U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

DOE Advanced Manufacturing Office 2017 R&D Peer Review

February 2018

(This page intentionally left blank)

Department of Energy

Washington, DC 20585

June 19, 2017

Dear Stakeholders,

In June 2017, the Advanced Manufacturing Office (AMO) conducted a review of the technology research and development (R&D) and technical partnerships supported by our office. Peer reviews are a critical component to R&D, both for public sector and private sector participants. They provide an opportunity for project performers and consortia partners to evaluate activities, receive constructive feedback from technical experts, and ensure projects are on track toward success. Peer reviews are also allow project performers to exchange knowledge and ideas with one another so they can integrate new technical information and best practices into their work and identify potential opportunities for future partnerships to achieve aligned goals. We are reassured by the fact that AMO continues to support groundbreaking work in early stage applied R&D.

For AMO's peer review, over 100 representatives from the industrial, academic, and research communities gathered in the D.C. area to hear presentations by the research performers on our portfolio of ongoing and recently completed efforts. After an introduction, overview of AMO's Multi-Year Program Plan and strategic analysis activities, and summary of our national laboratory manufacturing consortia programs, peer review participants split up into two tracks. In "Track A," team leads for each R&D project gave a presentation, followed by a question and answer period. "Track B" of the peer review included presentations by team leads for each of our technical partnership areas and R&D consortia. An independent expert panel formally reviewed the portfolio and is preparing a report on their findings and recommendations. This feedback is crucial to inform the direction of applied R&D and validate AMO research results with the private sector.

This year also included a new Technical Resources Network Forum that highlighted resources, tools, and partnership opportunities available through AMO. It was an opportunity for partners and stakeholders to explore opportunities to engage with AMO. Specifically, the forum included panels focused on opportunities for partners to interface with DOE's world class national laboratories and other federal research consortia.

Manufacturing is the most diverse part of the economy in terms of its energy sources, technologies employed, and economic impact. The diversity of manufacturing means there are a wide range of technical opportunities and challenges to advance the goals of energy productivity and competitiveness. The peer review helps AMO to continuously improve as we continue to support early-stage R&D and the discovery of new knowledge in energy-efficient technologies and practices in U.S. manufacturing. These investments in broadly-applicable, platform technologies can have an impact by saving energy and enhancing U.S. global competitiveness.

I'd like to express my gratitude to all the peer review team and research participants for helping AMO become a more effective innovation driver and partner for industry, small business, universities, national labs, and other stakeholders.

Sincerely,

Mark Johnson
Director, Advanced Manufacturing Office
Energy Efficiency and Renewable Energy
U.S. Department of Energy

Table of Contents

Executive Summary

The U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) requires each program to conduct periodic peer reviews to enhance EERE program planning. The EERE Advanced Manufacturing Office (AMO) held a peer review of its program activities in Arlington, Virginia on June 13-14, 2017. The purposes of the peer review were to learn from each other, provide feedback to AMO, baseline for comparison over time, and identify possible course correction and new direction. To the extent possible, the peer review process followed the guidelines set forth in EERE 810: Peer Review Guidance (June 2016) and the EERE Peer Review Guide (2004). An independent panel of experts attended the meeting and provided comments on AMO activities. Their findings are summarized in this report.

The AMO is facing somewhat uncertain times. The current administration has provided indications that it is interested in a shift in the focus of the program while Congress has indicated that it believes in the current focus of the program. Luckily, the AMO Vision, Mission, and Strategic Goals are solid and administration agnostic. For example, the AMO mission to "catalyze research, development and adoption of energy-related advanced manufacturing technologies and practices." The foundation is solid and a modification to a focus on early-stage research seems reasonable while coupled with accelerating the manufacturing scale curve more quickly. Hence, the transition that is occurring can be described as a shift of focus rather than a change in direction. Most of the projects/programs had at least an element of new knowledge creation (early-stage research), hence this shift in focus should be a smooth one.

The AMO program is well designed from the top level and aimed at the right subject matter to achieve the AMO objectives. The current budget is appropriate for government funding for this work.

The review panel made a number of recommendations to AMO for strengthening the program, which included the following specific suggestions:

- The panel encourages AMO to use the MYPP in designing future FOAs, measuring progress, defending budgets, and structuring future peer reviews.
- The AMO is encouraged to implement a transparent go/no-go decision making process for R&D projects that are underway. While the practical need for making a commitment to funding the full multi-year project is clear, AMO needs to have a process for assessing the direction of a project during its course, with the expectation that the focus and/or direction for some of these projects would need to shift as a result of those initial assessments.
- In assessing the program's long-term success, it would be helpful to have follow-up regarding completed projects. Follow-up interviews after a project ends could evaluate the degree to which efforts for new technology development, knowledge generation, commercialization and/or wide-scale market adoption of a developed technology were successful. If not, it can help identify the stumbling blocks. That information would be helpful, not only in evaluating the past success of the program, but provide guidance for future efforts.

Introduction

The U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) requires each program to conduct periodic peer reviews to enhance EERE program planning. The EERE Advanced Manufacturing Office (AMO) held a peer review of its activities in Arlington, Virginia on June 13-14, 2017. The purposes of the peer review were to learn from each other, provide feedback to AMO, baseline for comparison over time, and identify possible course correction and new direction. To the extent possible, the peer review process followed the guidelines set forth in forth in EERE 810: Peer Review Guidance (June 2016) and the EERE Peer Review Guide (2004). An independent panel of experts attended the meeting and provided comments on the overall AMO Program. Their findings are summarized in this report.

EERE Peer Review Requirements

The EERE Peer Review Guide sets forth a number of guidelines for program and project peer reviews. EERE requires all programs to conduct a peer review, on average, every two years. Program reviews should consider budget, output generated, management structure and complexity, stakeholder participation, and information needed to support management decisions. Activities reviewed should typically cover 80-90% of the program's funding, supporting business analysis, and management programs.

EERE Peer Review guidelines also require a minimum of three reviewers for each discrete program element or smallest unit that is assessed and reported on. Each reviewer should be independent, competent, and objective, selected by a transparent, credible process that involves external parties. Together, the reviewers cover the subject matter.

After the review, the peer review panel is expected to produce and submit a peer review report to AMO management of the findings, and obtain his or her feedback on the draft, including actions to be taken. After AMO's review and comment, the report is finalized and submitted to senior EERE management, associated staff and researchers involved with the R&D program or project, and all persons involved in the review. The report is to be made available publicly.

2017 AMO Program Peer Review Process

The AMO Program Peer Review was held on June 13-14, 2017 in Arlington, Virginia. The agenda is listed in Appendix A. The review panel attended the opening session on Day 1 in which the AMO Office Director presented the historical context of manufacturing and its evolution over time, the role of energy and innovation in manufacturing, and AMO's technical focus areas and three program modalities. A briefing was also provided on the December 2016 version of the draft AMO Multi-Year Program Plan (MYPP) along with efforts to solicit and incorporate stakeholder feedback on the MYPP, and an overview of AMO strategic analysis efforts. Afterwards on Day 1 and Day 2, presentations were provided primarily in two separate tracks focusing on individual R&D Projects, R&D Consortia, and Technical Assistance activities. Each time slot consisted of a presentation by the Principal Investigator or AMO staff, along with time for questions and answers. A poster session for several other R&D Projects was held at the end of Day 1.

Prior to the meeting, the review panel was provided with information about the upcoming peer review, the AMO Program, and the 2016 Peer Review report. Included were evaluation forms which allowed reviewers to comment on strengths, weaknesses, and provide other recommendations for each activity. The reviewers also rated the activities on a scale of 1 to 4 (1 = disappointing; 4 = excellent). Separate sets of feedback responses were developed for the Program and for individual activities (based on criteria in Appendix B and Appendix C); the observations on individual activities have been provided to AMO separately.

As part of the peer review process, AMO management is provided an opportunity to respond to the peer review findings. Appendix D provides AMO's management response.

Review Panel Membership

Name	Email	Position
Frank Pfefferkorn	*frank.pfefferkorn@wisc.edu*	Associate Professor of Mechanical Engineering, University of Wisconsin-Madison (previously served as Assistant Director for Research Partnerships, Advanced Manufacturing National Program Office)
John Wall	*jcwall322@gmail.com*	Retired (formerly served as Chief Technical Officer of Cummins Inc.)
Lisa Ferris	*Lisa.Ferris@thirdwavesys.com*	Chief Operating Officer at Third Wave Systems
Mike McGrath	*mfm@mcgrath-analytics-llc.com*	Independent consultant; (former Vice President at Analytic Services Inc.)
Jim Lancaster	*jlancaster@nas.edu*	Acting Director of the National Materials and Manufacturing Board (NMMB) at the National Academy of Engineering; Director of the Board on Physics and Astronomy (BPA) at the National Academy
James Lyons	*jlyons@capricornllc.com*	Principal, Farmington River Technologies; and Chief Technologist for venture investment teams at Capricorn Investment Group and Energy Innovation

Appendix E contains the biographies of each panel member.

AMO Strategy, Mission, and Goals

The AMO Vision, Mission, and Strategic Goals are solid and administration agnostic. The foundation is solid and a modification to a focus on early-stage research seems reasonable while coupled with accelerating the manufacturing scale curve more quickly. This is more like a shift of focus than a change in direction. Most of the programs had at least an element of new knowledge creation (early-stage research), hence this shift in focus should be a smooth one.

The AMO is encouraged to make statements that are more specific and more instructive. For example, the Vision could be edited to state: "Enable U.S. global leadership in sustainable and efficient manufacturing for a growing and competitive economy." As another example, the strategic goals could include an overarching introduction stating: "Support early-stage technology development and transfer to enable: …"

Overall, the panel felt that the AMO's strategic focus has never been sharper and is well aligned with the strategic direction of EERE. It is understood that some adjustments are happening to align itself with the new administration's priorities. The AMO is doing a good job of connecting its multiple investments under a unifying vision.

AMO Portfolio

The AMO portfolio felt well balanced across key issues, potential solutions, company sizes, academia, labs, and industries. The vast majority of projects and programs address a particular knowledge gap. Almost all of the projects have elements that satisfy both the new administration's focus on early-stage (basic) research and the broader interest in adoption reflected in the program's mission statement. However, many of the individual projects did tend to emphasize one area or the other. For example, several of the projects that principally involved national laboratories had less strong connections to adoption/market implementation. In contrast, those projects that were principally initiated and run by commercial enterprises often were principally focused on market implementation, with less focus on fundamental research. Clarification of the mission for the program should help to guide future projects, both in developing their focus and reporting their results.

It was not clear from the presentations how the individual projects fit into a more comprehensive strategy for the overall program. All of the projects seem to fall within one of the 14 manufacturing technologies identified in the constellation diagram referred to by AMO presenters. However, it is not clear how choices are made by the program in selecting the particular areas that it ends up emphasizing.

AMO Activity Level Observations

- In general, presentations need to more clearly articulate what's the high-level need for new knowledge, how that leads to a specific project, and the path after AMO funding ends. For example, each presentation should more clearly answer the following questions:
  - What's the objective?
  - What's the barrier/unknown?
  - How are we investigating/discovering/validating the critical new/enabling knowledge?
  - How will we transfer it into commercial application by someone else?
- Additive Manufacturing. This technology is very important. The 3D printed Shelby Cobra is interesting to the casual observer, however, it would also be nice to see critical parts (e.g., blocks, heads, turbine wheels, gears) that can be produced at rates competitive to conventional casting and forging and with equal or better mechanical properties. Other examples that the manufacturing community would like to see include hip and knee joints and surgical tools, common parts that can be printed fast enough locally so an engine manufacturer doesn't have to store years of parts inventory for obsolete engine, or fluid control components that benefit from "curved passages" and not straight drillings. AMO should clearly articulate the practical impact of additive manufacturing, as well as the current unknowns.

- High Performance Computing for Manufacturing (HPC4Mfg) is an important program. The panel believes that this program exemplifies the need to invest in advanced tool development in addition to advanced manufacturing technology development. The program is encouraged to focus more on the models it runs and why we need high-performance computing (HPC) for these specific models. The program should clarify the envisioned process to transform U.S. manufacturing with HPC. This includes clarification of how companies (of all sizes) know they need HPC and what models exist or should be developed, and how any barriers to access (perceived or real) are being removed for small- and medium-size companies.
- The Lab-Embedded Entrepreneurship Programs are absolutely critical to the AMO mission. These programs give young innovators the opportunity to validate their AMO concepts to a point that will bridge them to carry-on funding for concept and product development that would not otherwise be offered at their stage of development by any other mechanism in government, in the "tech VC space," or in industry. The budget for this program should be increased.
- The Technical Assistance Program is a critical "two-way street" that fosters and supports transfer of advanced technologies and knowledge from AMO-sponsored programs into industry, and also gives AMO better insight into industrial applications and needs. The review gave the impression that knowledge transfer was primarily from AMO outward. It is recommended that AMO work to make the flow of information two way to enable learning across AMO from direct customer contact and experiences gained through the Technical Assistance Program. In addition, AMO should clarify how it changes its level of assistance depending on company size: e.g., large, medium, small. The panel also suggests an examination of what products and training can be developed and made available to medium and small companies, who are far too numerous and varied for individual contact.
- AMO is commended for its plan to modernize its Energy Tool Suite. AMO is encouraged to plan for an ongoing commitment to keep the Energy Tool Suite up to date. The three focus areas (Energy Performance Tracking, Energy Management, Energy Systems Analysis) are good. The panel believes it would be valuable to have feedback on tool use: i.e., statistics on how often software is accessed and by whom.
- The Industrial Assessment Centers are a very important part of AMO's portfolio. These centers are developing awareness and capability in small businesses and developing skilled talent. Both are critical to the AMO Vision and Mission.
- The Critical Materials Institute is doing good work that is very important to national security. The degree of collaboration across companies, universities, and National Labs is noteworthy. The examples were clear and well-articulated. The Critical Materials Institute has clear objectives, focus, discipline, and accomplishments. They have met their original objectives and have now added to them. This approach should be rewarded and replicated where possible.
- The Manufacturing Demonstration Facility is doing very important work that is well aligned with the AMO Vision and Mission. The ability to demonstrate advanced manufacturing technologies at a useful scale, and to deal with the early-stage challenges associated with scale-up, is critical to broader application and adoption of new manufacturing processes. The current concentration on additive manufacturing is appropriate given the still nascent state of the art. The 1:1 cost match from industry reinforces strong industrial partnerships and leverages the government investment +100%.
- The RAPID Manufacturing Consortium is a good investment for AMO. Modular chemical process intensification has promise to not only reduce energy consumption in chemical processing but also create deployable modules that can be applied by companies that would not otherwise be capable of such development. It is good that analytical tools are being developed along with the physical modules.

AMO Strategic Recommendations

- The draft Multi Year Program Plan (MYPP) needs to be updated to reflect the new administration's focus on early-stage research and to align with the new funding levels and the status of Manufacturing USA.

- The panel encourages AMO to use the MYPP in designing future FOAs, measuring progress, defending budgets, and structuring future peer reviews.
- There was discussion in the AMO Leadership's presentations about the importance of go/no-go decision making, but there was scant evidence in the R&D projects' presentations on how that comes into play. While the practical need for making a commitment to funding the full multi-year project is clear, one would expect a process for assessing the direction of a project during its course, with the expectation that the focus and/or direction for some of these projects would need to shift as a result of those initial assessments. It was not clear from the presentations whether this type of decision making takes place.
- In assessing the program's long-term success, it would be helpful to have follow-up regarding completed projects. Follow-up interviews after a project ends could evaluate the degree to which efforts for commercialization and/or wide-scale market adoption of a developed technology were successful, and if not, what were the stumbling blocks. That information would be helpful, not only in evaluating the past success of the program, but provide guidance for future efforts.
- Taking the portfolio approach one step further, AMO might consider a visual that shows investment attribution across the technology areas. A bubble chart or something like that would highlight where the portfolio is intentionally overweight or underweight as well as the investment concentrations.
- AMO should attempt to aggregate the results of its portfolio at some manageable level (e.g., Technical Partnerships, R&D Consortia, and National Lab Manufacturing Consortia Programs, R&D Programs) and measure the progress each has and is expected to contribute to each of the AMO Success Indicators.
- It is important for the AMO to demonstrate how and where the investments are leading to advanced technology readiness levels and manufacturing scale.

AMO Individual Activity Recommendations

Comments on individual projects and activities have been provided separately to AMO. Activities that require particular attention are summarized here:

- ISO 50001 is a very important addition to the ISO Quality "suite." Only a small fraction of the ISO 50001 sites in the United States are manufacturing plants. Because of this, the AMO should explore what role NIST/DOC should play.
- The AMO should carefully scrutinize the Combined Heat and Power (CHP) Deployment program to ensure that its objectives fall within the AMO mission. For example, the panel identified the main barriers to CHP deployment as policy issues and not technology issues. The AMO should highlight any early-stage research that they are supporting on CHP. Without these clarifications, it is difficult to argue that the CHP program belongs in the AMO portfolio.
- The Smart Manufacturing activities (individual project and Manufacturing USA consortium) need to focus significant effort on clearly articulating the fundamental concept of "smart manufacturing." In addition, this activity must clarify what advanced technologies their early-stage research is pursuing. Without these clarifications, it is difficult to argue that the Smart Manufacturing program belongs in the AMO portfolio.
- PowerAmerica needs to clarify what basic technology research and development is being done to enable wide-band-gap semiconductor manufacturing in the United States.

Feedback on the Peer Review Process

- The review sheets align with most R&D projects that are presented at the AMO review. However, there are some presentations, most notably the workforce development projects, where different metrics should apply in determining the impact and effectiveness of these activities.

- As the mission of the AMO aligns with the current administration, the review forms need to be revised to ensure that the reviewers' comments are in line with the current mission of the program.
- There are a number of suggested actions that should result in more detailed feedback to individual projects and the AMO, as well as the expedited delivery of a report from the review panel. In general, providing more time during the review for taking notes, discussing feedback, and drafting sections of the panel's report would be very helpful. The main benefit of this is that the presentations are fresh in the reviewers' thoughts and that they can formulate feedback without being distracted. The following specific suggestions should be considered by the AMO as means of improving the efficacy of the review panel. However, the AMO should not feel obligated to implement all of these.
    - Providing an extra 5-10 minutes after each presentation for the reviewers to complete their notes and fill out review sheets provided by the AMO.
    - Currently, each reviewer needs to listen to the presentation, ask questions, take notes, and fill out the review sheet. It is a challenge to complete all four of these tasks during the presentation and during the transition period between presentations. The AMO should consider assigning one of the reviewers for each presentation as the "scribe," with the primary responsibility of taking notes, thereby letting the other reviewers focus on the presentation, questions, and answers. The "scribe" could also take the lead in filling out the review sheet with the feedback from the other reviewers.
    - Longer breaks after a set (3 – 5) of project presentations could be implemented to allow the reviewers to discuss the presentations and write elements of the panel's report.
    - The AMO should consider adding a half- or full-day after the presentations during which the reviewers stay at the peer review location and draft the report. This would provide an environment without distractions, in which the reviewers have the contiguous hours needed to synthesize information and draft the report.
    - Having a technical scribe (something like a stenographer) during the breaks that are proposed would be helpful in quickly recording the discussion.
    - Articulating a clear plan of what the goal is for each break would be helpful in guiding the reviewers' efforts. For example, during the shorter breaks between presentations the goal may be to complete the review form.

Appendix A: Final Agenda

Day 1 (June 13)		
8:00 – 8:45 am	**Peer Reviewer Briefing Breakfast** **Mark Johnson, Rob Ivester, Isaac Chan, Valri Lightner, and Jay Wrobel, DOE-AMO**	
8:45 – 9:00 am	**BREAK**	
8:00 – 9:00 am	**REGISTRATION FOR ATTENDEES**	
9:00 – 9:30 am	Welcome and AMO Overview	**Mark Johnson** AMO Director
9:30 – 10:00 am	Overview of the AMO Multiyear Program Plan	**Valri Lightner** Program Manager, R&D Consortia
10:00 – 10:20 am	AMO Strategic Analysis Activities	**Joe Cresko** AMO Analysis Lead
10:20 – 10:40 am	**NETWORKING BREAK**	
	National Laboratory Manufacturing Consortia Programs	
10:40 – 11:00 am	High Performance Computing for Manufacturing	Lead Lab: LLNL Other Labs: ORNL, LBNL
11:00 – 11:20 am	Lab Embedded Entrepreneurship Programs	Lead Lab: LBNL Other Labs: ANL, ORNL
11:20 – 11:40 am	Catalysis Development and Testing Program	Lead Lab: INL Other Labs: ORNL, ANL
11:40 am – 12:00 pm	Roll-to-roll Advanced Materials	Lead Lab: ORNL Other Labs: ANL, NREL, LBNL
12:00 – 1:00 pm	**LUNCH** **(Private Lunch for Reviewers)**	

TRACK A			TRACK B	
R&D Projects Review			**Technical Assistance Review**	
1:00 – 1:20 pm	***Additive Manufacturing***		1:00 – 1:05 pm	Introductions
	Powder Synthesis and Alloy Design for Additive Manufacturing	Ames Laboratory	1:05 – 1:30 pm	Tools and Training **Jay Wrobel**
1:20 – 1:40 pm	In-Situ Data Acquisition and Tool Development for Additive Manufacturing Metal Powder Systems	SLAC		
1:40 – 2:00 pm	***Advanced Materials Manufacturing***		1:30 – 2:00 pm	Better Plants **Eli Levine**
	Energy Efficient Thermoplastic Composite Manufacturing	The Boeing Company		
2:00 – 2:20 pm	A Novel Flash Ironmaking Process	American Iron and Steel Institute	2:00 – 2:25 pm	Industrial Assessment Centers **John Smegal**
2:20 – 2:40 pm	Carbon Fiber Test Facility	ORNL	2:25 – 2:45 pm	Superior Energy Performance **Paul Scheihing**
2:40 – 3:00 pm	Processes for 2G HTS Wire Manufacturing	Superconductor Technologies Incorporated	2:45 – 3:00 pm	50001 Ready **Pete Langlois**
3:00 – 3:20 pm	**BREAK**		3:00 – 3:20 pm	**BREAK**

Day 1 (June 13) Continued				
TRACK A			**TRACK B**	
3:20 – 3:40 pm	Enhanced 2G HTS Wire for Electric Motor Applications	American Superconductor Corporation	3:20 – 3:50 pm	CHP Deployment Jay Wrobel
3:40 – 4:00 pm	Metal (Cu, Al) CNT Composite Wires for Energy Efficient Motors	University of Central Florida	3:50 – 4:00 pm ***Transition to R&D Projects Review***	
R&D Projects Review				
4:00 – 4:20 pm	Carbon Conductors for Lightweight Motors and Generators	Rice University	***Process Heating*** Coatings and Process Development Reduced Energy Automotive OEM Manufacturing	PPG Industries, Inc.
4:20 – 4:40 pm	Amorphous and Nanocomposite Magnets for High Efficiency, High Speed Motor Designs	Carnegie Mellon University	***Materials for Harsh Service Conditions*** Wear-Resistant Surface Technologies for Low-Leakage NG Compressors	Argonne National Laboratory
4:40 – 5:00 pm	Si-Al-Cr-Mn Alloy for High Specific Resistivity	AK Steel Corporation	***Smart Manufacturing*** Industrial Scale Demonstration of Smart Manufacturing Achieving Transformational Energy Productivity Gains	University of Texas at Austin
5:00 – 5:10 pm	Introduction to Poster Session	AMO Staff	Introduction to Poster Session	AMO Staff
5:15 – 6:15 pm	**Private Dinner and Discussion for Reviewers**			
5:10 – 7:30 pm	**POSTER SESSION AND NO-HOST RECEPTION (27 Posters)**			

#	Project Title	Performer
1	HPC4Mfg: Massively Parallel Multi-Physics Multi-Scale Large Eddy Simulations of a Fully Integrated Aircraft Engine Combustor and High Pressure Stage One Nozzle	ORNL, LLNL, General Electric
2	HPC4Mfg: Numerical Simulation of Fiber Glass Drawing Process via a Multiple-Tip Bushing	LLNL, PPG Industries, Inc.
3	HPC4Mfg: Increased Efficiency Low Temperature Drying Process	LLNL, ZoomEssence, Inc.
4	HPC4Mfg: Highly-Scalable Multi-Scale FEA Simulation for Efficient Paper Fiber Structure	LLNL, The Procter & Gamble Company
5	HPC4Mfg: Multi-physics Modeling of Continuous Liquid Interface Production (CLIP) for Additive Manufacturing	LBNL, Carbon, Inc.
6	HPC4Mfg: Integrated Predictive Tools for Customizing Microstructure and Material Properties of Additively Manufactured Aerospace Components	ORNL, LLNL, United Technologies Research Center

<table>
<tr><td>7</td><td>HPC4Mfg: Process Map for Tailoring Microstructure in Direct Metal Laser Melting (DMLM) additive Manufacturing Process</td><td>ORNL, General Electric</td></tr>
<tr><td>8</td><td>Phase III SBIR: Flash Processed Steel for Automotive Applications</td><td>SFP Works</td></tr>
<tr><td>9</td><td>Phase II SBIR: Low-Cost Modular Plasma System for Reforming of Natural Gas</td><td>Rivis, Inc.</td></tr>
<tr><td>10</td><td>Phase II SBIR: Capability of Rolling Efficiency for 100M High-Speed Rails</td><td>OG Technologies</td></tr>
<tr><td>11</td><td>Phase II SBIR: High Ion-Accessible Surface Area CNT-Ultracapacitors for Groundwater Desalination</td><td>Mainstream Engineering Corp.</td></tr>
<tr><td>12</td><td>Phase II SBIR: Gliding Arc Plasma Reformer with Efficient Heat Recuperation</td><td>Advanced Cooling Technologies</td></tr>
<tr><td>13</td><td>Phase II SBIR: Magnetocaloric Generator for Waste Heat Recovery</td><td>Aqwest LLC</td></tr>
<tr><td>14</td><td>Cyclotron Road</td><td>Lawrence Berkeley National Laboratory</td></tr>
<tr><td>15</td><td>Chain Reaction Innovations</td><td>Argonne National Laboratory</td></tr>
<tr><td>16</td><td>Innovation Crossroads</td><td>Oak Ridge National Laboratory</td></tr>
<tr><td>17</td><td>CaloriCool</td><td>Ames National Laboratory</td></tr>
<tr><td>18</td><td>“SMASH” Project</td><td>Stanford Linear Accelerator</td></tr>
<tr><td>19</td><td>Covetics: Melt Processing of Covetic Materials</td><td>National Energy Technology Laboratory (Albany, Oregon)</td></tr>
<tr><td>20</td><td>Covetics: High Performance Electrical and Thermal Conductors</td><td>Argonne National Laboratory</td></tr>
<tr><td>21</td><td>Covetics: Synthesis and Characterization of Covetic Nanomaterial</td><td>Oak Ridge National Laboratory</td></tr>
<tr><td>22</td><td>Crosscutting Manufacturing R&D</td><td>Argonne National Laboratory</td></tr>
<tr><td>23</td><td>Combined Heat and Power R&D</td><td>Oak Ridge National Laboratory</td></tr>
<tr><td>24</td><td>Analysis 1: Manufacturing in a Connected Economy</td><td rowspan="4">• Lawrence Berkeley National Laboratory
• Oak Ridge National Laboratory
• Argonne National Laboratory
• National Renewable National Laboratory
• Energetics, Inc.</td></tr>
<tr><td>25</td><td>Analysis 2: Clean Water</td></tr>
<tr><td>26</td><td>Analysis 3: Analysis Methodology, Tools & Integrating Analysis</td></tr>
<tr><td>27</td><td>Analysis 4: Sustainable Manufacturing</td></tr>
</table>

<table>
<tr><th colspan="5">Day 2 (June 14)</th></tr>
<tr><th colspan="3">TRACK A</th><th colspan="2">TRACK B</th></tr>
<tr><td>8:00 – 9:00 am</td><td colspan="4">REGISTRATION FOR ATTENDEES</td></tr>
<tr><td colspan="3">R&D Projects Review</td><td colspan="2">R&D Consortia Review</td></tr>
<tr><td>9:00 – 9:05 am</td><td colspan="2">Welcome, AMO R&D Staff</td><td colspan="2">Welcome, Valri Lightner, Program Manager, R&D Consortia</td></tr>
<tr><td rowspan="2">9:05 – 9:25 am</td><td colspan="2">Advanced Materials Manufacturing</td><td rowspan="3">9:05 – 9:45 am</td><td rowspan="3">Power America
North Carolina State University</td></tr>
<tr><td>High-Silicone Steel Sheet By Single Stage Shear-Based Processing</td><td>Purdue University</td></tr>
<tr><td>9:25 – 9:45 am</td><td>Cost-effective Conductor, Cable, and Coils for High Field Rotating Electric Machines</td><td>Florida State University</td></tr>
</table>

Day 2 (June 14) Continued				
TRACK A			**TRACK B**	
9:45 – 10:05 am	Resistively Graded Insulation System for Next-Generation Converter-Fed Motors	General Electric	9:45 – 10:25 am	Critical Materials Institute Ames Laboratory
10:05 – 10:25 am	Polydopamine/PTFE Composite Coating for Large-Scale Journal Bearings in Next Generation Electric Machines	SurfTech, LLC		
10:25 – 10:40 am	**BREAK**			
10:40 – 11:00 am	Highly Efficient Conical Air Gap Axial Motor Using Soft Magnetic Composites and Grain-Oriented Electrical Steel	Regal-Beloit	10:40 – 11:20 am	Institute for Advanced Composite Materials Innovation
11:00 – 11:20 am	Advanced Manufacturing of High Performance Superconductor Wires	University of Houston		
11:20 – 11:40 am	Nanometal-Interconnected Carbon Conductors for Advanced Electric Machines	Rochester Institute of Technology	11:20 – 12:00 pm	Manufacturing Demonstration Facility Oak Ridge National Laboratory
11:40 – 12:00 pm	***Wide Bandgap Semiconductors***			
	Medium Voltage Integrated Drive and Motor	CalNetix Technologies		
12:00 – 1:00 pm	**LUNCH** *(Private Lunch for Reviewiers)*			
1:00 – 1:20 pm	***Wide Bandgap Semiconductors***		1:00 – 1:25 pm	Clean Energy Smart Manufacturing Innovation Institute Smart Manufacturing Leadership Coalition
	SiC enabled High-Frequency Medium Voltage Drive for High-Speed Motors	General Electric		
1:20 – 1:40 pm	Integrated 10kV SiC VSD and High-Speed MW Motor for Gas Compression Systems	Eaton Corporation	1:25 – 1:50 pm	Rapid Advancement in Process Intensification Deployment (RAPID) Institute AIChE
1:40 – 2:00 pm	Fully Integrated High Speed Megawatt Class Motor and High-Speed MW Motor for Gas Compression Systems	Clemson University	1:50 – 2:15 pm	Reducing Embodied-energy and Decreasing Emissions (REMADE) Institute Sustainable Manufacturing Innovation Alliance
2:00 – 2:20 pm	Integrated Electric Drive with HV2 Modular Electric Machine and SiC Based Power Converters	The Ohio State University		
2:20 – 2:35 pm	**BREAK**		2:15 – 2:35 pm	**BREAK**

Day 2 (June 14) Continued				
	TRACK A		TRACK B	
2:35 – 2:55 pm	Graduate Study and Research Program Focused on the Experimentation, Design, Development, and Manufacturing of WBG-Based Power Electronics, Grid Equipment, and High-Efficiency Electrical Systems	Virginia Polytechnic Institute and State University	***Research and Development Projects***	
			Sustainable Manufacturing	
			Development of an Automatic Continuous Online Monitoring and Control Platform for Polymerization Reactions	Tulane University
2:55 – 3:15 pm	Design-Oriented Education and Hands-On Training with Wide Bandgap Power Electronics for the Next-Generation Power Engineering Workforce	University of Tennessee-Knoxville	Rapid Freeform Sheet Metal Forming: Technology Development and System Verification	Ford Motor Company
3:15 – 3:35 pm	***Process Intensification***		Development of Energy Efficient Integrated Die Casting Process For Large Thin-Walled Magnesium Applications	General Motors LLC
	Low-Energy, Low Cost Production of Ethylene by Low Temperature Oxidative Coupling of Methane	Siluria		
3:35 – 3:55 pm	New Design Methods and Algorithms for Energy Efficient Distillation Trains	Purdue University	A Novel Unit Operation to Remove Hydrophobic Contaminants	Doshi & Associates
3:55 – 4:15 pm	One Step Hydrogen Generation through Sorption Enhanced Reforming	Gas Technology Institute	Advanced, Energy-Efficient Hybrid Membrane System for Industrial Water Reuse	Research Triangle Institute
4:15 – 4:35 pm	Sacrificial Protective Coating Materials that can be Regenerated In-Situ to Enable High Performance Membranes	Teledyne Scientific and Imaging	Bio-Oxo Technology	Easel Biotechnologies
4:35 pm	**PEER REVIEW MEETING ADJOURNS**			
4:45 – 6:00 pm	**PRIVATE MEETING OF REVIEW PANEL** *(including time with AMO management to address outstanding questions)*			

Appendix B: Evaluation Criteria for Program Overall Activity

Relevance and Approach

Mission

- How well does the AMO Program fit within the EERE mission and the overall DOE mission?
- Is the justification for a federal program clear and compelling?

Approach

- Assess how well the overall AMO Program approach, including goals and programs, addresses the AMO mission.
- Do activities address high impact areas and address appropriate markets and technical barriers?

Resources

- Are there adequate resources in terms of dollars for the current mission?
- Is the allocation of resources reasonable?

Overall Assessment of Relevance

- On a scale of 1-4, with 4 representing excellent, 3 representing good, 2 representing fair, and 1 representing disappointing, what is the your overall assessment of relevance and approach?
- What recommendations do you have on relevance and approach?

Management

Execution

- Are the activities likely to result in high quality products and outcomes? How can their impact be improved?
- How can AMO improve the way its new technologies are received and used by target audiences/stakeholders?

Resource Leveraging

- How well is the program coordinating with and learning from other EERE, DOE, and federal activities?
- What other resources could be used or leveraged to meet AMO goals?

Overall Assessment of Management

- On a scale of 1-4, with 4 representing excellent, 3 representing good, 2 representing fair or adequate, and 1 representing disappointing, what is the panel's overall assessment of the organization and management of the AMO Program?
- What recommendations does the panel have on program management?

Overall Program Assessment

- What are the best aspects of the AMO Program? What area needs the most improvement?
- On a scale of 1-4, with 4 representing excellent, 3 representing good, 2 representing fair, and 1 representing disappointing, what is the panel's overall assessment of the program?
- What recommendations does the panel have for the program?

Appendix C: Evaluation Criteria for Individual Activities

R&D Projects

Technical Merit and Innovation

The degree to which the project has a high level of scientific and technical merit, has a high degree of innovation, and will be compatible with current or future U.S. manufacturing operations.

- ☐ 4 - Outstanding
- ☐ 3 - Good
- ☐ 2 - Fair
- ☐ 1 - Poor

Energy and Market Impacts

The degree to which the project expects to provide a high level of energy productivity improvements, addresses a significant market opportunity, and will provide attractive economics for end-users compared to existing technology.

- ☐ 4 - Outstanding
- ☐ 3 - Good
- ☐ 2 - Fair
- ☐ 1 - Poor

Technical Approach

Degree to which the technical approach appears reasonable, and the project team's knowledge of the techno-economic issues specific to the technology.

- ☐ 4 - Outstanding
- ☐ 3 - Good
- ☐ 2 - Fair
- ☐ 1 - Poor

Technology Transition Plan

Degree to which the project staff has a sound approach for transitioning the technology forward, and collaborates or coordinates with industry or other relevant stakeholders to accelerate movement of technologies or practices towards the market.

- ☐ 4 - Outstanding
- ☐ 3 - Good
- ☐ 2 - Fair
- ☐ 1 - Poor

For each criteria, provide comments about the project's strengths and weaknesses to substantiate the scores. Offer any additional comments or recommendations for the project.

R&D Facilities

Technical Merit

Degree to which the activities at the Hub/Facility/Institute align with the mission of AMO/EERE/DOE, and address appropriate technical barriers.

☐ 4 - Outstanding

☐ 3 - Good

☐ 2 - Fair

☐ 1 - Poor

Energy and Market Impacts

Degree to which the activities at the Hub/Facility/Institute address high impact areas.

☐ 4 - Outstanding

☐ 3 - Good

☐ 2 - Fair

☐ 1 - Poor

Objectives and Approach

Degree to which the objectives and approach of the Hub/Facility/Institute are clear, and degree to which the objectives, approach, and partnership models are well suited to address critical technology challenges.

☐ 4 - Outstanding

☐ 3 - Good

☐ 2 - Fair

☐ 1 - Poor

Transition Plan

Degree to which the Hub/Facility/Institute has a sound approach for addressing market barriers and accelerating movement of technologies or practices into the market.

☐ 4 - Outstanding

☐ 3 - Good

☐ 2 - Fair

☐ 1 - Poor

Technical Accomplishments and Progress *(for select activities only)*

Degree to which the Hub/Facility/Institute has achieved technical accomplishments and made progress, measured against specific performance indicators for the Hub/Facility/ Institute and demonstrated progress relative to AMO technical targets.

☐ 4 - Outstanding

☐ 3 - Good

☐ 2 - Fair

☐ 1 - Poor

For each criteria, provide comments about the activity's strengths and weaknesses to substantiate the scores.

Offer any additional comments or recommendations you have for the activity.

Technical Assistance Activities

Merit

Degree to which the activity aligns with the mission of AMO, and address appropriate barriers.

☐ 4 - Outstanding

☐ 3 - Good

☐ 2 - Fair

☐ 1 - Poor

Energy and Market Impacts

Degree to which the activity addresses high impact areas.

☐ 4 - Outstanding

☐ 3 - Good

☐ 2 - Fair

☐ 1 - Poor

Objectives and Approach

Degree to which the objectives and approach are clear, and degree to which the objectives, approach, and partnership models are well suited to address market challenges.

☐ 4 - Outstanding

☐ 3 - Good

☐ 2 - Fair

☐ 1 - Poor

Accomplishments

Degree to which the activity has measurable accomplishments and has made progress, measured against performance indicators for the activity and progress relative to AMO targets.

☐ 4 - Outstanding

☐ 3 - Good

☐ 2 - Fair

☐ 1 - Poor

For each criteria, provide comments about the activity's strengths and weaknesses to substantiate the scores. Offer any additional comments or recommendations you have for the activity.

Appendix D: AMO Management Response

Dear Peer Review Participants,

I want to extend my thanks to the members of the Peer Review Committee for contributing their time and expertise during the 2017 Advanced Manufacturing Office Peer Review.

Peer reviews are a critical component to maintaining a cutting-edge, taxpayer-funded R&D portfolio, both for public and private sector participants.

The Committee's feedback contains excellent suggestions on improving AMO's project oversight, internal processes, and external positioning. As director I am committed to incorporating input in order to improve the overall performance of the AMO portfolio. However, I'd like to focus on three items that resonated strongly with me as I reviewed the report:

- **Tighten the loop between the MYPP, budget planning, and project execution.** The Multi-Year Program Plan (MYPP) sets forth the mission, goals, and plan of the Advanced Manufacturing Office for Fiscal Years 2017 through 2021, as well as a tool to communicate its priorities and opportunities to stakeholders. As noted, linking the MYPP to future funding opportunities would help the office maintain its strategic trajectory. AMO will establish a reinforcing feedback loop between the MYPP and budget development that ensure office priorities are properly delineated and executed on from a budget perspective.
- **Ensure transparency around decision-making.** Transparency, not only in the form of go/no-go decisions that help keep R&D projects on a successful trajectory, but through clear processes that help public and private stakeholders understand AMO's decision-making is critical to establishing trusted relationships with partners. AMO will use its established Active Project Management approach to facilitate communication round decision-making with project participants and stakeholders.
- **Shorten the peer review feedback process.** The committee provided a number of useful suggestions, and AMO is in the process of developing a plan to address each item by the 2018 Peer Review. However, shortening the iterative feedback process between AMO and the committee would allow AMO to implement and adjust recommendations well in advance of the subsequent review – and provide practical feedback on the recommendations within one. AMO is committed to finding was to shorten this post-review process.

Peer reviews provide a forum for project performers and consortia partners to evaluate activities, receive constructive feedback from technical experts, and ensure projects are on track toward success. Peer reviews also allow project performers to exchange knowledge and ideas with one another so they can integrate new technical information and best practices into their work and identify potential opportunities for future partnerships to achieve aligned goals.

Administration research and development priorities have shifted towards early-stage applied R&D. However, the AMO mission to "catalyze research, development and adoption of energy-related advanced manufacturing technologies and practices" is administration agnostic. AMO continues, with feedback, to pursue high-impact manufacturing-related R&D challenges with academic, industry, lab, and other stakeholders.

Once more, let me express my thanks and gratitude to each member of the peer review committee for taking their time to review AMO's portfolio and provide input and feedback.

Rob Ivester

Director, Advanced Manufacturing Office
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy Appendix E: Review Panel Member Biographies

Appendix E: Review Panel Member Biographies

Frank Pfefferkorn (Chair)

Frank Pfefferkorn is currently an Associate Professor of Mechanical Engineering at the University of Wisconsin-Madison, returning to Madison after serving for a year as Assistant Director for Research Partnerships at the Advanced Manufacturing National Program Office. His teaching and research have focused on manufacturing processes and heat transfer as it applies to manufacturing processes. His work goals are to: (1) educate/develop manufacturing and heat transfer engineers/workforce, and (2) help move laser polishing, friction stir welding, cryogenic machining, additive-subtractive manufacturing, and micro end milling from arts to science-based technologies that will help U.S. manufacturers. He also served as the Director of the Manufacturing Systems Engineering Program and on the Executive Committee of the Center for German and European Studies.

Frank is a member of the International Academy of Production Engineering, American Society of Mechanical Engineers, and Society of Manufacturing Engineers. He is also Technical Program Chair for the 2016 ASME Manufacturing Science and Engineering Conference. Frank holds a B.S. in Mechanical Engineering from the University of Illinois at Urbana-Champaign, and M.S. and Ph.D. degrees in Mechanical Engineering from Purdue University.

James (Jim) Lyons

James (Jim) Lyons entered the venture capital business in 2008 after a 30-year technology career at General Electric. Jim is currently the principal at the Farmington River Technologies consulting firm and also serves as chief technologist for the venture investment teams at the Capricorn Investment Group and Energy Innovation focused on the creation and growth of clean/renewable energy companies. Formerly, Jim was Chief Engineer for Electrical Technologies at GE Research serving as technology leader and mentor for a 250-member global team. He was a leading advocate for renewables within GE and corporate champion behind the formation of GE Wind Energy in 2002 - which quickly grew to $8B annual revenues.

In 2000, Jim was the technology leader during the creation of GE's Digital Energy business unit. While at GE, he served on the board of directors of Powerex, the Electric Drive Trade Association, and the US Offshore Wind Collaborative as well as becoming a principal company spokesperson for renewable energy. In 2006, Jim was co-chair of the American Wind Energy Conference, initiating the AWEA/DOE 20% wind energy roadmap. He has led many additional technology and business initiatives e.g. waste gasification, electric vehicles, advanced batteries, power electronics, solid-state lighting, solar PV, rural electrification, and nuclear fusion. He currently serves on a variety of technical board assignments including: Curent ERC, Servato, Encell, Sunpreme, Kinestral, and Norwegian Crystals. Jim is a reviewer for the DOE and the National Science Foundation. He holds 40 patents and has a B.S. in Electrical Engineering from Rensselaer Polytechnic Institute, an M.S. in Electrical Engineering from Virginia Polytechnic Institute and a Ph.D. from Cornell University.

Michael McGrath

Michael McGrath is an independent consultant. As a former Vice President at Analytic Services Inc. (ANSER), he led government services operations in Systems and Operations Analysis. He previously served as the Deputy Assistant Secretary of the Navy for Research, Development, Test and Evaluation, where he was a strong proponent for improvements in technology transition, modeling and simulation, and test and evaluation. In prior positions, he served as Vice President for Government Business at the Sarnoff Corporation (former RCA corporate lab), ADUSD for Dual Use and Commercial Programs in the Office of the Secretary of Defense (OSD), Assistant Director for Manufacturing at the Defense Systems Research Projects Agency (DARPA), and Director of the DoD Computer-aided Acquisition and Logistics Support (CALS) program.

His early government career included positions in Logistics Management at Naval Air Systems Command and in Acquisition Management in OSD, where he was principal author of the policy on Integrated Logistics Support (DoD Directive 5000.39).

Michael has maintained research interests in information systems, systems engineering, logistics and manufacturing technologies. He has participated in Defense Science Board studies and studies by the National Research Council, where he is a member of the National Materials and Manufacturing Board and chairs the Defense Materials, Manufacturing and Infrastructure Committee. He is a Senior Fellow of the Potomac Institute for Policy Studies. Michael holds a B.S. in Space Science and Applied Physics, an M.S. in Aerospace Engineering from Catholic University, and a doctorate in Operations Research from George Washington University (where he also was an adjunct associate professor).

Jim Lancaster

Jim Lancaster is Acting Director of the National Materials and Manufacturing Board (NMMB) at the National Academy of Engineering. Dr. Lancaster is also the Director of the Board on Physics and Astronomy (BPA) at the National Academy. Dr. Lancaster joined the BPA as a program officer in 2008 and was responsible staff officer for a number of studies, including An Assessment of the Science Proposed for the Deep Underground Science and Engineering Laboratory (DUSEL), Research at the Intersection of the Physical and Life Sciences, Frontiers in Crystalline Matter: From Discovery to Technology, and Selling the Nation's Helium Reserve. Prior to joining the BPA, Dr. Lancaster served on faculty at Rice University, where he taught introductory physics to science and engineering students, and as a staff researcher, where he participated in experimental investigations of the interactions of highly excited atoms with electromagnetic pulses and surfaces. During his time at Rice, Dr. Lancaster received both the Wilson Prize for outstanding doctoral thesis in physics and astronomy, and the APS teaching award for his work as instructor of undergraduates. He is the co-author of over 25 peer-reviewed articles and is a member of the American Physical Society.

In addition to M.A. and Ph.D. degrees in Physics from Rice University, Dr. Lancaster holds a B.A degree in Economics from Rice University and a J.D. degree from the University of Texas. Prior to entering the field of physics, Dr. Lancaster practiced law for over 12 years, specializing in the financial structuring and restructuring of businesses.

John Wall

John Wall has more than 35 years of industry experience in internal combustion engine technology, fuels and emissions, and in global engineering organization development. Most recently, John served as Chief Technical Officer of Cummins Inc., the world's largest independent manufacturer of diesel engines and related technologies, retiring in 2015. As he progressed from research and product engineering into engineering leadership, John remained directly involved in the most critical technology programs for low emissions, powertrain efficiency and alternative fuels. He also led the growth of Cummins technical organization from 1000 engineers, mostly centered in the U.S., to more than 6000 engineers globally, establishing new technical centers in India and China. Prior to joining Cummins in 1986, John led Diesel and Aviation Fuels Research for Chevron, where his team was first to discover the important contribution of fuel sulfur to diesel particulate emissions.

Today, he stays active technically as an advisor for the DOE Joint BioEnergy Institute and Co-Optima Program, the Cyclotron Road energy incubator at Lawrence Berkeley Laboratory, with the National Academies, and as Chair of the Cummins Science and Technology Council. He has been recognized for his technical contributions by election to the National Academy of Engineering and as a Fellow of the Society of Automotive Engineers. He has received the SAE Horning Memorial Award and Arch T. Colwell Merit Award for research in the area of diesel fuel effects on emissions, the ASME Soichiro Honda Medal for significant engineering contributions in the field of personal transportation, and the California Air Resources Board Haagen-Smit Clean Air Award and US EPA Thomas W. Zosel Individual Achievement Award for career accomplishments in diesel emission control. Dr. Wall studied Mechanical Engineering at the Massachusetts Institute of Technology, where he received his S.B. and S.M. in 1975, and his Sc.D. in 1978.

Lisa Ferris

Lisa Ferris is Chief Operating Officer (COO) at Third Wave Systems, and is responsible for the development and delivery of Third Wave Systems' commercial products, finance and operations.

Prior to joining the Third Wave Systems, Ms. Ferris spent more than 20 years building businesses and was the COO for RBC Dain Raucher's $1 billion U.S. Wealth Management Division. Ms. Ferris worked with investment bankers and internal M&A teams on both the buy and sell sides, resulting in acquisitions which increased business by more than 80 percent. Ms. Ferris has a B.S. in Business from the University of Minnesota's Carlson School of Management, and an MBA from the University of St. Thomas.

U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

For more information, visit: energy.gov/eere/amo

DOE/DOE/EE-1758 · February 2018