12. Propulsion Materials

Introduction

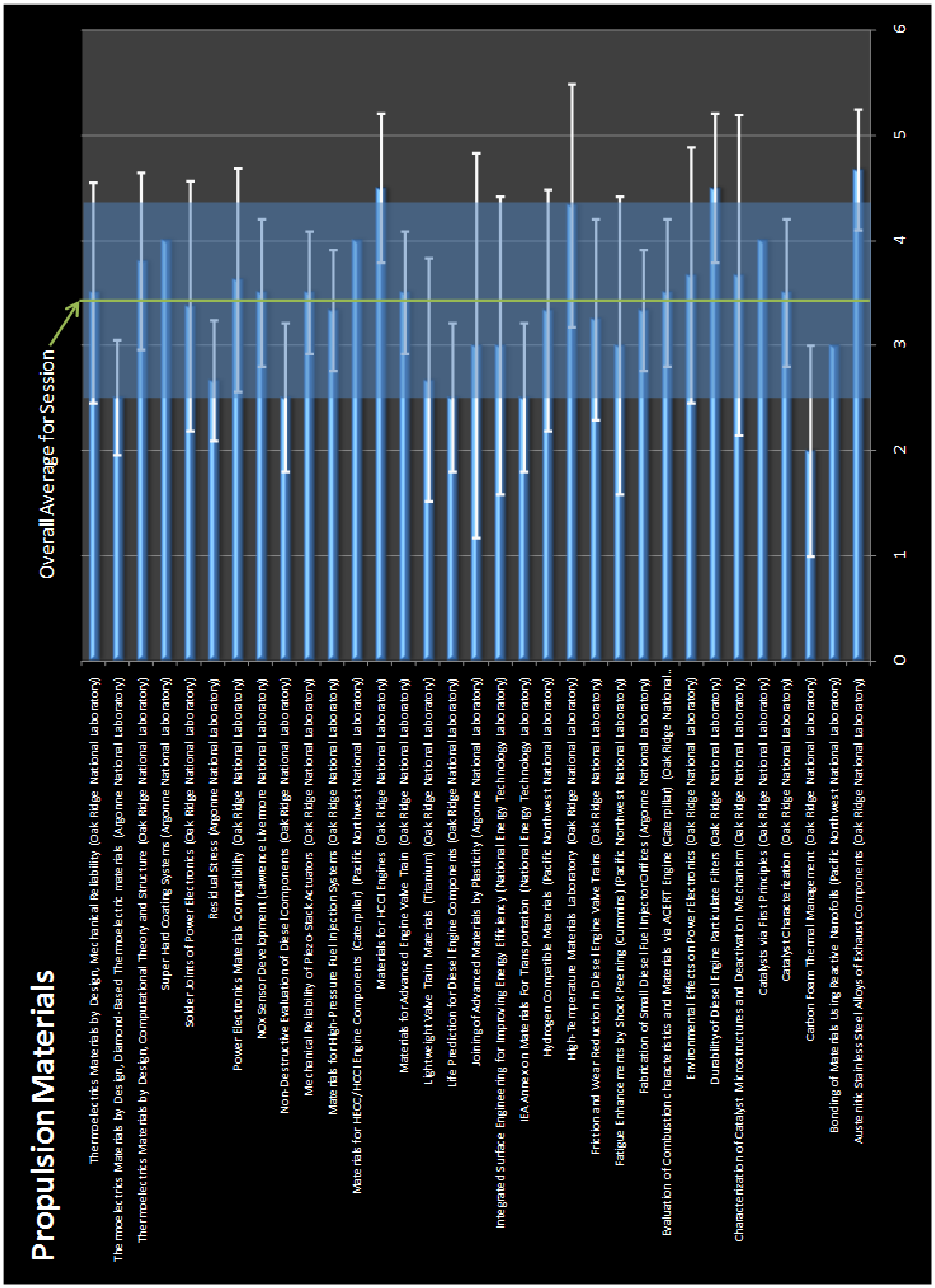
Propulsion materials research is critical to bringing advanced high-efficiency powertrains to the marketplace. The use of innovative materials in specialized applications throughout the powertrain can help to improve system efficiency and reduce emissions. Applications include engines, electrical drive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

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

Page	Project Title and Principal Investigator	Project Average Score	Project Score Standard Deviation
12-5	Austenitic Stainless Steel Alloys of Exhaust Components (Phil Maziasz, Oak Ridge National Laboratory)	4.67	0.58
12-8	Bonding of Materials Using Reactive Nanofoils (Xin Sun, Pacific Northwest National Laboratory)	3.00	0.00
12-10	Carbon Foam Thermal Management (Nidia Gallego, Oak Ridge National Laboratory)	2.00	1.00
12-13	Catalyst Characterization (Thomas Watkins, Oak Ridge National Laboratory)	3.50	0.71
12-15	Catalysts via First Principles (C.K. Narula, Oak Ridge National Laboratory)	4.00	0.00
12-17	Characterization of Catalyst Microstructures and Deactivation Mechanism (Larry Allard, Oak Ridge National Laboratory)	3.67	1.53
12-20	Durability of Diesel Engine Particulate Filters (Thomas Watkins, Oak Ridge National Laboratory)	4.50	0.71
12-22	Environmental Effects on Power Electronics (A. Wereszczak, Oak Ridge National Laboratory)	3.67	1.21
12-25	Evaluation of Combustion characteristics and Materials via ACERT Engine (Caterpillar) (Ron Graves, Oak Ridge National Laboratory)	3.50	0.71
12-27	Fabrication of Small Diesel Fuel Injector Orifices (George Fenske, Argonne National Laboratory)	3.33	0.58

Page	Project Title and Principal Investigator	Project Average Score	Project Score Standard Deviation
12-30	Fatigue Enhancements by Shock Peening (Cummins) (Dean Paxton, Pacific Northwest National Laboratory)	3.00	1.41
12-32	Friction and Wear Reduction in Diesel Engine Valve Trains (Peter Blau, Oak Ridge National Laboratory)	3.25	0.96
12-35	High-Temperature Materials Laboratory (Edgar Lara-Curzio, Oak Ridge National Laboratory)	4.33	1.15
12-37	Hydrogen Compatible Materials (Jim Holbery, Pacific Northwest National Laboratory)	3.33	1.15
12-40	IEA Annex on Materials For Transportation (Stephen Hsu, National Energy Technology Laboratory)	2.50	0.71
12-42	Integrated Surface Engineering for Improving Energy Efficiency (Aaron Yocum, National Energy Technology Laboratory)	3.00	1.41
12-44	Joining of Advanced Materials by Plasticity (Jules Routbort, Argonne National Laboratory)	3.00	1.83
12-47	Life Prediction for Diesel Engine Components (Nate Phillips, Oak Ridge National Laboratory)	2.50	0.71
12-49	Lightweight Valve Train Materials (Titanium) (Nate Phillips, Oak Ridge National Laboratory)	2.67	1.15
12-52	Materials for Advanced Engine Valve Train (Phil Maziasz, Oak Ridge National Laboratory)	3.50	0.58
12-55	Materials for HCCI Engines (G.Muralidharan, Oak Ridge National Laboratory)	4.50	0.71
12-57	Materials for HECC/HCCI Engine Components (Caterpillar) (Glenn Grant, Pacific Northwest National Laboratory)	4.00	0.00
12-60	Materials for High-Pressure Fuel Injection Systems (Peter Blau, Oak Ridge National Laboratory)	3.33	0.58
12-63	Mechanical Reliability of Piezo-Stack Actuators (A. Wereszczak, Oak Ridge National Laboratory)	3.50	0.58
12-66	Non-Destructive Evaluation of Diesel Components (Nate Phillips, Oak Ridge National Laboratory)	2.50	0.71
12-68	NOx Sensor Development (Robert Glass, Lawrence Livermore National Laboratory)	3.50	0.71
12-70	Power Electronics Materials Compatibility (B.L. Armstrong, Oak Ridge National Laboratory)	3.63	1.06
12-75	Residual Stress (Jules Routbort, Argonne National Laboratory)	2.67	0.58
12-77	Solder Joints of Power Electronics (G. Muralidharan, Oak Ridge National Laboratory)	3.38	1.19
12-82	Super Hard Coating Systems (Ali Erdemir, Argonne National Laboratory)	4.00	0.00
12-85	Thermoelectrics Materials by Design, Computational Theory and Structure (David Singh, Oak Ridge National Laboratory)	3.80	0.84

Page	Project Title and Principal Investigator	Project Average Score	Project Score Standard Deviation
12-87	Thermoelectrics Materials by Design, Diamond-Based Thermoelectric materials (Dieter Gruen, Argonne National Laboratory)	2.50	0.55
12-92	Thermoelectrics Materials by Design, Mechanical Reliability (A. Wereszczak, Oak Ridge National Laboratory)	3.50	1.05
	Overall Session Average and Standard Deviation	**3.40**	**1.00**


Propulsion Materials
Overall Average for Session
Thermoelectrics Materials by Design, Mechanical Reliability (Oak Ridge National Laboratory)
Thermoelectrics Materials by Design, Diamond-Based Thermoelectric materials (Argonne National Laboratory)
Thermoelectrics Materials by Design, Computational Theory and Structure (Oak Ridge National Laboratory)
Super Hard Coating Systems (Argonne National Laboratory)
Solder Joints of Power Electronics (Oak Ridge National Laboratory)
Residual Stress (Argonne National Laboratory)
Power Electronics Materials Compatibility (Oak Ridge National Laboratory)
NOx Sensor Development (Lawrence Livermore National Laboratory)
Non-Destructive Evaluation of Diesel Components (Oak Ridge National Laboratory)
Mechanical Reliability of Piezo-Stack Actuators (Oak Ridge National Laboratory)
Materials for High-Pressure Fuel Injection Systems (Oak Ridge National Laboratory)
Materials for HECC/HCCI Engine Components (Caterpillar) (Pacific Northwest National Laboratory)
Materials for HCCI Engines (Oak Ridge National Laboratory)
Materials for Advanced Engine Valve Train (Oak Ridge National Laboratory)
Lightweight Valve Train Materials (Titanium) (Oak Ridge National Laboratory)
Life Prediction for Diesel Engine Components (Oak Ridge National Laboratory)
Joining of Advanced Materials by Plasticity (Argonne National Laboratory)
Integrated Surface Engineering for Improving Energy Efficiency (National Energy Technology Laboratory)
IEA Annex on Materials For Transportation (National Energy Technology Laboratory)
Hydrogen Compatible Materials (Pacific Northwest National Laboratory)
High-Temperature Materials Laboratory (Oak Ridge National Laboratory)
Friction and Wear Reduction in Diesel Engine Valve Trains (Oak Ridge National Laboratory)
Fatigue Enhancements by Shock Peening (Cummins) (Pacific Northwest National Laboratory)
Fabrication of Small Diesel Fuel Injector Orifices (Argonne National Laboratory)
Evaluation of Combustion characteristics and Materials via ACERT Engine (Caterpillar) (Oak Ridge National...
Environmental Effects on Power Electronics (Oak Ridge National Laboratory)
Durability of Diesel Engine Particulate Filters (Oak Ridge National Laboratory)
Characterization of Catalyst Microstructures and Deactivation Mechanism (Oak Ridge National Laboratory)
Catalysts via First Principles (Oak Ridge National Laboratory)
Catalyst Characterization (Oak Ridge National Laboratory)
Carbon Foam Thermal Management (Oak Ridge National Laboratory)
Bonding of Materials Using Reactive Nanofoils (Pacific Northwest National Laboratory)
Austenitic Stainless Steel Alloys of Exhaust Components (Oak Ridge National Laboratory)
0
1
2
3
4
5
6

Austenitic Stainless Steel Alloys of Exhaust Components (Phil Maziasz, of Oak Ridge National Laboratory)

Reviewer Sample Size
This project had a total of 3 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
The first response stated that the use of this alloy will definitely benefit development of high-efficiency engines with advanced emission controls. Another reviewer added that it allows higher exhaust temperatures; this opens the way for more efficient engines. One other person commented that the group developed and commercialized CF8C-Plus cast stainless steel for exhaust components to provide higher temp capability and durability.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer commented that the current phase of this project is mostly deployment, while another noted that the project was executed in close cooperation with foundries and an OEM. One final respondent stated that the group has developed alloys and extensively tested them to qualify for diesel exhaust component applications. They have also worked with ORNL in generating short- and long-term creep and fatigue data. The reviewer also noted that CAT and ORNL work together to attract industrial end users.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer commented that high-temperature alloys are needed for turbochargers and emission control devices, and this requirement becomes more severe with high-efficiency engines. Another person stated that, although the project is very successfully moving forward, its effect on petroleum displacement is relatively small.

One individual indicated that there was clear problem definition. The first commercial heats were done only 1.5 years after the initial lab-scale heat. CF8C performed more than 10 times better in creep life than the SiMo Cast iron. The reviewer also commented on Ni-Resist and the extensive test data being collected.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One reviewer stated that the need and application of this alloy is obvious for turbochargers and exhaust manifolds, while another commented that the developed material will be used on the short term. One final reviewer commented on the CRADA with CAT, and that they are in the process of commercialized the new material. The reviewer adds that, to date over one million pounds of CF8C-Plus steel have been cast for regeneration housings by CAT. There is one patent between CAT and ORNL, and they have applied for a new ASTM alloy grade to support commercial licensing interests.

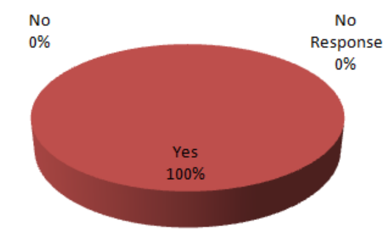
Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
The lone respondent stated that the level of funding appears to be reasonable to support the deployment to a turbocharger application.

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

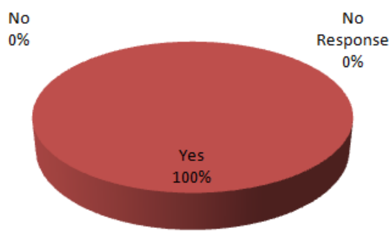
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Austenitic Stainless Steel Alloys of Exhaust Components

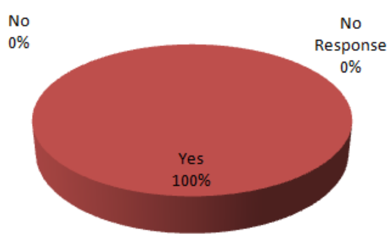
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



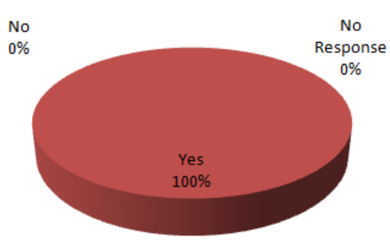
Question 2a: Are the goals of the project technically achievable?



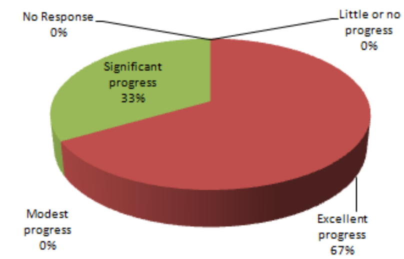
Question 2b: Have the technical barriers been identified and addressed?



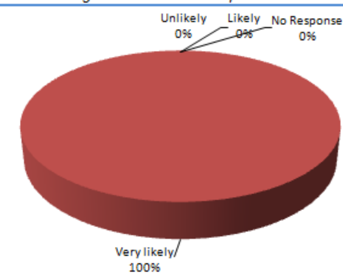
Question 2c: Is the proposed work likely to overcome technical barriers?



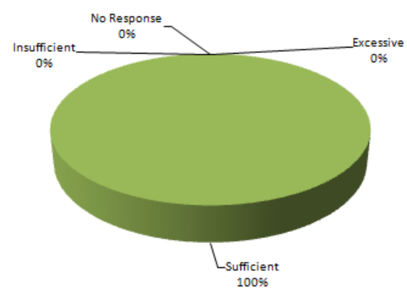
Question 3: Characterize the technical accomplishments and progress toward goals.



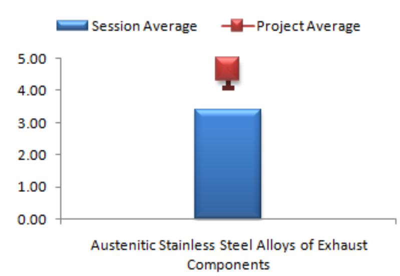
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



Bonding of Materials Using Reactive Nanofoils (Xin Sun, of Pacific Northwest National Laboratory)

Reviewer Sample Size

This project had a total of 2 reviewers.

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

One reviewer stated that this work is enabling further vehicle weight reduction by investigating new reliable and cost-effective joining methods. The other response stated that it aims at reducing weight. It is a challenging idea. Application will be most likely outside the engine in the rest of the power train and chassis.

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

One person stated that it is difficult to assess, but there is a partner that could be helpful in deployment. They added that more evidence must be given on the OEM's interest. The other person listed the following as barriers: higher heat energy input, lack of reliable and cost-effective joining methods. They commented on the following approaches: acquire nanofoils of various layer thickness and lay-up, quantify amount of heat generation, braze solder steel and different materials.

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

One reviewer stated that the amount of weight savings is relatively modest. The other noted that the group had tested 4 mm SAE 1008 to SAE 1008 solder joint, 2mm AA5182 to AA5182 braze joint and completed a bond strength comparison with adhesion bond and developed a cost model for nanofoils.

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

The first response stated that the project is exploratory, and it has a lot of potential to be used in various applications. The other reviewer stated that it is a concept feasibility study only for now. The group has maintained close interactions with OEM, Tier 1 suppliers, and nanofoil suppliers, and some companies have showed interest.

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

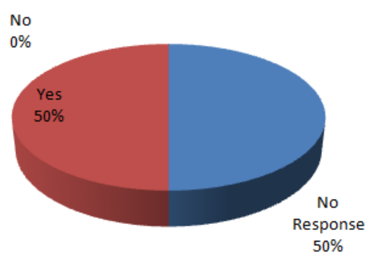
There were no responses to this prompt.

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

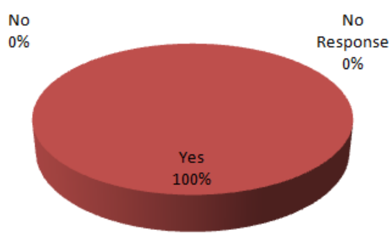
There were no expository comments for this question: refer to the graphic on the next page for this project’s summary score.

Project: Bonding of Materials Using Reactive Nanofoils

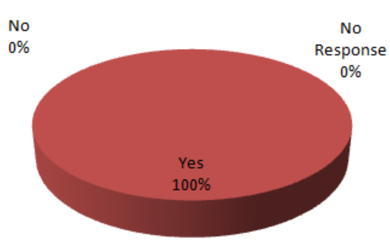
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



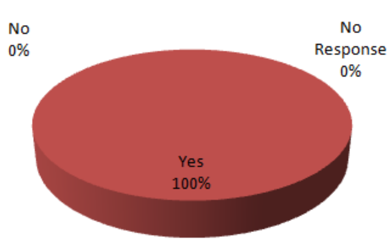
Question 2a: Are the goals of the project technically achievable?



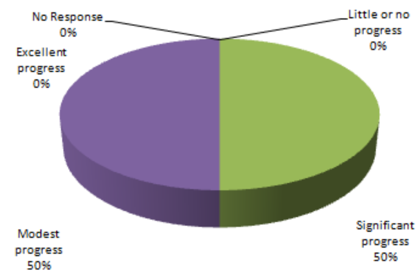
Question 2b: Have the technical barriers been identified and addressed?



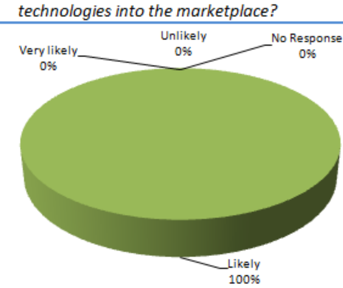
Question 2c: Is the proposed work likely to overcome technical barriers?



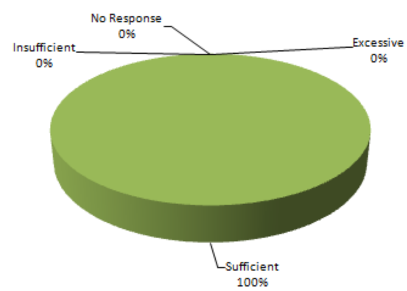
Question 3: Characterize the technical accomplishments and progress toward goals.



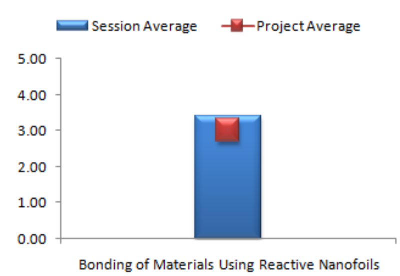
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



Carbon Foam Thermal Management (Nidia Gallego, of Oak Ridge National Laboratory)

Reviewer Sample Size

This project had a total of 3 reviewers.

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

Responses to this prompt were mixed overall. One person commented that this program supports the effort by looking at a graphite foam thermal siphon to cool the power electronics. Another wrote that the project is supportive for hybrid vehicles; as such, it will lead to a reduction of fuel consumption. It is not made clear whether or not the size and weight reduction are adequate for demands in new generation hybrids. One other reviewer wrote that it is not at all clear how performance obtained or realistically projected will substantially reduce weight in a vehicle, or reduce power requirement for a given amount of necessary cooling in an engine or vehicle. The analysis of the size of the potential impact seems not to have been made. Specifically, even though the material is lighter than copper or aluminum, the same heat transfer schemes cannot be used, and a completely new cooling system does not seem to have been carefully thought out with total system weight compared to conventional systems. A lighter heat transfer material in a heavier total heat transfer system would not be a win.

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

One person wrote that the strategy of interesting a supplier seems to be working, and deployment seems to be potentially achievable, but the potential impact on DOE goals does not seem to be high. Another response stated that in the consortium there is involvement of a foam manufacturer and a heat exchange manufacturer. What is missing is an OEM setting the demands for the heat exchanger. One other reviewer stated that the best uses of graphite foam for cooling have been addressed.

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

One reviewer stated that the improvement of 20% in cooling rates over a conventional thermal siphon can be seen as a modest amount of progress. The other responded indicated that the project's objectives were originally defined as an optimized heat exchanger design that best utilizes graphite foam to significantly reduce the size and weight of the thermal management system. The question is whether the project meets those requirements with a thermal siphon over other cooling technologies.

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

Comments were generally cautious or pessimistic to this question. One reviewer wrote that the team could bring the technology to the market, but it is not very likely since there is no insight into the needed reduction in size and weight. Another felt that, while vendor interest seems to be high, technical obstacles still seem to be high as well, in particular with regard to robust mechanical properties and fluid interactions. In an application that would significantly contribute to VT goals, success seems to be difficult to achieve. One other person wrote that for the traction application the size, weight and cost of the system may be too high. This person added that the thermo siphon with graphite foam may have applications within the industrial market.

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

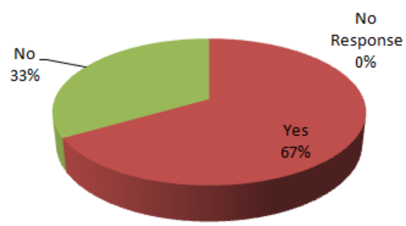
One person noted that it was indicated that the project will complete this year, so the total budget will be sufficient. The other response stated that it is likely that breakthrough understanding will be required, and this is probably not a function of funding.

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

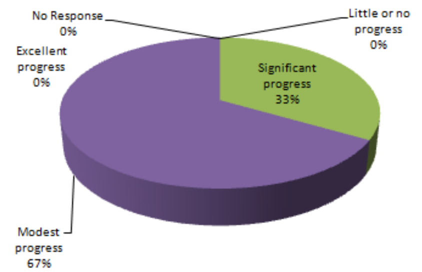
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Carbon Foam Thermal Management

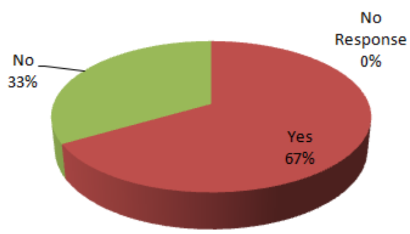
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



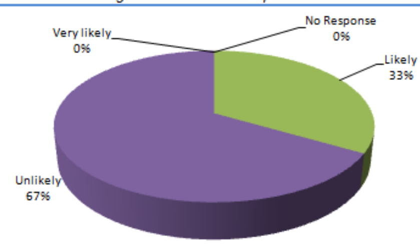
Question 3: Characterize the technical accomplishments and progress toward goals.



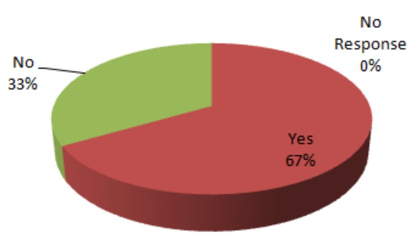
Question 2a: Are the goals of the project technically achievable?



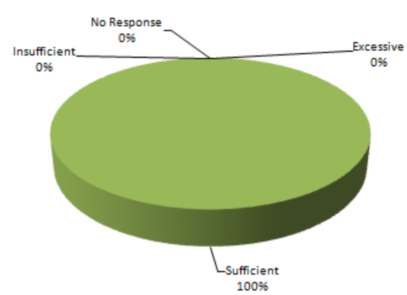
Question 4: How likely is the project team to move technologies into the marketplace?



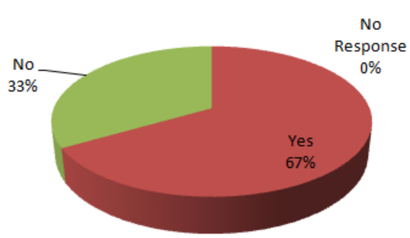
Question 2b: Have the technical barriers been identified and addressed?



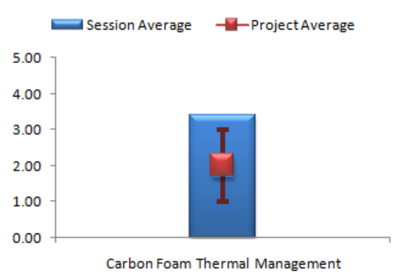
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Catalyst Characterization (Thomas Watkins, of Oak Ridge National Laboratory)

Reviewer Sample Size

This project had a total of 2 reviewers.

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

One reviewer stated that more efficient SCR allows a higher NOx engine without leading to lower fuel consumption. The other respondent stated that this project addresses a very important problem linked directly to fuel consumption.

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

One reviewer stated that the project is lacking the contribution of a catalyst supplier, while the other person stated that this is good work to do, with a workmanlike (though not spectacularly imaginative) approach. In this area, the reviewer adds, almost any careful and extensive evaluation will produce useful findings.

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

One response indicated that better optimized after-treatment systems will reduce fuel consumption. The project will lead to new characterization methods for SCR catalysts. The other reviewer commented that this work seems to be moving slowly, but moving. Application of existing techniques to a more rapid analysis of a wide range of sample thermal histories would seem to be very productive.

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

The first reviewer stated that any informative results will very rapidly find application in production systems, while the other person felt that missing the contribution of a catalyst supplier bares in itself the risk that the market introduction is not sure.

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

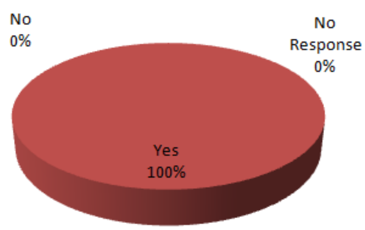
There were no responses to this prompt.

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

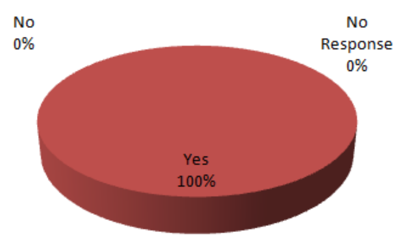
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Catalyst Characterization

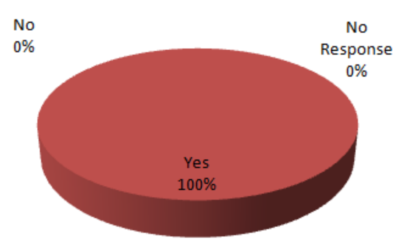
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



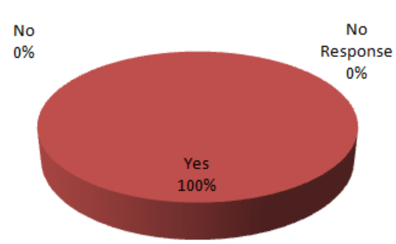
Question 2a: Are the goals of the project technically achievable?



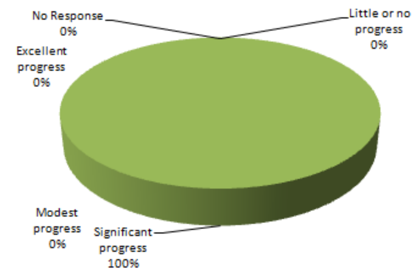
Question 2b: Have the technical barriers been identified and addressed?



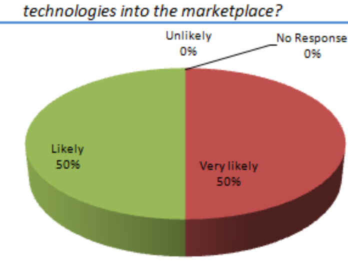
Question 2c: Is the proposed work likely to overcome technical barriers?



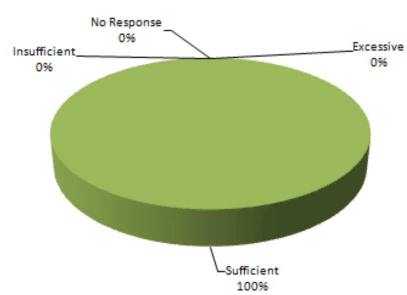
Question 3: Characterize the technical accomplishments and progress toward goals.



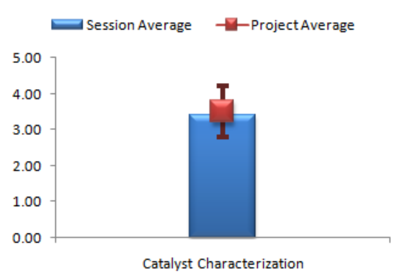
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



Catalysts via First Principles (C.K. Narula, of Oak Ridge National Laboratory)

Reviewer Sample Size
This project had a total of 2 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
The first reviewer commented that a more fuel efficient engine must also fulfill the emission requirements. So the project is not directly aimed at reducing fuel consumption. Also, alternative fuels will need a better understanding of the catalyst mechanisms. The other respondent indicated that, if this can be done in a meaningful way, it will provide useful insights. The reviewer added that fundamental understanding advances will immediately find application in production systems.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
The lone respondent stated that the research is aimed at building up base knowledge on the way to catalyst work. Based on this understanding, improved catalysts can be produced. The reviewer added that the interaction with catalyst suppliers is not very clear.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer stated that new understanding is emerging. This has been an area of much episodic investigation, and a more structured fundamental approach is immediately providing new perspective. This is useful. The other respondent stated that not having a proper understanding or having to work with a less efficient catalyst leads to increased fuel efficiency, since the air quality has to be respected.

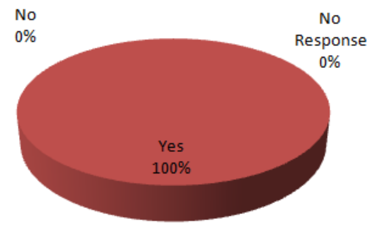
Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One respondent referenced the cooperation with John Deere and Ford, while the other person felt that, at this early stage, it is not clear how much guidance will be provided to engineering production systems in the near term. If the work continues at this pace, it is very likely to influence production systems.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
There were no responses to this prompt.

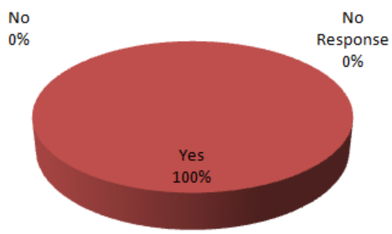
Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.
There were no expository comments for this question: refer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

Project: Catalysts via First Principles

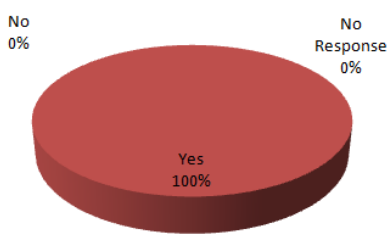
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



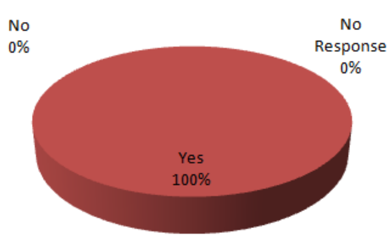
Question 2a: Are the goals of the project technically achievable?



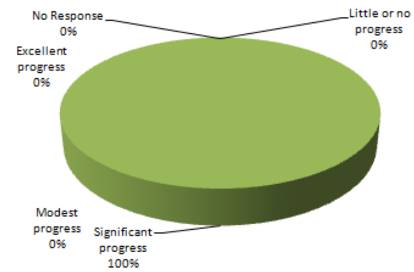
Question 2b: Have the technical barriers been identified and addressed?



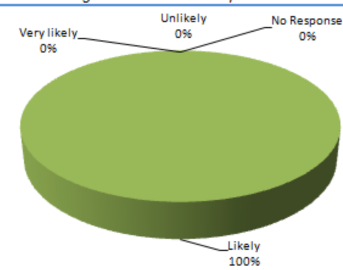
Question 2c: Is the proposed work likely to overcome technical barriers?



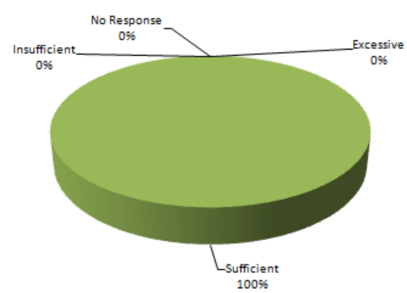
Question 3: Characterize the technical accomplishments and progress toward goals.



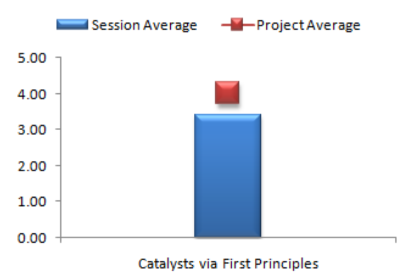
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



Characterization of Catalyst Microstructures and Deactivation Mechanism (Larry Allard, of Oak Ridge National Laboratory)

Reviewer Sample Size
This project had a total of 3 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One reviewer stated that the development of more efficient catalysts will allow all types of vehicles to be more efficient, with another person adding that the group is working to develop a novel new capability for in-situ studies on emission. One other respondent said that the answer is yes, but it is very indirect. Better understanding of catalysts will/can lead to more efficient catalyst conversion, opening the operating window for fuel reduction.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
The first respondent commented that the consortium has a good mix of academia and industry, and the contribution of BASF will be beneficial for deployment. Another person wrote that this project is developing new instrumentation that will allow new catalyst development. However, the barriers to develop this instrumentation have not been identified, so it is not possible to assess their capability to overcome them. The PI is working with many entities to deploy this technology to others. One other reviewer cited the following as a barrier: understand the interactions between individual atoms and studying high temperature interaction. This person noted the following approach: acquire the best microscopy and develop techniques for advanced catalyst characterization.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One person felt that sufficient visual evidence has been presented to demonstrate considerable progress. Another reviewer cited the extensive collaboration with many universities and entities, as well as the group's great publications and great capability in understanding catalyst interaction on an atomic scale. One other person indicated that, although sufficient evidence is given that the work is leading-edge, its connection to the DOE goals is indirect. It is aimed at implementation on the longer term. The work could lead to a breakthrough, but this is difficult to rank in the given format.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One reviewer stated that this question was not applicable, since this project is not developing a technology for application to engines or vehicles. Another commented that this is an enabling technology that has been widely used, and cited the great cooperation among UOP, PNNL, ORNL, UT-Austin, and ACEM. The final respondent noted that there is cooperation with a catalyst supplier. They will use the know-how. It would be an improvement if an OEM or engine manufacturer was involved. This would increase the possibility that the technology would lead to improved fuel efficiency.

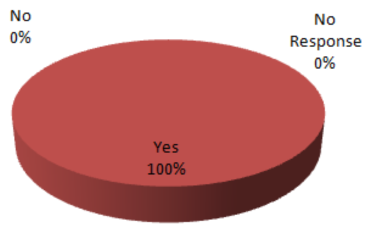
Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
The lone respondent stated that there is nothing to indicate that additional resources are needed by VT. Co-funding is being provided by DOE BES.

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

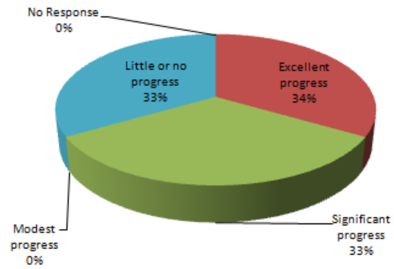
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Characterization of Catalyst Microstructures and Deactivation Mechanism

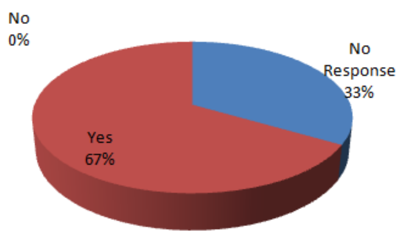
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



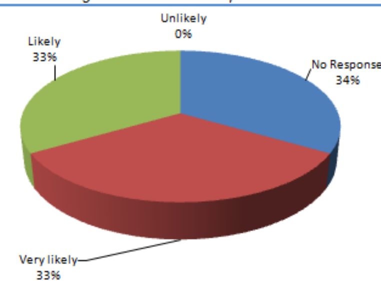
Question 3: Characterize the technical accomplishments and progress toward goals.



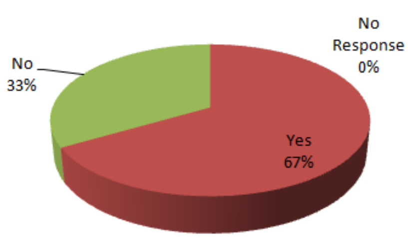
Question 2a: Are the goals of the project technically achievable?



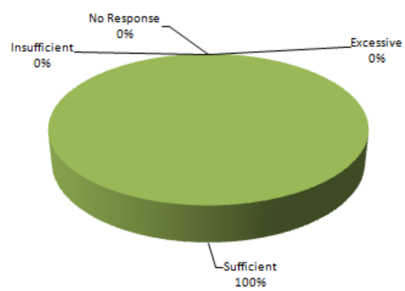
Question 4: How likely is the project team to move technologies into the marketplace?



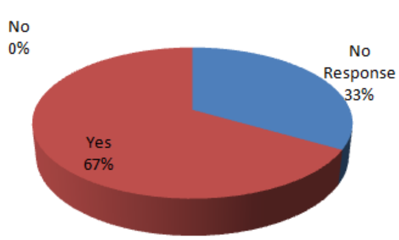
Question 2b: Have the technical barriers been identified and addressed?



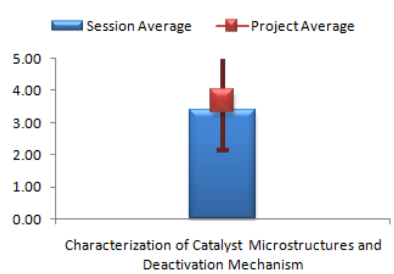
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Durability of Diesel Engine Particulate Filters (Thomas Watkins, of Oak Ridge National Laboratory)

Reviewer Sample Size
This project had a total of 2 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Responses were very positive here, with one person stating that the project is aiming at reducing fuel consumption used for regenerating the DPF. In this field, large progress is achievable. The other respondent stated that this is necessary development, with the pace of technological understanding well behind the pace of commercial application. This work badly needs to be done and done rapidly. The quality of the work being done is excellent.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
Both reviewers were positive in this section, with one stating that there is a good balance in the project contributors was shown. There is strong involvement of a tier 1 supplier working in close cooperation with an OEM. Also, laboratories are involved. The other person stated that this is a well thought out program, and that the necessary tools are in place. Any success will immediately be applied in production.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One person stated that the regeneration fuel consumption is greatly reduced, which can be considered as a significant fuel consumption. The other reviewer commented that the project has shown good progress given the difficulty of the problems.

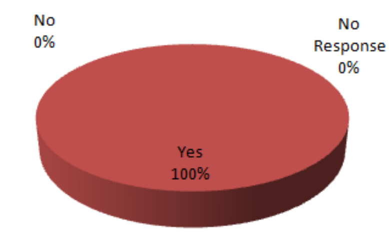
Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One reviewer stated that the cooperation of Cummins with Dodge will lead to market introduction as soon as the technology is available, and the other response stated that there will be useful findings resulting from this project, and they will immediately be taken into account in the improvement of production filters.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
The lone respondent stated that the quality of the work being done and the thought processes around the results are excellent.

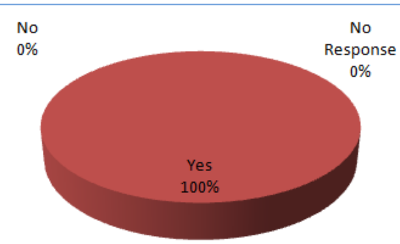
Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.
There were no expository comments for this question: refer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

Project: Durability of Diesel Engine Particulate Filters

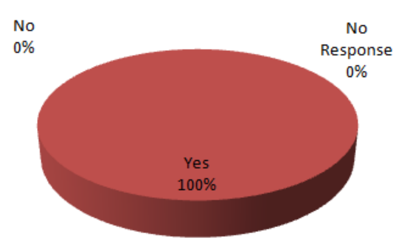
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



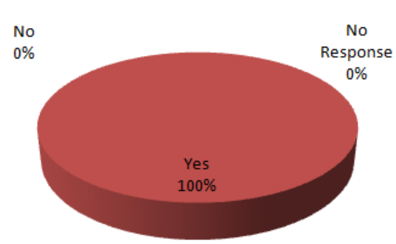
Question 2a: Are the goals of the project technically achievable?



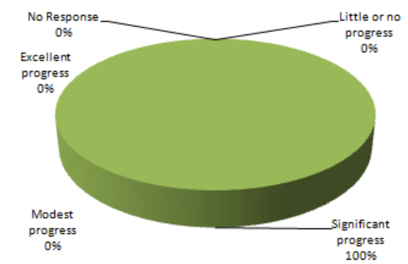
Question 2b: Have the technical barriers been identified and addressed?



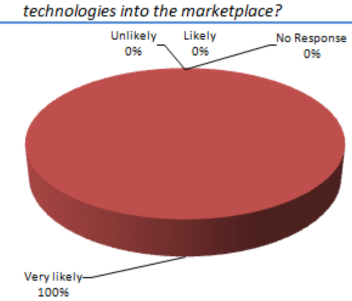
Question 2c: Is the proposed work likely to overcome technical barriers?



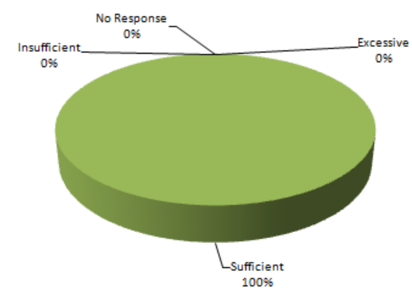
Question 3: Characterize the technical accomplishments and progress toward goals.



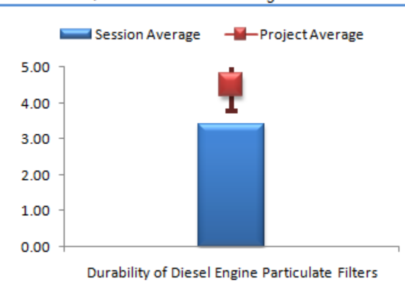
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



Environmental Effects on Power Electronics (A. Wereszczak, of Oak Ridge National Laboratory)

Reviewer Sample Size

This project had a total of 8 reviewers.

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

One person stated yes, because it is supportive of high power electronics. This is needed for future generations of hybrids. Similarly, another reviewer commented that the focus on power electronics size and mass reduction is critical to the success of future HEV and PHEV deployment and thereby displacement of oil imports. One other response stated that wider adoption of hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV) products will save millions of barrels of oil due to a higher fleet MPG average. However, before this can occur the cost of these products must be much closer to that of traditional vehicles. One way to assist industry in achieving that goal is to develop technologies that can reduce the cost of the cooling systems in existing HEV and PHEV products. This goal can be achieved by either developing power electronics that can operate at higher temperatures and therefore reduce the cooling requirements, or by reducing the thermal resistance between the power electronics and the coolant so that the standard ICE coolant can be used for the power electronics as well. This work has the potential to achieve the second goal and therefore could make a significant contribution to a much lower cost PHEV / HEV product line and therefore, significantly higher average MPG and the associated saving in oil.

One reviewer stated that this was well-thought-out and is likely critical path work. Another felt that the proposed work has good synergy with other NTRC projects (direct substrate cooling). The results of the environmental tests on PEMs will be very helpful to PEM manufactures and users to determine their qualification criteria with new materials for the higher temperature application. Another added that the high temperature operation is a trend for HEV application, and it is important to understand the reliability under more stringent environments.

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

Comments were generally positive here, with one person indicating that the development of ceramic substrates that can increase the reliability of these modules and decrease the thermal resistance between the power devices and the heat sink is a good approach and will be a likely outcome of this work. Another stated that the approaches are laid out carefully, while one person commented on the solid strategy and focus on enhancing power electronics capability, performance and lifetime. These are all of an utmost importance to vehicle OEM's. One person stated the strategy to work with a substrate manufacturer is good idea. It is probably necessary to also include a PEM manufacturer.

One reviewer commented that this technology is in competition with other solution investigated in other presented project like carbon foam cooling and refrigerant cooling. As a whole, the materials for electric and hybrid drive systems projects all deal with different parts needed for solving the issues with high temperature in electronics. It is not very likely that all proposed solutions will find their way in the industry, but it is likely that one will come through.

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

One person commented that these are still the early days of the program, but the approach seems likely to make good progress, while another reviewer stated that the progress is on track. One response indicated that good progress has been made to date in understanding the state of the art in these products as well as in the initial steps towards the development of new materials that may enable the objective. Another reviewer commented, similarly, that progress is good and focus on conventional coolants (automotive WEG - water ethylene glycol) is very appropriate for high temperature power electronics and supports programs aimed at 200ºC junction temperatures. One reviewer felt that several significant accomplishments were listed and the project approach seems quite reasonable. One other person felt hybrids in themselves will partly be able to overcome the barriers mentioned, and this will only be a small contribution to the further introduction of Hybrids.

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

Reviewers were generally positive in this section, with one person stating that it is very likely that improved materials will result from this work and enable lower thermal resistance between the power die and the coolant. Since this could dramatically improve the performance of these products, adoption by industry is very likely. Another person commented that he or she sees this project having a very likely chance of panning out.

One reviewer stated that the technology that will be transferred is the test results that will give OEM manufacturers the necessary information to evaluate some new packaging concepts. Similarly, one person wrote that the test results can be of benefit to the component suppliers.

To contrast, one final reviewer stated that the use of engine coolant is a high risk because of the cleanliness of this fluid over time. So testing with clean fluids will not give a clear view on real operating conditions.

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

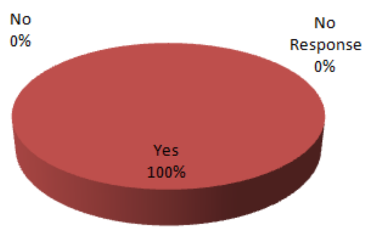
Responses were somewhat mixed in this section. One person stated that the resources appear adequate to achieve the project goals, and another stated that they are sufficient. One other reviewer commented that the goal is too broad to be achieved.

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

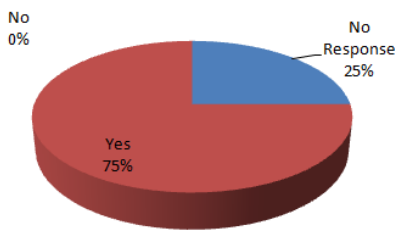
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Environmental Effects on Power Electronics

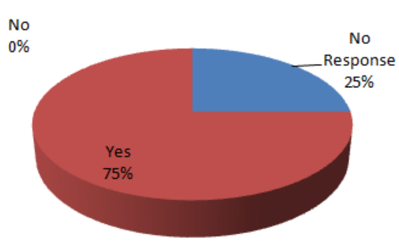
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



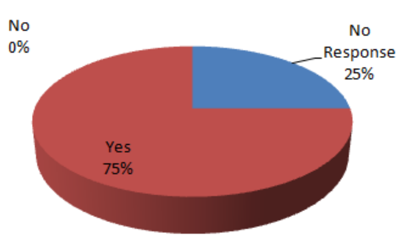
Question 2a: Are the goals of the project technically achievable?



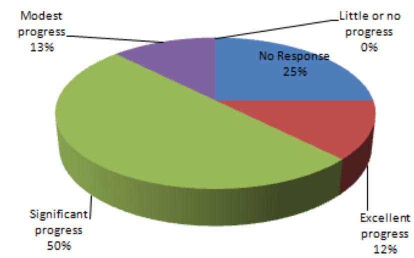
Question 2b: Have the technical barriers been identified and addressed?



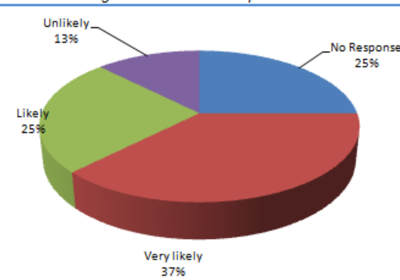
Question 2c: Is the proposed work likely to overcome technical barriers?



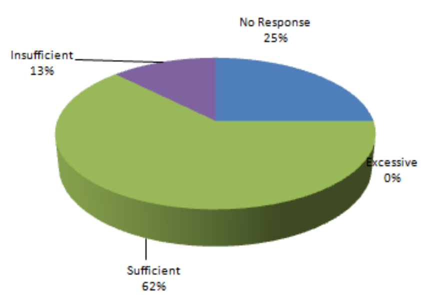
Question 3: Characterize the technical accomplishments and progress toward goals.



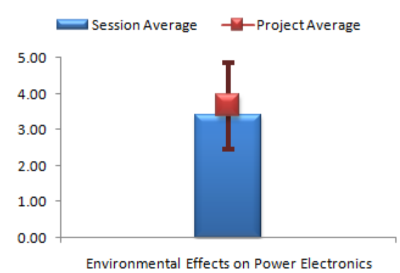
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



Evaluation of Combustion Characteristics and Materials via ACERT Engine (Caterpillar) (Ron Graves, of Oak Ridge National Laboratory)

Reviewer Sample Size

This project had a total of 2 reviewers.

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

The first reviewer stated that this project will improve diesel engine performance, efficiency, and emissions. The goal is to achieve 55% efficiency for a diesel engine. The other respondent also commented that the aim is to have materials available that will allow 55% fuel efficiency, adding that this is a multidisciplinary project.

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

One person indicated that the project is still in its early phases, adding that the partnership covers the supply chain. Another commented that the barriers are parasitic, friction, and heat transfer losses, while the approach includes an industrial-National Lab partnership.

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

The first response stated that the aims of the project are fully aligned with DOE's goal, but added that the project is in its early phase and the main aim right now is to define the path forward. The other reviewer commented that they have assembled a research team and are working together to procure hardware from CAT.

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

One reviewer noted that CRADA will be executed with CAT, adding that CAT provided the engine for ORNL to test. Following up on this, another reviewer stated that the involvement of an OEM will ensure that the results find their way to the market.

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

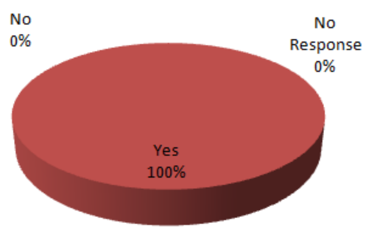
The lone respondent stated that the budget was discussed, and the outcome of this discussion was that it was sufficient.

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

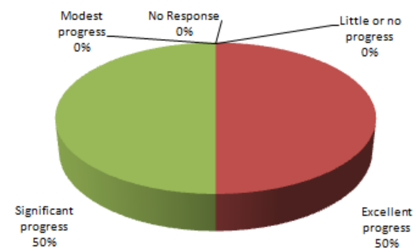
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Evaluation of Combustion characteristics and Materials via ACERT Engine (Caterpillar)

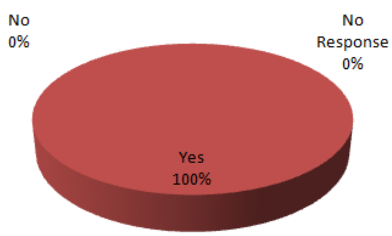
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



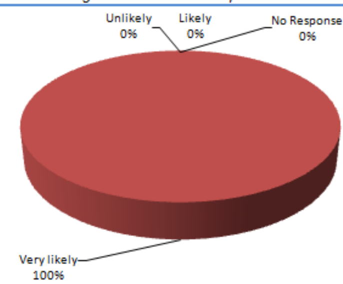
Question 3: Characterize the technical accomplishments and progress toward goals.



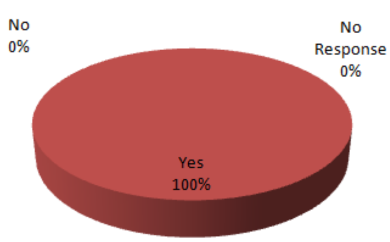
Question 2a: Are the goals of the project technically achievable?



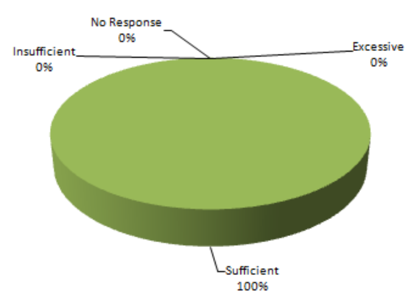
Question 4: How likely is the project team to move technologies into the marketplace?



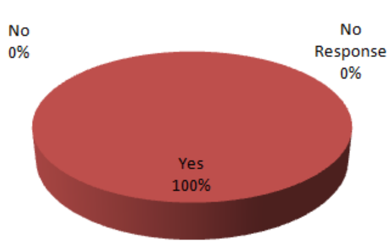
Question 2b: Have the technical barriers been identified and addressed?



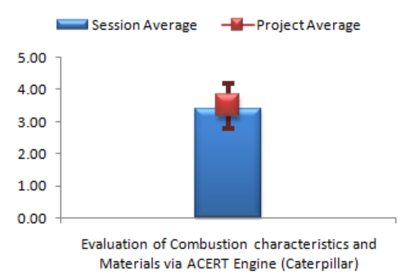
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Fabrication of Small Diesel Fuel Injector Orifices (George Fenske, of Argonne National Laboratory)

Reviewer Sample Size

This project had a total of 3 reviewers.

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

One reviewer noted that smaller diameter orifices will improve combustion leading to reduced fuel consumption. It should be noted that the reduction of produced particulates allows the engine engineer to reduce the fuel consumption further through wider engine operating conditions. Another person followed up by saying that experience outside of the presented work indicates that smaller holes in the injector nozzle will reduce smoke (soot) and possibly reduce NOx emissions, however extrapolating that to a significant petroleum displacement does not seem likely. One reviewer commented that this is a well-known pathway to improve combustion. This is an innovative approach, but not moving rapidly at all.

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

One reviewer stated that, although 2 a, b, and c are answered with "yes," fuel injection manufacturers are involved but not mentioned by name due to NDA. Another response commented that the body of the presentation mentions technical barriers with regards to emissions reduction without a fuel economy reduction; the data would indicate that this is likely to be achieved with this technology with the added benefit that it could result in a reduced overall system (power train system) cost. Identified, but not discussed in sufficient detail, were technical barriers; the adherence of the plated material and the consistency of the shape of the final hole or the consistency of the surface finish within the hole. These would seem to this reviewer to be significant technical barriers whose resolution must be demonstrated in a reliable manner for this project to be considered a success.

One other reviewer said yes to all of the above questions, but with large reservations. Adherence and durability of the coatings is likely to be a huge issue. Cavitation is a constant problem in high pressure injectors, and spalling due to modulus mismatch under cavitation conditions would be expected to be a huge problem. Microgeometry at the edge of the opening is also critical and may be difficult to manipulate.

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

One reviewer stated that this project could lead to a short term improvement in fuel economy by improved fuel injection. The other person responding commented that the demonstration of the capability to produce small spray holes has been shown and identification of technical barriers has been accomplished. The presentation implied that some or all of these issues have been addressed but did not provide details of how or demonstration of success. If these technical barriers have been addressed the progress is certain being made in a timely manner.

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

Responses were generally positive in this section. One reviewer stated that, assuming that the three technical barriers can be overcome in a way that can be implemented in high volume production, the results of this project are likely to be utilized very soon after they are available. Another commented that one of the key items not making it very likely is the change from laboratory to mass production. Also, cost can be an issue. Following this, one person stated that this community is relatively open to innovations, and the proposed process is not likely to be expensive in the grand scheme of injector technology.

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

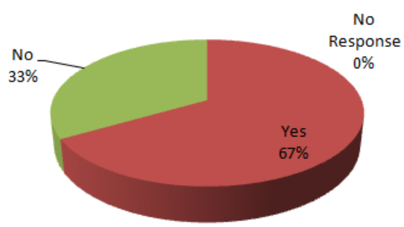
Both reviewers agreed that resources looked sufficient, with one person stating that, looking at the progress and the work package, the resources look sufficient. The other reviewer stated that he or she did not see any indications in the material that the project has either excessive or insufficient resources.

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

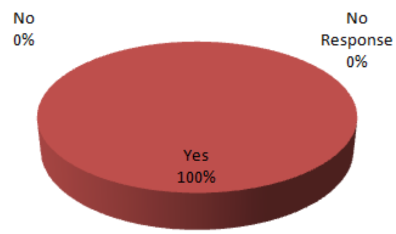
There were no expository comments for this question: refer to the graphic on the next page for this project’s summary score.

Project: Fabrication of Small Diesel Fuel Injector Orifices

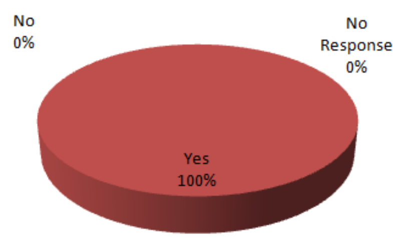
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



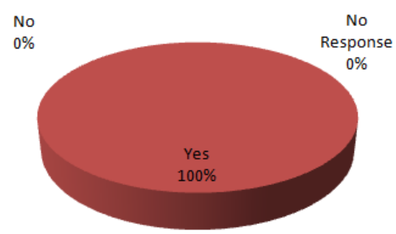
Question 2a: Are the goals of the project technically achievable?



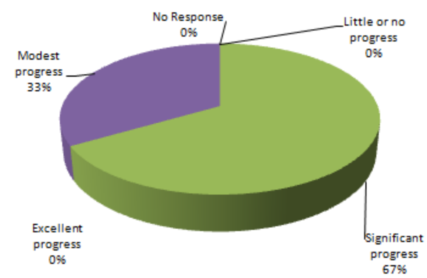
Question 2b: Have the technical barriers been identified and addressed?



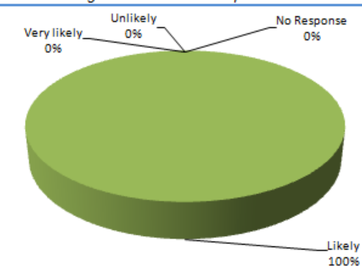
Question 2c: Is the proposed work likely to overcome technical barriers?



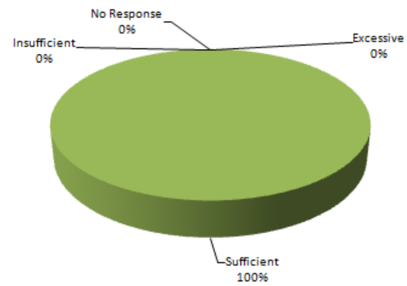
Question 3: Characterize the technical accomplishments and progress toward goals.



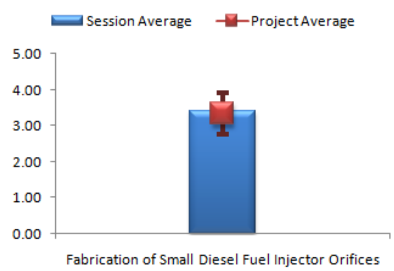
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



Fatigue Enhancements by Shock Peening (Cummins) (Dean Paxton, of Pacific Northwest National Laboratory)

Reviewer Sample Size

This project had a total of 2 reviewers.

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

One reviewer simply stated the goals are supported only very indirectly. The other respondent commented that improved fatigue properties are determining the maximum loads in critical components like fuel injection systems. This reviewer added that increasing the operational envelope will lead to reduced fuel consumption.

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

One reviewer stated that there is cooperation with engine manufacturers, and this will ensure that the results will lead to use. Also, suppliers of equipment are involved. The other respondent disagreed, stating that it is uncertain that these techniques, even if successful, would be deployed. What is missing, this reviewer adds, is the advantage that would occur from the success of this project.

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

One response began by commenting that there is a trend to increase fuel injection pressures for further fuel efficiency/emission reduction. The technology developed in this project will allow the industry to achieve this. This reviewer adds that the extra benefit is the fact that the introduction of high performance but difficult-to-machine materials is avoided.

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

The first person commented that a strong interest from industry had been shown, while the other reviewer stated that their response was only accurate if a significant advantage can be shown relative to current technologies.

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

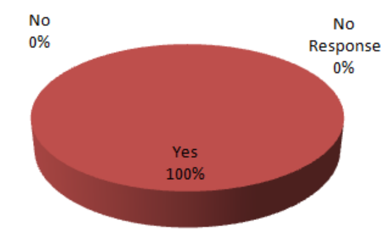
The lone respondent indicated that, in general, no financial data are presented to the reviewers in the propulsion materials group.

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

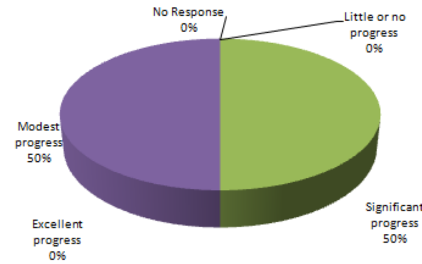
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Fatigue Enhancements by Shock Peening (Cummins)

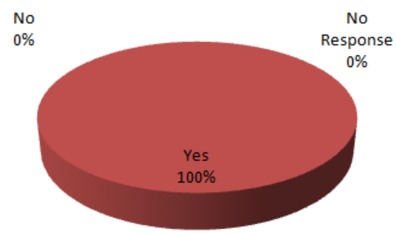
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



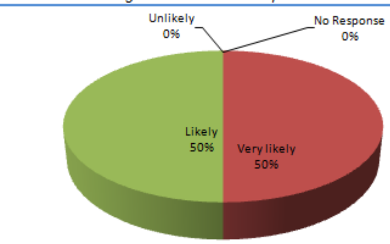
Question 3: Characterize the technical accomplishments and progress toward goals.



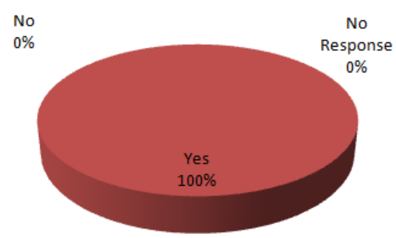
Question 2a: Are the goals of the project technically achievable?



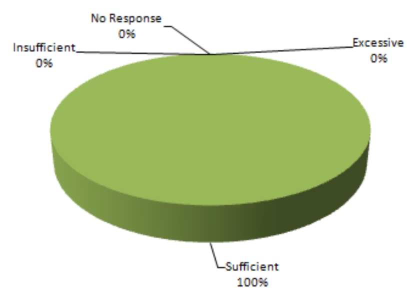
Question 4: How likely is the project team to move technologies into the marketplace?



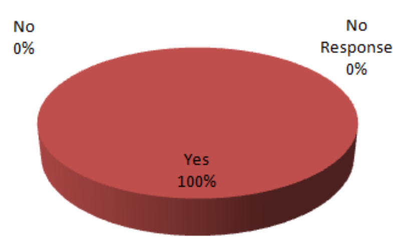
Question 2b: Have the technical barriers been identified and addressed?



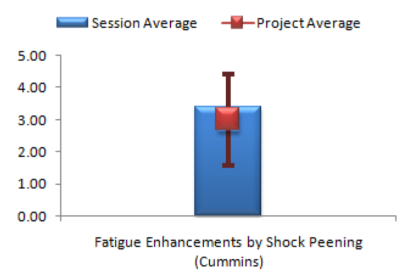
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Friction and Wear Reduction in Diesel Engine Valve Trains (Peter Blau, of Oak Ridge National Laboratory)

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

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Responses to this prompt were mixed. The first reviewer commented that the aim is to develop a next-generation valve material for fuel-efficient and low-emission engines. One other person commented that better valves will support development of higher efficiency engines, while another stated that the project aims at maintaining fuel efficiency over the lifetime of a vehicle. So it is indirectly supporting the overall DOE objective.

Another reviewer stated yes, but barely. This project is more focused on the long-term impact of late engine life compression loss due to worn valves versus friction reduction in engines. Therefore, its impact on fuel efficiency is very minimal over the total life of the engine. Though scientifically interesting, this project seems more focused on addressing a valve leaking issue versus the primary goal of DOE regarding reducing petroleum use.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer commented that there is some coordination with Caterpillar, but the value is unknown. Another noted that the project is to design and build a high temperature repetitive impact apparatus to test wear and do oxide damage tests. This work includes model development in 2008.

One person commented that using test apparatuses for characterization of the valve wear is not the same as the in-engine conditions. To contrast, another reviewer stated that the PI has developed or has very good experimental tools to assess various valve materials and their high temperature behavior under engine-like conditions, which will be critical to overcome high temperature issues associated with the various valve material constituents.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
Responses were generally mixed in this section. One reviewer stated that this project has shown good progress given the relatively short duration and limited funding. Another felt that great progress had been made in building apparatuses for conducting high temperature wear impact tests.

To contrast, one person noted that the goal of the project is to reduce wear of valve/valve seats. This would only reduce the use of fuel in a small part of the use of the engine. One reviewer stated that this project is only partially funded ($200K), which may contribute to its slow progress. It is understood that high temperature durability experiments to develop valve wear models are time-intensive, but the model development seems to still be lacking. This will be targeted in future plans.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One person noted that there is a follow-up CRADA with Caterpillar planned. This shows the interest of the industry. Another reviewer stated that this subject area is continually evolving as engine OEMs attempt to deliver durable engines to the marketplace. This project has very good potential to impact

the design of next or next-next generation of engine valves. One individual stated that industry should be able to use this information: whether they do use it is based on costs, benefits, and need. For example, these developments may not be needed on current technology engines.

One final reviewer suggested that the investigators should coordinate work with CAT, and added that the HTRI will become available for industries.

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

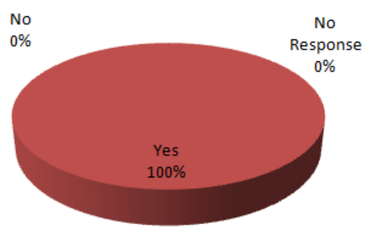
One reviewer stated that funding appears to have been reasonable for this project. Any extension and the associated costs should be weighed carefully. The other respondent felt that this project has outstanding experimental facilities/test apparatuses towards addressing the core valve leaking issue. The high temperature test rig in particular is an excellent and necessary resource for understanding and subsequently developing valve wear models.

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

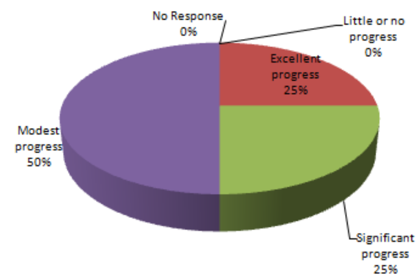
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Friction and Wear Reduction in Diesel Engine Valve Trains

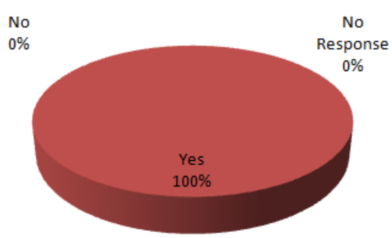
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



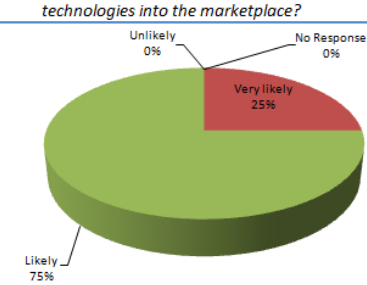
Question 3: Characterize the technical accomplishments and progress toward goals.



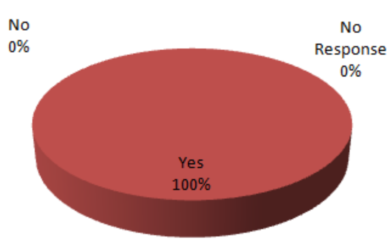
Question 2a: Are the goals of the project technically achievable?



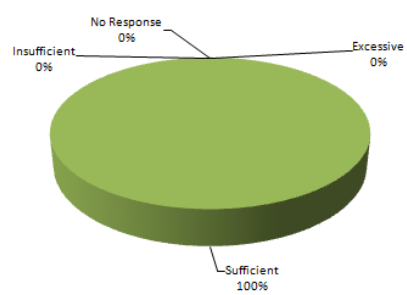
Question 4: How likely is the project team to move technologies into the marketplace?



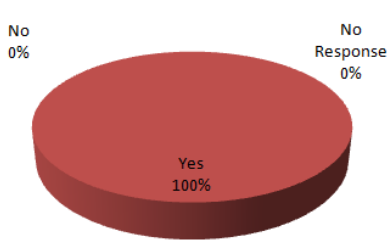
Question 2b: Have the technical barriers been identified and addressed?



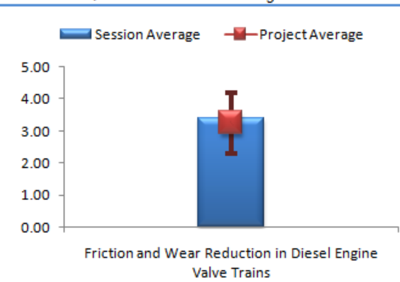
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



High-Temperature Materials Laboratory (Edgar Lara-Curzio, of Oak Ridge National Laboratory)

Reviewer Sample Size
This project had a total of 3 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One reviewer commented that development of stronger and lighter materials is essential to more fuel efficient vehicles. However, not all projects conducted result in transportation energy reductions. Another reviewer wrote that the program supports DOE-EERE-VT in meeting their goals by providing researchers from industry, universities, and government agencies access to a skilled staff and equipment for materials characterization. Similarly, one person stated that the HTML will be an enabler for innovation. Giving small enterprises access to state-of-the-art laboratory equipment will create innovations.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One person felt that, since this project provides a service, goals and barriers are not applicable here. Another commented that the HTML is organized into six user centers to serve different needs. One reviewer stated that a strong interaction with a great number of companies is foreseen.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
The first reviewer commented that, although it is difficult to see HTML as project, the presence of this facility will be key to achieving DOE's goals. Another person added that users have made technical accomplishments and indicate their support by continuing to use the facility. One person stated that great results have been archived in all the user centers.

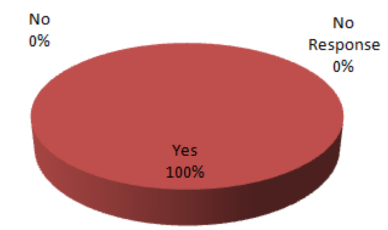
Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One reviewer noted that the HTML provides facilities for many organizations to advance their technologies into the market, while the other respondent stated, similarly, that many industries and universities utilized the user centers to conduct research that are practical and useful to them.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
The lone respondent stated that it was not possible to assess completely without knowing the costs of maintaining the facility and how many projects (and their complexity) are being accommodated throughout the year.

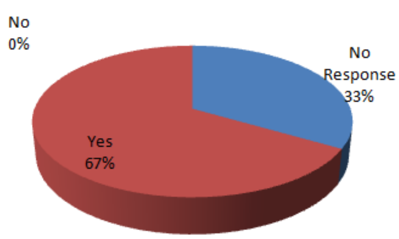
Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.
There were no expository comments for this question: refer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

Project: High-Temperature Materials Laboratory

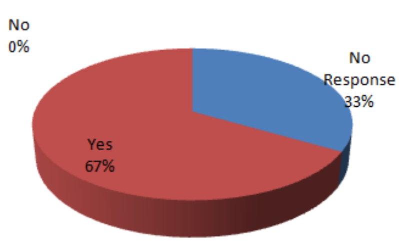
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



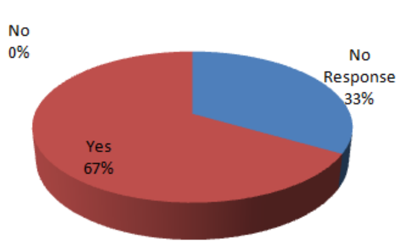
Question 2a: Are the goals of the project technically achievable?



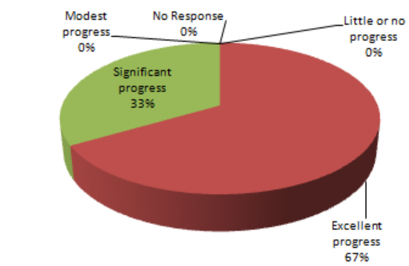
Question 2b: Have the technical barriers been identified and addressed?



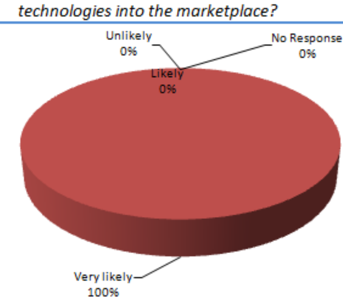
Question 2c: Is the proposed work likely to overcome technical barriers?



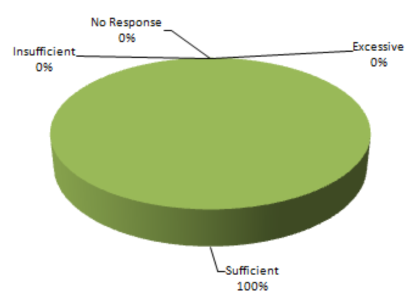
Question 3: Characterize the technical accomplishments and progress toward goals.



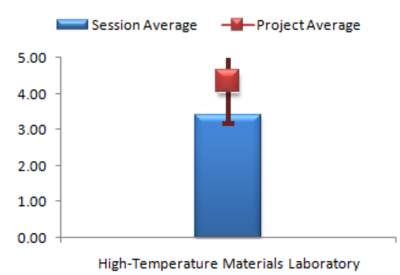
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



Hydrogen Compatible Materials (Jim Holbery, of Pacific Northwest National Laboratory)

Reviewer Sample Size

This project had a total of 3 reviewers.

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

One person stated that this project is needed to enable introduction of direct injection of hydrogen. This is a technology having the potential for reduced gasoline consumption in the future. Another commented that the activity should enable practical/commercial applications of hydrogen injection systems in internal combustion engines, thereby making hydrogen a more viable alternative to petroleum based fuels.

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

Comments in this section were mixed, with one person stating that the consortium covers the whole supply chain. Another indicated that close linkages to key organizations capable of utilizing the results in commercial applications have been established or identified for establishment. To contrast, another began by stating that the material systems problems in this system are truly significant. Previous huge programmatic efforts in this general area have only met with marginal success, so a series of major breakthroughs seems somewhat optimistic. Commercial success would depend on achieving performance competitive with hydrocarbon-fueled (lubricated) systems. This is a tough target.

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

One reviewer felt that the results of the project so far look good. It leads to a better understanding of the effects of hydrogen on various materials used in the fuel injection equipment. However, the project will not lead to application in the coming years. One other person stated that, from the presentation, it was not clear that a substantial amount of results have been wholly verified. It appeared to this reviewer that much has been accomplished analytically, but verification of the results is in the near-term plans. The reviewer felt that by only seeing the written material and the presentation he or she may have developed the wrong impression on this point.

Another response commented that even slow progress is remarkable. The program is well structured and creative, but the task is a tough one. If the program succeeds, it will be a big accomplishment.

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

Responses were generally positive here, but a reviewer was hesitant to speculate due to the surrounding unknowns. One person stated that the project team is balanced with the OEM involved, making it likely that positive results will be introduced. Of course this project solves only part of the total number of questions to be solved before this technology can be made available to the automotive industry. Another believes the work will be a key enabler for hydrogen internal combustion engine commercialization, but moving this into the market place is heavily dependent upon many other factors beyond the scope of this project. Those out-of-scope barriers shifted this reviewer’s opinion from very likely to likely. One other person commented that, again, the problem is very significant.

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

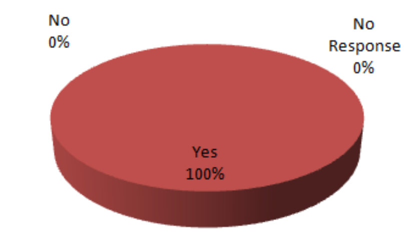
One reviewer stated that the project appeared to have adequate resources, but again he or she may have gleaned more from seeing the presentation than from only reading the written material. Another respondent stated that they are not sure that any funding level would be sufficient at the moment for this task.

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

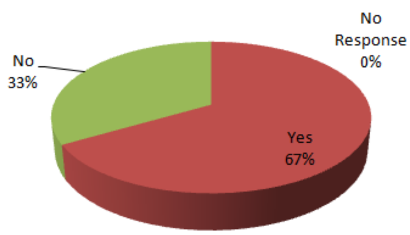
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Hydrogen Compatible Materials

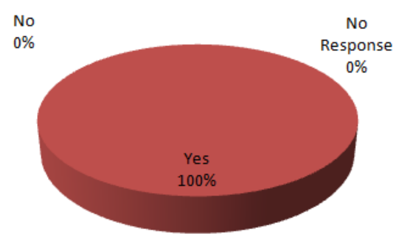
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



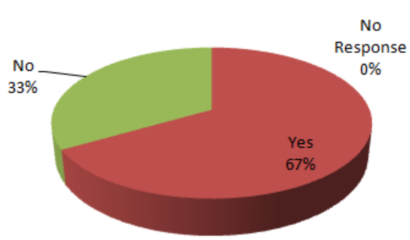
Question 2a: Are the goals of the project technically achievable?



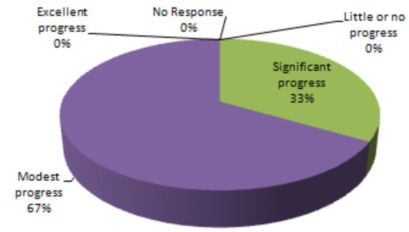
Question 2b: Have the technical barriers been identified and addressed?



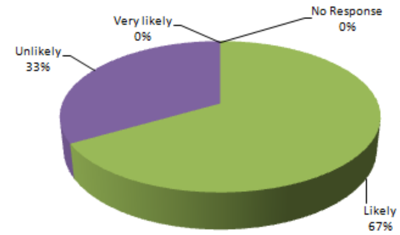
Question 2c: Is the proposed work likely to overcome technical barriers?



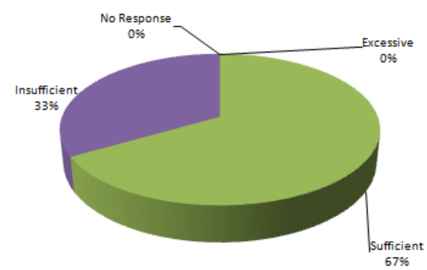
Question 3: Characterize the technical accomplishments and progress toward goals.



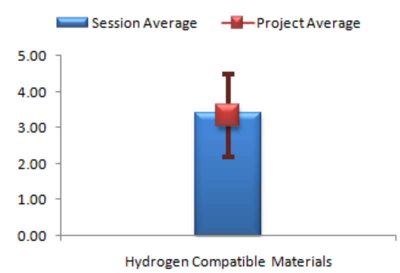
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



IEA Annex on Materials for Transportation (Stephen Hsu, of National Energy Technology Laboratory)

Reviewer Sample Size

This project had a total of 2 reviewers.

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

The lone respondent stated that the project will improve energy efficiency and reduce fuel consumption, thus achieving petroleum conservation and displacement.

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

The lone respondent commented on the work with international organizations to achieve common goals.

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

The lone respondent commented on the leveraging technical efforts to reduce oil consumption.

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

The lone respondent stated that there is great collaboration across the globe.

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

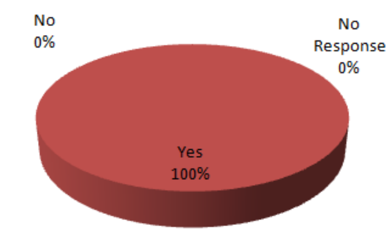
There were no responses to this prompt.

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

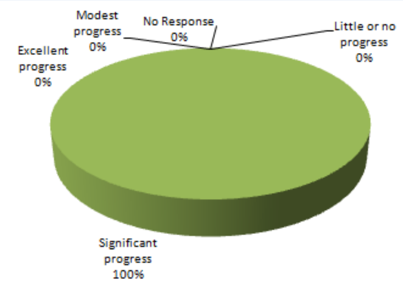
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: IEA Annex on Materials For Transportation

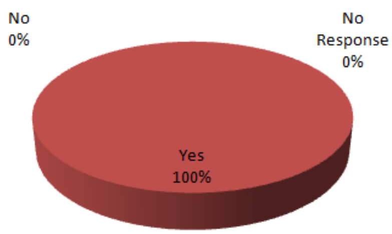
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



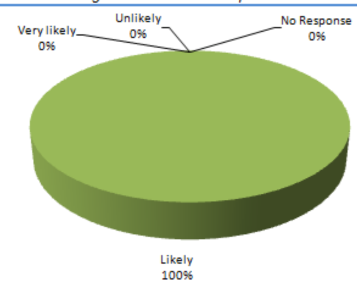
Question 3: Characterize the technical accomplishments and progress toward goals.



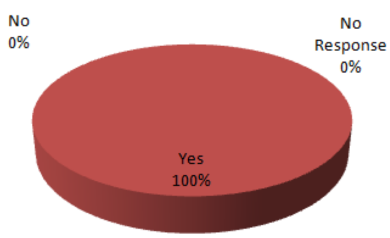
Question 2a: Are the goals of the project technically achievable?



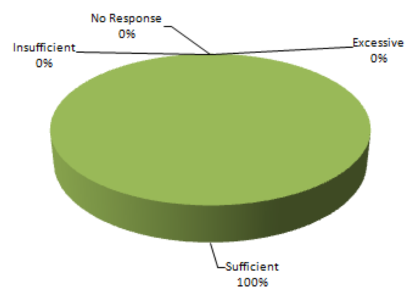
Question 4: How likely is the project team to move technologies into the marketplace?



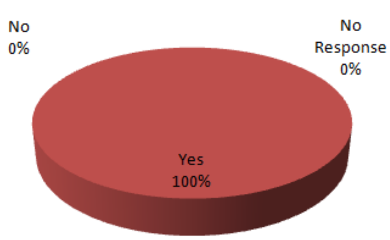
Question 2b: Have the technical barriers been identified and addressed?



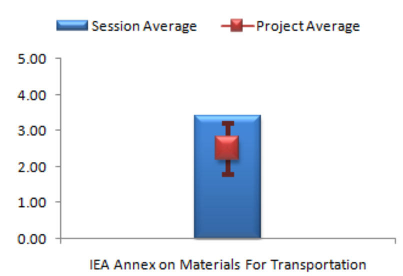
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Integrated Surface Engineering for Improving Energy Efficiency (Aaron Yocum, of National Energy Technology Laboratory)

Reviewer Sample Size

This project had a total of 2 reviewers.

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

One person commented that the project will improve energy efficiency and reduce fuel consumption, thus achieving petroleum conservation and displacement. The other noted that the project aims at reducing friction losses and, through the integrated approach, 5% fuel efficiency improvement is aimed for.

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

One reviewer noted that the consortium has representatives from the whole supply chain, adding that this will be helpful in introduction of the technology. The other response cited the following barriers: lack of theory and understanding of how surface textures control/reduce friction, demonstrated success for conformal contacts, cost effectiveness of texturing, and fabrication cost and ease of texturing on actual engine parts. The reviewer cited the following approaches: conducting control experiments and developing a model.

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

The first reviewer commented that friction reduction with the studied technology is beneficial for fuel efficiency, while the other commented that the group has worked on three regimes of friction reduction and studied different surface texturing effects on friction reduction at different speeds.

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

One person indicated that the group is working with CAT, Timken, United Technologies, Crane Packing, and other smaller engine manufacturers. The other reviewer stated that similar surface modifications are already in the market, and the progress in the project is relatively slow or too slow. The reviewer added that VW is already to its second generation of the type of surface modification mentioned.

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

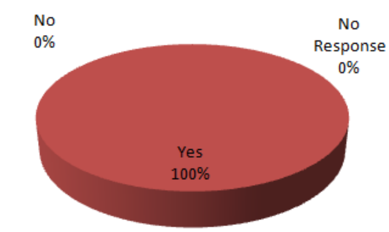
The lone respondent commented that the group is developing thin film coatings on textured samples, including developing compatible surface chemical coatings and discussing these results with industrial partners.

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

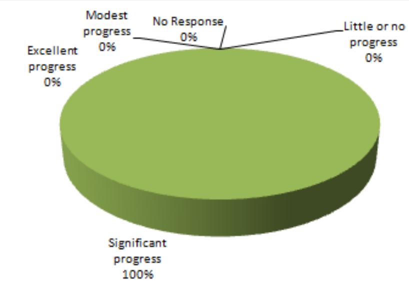
There were no expository comments for this question: refer to the graphic on the next page for this project’s summary score.

Project: Integrated Surface Engineering for Improving Energy Efficiency

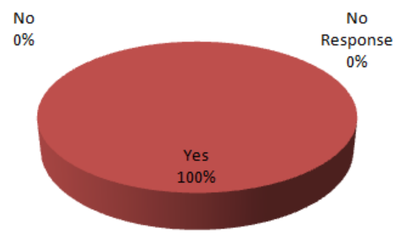
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



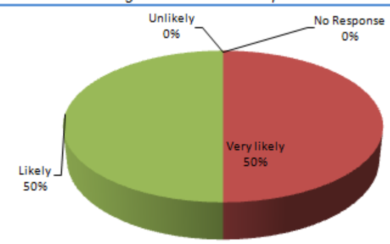
Question 3: Characterize the technical accomplishments and progress toward goals.



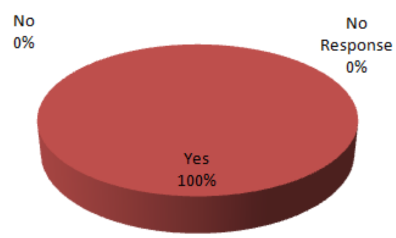
Question 2a: Are the goals of the project technically achievable?



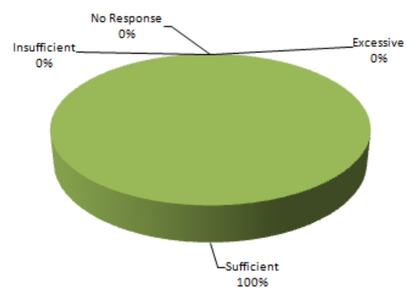
Question 4: How likely is the project team to move technologies into the marketplace?



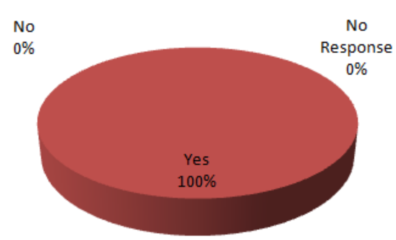
Question 2b: Have the technical barriers been identified and addressed?



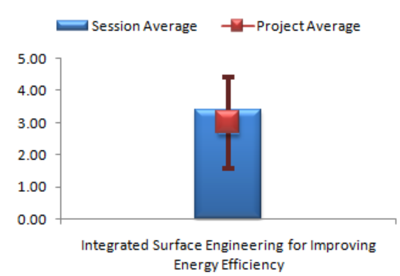
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Joining of Advanced Materials by Plasticity (Jules Routbort, of Argonne National Laboratory)

Reviewer Sample Size

This project had a total of 4 reviewers.

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

One reviewer commented that this is basic research initially, but becomes an enabling technology. There are multiple possible applications including valves, sensors, fuel cells, optical, and biomaterials, etc. Another person stated that it opens up the potential for introducing a whole set of new locally improved materials. The application is not on the short term. One reviewer, similarly, commented that this was good basic R&D, but the application to high-efficiency engines in tenuous. The need for using this in NOx sensors is unproven. One final reviewer commented that this work has been focused on coal-fired plants versus piston engines, and thus has really not been focused on reducing vehicle-level fuel consumption. The future work will include development of a NOx sensor, which would be applicable to engines.

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

One reviewer commented that the researchers had demonstrated grain boundary sliding to be the mechanism by X-ray testing, while another person stated that, in the case of an oxygen sensor, the technology was demonstrated. This reviewer adds that direct deployment of the technology in cars, however, is not yet realized. The first potential application mentioned was a NOx sensor. Another individual added that there was no discernable deployment strategy for engine applications. One final respondent stated that this was not applicable. The PI admitted this project hasn't been focused on ground vehicle applications, and thus the related technical barriers were not addressed to date.

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

Results to this prompt were mixed. One reviewer stated that there were excellent results for the time and money spent. Another commented that the group had produced pore-free strong joints using plastic deformation in a variety of advanced materials. The application of an oxygen sensor had been demonstrated. Many publications and patents issued and applied.

In contrast, one reviewer felt that this was difficult to assess since the first application was not for transport industry. Following up on this, the final reviewer stated that, again, this project has zero relevance toward DOE vehicle economy improvement, and thus has made zero progress toward overcoming related barriers.

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

Results in this section were mixed, with one reviewer commenting on the accolades of the group: one patent issued (or two applied), 22 publications, awarded R&D 100, and currently have two post docs and one Ph.D. student. This reviewer added that they are doing great work.

In contrast, others felt this project was not applicable to the transportation industry. One stated that it was probably not relevant for engine applications. Another noted that it was demonstrated, but unfortunately not in the transport industry. One final respondent noted the oxygen sensor, and followed up by stating that this project is not relevant toward DOE goals and will not transition to a vehicle or engine OEM.

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

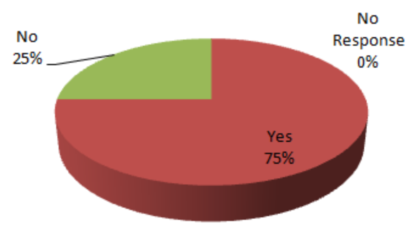
One reviewer stated that this is hindsight since the project is essentially done, and another person stated that this question was not applicable. One other person commented on the good cooperation between ANL and OSU.

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

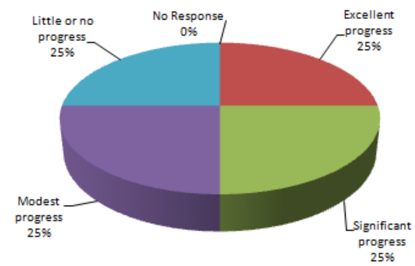
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Joining of Advanced Materials by Plasticity

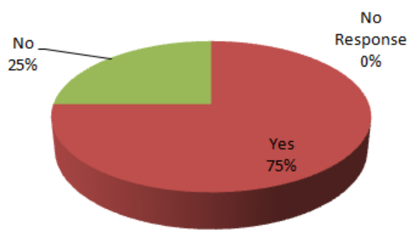
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



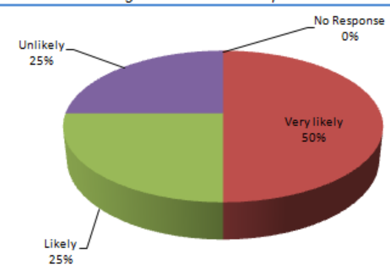
Question 3: Characterize the technical accomplishments and progress toward goals.



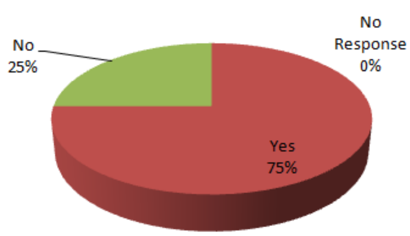
Question 2a: Are the goals of the project technically achievable?



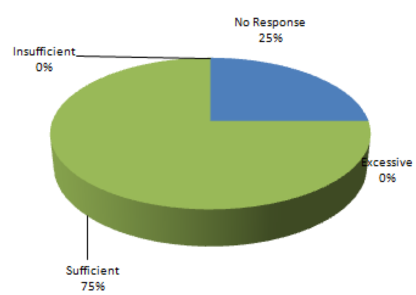
Question 4: How likely is the project team to move technologies into the marketplace?



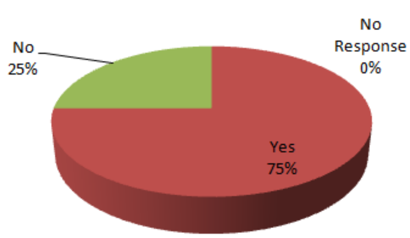
Question 2b: Have the technical barriers been identified and addressed?



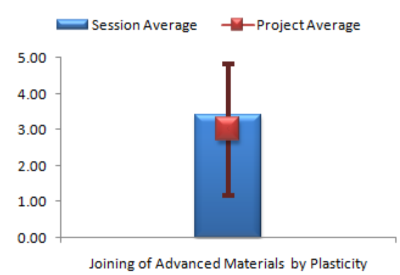
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Life Prediction for Diesel Engine Components (Nate Phillips, of Oak Ridge National Laboratory)

Reviewer Sample Size

This project had a total of 2 reviewers.

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

One reviewer stated that the project supported lightweight valve material to achieve higher fuel efficiency, while the other noted that a 5% increase in fuel efficiency is claimed.

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

The first commenter stated that there were good analysis results. The other respondent noted that the consortium has research institutes and an OEM involved. It would be a good addition if there was also a valve manufacturer involved. The outcome of the engine test showed that some technical barriers still exist.

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

The lone respondent noted that the engine test was performed on a natural gas engine and no fuel savings were measured.

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

One reviewer simply noted the CRADA with CAT. The other respondent commented that the project did not show a positive effect on fuel economy based on the use of ceramics, adding that this is because of a premature engine failure.

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

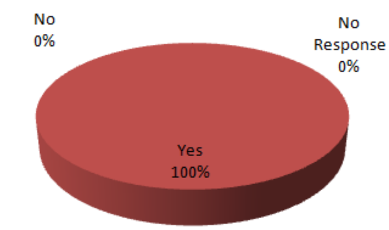
There were no responses to this prompt.

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

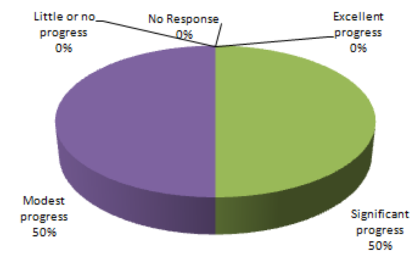
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Life Prediction for Diesel Engine Components

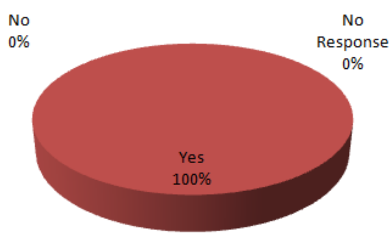
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



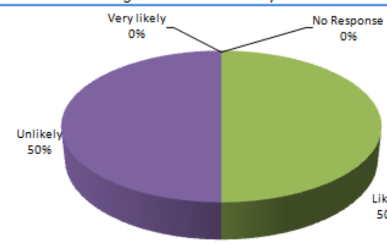
Question 3: Characterize the technical accomplishments and progress toward goals.



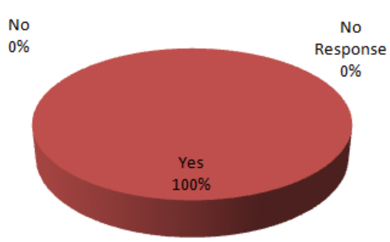
Question 2a: Are the goals of the project technically achievable?



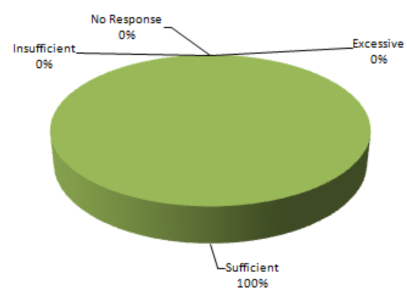
Question 4: How likely is the project team to move technologies into the marketplace?



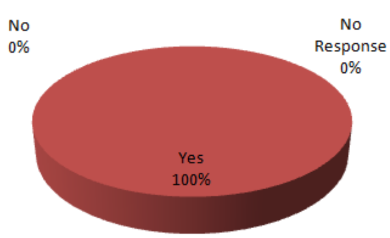
Question 2b: Have the technical barriers been identified and addressed?



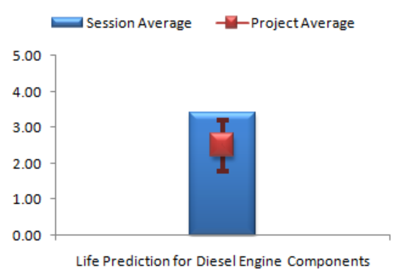
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Lightweight Valve Train Materials (Titanium) (Nate Phillips, of Oak Ridge National Laboratory)

Reviewer Sample Size
This project had a total of 3 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One reviewer stated positively that the program has been going on for eight years already, and resulted in valves 30% lighter than steel, a 200% increase in service lifetime, and a 5% increase in fuel efficiency. One other reviewer also indicated that a 5% increase in fuel efficiency is claimed.

To contrast, one reviewer commented that this project had an objective of assessing the thermal efficiency improvement in a heavy-duty engine, but never was able to quantify the claimed 5% gain. This is very disappointing and it appears most time was spent exploring the durability of alternative material, lightweight valves. Also, the PI could not quantify claimed over-speed or high speed operation and its impact on fuel economy.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
The first reviewer noted that the consortium includes research institutes and an OEM. It should be a good addition to have a valve manufacturer involved as well. The outcome of the engine test showed that some technical barriers still exist. To contrast, another stated that one key objective was a 5% reduction in fuel consumption for a heavy-duty engine. This appears to have been an unrealistic goal according to the presentation which highlighted the PI's inability to experimentally quantify any gain. This 5% goal was very aggressive and implied that lightweight materials would eliminate almost all valve train friction loss.

One final reviewer noted that the primary barriers are high cost, unproven methodology, durability and reliability. The group is taking a three-prong approach via material properties, component stress analysis, and component prototype testing.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer noted that the engine test was on a natural gas engine and no fuel savings were measured. Another person commented that the project has made almost no progress in addressing DOE fuel economy goals. The reviewer adds that the good news is that the PI did show that lightweight materials can exhibit some level of durability in a relevant engine environment, though such materials are far from ready for production purposes.

One final person noted that the group had completed a life prediction model, valve fabrication, and determined the effect of machining procedures on the strength of ceramics. They also did NDE laser scattering inspection of the parts, residual stress measurements on Si_3N_4 test samples, rig tests on valves, and engine tests. Despite the failure in the long-term engine testing, good technical information was obtained.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
The first reviewer commented on CRADA with CAT, noting that CAT is testing the new valve material for their applications. This person added that possible future uses include HD engines that currently

use Ni-Superalloys, Marin and EPG engines. Another person stated that the project did not show a positive effect on fuel economy based on the use of ceramics. This is because of a premature engine failure. One final reviewer indicated that the proposed technology did not show much promise toward a production situation.

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

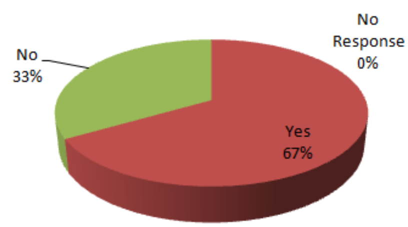
The lone respondent commented that this project included enough test resources to assess its objectives, i.e. engine and bench testing of lightweight valves. It would have been nice if the PI could have given more thought in addressing fuel economy targets during the engine test protocol, but this does not appear to be a resource issue.

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

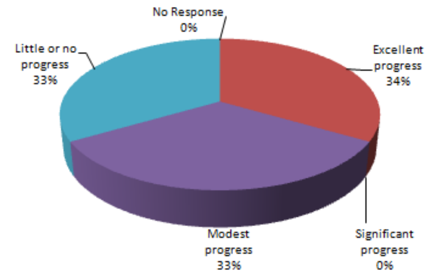
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Lightweight Valve Train Materials (Titanium)

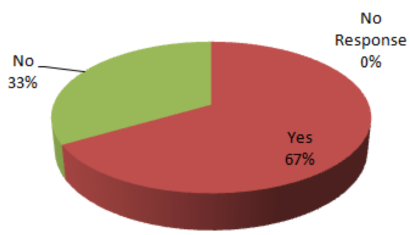
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



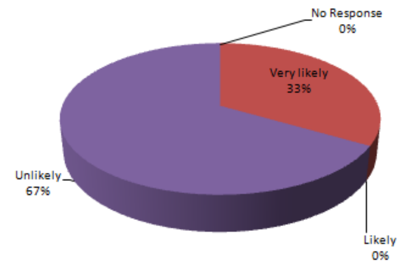
Question 3: Characterize the technical accomplishments and progress toward goals.



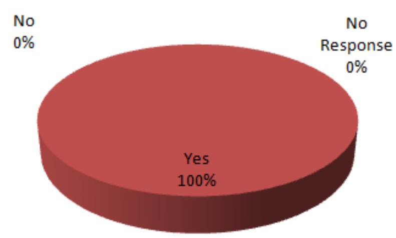
Question 2a: Are the goals of the project technically achievable?



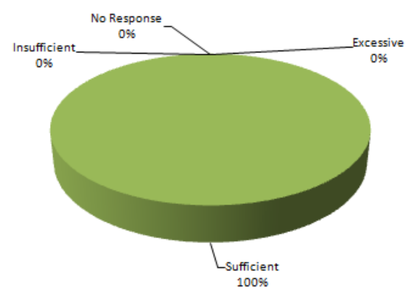
Question 4: How likely is the project team to move technologies into the marketplace?



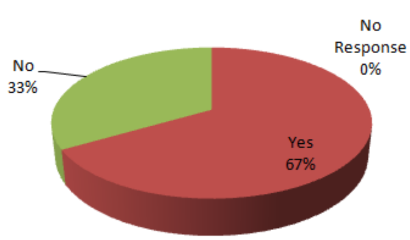
Question 2b: Have the technical barriers been identified and addressed?



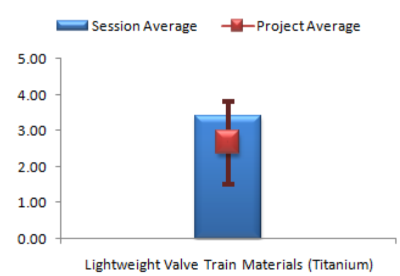
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



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

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

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Three reviewers stated that there is a need for higher temperature components, including valves and seats for high-efficiency engines. This will help achieve higher fuel efficiency and lower emissions. To contrast, one other respondent stated that this is not clear, and that it appears this project is more focused on assessing valve wear and durability under current and future high temperature combustion conditions. The impact on fuel efficiency is unclear. This project seems related to at least two other valve material projects that have focused on potentially current (?) or future valve issues at Caterpillar.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer noted that the project uses an integrated approach (design and material). This will increase the chance of success. Also, the project has a close cooperation with valve and valve seat manufacturers. Adding to this, another reviewer commented on the good, current CRADA with Caterpillar and the interaction with seat and valve suppliers. Another person indicated that the PI is working with the CAT team in defining the valve seat wear issue, and that ORNL is adding more in-depth microanalysis and materials behavior/mechanism analysis. Also, CAT has developed the Buettner Rig Wear Test for conducting component wear tests. One final reviewer stated that the PI and partners have a very good understanding of high temperature material behavior for engine valves in a real-world engine environment. This is a fairly high risk project, but one that is necessary for addressing future higher pressure and temperature combustion systems.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One reviewer commented that this is a brand new project and therefore little progress has been made to date, while another also stated that it is a new project, so not much progress was made in the project. This reviewer added, however, that the scope of the project is well defined. Another wrote that there has been good progress given the time that the project has been operating. One final reviewer stated that, in future engines, valves must be able to withstand more severe conditions. As such it is a needed enabling technology.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One reviewer noted that there is a close cooperation with the end user, while another stated that this project appears to have intimate involvement from a major engine OEM, which should allow for a likely transition assuming this project is successful. Another reviewer commented that the new CRADA with CAT began in September 2007 and will continue for 2.5 years. This reviewer added that CAT has formed a team of component suppliers who will provide parts to and receive data from this CRADA.

One final reviewer stated that the application of new alloys is readily doable. The question is whether they will be economically viable.

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

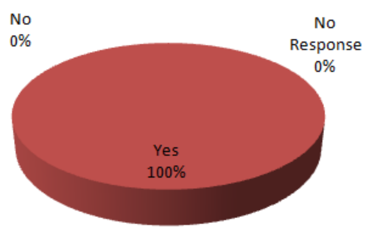
The first reviewer stated that, without knowing more about the project, these resources seem reasonable but may be a limiting factor to what is done later on. One reviewer added that the project is still in its early phase, so no remarks were made. The final respondent stated that, again, this is a new project, and it appears that the PI has enough resources to address the proposed work scope.

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

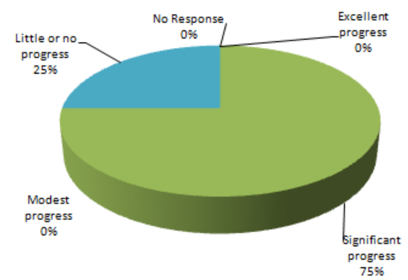
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Materials for Advanced Engine Valve Train

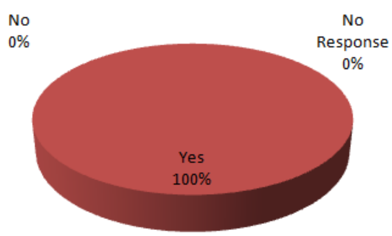
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



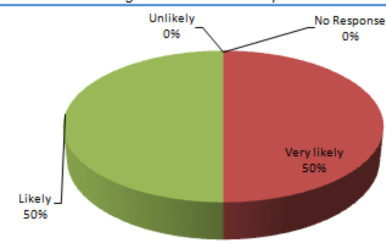
Question 3: Characterize the technical accomplishments and progress toward goals.



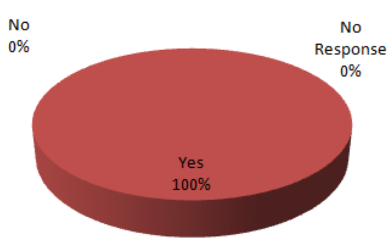
Question 2a: Are the goals of the project technically achievable?



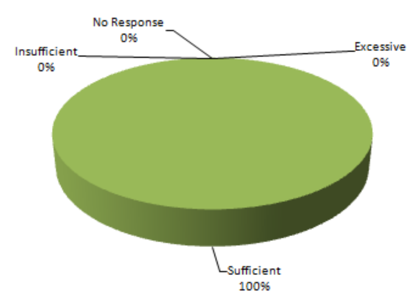
Question 4: How likely is the project team to move technologies into the marketplace?



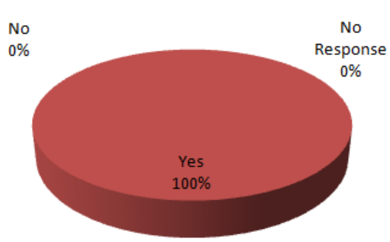
Question 2b: Have the technical barriers been identified and addressed?



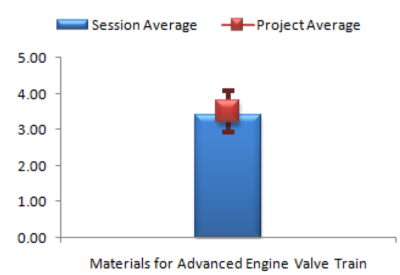
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Materials for HCCI Engines (G. Muralidharan, of Oak Ridge National Laboratory)

Reviewer Sample Size

This project had a total of 2 reviewers.

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

One person indicated that HCCI will be one of the most likely directions for improved fuel efficiency, and improvement of valves is important. Another person felt that the program was well thought out, and on a clear critical path. This is likely high-leverage work.

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

One reviewer stated that the project had a solid approach, working closely with eventual suppliers, based on solid science and past related success. Another stated that the cooperation with valve manufacturers will lead to proper feedback on the direction to develop the materials. This reviewer's only concern is that the budget is not adequate to do sufficient measurements.

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

The lone respondent stated that having valves able to withstand the higher temperatures and stresses at a reasonable cost is key for the introduction of new engines operating in the HCCI mode.

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

The lone respondent commented that higher temperatures will come but the cost of the eventual proposed solutions will be important. This will require a close cooperation with key players.

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

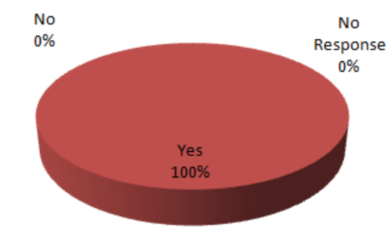
The lone respondent stated that a full characterization of valve material will require many tests. It is not very likely that sufficient confidence can be built up in the given budget.

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

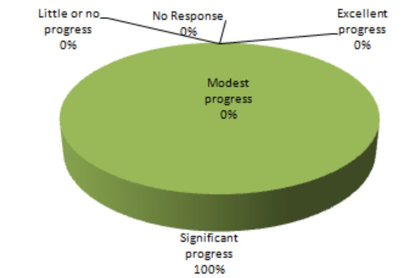
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Materials for HCCI Engines

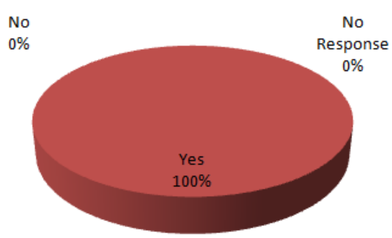
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



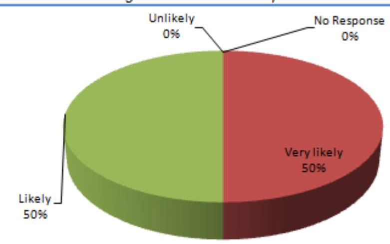
Question 3: Characterize the technical accomplishments and progress toward goals.



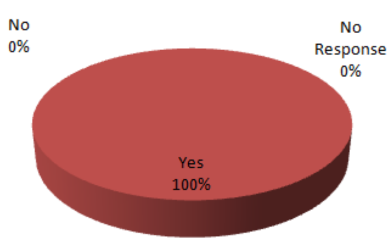
Question 2a: Are the goals of the project technically achievable?



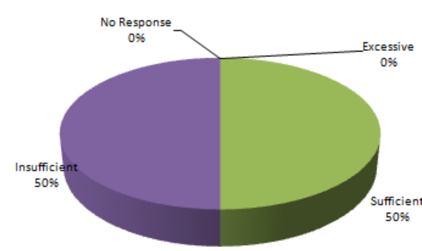
Question 4: How likely is the project team to move technologies into the marketplace?



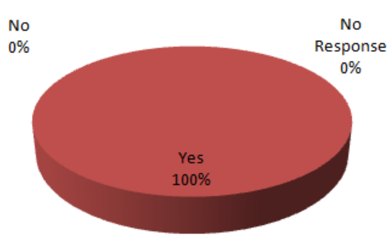
Question 2b: Have the technical barriers been identified and addressed?



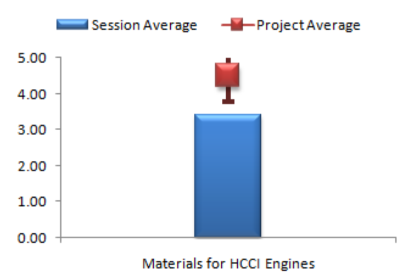
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Materials for HECC/HCCI Engine Components (Caterpillar) (Glenn Grant, of Pacific Northwest National Laboratory)

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

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Responses to this prompt were mixed. One reviewer commented that this technology is an enabler for HCCI, and this will result in lower fuel consumption. Another stated that it is unclear that this technology would have any specific application to HCCI or HECC engines. It seems that, if successful, this technology would benefit all engines, not just high efficiency engines. Another reviewer commented on the project's focus on FSP to enhance the thermal and mechanical efficiency of engine materials. The project is also trying to increase the durability of engine components.

One final reviewer stated yes, and a little no. This project is focused on improving the mechanical properties of certain engine components (piston and head application) and has a secondary focus on augmenting fuel efficiency in engines through the allowance of higher firing pressures in tomorrow's engines. With this said, it is an important R&D area for engine OEMs toward addressing engine life durability targets.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer stated that this is a very good project toward developing next-generation pistons, heads, and other engine components for high firing pressure engines The PI and its engine OEM partner appear to have a very good engineering 'feel' for what is possible from a materials selection viewpoint. Another commented that the project is in a very early phase, so it is not clear that technical barriers are overcome yet. It is an interesting approach to create local improved material properties. The consortium has a strong input from an OEM, so positive results will find their way.

Another person stated that deployment strategy is currently limited to CRADA with Caterpillar. One final reviewer commented on the selective surface enhancement for engine components. FSP has been applied for aluminum and bronze, but not much on steel and cast iron. Process development is needed, and tool design will be addressed.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One response stated that this was a good start for this project, which has been going on only a very short time. Another reviewer added that this project is relatively new and should make significant progress during the next fiscal year.

One person noted that CRADA was just signed in Nov. 2007. The project scope was defined, and there has been some progress made in designing and fabricating preheating tools. One final reviewer commented that HCCI will be a large step forward in fuel efficiency. This material will provide enabling technologies.

Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One reviewer stated that the project team demonstrates great insight into the processes, and has the equipment to do the job. Another person cited the CRADA with CAT. One reviewer felt that there is

still some question on how suitable the technology is for mass production. A final reviewer commented that this project has a very strong engine OEM influence, which will give the project the best possible probability for future engine application, especially since the engine OEM has dedicated engine test resources for evaluating any new components under real-world conditions. It will be necessary for engine OEMs to continue increasing firing pressures to meet both future fuel economy goals and also emission standards, and thus this project could be one enabler.

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

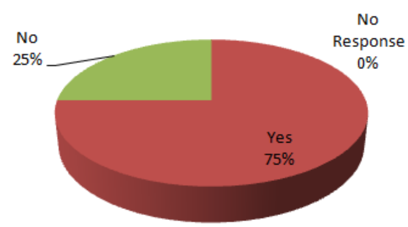
Responses were generally positive here. One person stated that the resources appear to be reasonable for the scope. Another noted the 50% cost-share with CAT. One reviewer commented that milestones were mentioned and that the project is within the planning. One final reviewer indicated that excellent bench test and engine test rig resources are dedicated to this project.

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

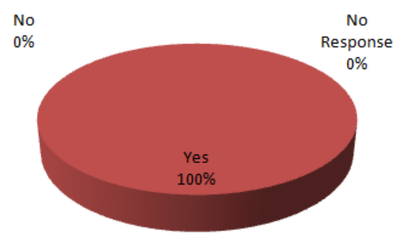
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Materials for HECC/HCCI Engine Components (Caterpillar)

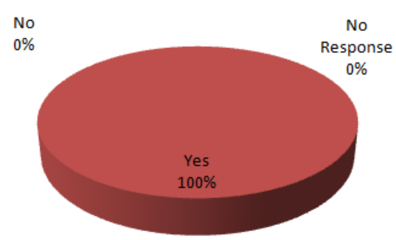
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



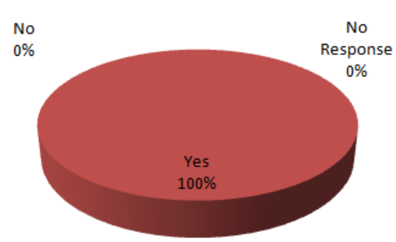
Question 2a: Are the goals of the project technically achievable?



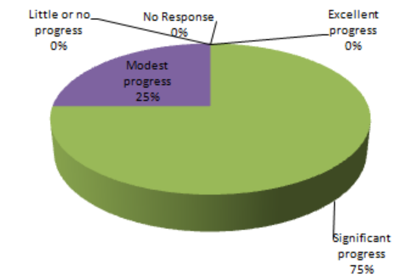
Question 2b: Have the technical barriers been identified and addressed?



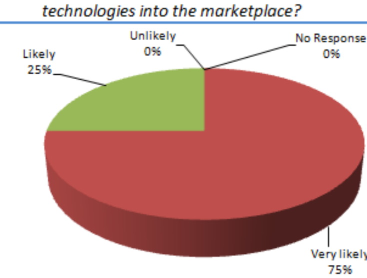
Question 2c: Is the proposed work likely to overcome technical barriers?



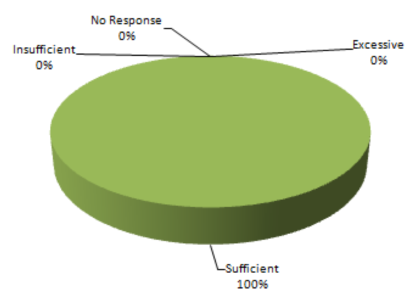
Question 3: Characterize the technical accomplishments and progress toward goals.



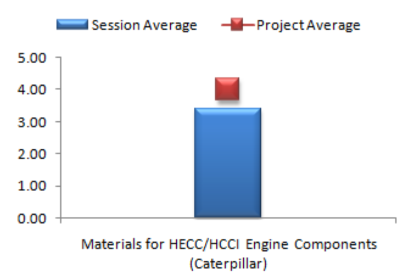
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



Materials for High-Pressure Fuel Injection Systems (Peter Blau, of Oak Ridge National Laboratory)

Reviewer Sample Size

This project had a total of 3 reviewers.

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

One reviewer commented that pressure demands on the materials for the fuel injection system have significantly increased. This project will increase fuel efficiency. One other person added that fuel injector improvements are needed for lower fuel consumption. One final respondent stated that this project indirectly addresses DOE fuel economy goals through the exploration of materials that allow for higher pressure fuel injection and also a more precise metering of fuel during various injection schemes. Nevertheless, it is unclear how specifically such fuel injection strategies will improve fuel economy.

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

The first respondent commented that the team working on this project has shown that they are able to deploy technologies successfully. Another reviewer stated that the implied goal of materials for higher pressure injector nozzles is possible, though the quantitative goals are not clear, i.e. injection pressure, amount of injected fuel, etc. One final reviewer felt that the main challenges are cavitation and erosion, microdefects, and life prediction. This person added that the approach will be to take residual stress measurements of nozzle tips, CFD of mixture flow, develop and apply test methods to measure the effect of pressurizations, and to take bore-hole roughness measurements.

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

One reviewer noted that this is a new project, and therefore little progress has been made to date. Similarly, one other person stated that it is a new project, so not much progress was made. This reviewer added that the focus will be on developing specialized methods to characterize the injector nozzle hole. One respondent stated that one of the limitations for future fuel efficiency improvement lies in the ability for future fuel injection components to withstand these conditions. The outcome of this project can be important.

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

One reviewer noted the CRADA with CAT, adding that they will be involved with CAT in the project. Similarly, one person noted that the project is a CRADA, such that a close collaboration with an OEM is ensured, opening the way towards the market. One final respondent commented that this project has a strong engine OEM partnership that will be critical in transitioning this R&D toward a production situation.

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

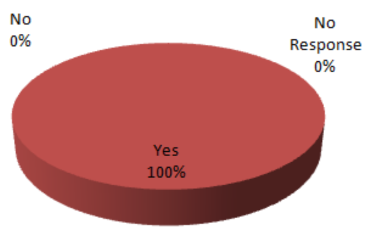
One reviewer commented that no start was made yet and that the project is not yet fully defined. The other reviewer added that this is a new project, and it appears the PI has the necessary monetary and experimental/analytical tools to address the proposed work scope.

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

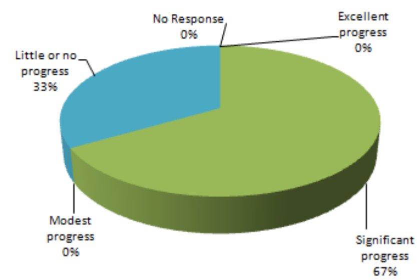
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Materials for High-Pressure Fuel Injection Systems

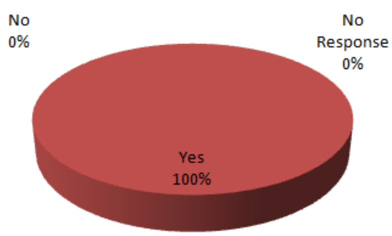
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



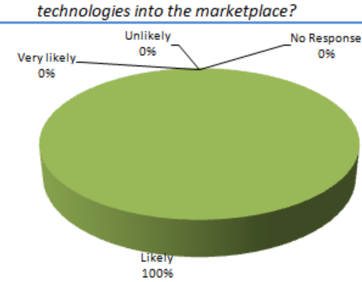
Question 3: Characterize the technical accomplishments and progress toward goals.



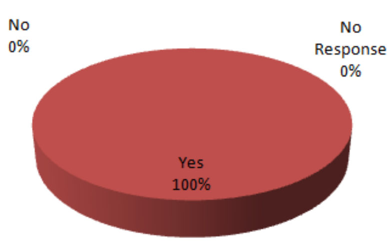
Question 2a: Are the goals of the project technically achievable?



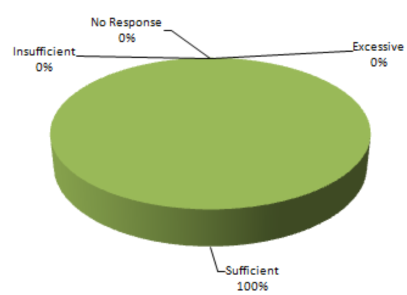
Question 4: How likely is the project team to move technologies into the marketplace?



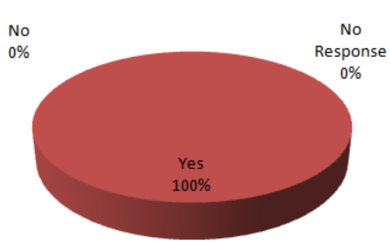
Question 2b: Have the technical barriers been identified and addressed?



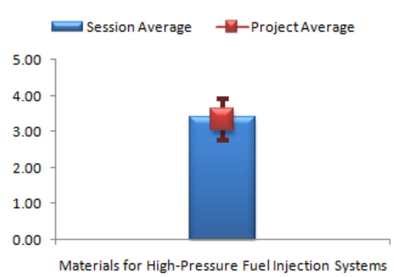
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Mechanical Reliability of Piezo-Stack Actuators (A. Wereszczak, of Oak Ridge National Laboratory)

Reviewer Sample Size

This project had a total of 4 reviewers.

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

One reviewer commented that the technology is enabling a further optimization of fuel injection strategies, leading to reduced fuel consumption. Another person stated that the project supports these goals indirectly, through more precise and faster injectors. One person remarked that the project investigates potential replacement of solenoid actuators with the PMLA for better fuel control, for better fuel efficiency, and for heavy-duty diesel engine applications. One final reviewer, similarly, states that this project indirectly supports DOE's fuel efficiency goals through the potential improvement of today's high pressure common rail injectors toward better controlling and thus meeting the fuel delivery schedule. This reviewer adds that it is apparent throughout the last ten years that continual, more precise control of the injection event is necessary to enable the various combustion modes present in today's and tomorrow's advanced diesels and also to move toward better control of aftertreatment devices.

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

Responses to this prompt were mixed, with one reviewer stating that this project seems more focused on assessing materials for use in advanced fuel injectors than developing new materials, and thus its success will be dependent on today's materials. It is too early to assess if today's materials will provide a solution. Another reviewer wrote that it is dependent on injector manufacturers to implement these findings. Similarly, one other person began by stating that one thing of importance is the reduction of flaw sizes in the ceramic materials. The reduction of this is left to the supplier. It would be an improvement when this activity at the supplier is supported more actively.

One reviewer noted that the investigators intend to work with Cummins in developing the technology.

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

Results were generally positive here, with one person stating that the project shows reasonable progress for the time spent to date and the funding for this work. Another commented that some progress has been made. One reviewer stated that this project is aimed at reducing fuel consumption by an improved fuel injection strategy. This is most likely to be successfully. It also has a high level of realizing this improved fuel efficiency.

To contrast, one person felt this project overall is truly exploratory in nature, which tends to have a discovery rate that is partially a function of luck. It appears to date that very little can be reported on potential material types, though this is coming soon, maybe in the next review. It would have been nice to see more of a discussion on potential materials.

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

One reviewer stated that, to date, no progress has been made in this area, but the CRADA with Cummins is a good start. Another similarly stated that ORNL intended to work with Cummins in getting the technology further developed. One other reviewer noted that interest from industry was already shown, and this technology is already used in cars.

One final reviewer stated that transfer will come down to durability and cost. This person added that the information presented today leads him or her to believe there is a reasonable opportunity that one engine OEM could transition this technology into their future high-pressure common rail injector product.

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

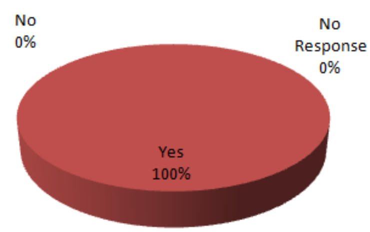
One reviewer stated that the amount of funding appears to be about right given the objectives. New findings of difficulty to achieve the barriers could change this. The other respondent indicated that, based on the presentation, it appears that the PI has adequate computational resources to complete the tasks in hand.

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

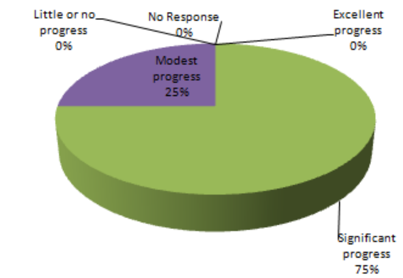
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Mechanical Reliability of Piezo-Stack Actuators

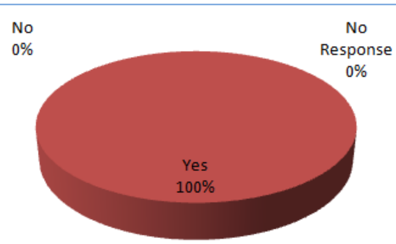
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



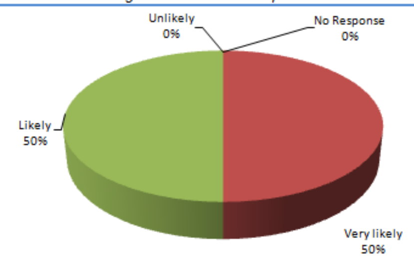
Question 3: Characterize the technical accomplishments and progress toward goals.



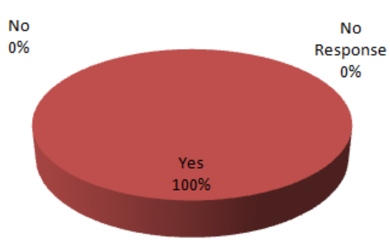
Question 2a: Are the goals of the project technically achievable?



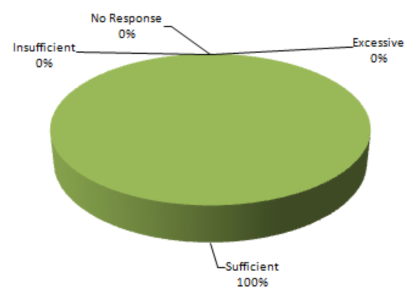
Question 4: How likely is the project team to move technologies into the marketplace?



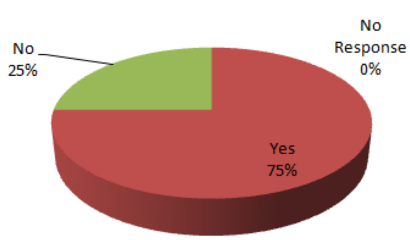
Question 2b: Have the technical barriers been identified and addressed?



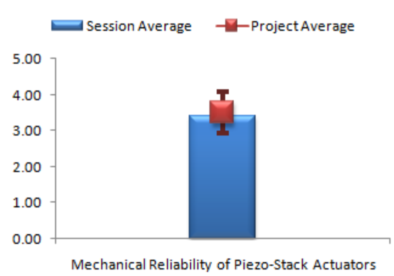
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Non-Destructive Evaluation of Diesel Components (Nate Phillips, of Oak Ridge National Laboratory)

Reviewer Sample Size
This project had a total of 2 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
The first reviewer noted that this is part of the lightweight valve train material project, and the goal is to reduce weight to improve fuel efficiency and lower emissions. The other reviewer commented that a 5% increase in fuel efficiency is claimed.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer commented that the group worked with ANL in using NDE in evaluating tested components. The other individual stated that the consortium has research institutes and an OEM. It should be a good addition when there is also a valve manufacturer was involved. The outcome of the engine test showed that some technical barriers remain.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
One person stated that there was good progress being made, while the other commented that the engine test was done on a natural gas engine and no fuel saving was measured.

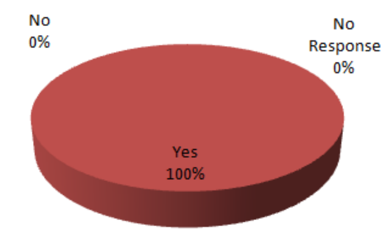
Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One reviewer commented on CRADA with CAT, noting that CAT is intending to use it in production. The other respondent stated that the project did not show a positive effect on fuel economy based on the use of ceramics. This is because of a premature engine failure.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
There were no responses to this prompt.

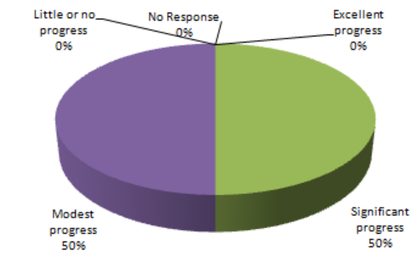
Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.
There were no expository comments for this question: refer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

Project: Non-Destructive Evaluation of Diesel Components

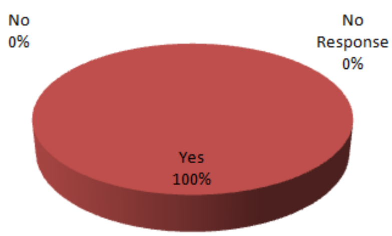
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



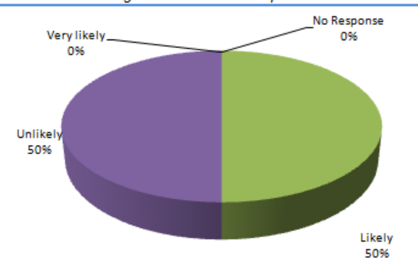
Question 3: Characterize the technical accomplishments and progress toward goals.



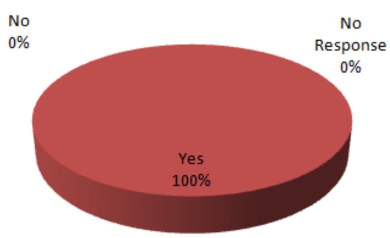
Question 2a: Are the goals of the project technically achievable?



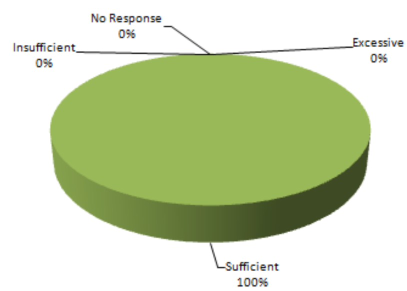
Question 4: How likely is the project team to move technologies into the marketplace?



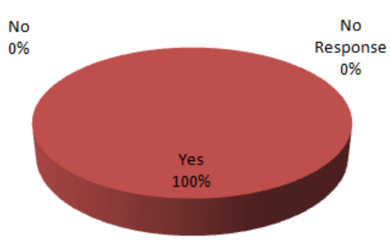
Question 2b: Have the technical barriers been identified and addressed?



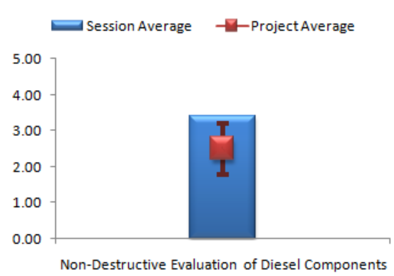
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



NOx Sensor Development (Robert Glass, of Lawrence Livermore National Laboratory)

Reviewer Sample Size
This project had a total of 2 reviewers.

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One person commented that further introduction of diesel engines in light-duty applications would lead to a significant reduction in oil consumption. Since NOx sensors are costly, this leads to a reduced attractiveness of diesel powered vehicles. Another stated that this is a well-known problem, which still needs to be solved. Several people are working in this area, as has been the case for several years. This is very important work and is on a critical path for widespread dieselization.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer remarked that the consortium covers the supply chain, so there is a good feedback on the results and a clear understanding of the requirements is guaranteed. One other person commented that sensitivity to fuel quality and impurities is likely to be an issue, as has been the case for several other related efforts.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
The lone respondent stated that the influence of the current price level of NOx sensors on the further proliferation of diesel-powered cars is likely to be limited. So the execution of this project will only have a mild effect.

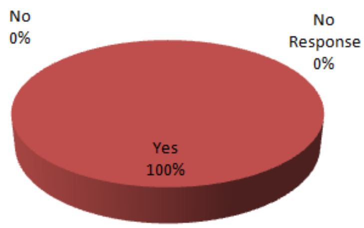
Question 4: What is the likelihood that the project team will move the technologies toward or into the marketplace? Please state the reasons for your selection.
One person noted that an OEM is involved in case of lower cost, such that this will likely lead to introduction. The other respondent stated that someone will eventually round up the results of much prior work, along with a slightly new approach, and make a workable system. This may be the winner. The connection to Ford is likely to provide a door to the market if viable technology is identified. However, this work has been in play for several years, and has missed several product generation changes. One wonders how and when Ford will come to life.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
There were no responses to this prompt.

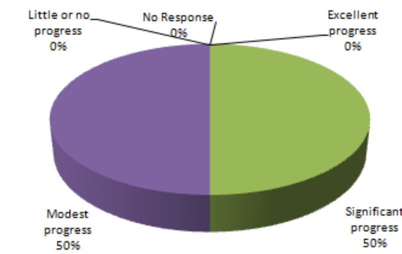
Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.
There were no expository comments for this question: refer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

Project: NOx Sensor Development

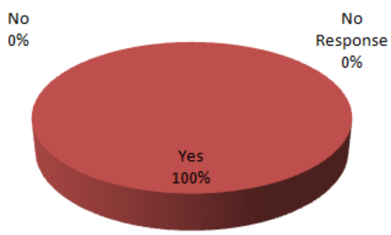
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



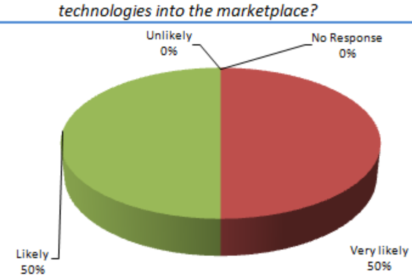
Question 3: Characterize the technical accomplishments and progress toward goals.



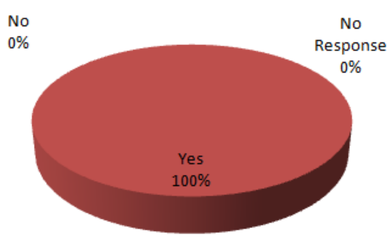
Question 2a: Are the goals of the project technically achievable?



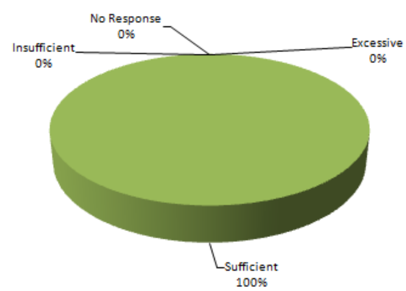
Question 4: How likely is the project team to move technologies into the marketplace?



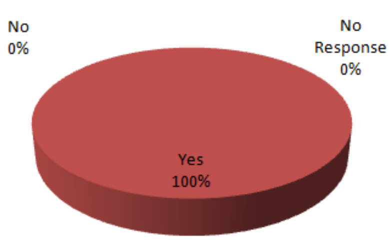
Question 2b: Have the technical barriers been identified and addressed?



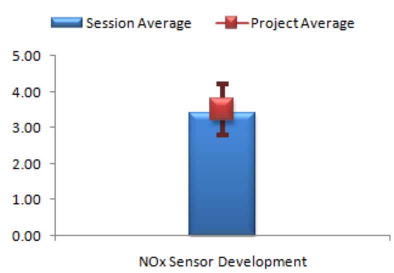
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Power Electronics Materials Compatibility (B.L. Armstrong, of Oak Ridge National Laboratory)

Reviewer Sample Size

This project had a total of 8 reviewers.

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

Multiple reviewers commented on the importance of this project for hybrid technology. One person stated that it aims at solving the high temperature issues in power electronics for hybrids, thus enabling a wider introduction of hybrids, while another reviewer wrote that the focus on automotive air conditioning working medium (R134a and similar) supports a move to hybrid and plug-in vehicles that will result in substantial reduction of petroleum imports. In a more detailed response, one reviewer stated that wider adoption of hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV) products will save millions of barrels of oil; however, before this can occur the cost of these products must be much closer to that of traditional vehicles. One way to assist industry in achieving that goal is to develop technologies that can reduce the cost of the cooling systems in existing HEV and PHEV products. Today, a common strategy is the use of two separate cooling loops in these products: one for the ICE and one for the power electronics. This extra cooling loop is expensive and is part of the higher cost of these products. The technology underdevelopment in this work could enable the use of the existing AC cooling loop to cool the power electronics and reduce the cost of these products. That would then lead to wider adoption of these products and an enormous amount of savings in oil due to a higher fleet MPG average.

One response stated that, although R134a is not a common coolant for cooling power electronics, it is readily available on vehicle systems and should be considered as a coolant for electronics. Another person felt that the impact on power consumption is likely to be high, but is not talked about at all. This reviewer wondered if PI's even understand the need to think through the potential impact on petroleum displacement in specific terms. The technology enabled is highly leveraged and needs to be pursued. One other respondent stated that this project will determine the reliability of direct contact refrigerant coolant of the power electronic components. This coolant technology could enable the reduction in size, weight and cost of the power electronics. This could be an enabling technology for the power electronics.

One reviewer admits some uncertainty regarding this question, adding that if the author is proposing to cool electronics with a refrigerant, then additional vehicle power will be needed to cool the refrigerant, which would seem to have a negative effect on saving power. As long as the gains achieved by cooling the electronics outweigh the losses associated with additional cooling, then the reviewer states a tentative yes. One final review noted that the objective of this project doesn't match the title of the project.

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

One person commented that long-term compatibility and the impact of contamination within the AC system itself and the effect on the power electronics is the key issue that must be resolved. This work is on track to address that issue and appears to have a solid plan of action that will resolve it. Another stated that all resources needed in the project are available. The project is aimed at a determining the effect of coolants on the materials used in high power electric components. One person noted that the test plan outlines material compatibility concerns and corrosion expectations of R134a on power electronic packaging materials. One reviewer suggest that, besides looking at the comparability of the power components, other metals, metal combinations and solders, the control electronic components, and PC boards should also be covered.

Some reviewers were not certain about the deployment strategy, with one person stating that a deployment strategy was not seen in the presentation, and another stating that the technical approach is not clear. One reviewer felt strongly that more thought could be put into potential payoffs of success in the work. There is clear payoff for enabling other technologies. At the same time, how those technologies are enabled can have a wide variety of impacts into fuel consumption, independent of the target technology enabled. This really ought to receive some thought.

Lastly, one reviewer stated he or she liked this concept, at least in terms of using R134a as a direct coolant. The module is effectively sealed from the environment (which has significant gains by itself), it is contained in a material of high dielectric strength, it can be cooled with existing vehicle cooling systems, and the PI is investigating the material interactions with the refrigerant and the packaging materials. The list of compatibility issues seems sufficient, but the author does not disclose how he'll actually measure or determine good/bad. Will it be visual only? Will mechanical studies be performed, or will electrical output be measured? The PI should be clearer about what he'll define as success or lack thereof. The reviewer likes the idea of accelerated testing, but considering that the author will have no baseline to compare to (multiple years in service, for example), it will be difficult to correlate anything from his accelerated efforts. It's a worthy endeavor, but the reviewer is not sure what will be gained. Lastly, the author also does not disclose the exact materials that he will evaluating, so one cannot assess if his study will capture all of the existing high power packaging materials used in industry today.

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

Comments in this section tended to be either positive or acknowledge that this project is relatively new. One person stated that good progress appears to have been made to date. Another indicated that being able to cool the high power electronics in a future generation can be seen as a small enabling step for the future progress in hybrids. One reviewer simply referred to the group's test methodology that had been identified to accelerate materials corrosion from exposure to automotive coolant system working fluids.

Multiple reviewers noted that this is a new project, or that there is no evidence yet. One reviewer wrote that it was very early to judge; the project is just getting started, but this seems like a reasonable path forward. Another simply wrote that no achievements were presented. One final reviewer stated that he or she was not sure if the PI has had sufficient time to make significant progress towards his goal, but the plan seems laid out well enough and significant thought has gone into the effort. Progress has been made.

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

Most of the reviewers were generally positive regarding this question. One person wrote that, since the coolant would ideally be in contact with the die and wire bonds in order to achieve maximum cooling efficiency, the data generated by accelerated compatibility test under development in this work will be very valuable to industry. In this reviewer's opinion, this is a key barrier to the adoption of this technology, and by providing data that resolves the issue, transfer of technology to industry is very likely. Another person added that the reduction of power electronics center physical size and mass are top priorities in OEM hybrid vehicle deployment. The project addresses those needs. Similarly, one person stated that automotive manufacturers will be very interested to review the results to determine the viability of using the refrigerant as a coolant for power electronic modules. Another reviewer commented that this has the potential to meet the cooling needs of all the components in the power electronic system. The project needs to be done to determine if the risk can be overcome.

One person stated that it was difficult to determine since the project is not aimed at a product but an understanding of the behavior of materials. Similarly, another reviewer stated that it was not clear what to achieve.

One final reviewer stated that they are not qualified to answer this question, mostly because the question is bigger than the reviewer, or the efforts at ORNL. Moving the technologies toward the marketplace is a direct function of acceptance of the technology by the marketplace. As long as the PI is working or collaborating with industry experts on electronic cooling systems, then the program stands a chance of being successful. Otherwise, there will be some challenges, especially time to market. If a systems supplier picks up this technology when it's complete (2010?) and spends further time/effort developing a cooling system around it, it may not see the market until 2015 or later. The PI needs to begin sharing preliminary data with systems suppliers to gauge interest in the program to see if it will have acceptance in the marketplace.

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

Three different reviewers stated that the resources were sufficient, with one stated that the resources appear adequate to achieve the project goals, while another said that the project will be accomplished with the given resources.

Another person commented that they see no issues in the PI achieving his milestones. This person adds that “developing a methodology” and “initiating testing” aren’t exactly aggressive achievements, and those elements could already be accomplished at the time of this writing. “Continued testing during the next FY” is also generic enough to be easily met. As mentioned, the reviewer likes this approach. If at all possible, the reviewer never advocates pushing electronics above the 150-175ºC threshold, specifically for automotive applications. Using a cooling system is a fundamentally better idea and using R134a also has benefits. The only concerns are the system-level issues associated with this module concept. The reviewer understands that the scope of the work is not the system, but at some point this idea will need to be transferred to an OEM. The reviewer has concerns about pressurizing and sealing the module, especially with electrical connections coming to the outside world, and the costs associated with such a connector system. The reviewer has issues about servicing the module and the efforts involved to safely extract the electronics should something go wrong with them. The reviewer also has issues about the additional power draw required to cool the electronics and how the HVAC system engineers would feel about another draw on their compressor. The reviewer is sure all these issues can be resolved, but they are just a few concerns. Otherwise, this reviewer likes this novel approach.

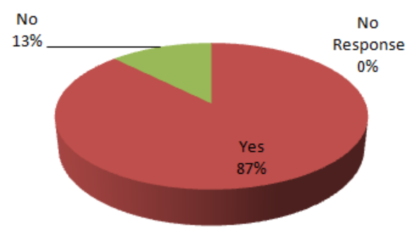
One person commented that the project will take longer than a year to complete unless compatibility issues are found, and another said it was not clear what the tasks are.

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

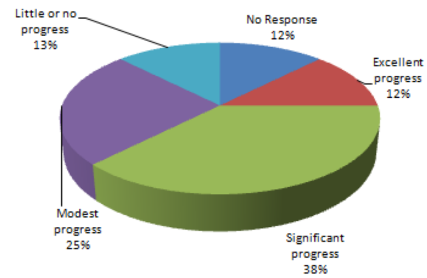
There were no expository comments for this question: refer to the graphic on the next page for this project’s summary score.

Project: Power Electronics Materials Compatibility

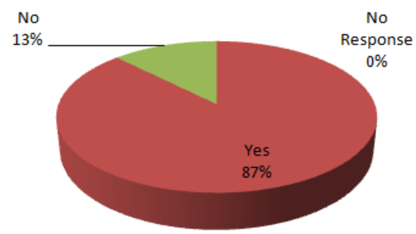
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



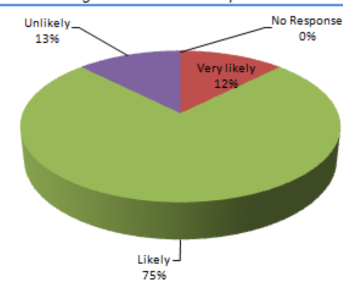
Question 3: Characterize the technical accomplishments and progress toward goals.



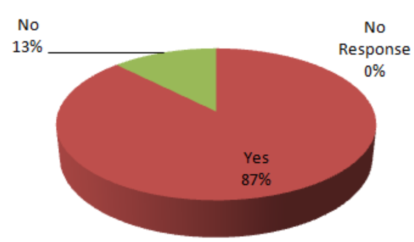
Question 2a: Are the goals of the project technically achievable?



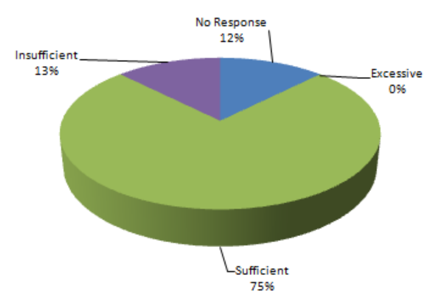
Question 4: How likely is the project team to move technologies into the marketplace?



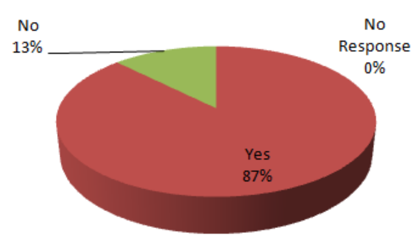
Question 2b: Have the technical barriers been identified and addressed?



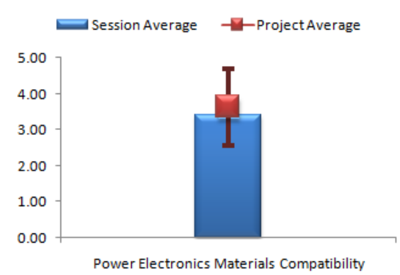
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Residual Stress (Jules Routbort, of Argonne National Laboratory)

Reviewer Sample Size

This project had a total of 3 reviewers.

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

One response indicated, yes, but added that this project and 13721 should be considered together as there is no additional petroleum savings for this project over 13721. Another reviewer stated that this is a supportive project for improved application of thin super hard coatings, and the support is indirect. One final reviewer began by stating that reducing friction and wear in the drive train resulted in 3-4% fuel efficiency. Performance strongly depends on residual stress profile. Currently, no method exists. This project develops and refines high-energy X-ray techniques to measure residual stresses.

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

One person stated that the deployment activities were covered in 13721, and no additional activities were identified in this project, while another reviewer also commented that the project is linked to project 13721, adding that in this project there is close cooperation within the supply chain. One other reviewer commented that the approach is to use high energy x-rays for profiling residual stress in thin coatings and develop indentation-based techniques to measure hardness, fracture toughness, and adhesion energy.

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

One reviewer stated that the progress is commensurate with the duration to date and the budget. Another person stated that it is difficult to see the link between the ability to measure the internal stresses and a reduction in the use of fuel. The technology helps to understand the behavior of hard coatings. One final respondent commented that the group has measured thin coatings of nanocrystalline MoN and MoNCu, created strain measurement techniques (cross-sectional microdiffraction; measured depth-resolved strain/structure in MoN films and MoNCu film), and measured adhesion energy using indentation.

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

One person stated that successful low-friction coatings have many applications in engines, and some are no doubt economically viable today. To contrast slightly, another reviewer stated that there was no technology transfer mentioned in the presentation, and that this is an enabling technology. One other person commented that measurement technology is difficult to transfer due to the very expensive equipment used.

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

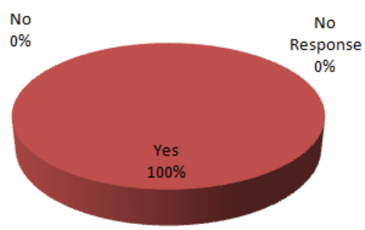
The lone respondent stated that the budget appears reasonable given the activities identified to be completed.

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

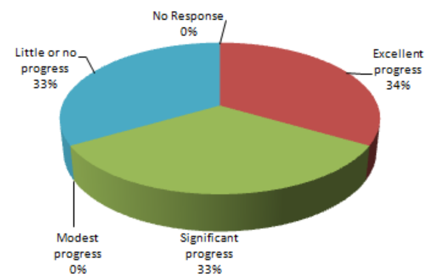
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Residual Stress

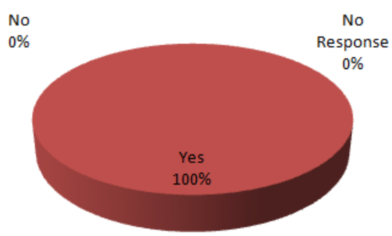
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



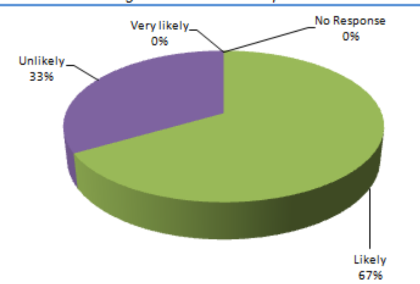
Question 3: Characterize the technical accomplishments and progress toward goals.



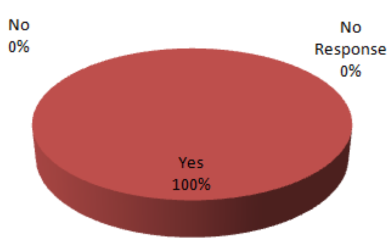
Question 2a: Are the goals of the project technically achievable?



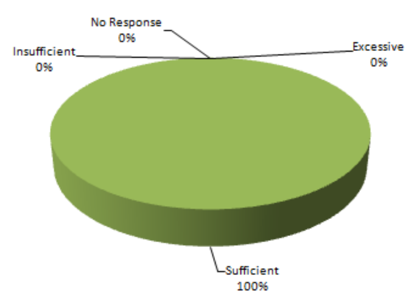
Question 4: How likely is the project team to move technologies into the marketplace?



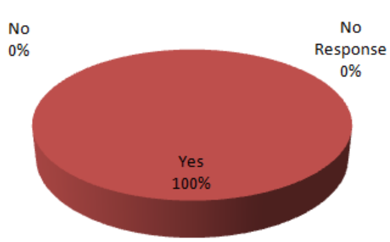
Question 2b: Have the technical barriers been identified and addressed?



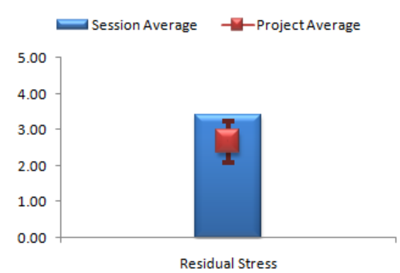
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Solder Joints of Power Electronics (G. Muralidharan, of Oak Ridge National Laboratory)

Reviewer Sample Size

This project had a total of 8 reviewers.

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

Responses in this section tended to depend upon how familiar reviewers were with the importance of high-temperature soldering techniques. One individual wrote that future generations of hybrids will lead to higher temperatures in the power electronics. The conventionally-used solder materials can not deal with this temperature. For this reason, alternative solder material is needed. Another stated that, in order to enable a wider adoption of hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV), the cost of these products must be much closer to that of traditional vehicles. One way to assist industry in achieving that goal is to develop technologies such as SiC based power electronics that can replace the current Si based systems. Since the SiC modules could operate at much higher temperatures, significant cost, weight and size could be saved and facilitate the goal of lower overall product cost. However, a key problem is that the existing packaging technology used in power modules is not capable of working at these high temperatures. Therefore, this work is critical to achieving this goal. The reviewer added that wider adoption of HEV and PHEV products will save millions of barrels of oil. One reviewer simply stated that hybrids lead to lower fuel consumption.

Similarly, one reviewer stated that higher temperature electronics such as SiC and GaN require mounting systems and bonding materials that can withstand 200°C temperatures. This project has this requirement in its sights and the expertise needed to execute. Another person added that the present solder joints used in die bonding the power silicon die are only good to 125°C. In order to get the power electronics to operate with 105°C coolant, a 175° die bond material will be required. This project is very critical in getting reliable power electronics. One response simply stated that high temperature power electronics for vehicle applications is the technical trend. Solder joint reliability is one of the key factors to achieving this goal.

In contrast, some of the briefer responses were less convinced by the importance of the work. One respondent stated that new packaging concepts eliminate the need for solder or wirebonds; however, a better understanding of the solder composition can improve today's power module performance. Another reviewer felt that there was no direct relation that has been analyzed to connect improvements in this area to petroleum displacement. This person suspects that this is not a critical path to enabling other technology, and that this work would get done as routine process development at a vendor. One final reviewer stated that it may contribute indirectly, but this person doesn't think this question should apply to a materials evaluation. He or she does not think it is the fault of the paper, but this person was not sure how to correlate a study on solder joint reliability to saving barrels of petroleum. However, since higher efficiency engines require reliability at higher temps, the reviewer felt that this was okay.

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

Comments to this prompt were generally mixed. One person stated that the approach adopted by the researchers is solid and appears on track to achieve the project's goals. The key problem in the industry is that there are more than 100 solders, brazes, and adhesives that could theoretically be used as die attaching materials for this application. The adhesives can be ruled out due to inadequate thermal and electrical conductivity. However, many of the solders are good candidates for this role, and the proposed methodology will identify which materials make sense as well as provide the required reliability data. One other person wrote that the barriers and technology gaps are identified. This reviewer was pleased to see that the investigators have cited the issue with eutectic AuSn voiding. Concerns with solder layer voiding and trends towards the progressive worsening of voids with temperature cycling are a major issue. The project strategy correctly identifies solder integrity as one of the prime focal points, though the person didn't see a deployment strategy in the presentation.

Other responses offered suggestions or were less positive. One person stated that this project needs to look at some of the newer die bond technologies such as sinter die bond materials. Another wrote that the project is missing the information from an OEM to define the requirements in relation to 15 years of operation. One reviewer wrote that this does not seem to be appropriate work for DOE. This looks like very mundane process development work that should be done by vendors headed for production with specific systems. One other response stated that the approach set in this project is more on testing and evaluating of different solders. It may be that none of the existing solders would work.

Lastly, one reviewer offered a lengthy commentary on the trajectory of this project. The response states that, since the reviewer was not involved at the inception of this project, it is unclear if the PI performed any literature studies or if the PI explored any previous work in the industry or academia. Hopefully the PI is aware of work at the University of Maryland (CALCE) with Patrick McClusky or the University of Auburn with Wayne Johnson. The reviewer cannot confirm all activities at Maryland or Auburn, but there have been significant efforts towards high temperature applications. Furthermore, this person hopes that the PI would attend or participate in the IMAPS HiTEC conference in Albuquerque in May (http://www.imaps.org/hitec/). Regarding the work, the reviewer expects that a facility such as ORNL would perform a more thorough high temperature solder investigation than just the industrial standard of building a module and then thermal cycling it. The reviewer would like to see thermomechanical modeling, including creep and fatigue, at elevated temperatures, and then correlate them to failure analysis findings. Finding material parameters to effectively model different solder compositions would have a far greater impact than just cross-sections of solder joints. Also, the PI points to testing ‘alternate solders’, but fails to disclose what solders he would be testing, and the reviewer is also curious if the PI intends to create new solder compositions or only use commercially available ones. Also, the PI points to wirebond investigations but does not disclose plans to look at them, at least not in FY08. A high temperature study on wirebonds could occupy years of time by itself. The bottom line is that the scope of the study undertaken by the PI is FAR GREATER than what he may be anticipating. There are multiple, more highly-focused projects that could be created instead of this effort. The idea to investigate solders for high temperature applications IS REQUIRED in this industry, but the reviewer would suggest re-evaluation and possible collaboration with other industrial/academic teams who may be trying to solve the same problem. This reviewer does not think that the PI will effectively or completely solve this dilemma in the time required with the strategy presented.

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

More than half of the responses comments on the fact that this is a new project with minimal accomplishments. One person stated that either this is a new project or it is in its early stages to show any progress. Another noted that the PI has identified his approach to overcoming the technical barriers, but given that project has only recently kicked off (4th Quarter, 2007), one could not expect significant work to be accomplished by now. Similarly, one reviewer stated that this is a new project just started in 4th Quarter of FY07, adding that the result so far is not sufficient to make a comment.

One reviewer wrote that this does not seem to be targeted to significant barriers toward DOE goals, while another felt that the progress is modest because a better solution would be to avoid the high temperatures through advanced cooling.

Another reviewer indicated that the project statement is skimpy in technical details and the reviewer did not participate in the on-site merit review meeting, so he or she may have missed some of the supporting discussions on technical accomplishments. However, the reviewer does know the principal investigators and is confident they will make the progress outlined in this proposal. Lastly, one person commented that the initial findings using 80/20 Au/Sn and shear testing represent a good start, and vacuum soldering will reduce the void fractions observed to date. The investigators may wish to consider other materials since 80/20 is a very hard solder and is rather expensive, although the quantity required in a given HEV or PHEV would be very small and, therefore, the total module cost would not be significantly affected. Other materials can also be used and if time allows it would be useful to include those materials as well.

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

Responses to this question were somewhat mixed, but generally positive overall. One person wrote that, as stated above, this die attach is a key problem and resolving it effectively is expensive and time consuming. This work will provide the necessary data to enable industry to select the correct die attach materials for this application. Another felt that, once an alternative solder material is available, it is easy to use it in the industry, with one person adding that knowledge gained in this project can be transferred to a components manufacturer. Another reviewer stated that the project results can help improve reliability of some of the existing products in the market by allowing manufacturers to use better solder composition. One other response indicated that high-temperature electronics has been an industry want for 20 years now in automotive, and (the reviewer knows for fact) for downhole and other geophysical activities. Progress has been slow but steady and this project does advance the state of the art.

To contrast somewhat, one reviewer stated that, if they expand their look at other high-temperature die bond materials, the project is likely to move forward into the market place. One final reviewer stated that the work being proposed by the PI should have value to the marketplace, but in order to gain greater acceptance, the PI should be partnering or collaborating with market players (either power IC companies - On Semi, Fairchild, Infineon, etc., or with module manufacturers). Because the PI is only performing high temperature studies on existing systems, the PI's work should be validated by those where a direct impact will be made. If the marketplace does not accept these solutions or efforts because of cost, usage, availability, etc., then this study is of little or no value. Furthermore, if this study creates no solutions, then the PI will have confirmed what is already known about the difficulties of high temperature electronic packaging. This study should be a collective effort of die suppliers who can discuss bond pad metallizations, wirebond wire suppliers who can help select the correct wire composition based on power and temperature requirements, and substrate suppliers. Just 'throwing this work' into the marketplace may result in a less than enthusiastic response.

Question 5: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?
Two reviewers stated that the resources appear adequate to achieve the project goals, or that the resource statement is sufficient. Another person noted that the reliability test is very expensive and time consuming.

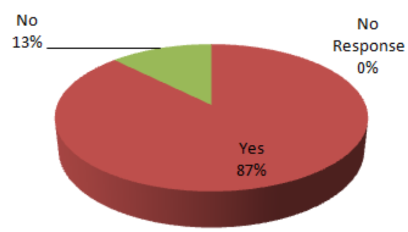
One person stated that the evaluation period for the materials will take longer than a year. Funding should be on going into 2009 and increase in funding should be looked at.

One final reviewer didn't know the milestones for the project, or they are not clearly identified, but the components identified to be completed are logical for the effort. The reviewer would like to know how many thermal cycles will be completed by the 9/08 milestone target, especially given that OEM's are now requiring up to 3000 cycles, and he or she would also like to understand more about the thermal cycle profiles that the PI is targeting, including temperature ranges (-50°C or –65°C, up to 150°C or 200°C), times at temperatures, and if the thermal testing will be thermal shocks (air-to-air chambers) or thermal cycles (single chamber). If the PI wants to make this study relevant, it would be ideal to see correlation to practices and procedures followed in the automotive electronics industry. The reviewer only identified one milestone in the Plans for FY08 section and, given that the PI appears to be evaluating only one solder, then it seems reasonable that the resources are sufficient to meet the timeline. The reviewer has already made comments about where this project lacks focus, but also wishes to emphasize that this work is extremely important and relevant to the high temperature packaging industry, so by no means is the reviewer asking the work to stop. The reviewer's belief is that this work should be done and it should be done correctly. Multiple teams of people should be involved in this effort or the PI will not complete everything on time. The reviewer sees a lot of work to accomplish, and believes that the work will be much more significant than what this work plan proposes.

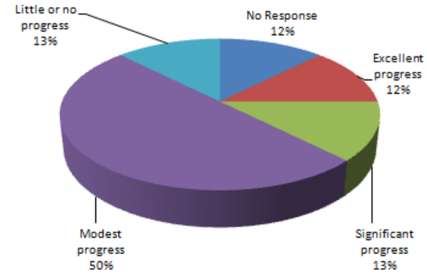
Question 6: Summary rating: when scoring this project, consider the relevance of the work to DOE's objectives, potential impacts on DOE/VT goals, project accomplishments, likelihood of technology transfer, and sufficiency of project resources.
There were no expository comments for this question: refer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

Project: Solder Joints of Power Electronics

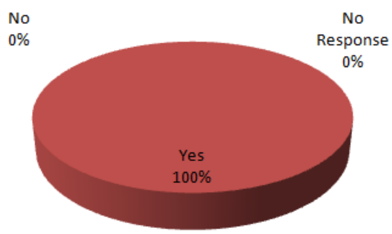
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



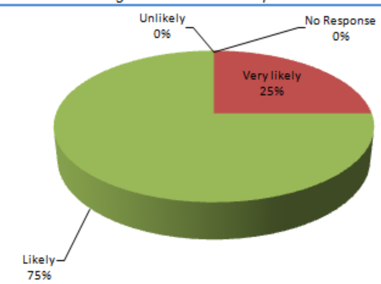
Question 3: Characterize the technical accomplishments and progress toward goals.



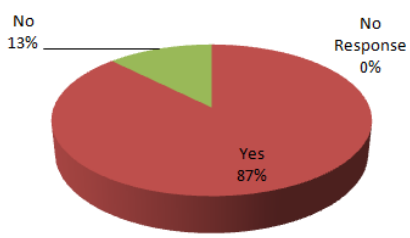
Question 2a: Are the goals of the project technically achievable?



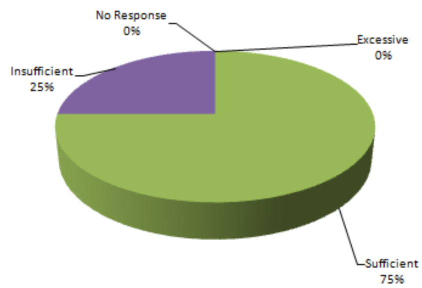
Question 4: How likely is the project team to move technologies into the marketplace?



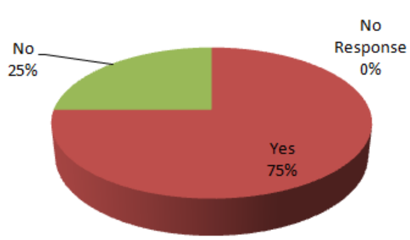
Question 2b: Have the technical barriers been identified and addressed?



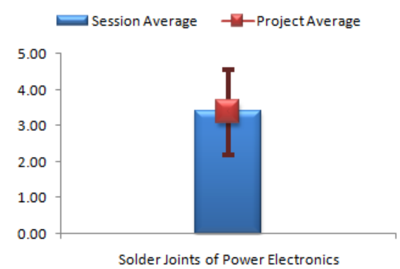
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Super Hard Coating Systems (Ali Erdemir, of Argonne National Laboratory)

Reviewer Sample Size

This project had a total of 3 reviewers.

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

One reviewer stated that friction reduction has broad application in all types of engines, while another commented that 10-15% of fuel energy is consumed by friction in the engine. They added that reduction of S and P in oil places more demand on the material for friction and wear control, and pointed to developing a low-friction coating to reduce friction. The final reviewer noted that the project targets the reduction of parasitic losses. They added that these losses are responsible for 10 - 15% of the energy consumption, and, as such, this project is in line with DOE's objectives.

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

One reviewer stated that they are working with component suppliers and it is presumed that if successful, economic coatings are developed, they will be implemented. Another added that one of the problems with hard coatings is the poor wetting characteristics with lubricants. This project aims at solving this issue. There is cooperation with a supplier. The whole supply chain is involved in this project.

One final reviewer commented that the barriers were: a predictive model for lubricious coating design, reproducibility/scalability/manufacturability, and performance. The team's approach is a bottom-up approach: use a crystal-chemical model as a predictive tool, demonstrate production/deposition, characterize structure and properties, verify tribological, and then perform engine tests.

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

One reviewer indicated that the progress achieved is reasonable given the duration of the project to date and the funding provided. Another commented that they have demonstrated production and completed coating design, development, and characterization. The group has also studied friction and wear tests, performed in EGR-contaminated/acidified oil, and done resistance-to-scuffing tests and XPS studies. One final reviewer stated that the improvement in parasitic losses only applies to a limited amount of components, and thus the overall effect will be limited. A full implementation of this technology would enable the use of low-viscosity lubricants in HD, giving it a higher potential in this market.

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

One person stated that low-friction coatings have many potential applications, including several where economics are not critical. Also, it is desirable to reduce the amount of wear additives in lubricating oils to protect emission control devices, creating demand for more low-friction coatings. Another commented that their selection was based on the group's contact with coating companies. These companies are successfully in introducing these technologies. The introduction will occur first in some nice market. Similarly, one person noted that they are working with a major industrial coating manufacturer to scale up: Burgess-Norton, Eaton, Mahle, Westport, CAT, Honda, and Hyundai. They will have the option to license an agreement with a company.

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

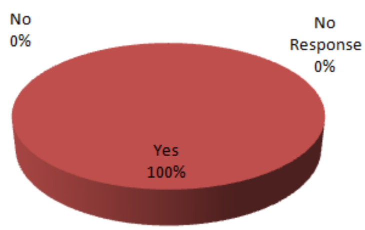
The lone respondent stated that the project is receiving co-funding and no activity has been identified that cannot be completed within the current budget.

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

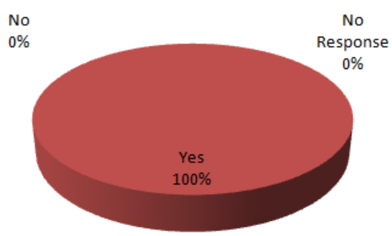
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Super Hard Coating Systems

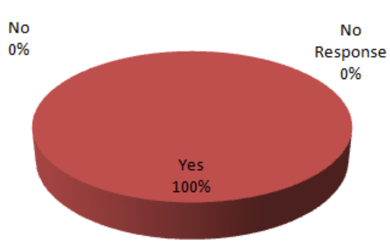
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



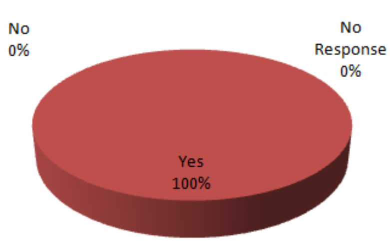
Question 2a: Are the goals of the project technically achievable?



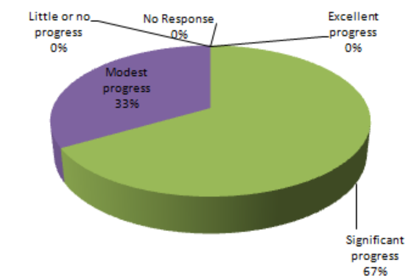
Question 2b: Have the technical barriers been identified and addressed?



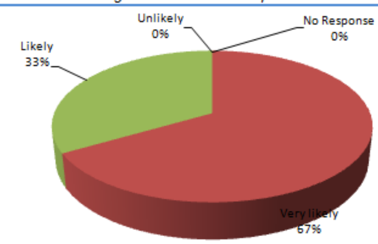
Question 2c: Is the proposed work likely to overcome technical barriers?



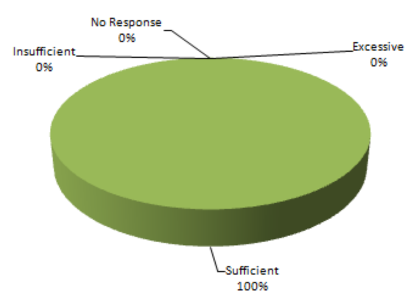
Question 3: Characterize the technical accomplishments and progress toward goals.



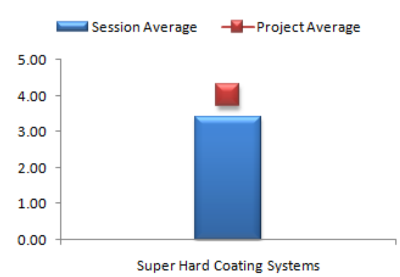
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



Thermoelectrics Materials by Design, Computational Theory and Structure (David Singh, of Oak Ridge National Laboratory)

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

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
One reviewer remarked that improved thermoelectric materials are essential to making them economically viable, while another noted that the investigators are trying to find promising thermoelectric materials for waste heat recovery in vehicles.

One response noted that the project addresses the use of waste heat and could lead to a potential 10% improvement of thermal efficiency. Similarly, another reviewer stated that the objectives of a 10% increase in fuel economy on a designated vehicle platform are well understood. This is a theoretical guidance program and is essential to complement the experimental work. Adding to this, one person stated that the program is both timely and important, and there is very little theoretical work on TE materials research as compared to the experimental effort.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
One reviewer commented that this project is exploring new thermoelectric materials, and while higher efficiency materials might be found, whether they are practical depends on their cost and reliability. Another noted that the main barrier is to find higher ZT materials at an appropriate operating temperature that are cost-effective, manufacturable, and durable. The group's approach is to use first principles calculations to obtain electronic structure and vibrational properties. One other reviewer stated that the project is limited to academia, and involvement of industrial partners would be beneficial for the deployment even though the project is long term.

One person indicated that the project goal of 10% increase in fuel efficiency is not likely, but significant progress can be made. The barriers have been identified. A lot of work on the development of the theory of the various materials has been accomplished, and this work should continue as an essential part of the experimental work to provide guidance. The PI's have a strong team in place to address these barriers. The PI's understand the overall goals of the program very well. One final respondent added that the PI is a very well-respected expert in the field. He is as good as you can get.

Question 3: Characterize your understanding of the technical accomplishments and progress toward DOE goals: please state the reasons for your assessment.
Reviews were generally positive in this section. One reviewer stated that the amount of progress is commensurate with the duration to date. Another noted this is a new project, but noted that promising results have been obtained for Mg-Ti-O and Zn-Ti-O ordered materials. Similarly, one person stated that the project is in its starting phase. There is a solid approach for improving the material properties. This is needed to get the technology in the market. One reviewer commented that this is a theoretical guidance program and is essential to complement the experimental work. Another simply stated, very well done.

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

The first reviewer stated that thermoelectrics have great potential and will be implemented if they are reliable and available at low cost, while another commented on the cooperation with ORNL researchers, adding that this project is configured to the Vehicle Technology Solid Waste Heat Recovery Program. One other respondent noted that this is a theoretical effort and will aid the experimental results transition into technology.

One reviewer felt that the potential is high, so if the benefits are shown the market will come. The reviewer added that no clear opinion is possible at this moment. One final person remarked that no information is available to respond to this prompt.

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

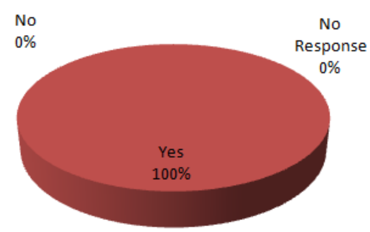
One person stated that the funding for this project is reasonable given its scope and activities, while another agreed, writing that the team has sufficient resources available. One final reviewer stated that there is a very good plan in place. The PI is an expert in the field. This is a very good project. Looking at oxide is appropriate for several very good reasons. This reviewer discourages work towards La_3Te_4 on the basis that Te is becoming increasingly expensive and there is not enough of this TE for large-scale applications.

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

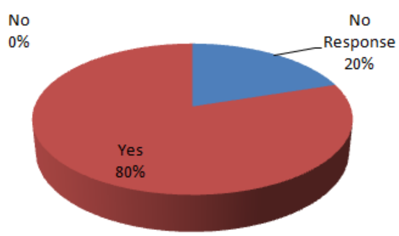
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Thermoelectrics Materials by Design, Computational Theory and Structure

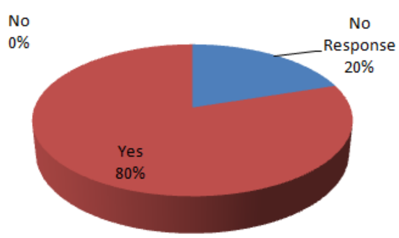
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



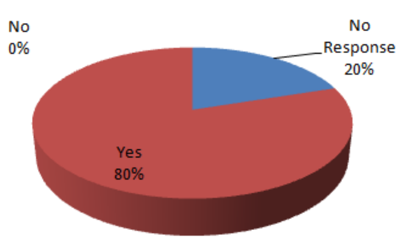
Question 2a: Are the goals of the project technically achievable?



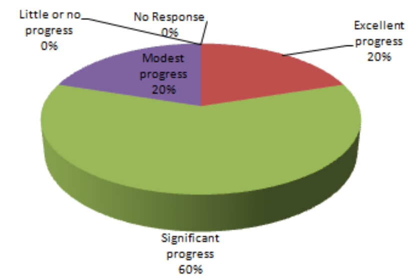
Question 2b: Have the technical barriers been identified and addressed?



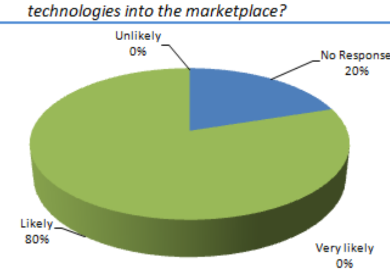
Question 2c: Is the proposed work likely to overcome technical barriers?



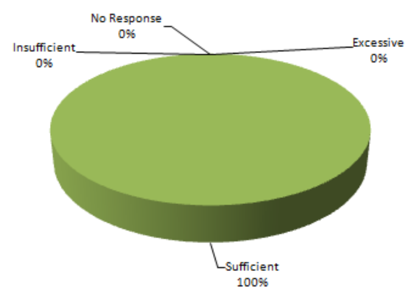
Question 3: Characterize the technical accomplishments and progress toward goals.



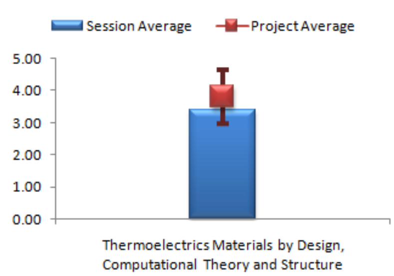
Question 4: How likely is the project team to move technologies into the marketplace?



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



Question 6: Overall Rating



Thermoelectrics Materials by Design, Diamond-Based Thermoelectric materials (Dieter Gruen, of Argonne National Laboratory)

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

Question 1: Does this activity support the overall DOE objectives of petroleum displacement? Why or why not?
Responses to this prompt were generally mixed. One reviewer stated that enhanced thermoelectric materials are essential to practical implementation, while another added that the recovery of waste heat will result in improved efficiency for transportation. Similarly, one person wrote that thermoelectric materials have the potential of improving fuel efficiency, adding that further improvement in material properties will increase the potential even further. Another reviewer commented that the project is aimed at creating breakthrough thermoelectric materials, which would definitely support the objective of petroleum displacement.

Other comments were less optimistic. One reviewer stated that the objectives of a 10% increase in fuel economy on a designated vehicle platform are not well understood. This program centers on thin-film diamond nanostructures. The team offhandedly comments that a ZT of 4 is possible, yet they have no data to base their conclusions on this. They have expertise on nanostructured diamond but no expertise in thermoelectrics. This is much needed. One final reviewer commented that the purpose of the program is to develop high ZT materials with high temperature stability. However, this reviewer is not sure if the PIs are on the right path.

Question 2: Are the goals of the project technically achievable? Have the technical barriers been identified and addressed? Is the project likely to overcome those technical barriers? Please comment on the project's strategy for deployment of technologies.
The first reviewer indicated that it is too early to tell whether this approach to developing new TE materials will be successful. Another person added that the project is exploratory. Deployment will start when more evidence for success is gathered. Similarly, another reviewer stated that the best answer would be "maybe". The materials proposed for this study have very high thermal conductivity, which is bad for thermoelectric materials. This reviewer did not see a good rationale for selecting these materials. One person noted that the initial project concept was based on ultra nanocrystalline diamond (UNCD) thin film work funded by Office of Science.

One reviewer commented that one of the approaches of this project is to explore the possibility of nanoscale-induced ZT enhancement in ultra–nanocrystalline dispersed diamond (slide 3/8). So far the project team only shows data on boron doping and annealing. This reviewer is not sure whether their approach is appropriate or not. Specifically, the investigators are supposed to have a high power factor for the nanocarbon ensembles already. One final respondent began by stating that the project's goal of a 10% increase in fuel efficiency is not likely. Significant progress is not likely to be made. The barriers have been well defined. They offhandedly comment that a ZT of 4 is possible, yet they have no data to base their conclusions on. They have expertise on nanostructured diamond, but no expertise in thermoelectrics. This is much needed. Their strategy is boiler-plate. Why not use this strategy on an already good TE material instead of one of the worst? Diamond is non-conducting and has a very high thermal conductivity. This reviewer adds that the PI's have a strong team in place to address nanostructured diamond, but need thermoelectric expertise. Also, they don't really understand the issues. The PI's understand the overall goals of the program very well, but this reviewer doesn't think they understand how they will achieve them. There was a gentleman in the audience that was asking good questions and the presenter just dismissed them instead of addressing them. Either they don't understand the issues or wanted to gloss over them.

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

Responses to this prompt were generally mixed. One reviewer stated that the extent of progress is reasonable given the project duration to date, while another commented that this is a new project, the initial results seem promising, and the investigators have a long-range plan for the project. One other person remarked that, due to the innovative nature of this project, this is difficult to assess but potential is shown on thin layers.

Other comments were less favorable. One person noted that some power factors (electrical properties) have been measured, but they are very poor, about a thousand times lower than those of good thermoelectric materials. No thermal conductivity results were given. Another reviewer indicated that they have only presented doping on the electrical conductivity of diamond films, but they don't state how low it is or how they might get it high enough. One other reviewer wrote that one of the goals of the project is to achieve $ZT > 4$. Based on the data they have shown in their review, even the boron doped samples have a power factor much less than many existing materials; one has to have extremely low thermal conductivity values to achieve $ZT = 4$.

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

Responses were mixed for this prompt, and tended towards the negative. One person stated that there are many applications for high efficiency TE materials, so implementation of good materials is likely, but two individuals stated that there was no mention about the technology transfer in the presentation.

One reviewer indicated that the current project team will not transfer the technology to the market. The team will aim at bringing the technology to a level that a more application-oriented project could start. Another person added that there is no industrial partner, and the commercialization of nanomaterials for an application that requires bulk solids is likely to be a long and difficult process. Another commented that this program centers on thin-film diamond nanostructures. They offhandedly comment that a ZT of 4 is possible, yet they have no data to base their conclusions on this. They have expertise on nanostructured diamond, but no expertise in thermoelectrics. This is much needed.

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

One reviewer commented that, at present, the funding appears reasonable given the activities being conducted. Another similarly stated that the team has sufficient resources available, but added that they need TE expertise on their team. One other respondent chose a neutral score because there was no budget given in the presentation.

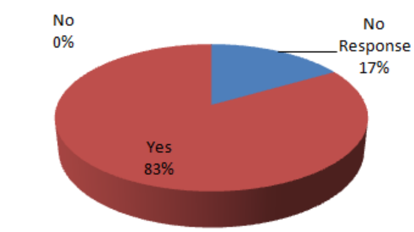
One final reviewer stated that next year's activity is not likely to meet the proposed milestones set forth for the project. This reviewer is not sure how this team plans to have the thermal conductivity, Seebeck, and electrical resistivity measured. The reviewer asks whether they have internal capabilities. The project is supposed to explore the effect of the enhanced power factor of their materials due to the quantum confinement. Their data so far shows the opposite, i.e., the nanocarbon assembles shows very small power factor values. It seems that the plan is to dope the materials and not to investigate the power factor as a function of, for example, size of nanocarbon. This reviewer suggested that it will be helpful if the project can establish some thermal conductivity data.

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

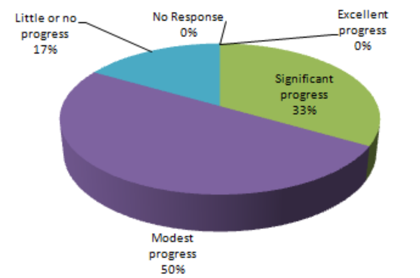
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Thermoelectrics Materials by Design, Diamond-Based Thermoelectric materials

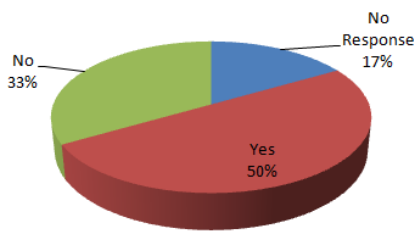
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



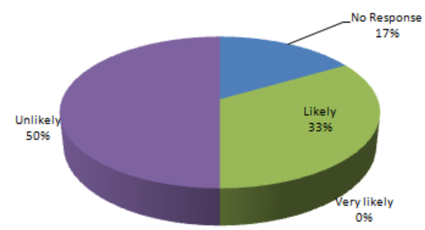
Question 3: Characterize the technical accomplishments and progress toward goals.



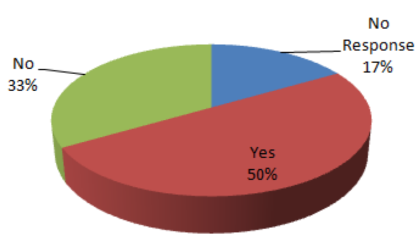
Question 2a: Are the goals of the project technically achievable?



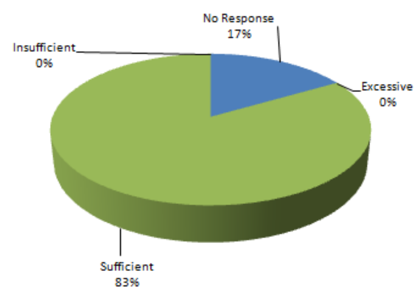
Question 4: How likely is the project team to move technologies into the marketplace?



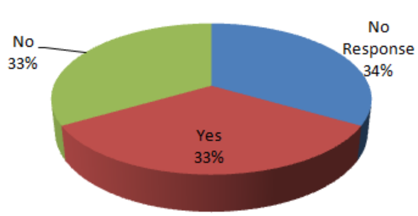
Question 2b: Have the technical barriers been identified and addressed?



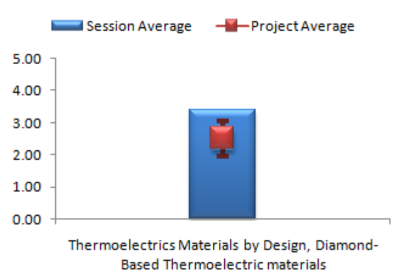
Question 5: Characterize the resources available for this project to achieve the stated milestones in a timely fashion.



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



Question 6: Overall Rating



Thermoelectrics Materials by Design, Mechanical Reliability (A. Wereszczak, of Oak Ridge National Laboratory)

Reviewer Sample Size

This project had a total of 6 reviewers.

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

Reviews to this question were generally positive. One person stated that thermoelectrics have a large potential to reduce petroleum consumption. This project does not improve their efficiency, only their strength, which is essential to implementation. Another person commented that the proposed work is necessary for large-scale deployment of thermoelectric generators in vehicles and/or energy-intensive industry for waste heat recovery. Similarly, one reviewer stated that a material's mechanical reliability is a critical, yet often overlooked, component of thermoelectric technology development. This project would provide very important data for the design and integration of thermoelectric devices using for waste heat recovery as well as for cooling.

Other reviews specifically commented on the proposed efficiency increases. One response stated that the project contributes to an achievement of a 21% thermal efficiency increase in thermoelectric devices by 2012 and 10% engine thermal efficiency increase by harvesting exhaust waste heat. Another noted that this 10 % improved thermal efficiency is claimed, when thermo electrical energy transformation is used. One final reviewer felt that the objectives of a 10% increase in fuel economy on a designated vehicle platform are well understood. This is an experimental program that aides the other programs and is essential to complement the experimental work of the other teams. They provide essential mechanical performance data in order to achieve the devices. Mechanical properties determination is essential to incorporating new materials into devices.

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

Reviewers were mixed with regards to this prompt. One person commented that the technical approach is very well in alignment with the effort of improving the thermo-mechanical properties of thermoelectric materials. Another indicated that the barriers of the project are that TE materials are brittle and need to manage thermal stresses, while the approach is to develop FEA model to examine stress development and enable design optimization. One other reviewer stated that the goals are relatively modest and should be achieved, but success requires finding new information on fatigue, which can be elusive.

Some individuals offered suggestions. One response stated that the project starts out with an overview of mechanical properties of already existing materials. A closer cooperation with future users could be beneficial. Another person noted that the approach includes materials selection, but the team also needs to consider the device design(s) that they will model. The traditional cooler might not be the best choice. One final respondent felt that the project goal of 10% increase in fuel efficiency in not likely, but significant progress can be made. The barriers have been identified. A lot of work on the development of the mechanical properties of the various materials has been accomplished, especially bismuth telluride materials. This work should continue as an essential part of the other experimental work to provide guidance. The PI's have a strong team in place to address these barriers, and the PI's understand the overall goals of the program very well.

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

Responses were again mixed for this prompt. One reviewer indicated that the team has made significant progress toward their goals, by creating a module mechanical model and beginning to measure properties of Bi_2Te_3 alloys. It is likely the team will continue to make steady progress. Another individual stated that this is an experimental program that aides the other programs and is essential to complement the experimental work of the other teams. They provide essential mechanical performance data in order to achieve the devices. Mechanical properties determination is essential to incorporating new materials into devices. Similarly, one person commented that this project has established some very important results and data for improving mechanical strength of thermoelectric materials. Another person noted that they had developed an FEA model, developed a test matrix, and purchased TE and fabricated fixtures for the tests.

Other reviews were less positive. One person stated that no quantification of progress was given. Another reviewer indicated that the project focuses on the thermo mechanical properties of the material, but felt that a better performing material would lead to a higher benefit. This is, however, covered in other projects.

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

One reviewer felt that, assuming thermoelectrics are viable economically, this technology should be employed. Another wrote that they provide essential mechanical performance data in order to achieve the devices. Mechanical properties determination is essential to incorporating new materials into devices. One person commented that Marlow Industrial wished to use their thermophysical property for cooling with a TE device.

Another individual stated that publication of this work will be most of what is necessary to transfer to the marketplace. Capable companies will be able to use these mechanical property results to help design reliable generators. It is important that the team choose the most relevant designs for waste heat recovery. One person suggested that the project team should explore collaboration with a high temperature thermoelectric module manufacturer to addresses issues and concerns regarding high temperature thermoelectric generators. One final reviewer stated that, if it becomes possible to retrieve electrical energy from waste heat in a reliable way, this will certainly lead to market attention. At this moment, this reviewer feels that the project is somewhat long term.

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

Reviews were generally mixed in this section. One person stated that the team has sufficient resources available, another indicated that chose a neutral score because there was no budget given in the presentation, and one other person stated that, given the results, project funding appears to be high.

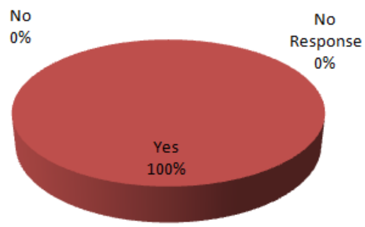
One final respondent began by saying that, again, it would be beneficial to see this project team extend their effort to investigate high-temperature materials and modules. This reviewer was not sure whether the project team has set aside resources for acquiring a sufficient quantity of high temperature materials and modules. The project is very well structured and has the appropriate expertise to tackle the technical challenges, which is both important and timely for the TE technology development community. The achievement in the past year is very impressive and the plan for next year is logical and appropriate. This reviewer expects this project to have an important impact on the recent quest for developing automotive waste heat recovery technology. The reviewer understands that acquiring an adequate amount of high temperature TE materials and devices for thermo-mechanical testing purpose is somewhat challenging, nevertheless, the reviewer encourages the PIs to make an effort to explore thermo-mechanical properties of high temperature modules and materials.

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

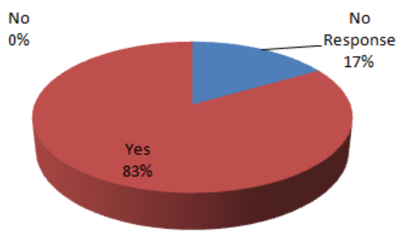
There were no expository comments for this question: refer to the graphic on the next page for this project's summary score.

Project: Thermoelectrics Materials by Design, Mechanical Reliability

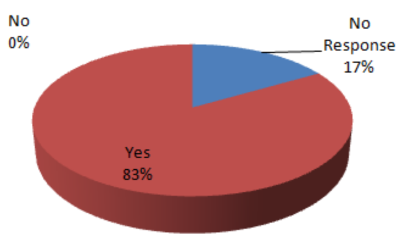
Question 1: Does this project support the overall DOE objectives of petroleum displacement?



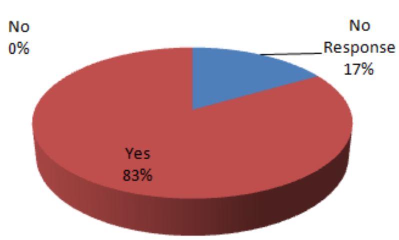
Question 2a: Are the goals of the project technically achievable?



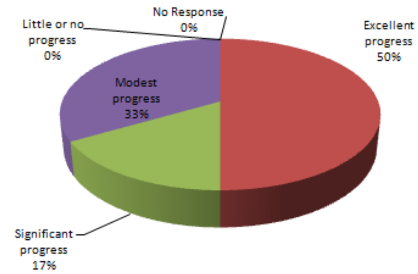
Question 2b: Have the technical barriers been identified and addressed?



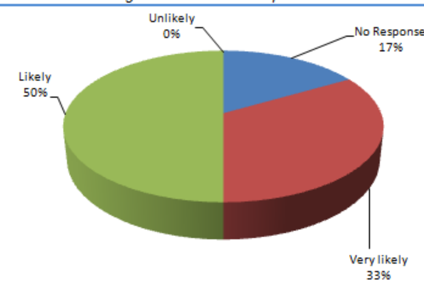
Question 2c: Is the proposed work likely to overcome technical barriers?



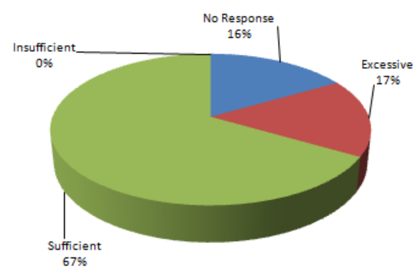
Question 3: Characterize the technical accomplishments and progress toward goals.



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



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



Question 6: Overall Rating