Concerning the approach, only one reviewer offered a comment, commending the "good use of go/no go gates" and a "logical progression of feasibility tests leading up to field studies/durability analyses and full-scale production investigation."

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

One reviewer noted that private industry is pursuing licensing agreements for commercial scale-up and production, observing the work has direct industry applications. The other stated, "Excellent accomplishments so far; won R&D award and work is underway to commercialize the technology."

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

"Well-balanced team of government, industry and original equipment manufacturers and parts suppliers," was one reviewer's assessment of collaboration and coordination with other institutions. The other noted that "Two private industry companies are interested in licensing from Argonne."

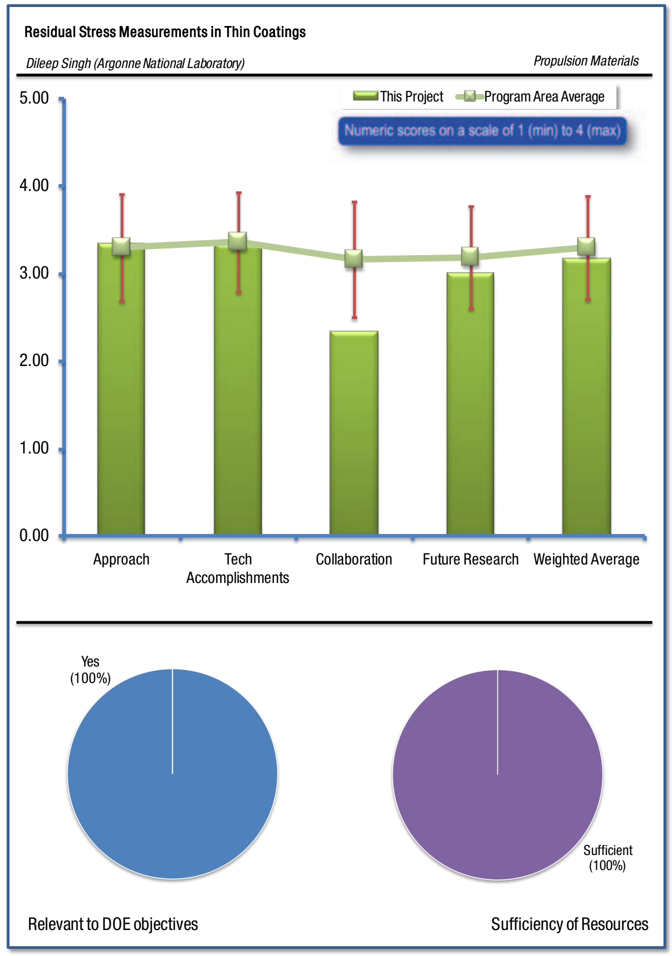
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer considered that future work builds upon initial success and will continue development with performance evaluation in fired engines. He also cited plans to reduce production costs by reducing coating thickness. The second reviewer notes that the briefing suggests the validation of optimized coating durability and performance under fired conditions and piston ring product specific bench top and field studies in a fired engine could be combined or accelerated. Is this possible?

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

A single reviewer commented on this question, saying the effort has shown good progress with a smaller amount of funding than usual for these projects. He was unsure of cost sharing, noting indications in the presentation that the team is getting some in-kind equipment from a manufacturer.

Residual Stress Measurements in Thin Coatings: Dileep Singh (Argonne National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

All reviewers agreed that this project supports and is relevant to DOE's petroleum conservation goal. A reviewer stated that this topic reduces petroleum use by reducing friction. Another observed that internal friction within the drive train of a vehicle contributes significantly to the fuel consumption. So the development of low frictions coatings is beneficial for fuel consumption. For the automotive industry reliability is important so control of quality is important; this project will contribute to this. The final reviewer said that the purpose of this project is to develop and measure depth-resolved residual stress in thin coatings to extend component life and reduce life-cycle costs. The final goal is to minimize friction and wear in vehicle drive trains and engine components that can significantly reduce parasitic energy losses, and consequently, will result in petroleum displacement.

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

"High-energy X-ray looks like a good tool to evaluate super-hard coatings," one reviewer said, adding that "process of evaluating and testing these coatings will give the techniques value with [the] vehicle industry." A second reviewer termed the approach straightforward; however, it looks that new technology has entered the project as progress is missing on the FIB experiments. The third reviewer enumerated several aspects of the approach: develop/refine high energy x-rays for profiling residual strains in thin coatings by measuring the change in the lattice parameter of the coating constituents; deposit low friction high wear resistance coatings and profile residual stresses; develop scratch-based techniques to measure hardness, fracture toughness, and adhesion energy of thin coatings; and relate residual stresses, mechanical & tribological properties, and processing to coating durability Develop scratch-based techniques to measure hardness, fracture toughness, and adhesion energy of thin coatings.

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

One reviewer acknowledged the milestones listed in the presentation: X-ray based techniques developed and applied for residual stress measurements; stresses correlated to processing conditions (deposition rates, power and time) for MoCuN, TiC, and ZrN coatings; adhesion energy for MoCuN coated samples measured; and nano-indentation technique has been demonstrated for characterization of coating. Another cited building the evaluation techniques to examine material coatings as being able to generate positive feedback from industry. Understanding adhesion energies will truly assist in the development of low friction coatings. One of the most important issues is a good correlation between de measured residual stresses and the tribological performance, according to the last reviewer. Once a good correlation is created it is clear that the barriers are overcome.

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

There doesn't seem to be strong collaboration with the coating community yet, in the first reviewer's opinion. However, the basic science is good which should produce more external interest. The second reviewer listed working with Borg Warner, Galleon International, and Hauzer Techno Coatings, Inc. as his response. The third reviewer said discussions have to start with industrial partners to collaborate, as is mentioned in the presentation. This was also mentioned in the 2009 presentation, so little progress is made.

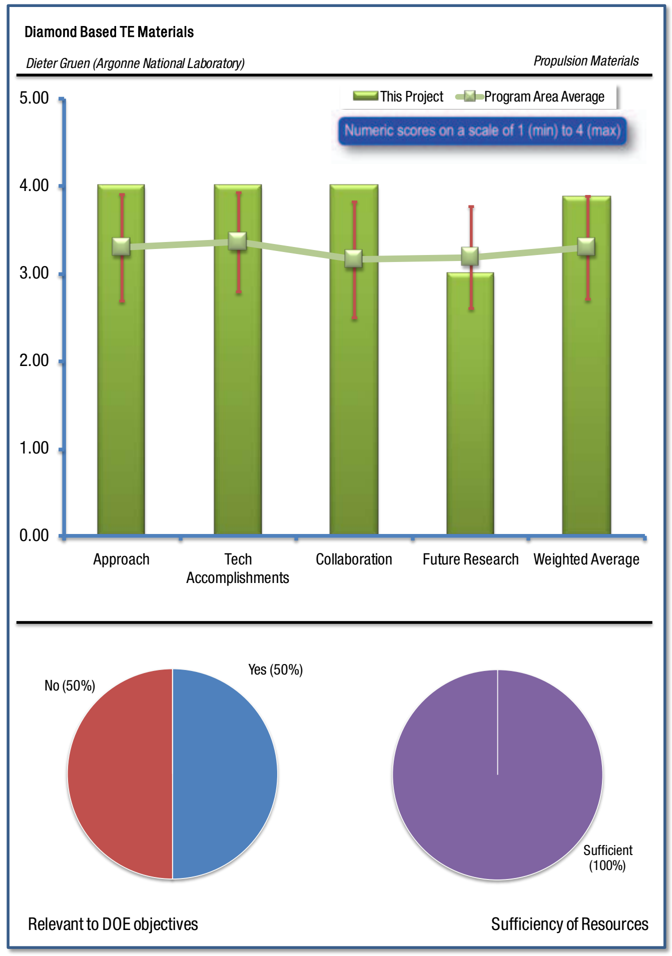
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

The future work plan is good, one reviewer said, but more industry input is needed to direct developed techniques to the most promising low-friction coatings. A second reviewer agreed in part, citing a clear, defined path forward building on past achievements. The third reviewer listed several points regarding the future work: complete adhesion energy evaluations for TiC and ZrN; complete mechanical properties of TiC and ZrN coated samples for varying processing conditions; measure tribological performance for MoCuN, TiC, and ZrN coated samples; correlate the measured residual stresses in MoCuN, ZrN, TiC coatings to tribological properties and processing; and initiate discussions with coating manufacturers for collaboration. This reviewer said the team needs to explore industrial applications of the NDE method and coating system developed

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

Only one reviewer spoke specifically to this question, saying "$200,000 seems adequate for the development work." Another found "no specific information was provided." The third said the project plan is on track.

Diamond Based TE Materials: Dieter Gruen (Argonne National Laboratory)



Reviewer Sample Size

This project had a total of 2 reviewers.

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

One reviewer noted that thermoelectrics can be used for recovery of waste heat and result in increased efficiency. However, the other reviewer, who viewed the presentation slides without hearing the presentation or the following discussion, felt that other than a general statement of supporting DOE goals, the briefing does not indicate any direct applicability to an end item or consumer requirement. As written, this briefing suggests a continuing basic research program potentially increasing the knowledge base. The briefing needs a clear goal of support to the consumer. The accomplishments all tend to support a very basic, in-house research program investigating the fundamentals of this 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?

One reviewer felt there was insufficient detail in the presentation to permit an evaluation of the project work approach. He suspected this was due to the confidentiality requirements of a CRADA and suggested a direct conversation with the researcher. The second reviewer, on the other hand, praised a robust program that includes environmentally benign materials, in-house fabrications and research complemented by theoretical calculations.

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

One reviewer acknowledged impressive increases in thermoelectric performance and development of in-house fabrication and test methods. The second reviewer said the accomplishments all appear to be in-house without direct consumer application.

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

In response to this question, one of the two reviewers noted the wide spectrum among team participants of government agencies, international, academic and industry. The other reviewer was under the impression the project elicited only academic interest with no private industry participation.

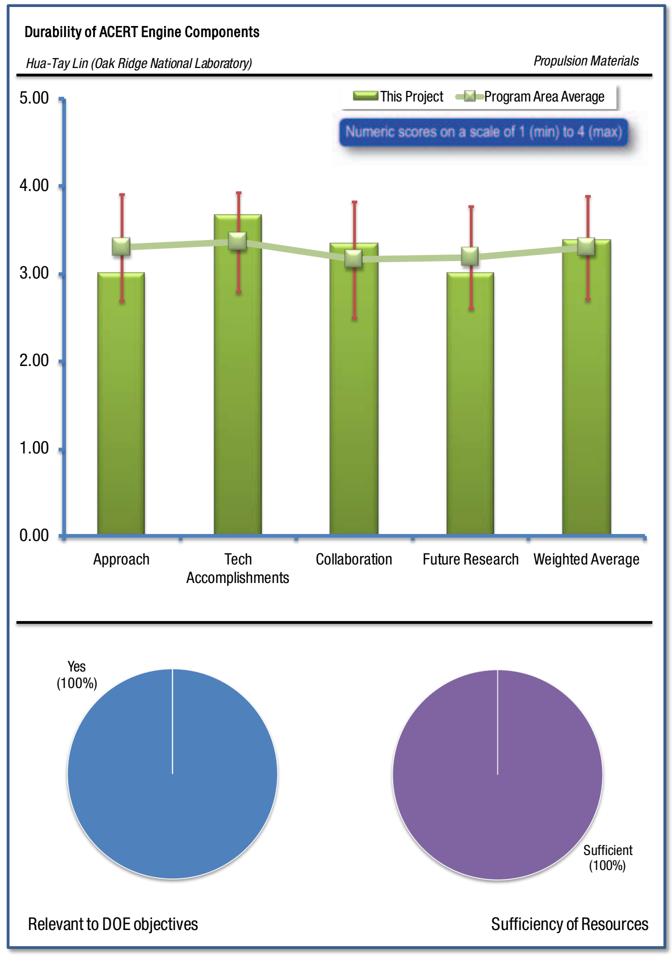
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer felt there was insufficient information for comment, but observed that the presentation materials suggest this project is either exploring areas not previously researched or is exploring a related or variation of an existing subject. If the former, this reviewer will agree on the need for a firm scientific foundation before proceeding to prototyping, manufacturing, etc. If the latter, better focus on the consumer is needed. The other noted that the work is almost completed, but the team will continue to seek to increase the Seebeck coefficient by exploiting compositional changes and new fabrication techniques.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

One reviewer deemed the project resources sufficient, while calling for the project to be focused and a project plan to be developed with definite deliverables and termination date. The other reviewer said the project was almost complete.

Durability of ACERT Engine Components: Hua-Tay Lin (Oak Ridge National Laboratory)



Reviewer Sample Size

This project had a total of 3 reviewers.

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

All three reviewers deemed this project relevant to the DOE petroleum conservation goal. The first noted that reducing high-temperature heat losses from heavy-duty diesel engines is a straightforward means of improving their fuel efficiency (provided the energy thus saved can be effectively used). The so-called "adiabatic engine" is a long-regarded goal. The second said that allowing for higher temperatures in general leads to higher fuel efficiency. In case of the exhaust, higher temperature gases provide more energy to the turbo, making it more efficient. Testing and characterizing materials for diesel engine components will provide valuable information for improving the energy efficiency, said the third reviewer.

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

The approach employed in this work is good to very good, in the first commenter's view. It is practical and logical and, given time, seems likely to result in a clear understanding of how durable and effective thermal barrier coatings can be applied, qualified and evaluated. To the second reviewer, the benchmarking of various valves and materials is good and will provide data for future development. The third comment was that the work had a solid approach. The strong point is the validation in the engine. Coatings can fail due to residual stresses as a result of the manufacturing process. Based on the provided information, no investigations are done in this direction. This information can be important to assess the robustness of the process.

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

One reviewer cited the excellent progress made in application of the coating in the exhaust manifold. Good progress is reported in the field of TiAl. The findings may prove essential for defining next steps. The other reviewer commenting echoed this prediction: "The information generated will provide the database for future material and component development. Various aspects such as material, design and process can be evaluated in the test bed."

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

"The choice of Caterpillar as industry partner is commendable," said one reviewer, "Cat has lengthy experience in this area (engine heat loss control). The ACERT engine, with its series turbochargers, should be responsive to reduced exhaust heat losses." Based on researchers' responses to questions posed at last year's Annual Merit Review, a second reviewer said "there is evidence for involvement of a great number of parties active in the field." The third reviewer's comments noted mention of the fact that products from various Tier 1 and Tier 2 suppliers are being tested, however the mechanism of disseminating the knowledge to them is not mentioned. If all the information will stay with Caterpillar, it may confer an undue advantage.

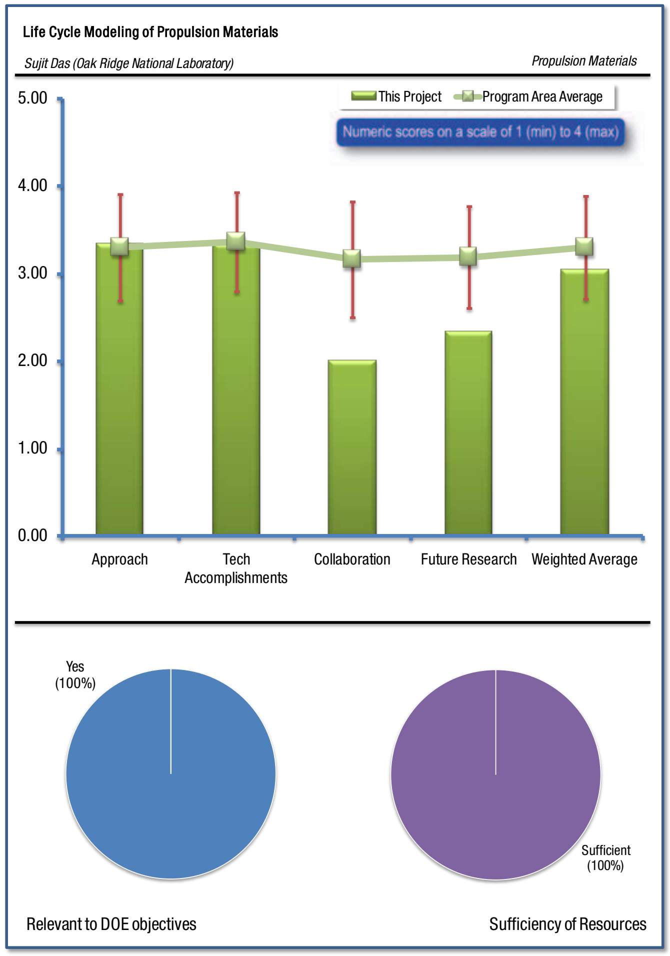
Question 5: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways?

One reviewer said the description of future work could be more specific, but nonetheless the proposed activities build on the progress mentioned in the presentation.

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

Funding is probably sufficient, one reviewer said, but contract duration may be insufficient to achieve maximum results. The second reviewer offering a comment on this question felt the project resources were sufficient for the materials investigation, but field testing will be challenging for the budget mentioned.

Life Cycle Modeling of Propulsion Materials: Sujit Das (Oak Ridge National Laboratory)



REVIEWER SAMPLE SIZE

This project had a total of 3 reviewers.

QUESTION 1: DOES THIS PROJECT SUPPORT THE OVERALL DOE OBJECTIVE OF PETROLEUM DISPLACEMENT? WHY OR WHY NOT?

One comment was that lightweight materials are an important component in reducing mass and petroleum consumption. Improving material cost also assists industry to sell new technologies. The second was increased heat resistance allows for higher exhaust temperatures. This opens the potential for further improvements of fuel efficiency. This potential is not mentioned; only weight savings are mentioned. However, it is a marginal contribution. The final reviewer stated that the work was to estimate the cost-effectiveness of the CF8C+ cast austenitic stainless steel in automotive applications.

QUESTION 2: WHAT IS YOUR ASSESSMENT OF THE APPROACH TO PERFORMING THE WORK? TO WHAT DEGREE ARE TECHNICAL BARRIERS ADDRESSED? IS THE PROJECT WELL-DESIGNED, FEASIBLE, AND INTEGRATED WITH OTHER EFFORTS?

One reviewer said, "Completely analyzing the cost effectiveness of CF8C+ through the entire useful life is an excellent example of truly understanding the total cost of this new material." He went on: "Evaluating this material against its alternatives shows the effectiveness of this product. Correlating the material costs to fuel savings brings the overall point home." The second reviewer said the approach "in itself is straightforward. The amount of information provided to assess the cost efficiency is limited. It should be mentioned what the expected fuel savings are." The final reviewer listed several aspects of the approach: cost-effectiveness estimation based on a range of competing, corrosion-resistant stainless steel and nickel-base superalloys currently used in applications where CF8C+ might be used; and analysis level considered both material (per pound replacement basis) and specific component application (addressing manufacturing differences)

QUESTION 3: CHARACTERIZE YOUR UNDERSTANDING OF THE TECHNICAL ACCOMPLISHMENTS AND PROGRESS TOWARD OVERALL PROJECT AND DOE GOALS.

Review comments included that evaluating this material against its alternatives shows the effectiveness of this product. Correlating the material costs to fuel savings brings the overall point home. Also stated was that the weight savings are limited. The total potential of the material must be stated to get a better insight in the potential gains. Also temperature limitations for mentioned alternative materials must be made clearer in the presentations. The final reviewer listed accomplishments: life cycle modeling of advanced propulsion materials was undertaken with an initial first-year effort determining cost-effectiveness of CF8C+ cast austenitic stainless steel; CF8C+ has been demonstrated successful in several high-temperature applications and so a life cycle assessment in terms of energy, economic, and environmental is consequential; and several analysis levels were considered, starting with raw material cost and ending with component cost with due consideration of fuel savings due to lightweighting.

QUESTION 4: WHAT IS YOUR ASSESSMENT OF THE LEVEL OF COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS?

Two reviewers said no collaboration was identified and that not much collaborating with industry was evident, respectively. The third mentioned having seen Caterpillar mentioned in earlier reviews.

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 said the proposed future work mentions other materials as potential weight-saving materials, but these materials are not foreseen for the applications mentioned for the material CF8FC+. This could lead to a loss of focus. The other reviewer offering an opinion said "Close-out plan is set up to provide industry with the results they would need to continue the development of this material." The third reviewer listed future work: energy savings analysis of CF8C+ cast austenitic stainless steel—ongoing; life cycle analysis of engine lightweighting in terms of downsizing vs. lightweight materials use—ongoing; liability of advanced propulsion materials in advanced powertrains such as hybrids and fuel cell vehicles; economic, energy, and environmental impact analyses from a life cycle perspective of advanced propulsion materials manufacturing technologies with an emphasis on aluminum, magnesium, titanium, and ceramics; and advanced propulsion materials' potential in heavy-duty vehicles.

QUESTION 6: HOW SUFFICIENT ARE THE RESOURCES FOR THE PROJECT TO ACHIEVE THE STATED MILESTONES IN A TIMELY FASHION?

"Resources should be sufficient for finalizing the study objective" was the sole relevant comment. Another comment offered was that the program plans look to be on target.