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Council on
Competitiveness

American Energy & Manufacturing Competitiveness Partnership

Materials Manufacturing Accelerator

Dialogue 2 Primer

June 25th, 2015

Executive Summary

On June 25th, 2015 the Council on Competitiveness (Council) and the U.S. Department of Energy Office of Fossil Energy (FE) and Argonne National Lab (ANL) will co-host the second American Energy & Manufacturing Competitiveness (AEMC) Partnership dialogue around the *Materials Manufacturing Accelerator*. This follows the first dialogue in the *Materials Manufacturing Accelerator* series, held on May 8th, 2015 at Oregon State University's Food Innovation Center, co-hosted by OSU President Dr. Ed Ray, and Director for the Office of Research at the National Energy Technology Laboratory, Dr. Cynthia Powell.

This dialogue continues from a progressive dialogue series convened as part of the AEMC Partnership – a three-year effort to bolster American competitiveness through advanced clean energy manufacturing and increased energy productivity, and to address the dynamic changes affecting the national and global energy landscape. During the 2014 and 2015 activities of the AEMC Partnership, participants consistently emphasized the importance of developing, manufacturing, and deploying advanced materials as a critical leverage point with the potential to unleash a U.S. manufacturing renaissance by creating the conditions in this country to promote the adoption of clean energy technologies, and deeper investment in energy technology manufacturing.

Through three regional *Materials Manufacturing Accelerator* dialogues, the Council and FE launch a targeted discussion around accelerating the development, deployment, and diffusion of advanced materials into the manufactured marketplace and the wider economy. AEMC Partnership *Materials Manufacturing Accelerator* Dialogue 2 gathers leaders from industry, academia, non-profit organizations, and the national laboratory system to discuss specific barriers and opportunities in developing, manufacturing, and deploying advanced materials to increase U.S. clean energy manufacturing competitiveness.

AEMC Partnership *Materials Manufacturing Accelerator* Dialogue 2 is another step in the ongoing conversation around increased U.S. energy, manufacturing, and economic competitiveness, and leads into the upcoming 2015 AEMC Summit that will take place in Washington, D.C. on September 16th at the Arena Stage.

The American Energy and Manufacturing Competitiveness (AEMC) Partnership Overview

The AEMC Partnership is a 3-year effort by the Council and EERE to bring together national leaders to address a rapidly shifting energy and manufacturing landscape. In a series of progressive dialogues from 2013 through 2015, participants consider actions that can be taken now to bolster American competitiveness in these areas. This is a new partnership formed under the DOE Clean Energy Manufacturing Initiative - a strategic integration of and commitment to manufacturing efforts focusing on American competitiveness in clean energy manufacturing. The goals of the CEMI and AEMC Partnership are:

- Increase U.S. competitiveness in the production of clean energy products: Strategically investing in technologies that leverage American competitive advantages and overcome competitive disadvantages and
- Increase U.S. manufacturing competitiveness across the board by increasing energy productivity: Strategically investing in technologies and practices to enable U.S. manufacturers to increase their competitiveness through energy efficiency, combined heat and power, and taking advantage of low-cost, domestic energy sources.

The AEMC Partnership is broadly divided into two phases, mapping the landscape and the AEMC Partnership progressive dialogue series.

Phase One: Mapping the Landscape

To cultivate topics for the progressive dialogue series, and to provide a foundation for the larger goals of the AEMC Partnership, the Council performed an extensive literature review and mapped 184 past and current research efforts across the United States and around the globe concerning three core topics:

- Linkages between manufacturer efforts in energy efficiency and renewable energy and manufacturing competitiveness;
- Energy-related barriers to manufacturing competitiveness; and
- Models for PPPs for fostering competitive industries.

The literature review is documented in the Council publication, *The Power of Partnerships*, and its companion piece, *A Summary of Public-Private Partnerships*.¹ The barriers identified during this literature review are also provided in the Appendix of this Primer as Figure A-1.

¹ These documents are available at <http://www.compete.org/about-us/initiatives/aemcp/>.

Phase Two: The AEMC Partnership Progressive Dialogue Series

The second phase of the AEMC Partnership includes a total of five progressive dialogues in 2013 and 2014, leading into AEMC Partnership *Materials Manufacturing Accelerator* Dialogue 1, in which participants generate new insights pertaining to the overall goals of the AEMC Partnership, as well as inform the creation of a public-private partnership concept to further advance the initiative's goals.

Reviewing Previous AEMC Partnership Dialogues

Inaugural Dialogue: Launch

The inaugural dialogue in Washington, D.C. on April 11-12, 2013, hosted by Mr. James Clifton, Chairman and CEO of Gallup, Inc., laid out the objectives of the AEMC Partnership, and began the process of closely examining a range of PPP model types and technology areas, drawing on the real-world experience, insights, and knowledge of leaders and practitioners from across a range of stakeholders— including government, industry, academia, labor and the national laboratories.



The Honorable David T. Danielson, Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy; the Honorable Deborah L. Wince-Smith, President & CEO, Council on Competitiveness; Mr. Jason Miller, Special Assistant to the President for Manufacturing Policy, National Economic Council; Ms. Elizabeth Wayman, Director, Clean Energy Manufacturing Initiative, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy; and Mr. Chad Evans, Executive Vice President, Council on Competitiveness



Dialogue 2: Bridge

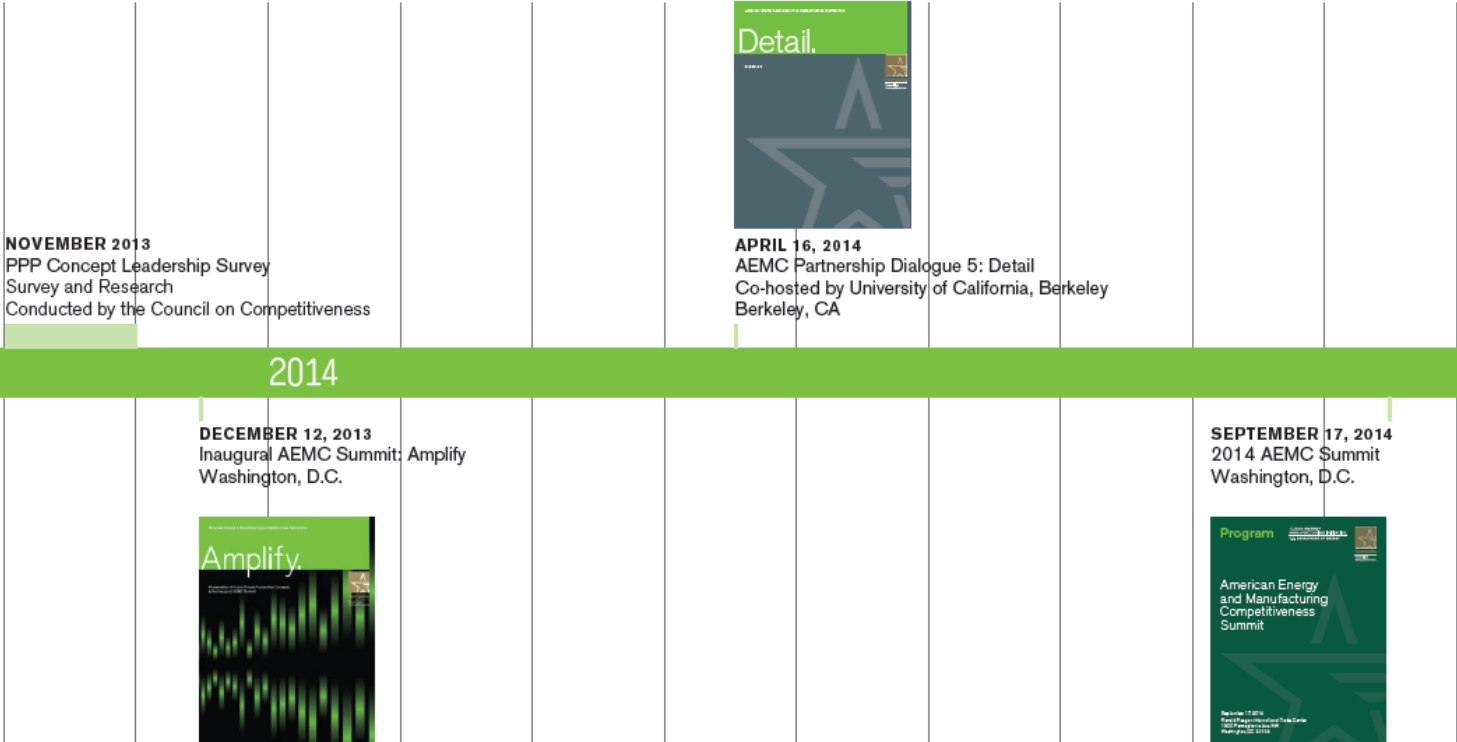
President Lloyd Jacobs of the University of Toledo hosted the second dialogue on June 20th, continuing the discussions sparked during the inaugural dialogue. This dialogue focused on Toledo as a case-study for successful informal and formal partnerships that can drive regional manufacturing transformation, in this case by leveraging materials science and engineering.



Dr. Jay Kim, Director, School of Dynamic Systems, University of Cincinnati; Mr. Lorry Wagner, President, Lake Erie Energy Development Corporation; the Honorable Deborah L. Winco-Smith, President & CEO, Council on Competitiveness; Dr. Lloyd A. Jacobs, President, The University of Toledo; and the Honorable David T. Danielson, Assistant Secretary of Energy Efficiency and Renewable Energy, U.S. Department of Energy

Dialogue 3: Evaluate

Dr. Mark Little, Senior Vice President and Chief Technology Officer of GE and Director of the GE Global Research Center at the GE Global Research Center in Niskayuna, New York, hosted the third dialogue at the GE Global Research Center in Niskayuna, New York. The Council and EERE presented five specific PPP concepts for dialogue participants to discuss and critique around the major themes of leveraging national laboratories for manufacturing competitiveness, facilitating the scaling of innovative technologies to mass-manufacturing in the United States, and bringing public and private sectors together to accelerate the development and deployment of advanced materials in supply chains.





**AEMC Partnership Dialogue 3
Niskayuna, NY**

Mr. Chad Evans, Executive Vice President, Council on Competitiveness; the Honorable Paul Tonko, U.S. House of Representatives; the Honorable Deborah L. Wince-Smith, President and CEO, Council on Competitiveness; the Honorable David T. Danielson, Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy; Ms. Elizabeth Wayman, Director, Clean Energy Manufacturing Initiative, Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy; Ms. Jetta Wong, Deputy Director, Clean Energy Manufacturing Initiative, Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy; and Dr. Mark Little, Senior Vice President and Chief Technology Officer, General Electric and Director, GE Global Research

Dialogue 4: Focus

Mr. Michael Splinter, Executive Chairman of the Board of Directors of Applied Materials, and Omkaram Nalamasu, Chief Technology Officer of Applied Materials, hosted the fourth dialogue that focused squarely on evaluating two PPP concepts and honing the attributes of a clean energy manufacturing public-private partnership:

Lowering risk and accelerating the adoption of advanced materials in the clean energy space through materials characterization, quantification, and standards development, and

Lowering barriers to the scaling of existing, promising prototypes in the clean energy space by placing strategic resources on both sides of the scale-up “valley of death.”



**AEMC Partnership Dialogue 4
Santa Clara, CA**

Mr. Michael R. Splinter, Executive Chairman of the Board, Applied Materials, Inc. and the Honorable Deborah L. Wince-Smith, President and CEO, Council on Competitiveness



**AEMC Partnership Dialogue 5
Berkeley, CA**

ABOVE: The Honorable Jennifer M. Granholm, Former Governor and Distinguished Practitioner of Law and Public Policy, University of California, Berkeley and The Honorable Deborah L. Wince-Smith, President and CEO, Council on Competitiveness



BELOW: Dr. Nicholas Dirks, Chancellor, University of California, Berkeley, the Honorable David T. Danielson, Assistant Secretary for Energy Efficiency and Renewable Energy, U.S. Department of Energy, and Dr. Jon Schaeffer, Senior Engineering Manager, GE Power & Water

Dialogue 5: Strengthen

Dr. Nicholas Dirks, Chancellor of The University of California, Berkeley hosted the fifth dialogue on the university campus, where the Council and EERE presented a case-study of one tool-based PPP centered around increasing awareness and access to advanced computing resources. Discussions during the fifth dialogue supported the mutual benefit of partnerships to organizations across the ecosystem, when aligned around a need such as materials characterization or manufacturing optimization or around streamlined access to a tool, such as advanced computing resources.

Setting the Stage for AEMC Partnership *Materials Manufacturing Accelerator Dialogue Series*

Advanced materials can drive significant enhancements products and the economy by increasing the efficiency and optimizing energy products. Moreover, material technologies have the ability to increase the competitiveness of all manufacturing sectors, for example through broadly applicable advances in heat recovery processes, lubricants that reduce wear and on process equipment, and shaping processes that reduce material waste. As such, materials science and engineering have remained a central leverage point capable of meeting the goals of the AEMC Partnership.

Building a program around accelerating the development, manufacture, and deployment of advanced materials also helps address three specific manufacturing barriers that inhibit dramatic progress in clean energy manufacturing: insufficient access to capital, technical uncertainties from technical risk and imperfect information, and insufficient access to innovation infrastructure.²

- **Capital Requirements:** While insufficient capital is often attributed to a dearth of new innovative energy technologies, insufficient capital also strangles the design, development, manufacture and deployment of advanced materials. The amount of investment required to design, develop, manufacture, and deploy advanced materials can shelve a project mid-stream or even inhibit a project from beginning.
- **Overcoming Technical Uncertainty & Imperfect Information** Market incentives encourage firms to focus on low-risk incremental improvements to existing technologies rather than investing in new and unproven transformational technologies. Often, innovators and investors lack adequate information to make informed decisions. These high technical risks dampen the incentives to the increased creation and use of new technologies.
- **Industrial Innovation Infrastructure & Expertise:** This barrier refers to a lack of access to shared infrastructure and expertise on which industry scientists and engineers could draw to increase speed and lower costs on the path from design to production and commercialization. Typically, innovation infrastructure refers not only to shared research and testing equipment, but also to university or national laboratory personnel with specialized knowledge and skills.

² The Council identified and documented twenty unique manufacturing barriers in the *Power of Partnerships* during Phase One of the AEMC Partnership. During Phase Two of the AEMC Partnership, regional and national clean energy manufacturing stakeholders from the public and private sectors shared insights and validated this list of barriers.

Dialogues 6-8: Spotlight on Advanced Materials

After gathering input from stakeholders, the Council and the Department of Energy considered the acceleration of advanced materials into products and processes in the marketplace as a cross-cutting method to achieve the goals of the Clean Energy Manufacturing Initiative. By engaging a broad industrial community and increasing access to national innovation capabilities – including expertise and tools – advanced materials may be better designed, developed, manufactured, and deployed to both accelerate the development and commercialization of clean energy technologies and increase the energy productivity of many sectors of the economy.

Several materials classes are of interest in this cross-cutting initiative, with relevance and interest across the Department of Energy Office of Fossil Energy, Office of Energy Efficiency and Renewable Energy, and Office of Nuclear Energy, including next generation alloys, separation materials such as sorbents and membranes, catalysts, and coatings which are discussed briefly below.³

Alloys

The desire for superior characteristics in metals has driven research in a continuous quest to find alloys that are stronger, more ductile, formable, corrosion resistant, high melting temperatures, yet capable of being joined, coated, and manufactured at low cost.

Inconel is an example of an alloy under investigation for use in advanced ultra-supercritical steam boilers (at temperatures up to 760 degrees Celsius and pressures up to 5500 pounds per square inch) which will allow for the generation of electricity from coal-fired power plants at higher efficiency.⁴ Materials such as Inconel have additional applicability for high temperature, high pressure piping in gas fired carbon dioxide Brayton cycles for carbon capture and solar powered carbon dioxide Brayton cycles.⁵ By better understanding microstructural factors, steam-side oxidation resistance, and other characteristics that can help predict the life of alloys, the Materials Manufacturing Acceleration initiative could help accelerate the design, development, characterization and standardization of alloys like Inconel which will allow for its deployment into the marketplace.

Figure 1: Extrusion of Inconel 740H Pipe at Wyman Gordon plant



³ This initiative will also collaborate with and integrate efforts from The Materials Project (www.materialsproject.org) and the National Network of Manufacturing Innovation Institutes.

⁴ Viswanathan, R. et al. U.S. Program on Materials Technology for USC Power Plants. *Advances in Materials Technology for Fossil Power Plants*. 2005 ASM International.

⁵ Shingledecker, J. et al. Materials Technology to Enable High-Efficiency Advanced Ultrasupercritical (A-USC) Steam Power Plants. "Advanced Technologies & Best Practices for Supercritical Thermal Power Plants." Partnership to Advance Clean Energy-Deployment (PACE-D) Technical Assistance Program (U.S. AID), 2013.

Separation products

Advanced materials that can increase the efficiency of separations processes could have an outsized impact on the energy and manufacturing sectors. Sorbents and membranes are two types of products used in applications such as carbon sequestration, fuel cells, chemical processing, and removing impurities from fluids ranging from power plant flue gas and water filtration.

Membranes like the poly (ether ether ketone) (PEEK) hollow fiber membrane can be used to separate carbon dioxide (CO₂) from flue gas, which is then absorbed into a liquid.⁶ The Materials Manufacturing Accelerator initiative could unleash the potential of advanced materials for separation processes by increasing access to tools such as modeling and simulation or high throughput experimentation to verify products that can separate desired components at preferred conditions such as higher pressures and temperatures and low concentrations, with reduced degradation over time.

Figure 2: PEEK Hollow fiber membrane contactor developed to increase the efficiency of carbon capture from power plant flue gas



Coatings

Coatings can increase the durability and corrosion resistance of metals and other materials, increasing the lifetime of products and reducing downtime of processes across the energy and manufacturing sectors. Advanced materials for coatings are especially important for extreme environments, where resistance to degradation by high temperatures and corrosive chemicals must be explored in addition to other desirable coating qualities such as good adherence while remaining inert with many substrates including varying types of metals and alloys, and low toxicity.

Figure 3: Aluminum fins from a geothermal power plant subjected to 24,000 cycles of exposure to briny conditions with: no protective coating (left), nano-coating with a low level of Cerium Oxide (middle), and a nano coating with a higher concentration of Cerium Oxide (right).



Coatings like an ultrathin coating with rare-earth metal oxide nanoparticles mitigate the corrosion effects from brine in aluminum fins in air-cooled condensers at geothermal power plants.⁷ By increasing access to materials data and expertise, modeling and simulation capabilities, and high throughput experimentation tools, the Materials Manufacturing Accelerator initiative could continue the discovery of durable, economical, and more environmentally friendly coatings and efficient and optimal methods for their application.

⁶ Li, S. et al. "Post-combustion CO₂ Capture Using PEEK Hollow Fiber Membrane Contactors." 2014.

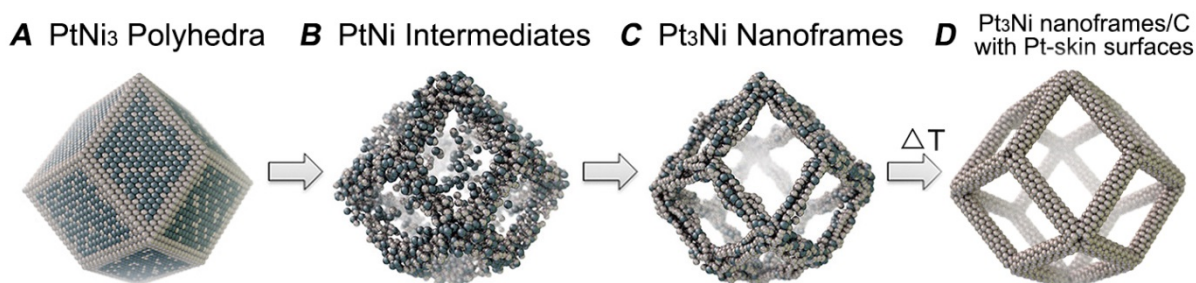
⁷ Larsen, KR. "Corrosion-resistant coatings incorporate metal oxide nanoparticles." *Materials Performance*, 2009.

Catalysts

Catalysts are commonly used in technologies and processes to increase the rate of desired chemical reactions and inhibit undesired reactions across sectors including chemical and petrochemical industries, the pharmaceutical industry, and power production for electricity and vehicles. Research continues to race forward in catalysis to find methods to create more effective and less expensive catalysts, find methods to increase exposure to catalysts, and reduce the degradation of catalysts from poisons and long periods of exposure to potentially harsh environments.

Catalysts like the nanoframe platinum nickel catalyst generated for fuel cells, have been designed and produced to use roughly 85% less platinum while enjoying over 30 times the catalytic activity of platinum dispersed on carbon.⁸ Further developments in catalysis could benefit from the activities envisioned in the Materials Manufacturing Accelerator, moving forward new discoveries such as these platinum nickel nanoframes into manufacturable and deployable products more quickly and with less expense.

Figure 4: Illustrations showing the evolution of platinum/nickel catalyst from a solid polyhedral structure to nanoframes with platinum-enriched skin.



⁸ "Big Step for Next-Generation Fuel Cells and Electrolyzers." Lawrence Berkeley National Laboratory, 2014.

Potential activities to include in an Advanced Materials Manufacturing initiative

The Department of Energy has an unparalleled resource with the potential to increase U.S. competitiveness – including resources within the national laboratory complex and the university research system. Within the wide-array of expertise, capabilities and scientific user facilities housed at these global centers of innovation and excellence, the Department of Energy is working to leverage advanced manufacturing expertise and infrastructure in addition to developing common computational tools with the potential to accelerate advanced materials manufacturing from materials discovery through deployment.

This initiative may include some of the following activities in the creation of a public-private partnership around accelerating advanced materials from discovery through deployment:

Public sector capabilities map

The Department of Energy Technology Transfer program provides a mechanism to search for expertise and facilities in specific scientific and technological areas of interest through the DOE national laboratories.⁹ The Department of Energy, as part of the *Materials Manufacturing Accelerator* initiative, could help fund and expand this effort into a full map of public sector capabilities, potentially even paired with a matchmaking or concierge service that could help private sector organizations find the relevant tools and expertise within the national laboratory and university research ecosystems.

Materials data repository, management, and informatics

The Materials Project,¹⁰ the instantiation of the Materials Genome Initiative, is the

Figure X: The Advanced Light Source at Lawrence Berkeley National Laboratory



Increased access to tools

The Department of Energy's national laboratory complex and supported university research programs are fountains of expertise, capabilities, and scientific user facilities that can be applied to accelerating the design, development, manufacture, and deployment of advanced materials. These resources have a history of partnering with industry to overcome industry problems and while many good examples of success exist,^{11,12,13} the broader community has not yet

⁹ Department of Energy, <http://techtransfer.energy.gov/doelabwork>.

¹⁰ The Materials Project, <https://www.materialsproject.org/>.

¹¹ Council on Competitiveness. Case Study: Goodyear Puts the Rubber to the Road with High Performance Computing. 2009. More information available at: <http://www.compete.org/publications/detail/685/goodyear-puts-the-rubber-to-the-road-with-high-performance-computing/>.

benefited. Through the Materials Manufacturing Accelerator initiative, the Department could clarify the methods to approach and use these capabilities at the national laboratories and university research programs, or fund projects for individual companies to use these capabilities towards solving industry-relevant problems.

Integrating state-of-the-art methods in high-throughput computation and experimentation

In a traditional and risk-averse sector such as national defense, Lawrence

Comprehensive suite of sensors and diagnostics

In a traditional and risk-averse sector such as national defense, Lawrence

Innovative business models

Intellectual property management and rapid product deployment

¹² Albuquerque Business First. "Los Alamos honors team for work with P&G." August 2013. Available at: <http://www.bizjournals.com/albuquerque/blog/morning-edition/2013/08/los-alamos-honors-team-for-work.html>.

¹³ Los Alamos National Laboratory. Chevron, GE form Technology Alliance. February 2014. Available at: <http://www.lanl.gov/newsroom/news-releases/2014/February/02.03-chevron-ge-tech-alliance.php>.

Looking Forward

AEMC Partnership *Materials Manufacturing Accelerator* Dialogue 1 presents potential ways to focus in on the problem of bringing advanced materials into manufactured processes and products and deploying these materials into the marketplace. Suggesting focus on either specific classes of materials, specific capabilities that can be applied to large swaths of material classes, or a mixture of the two, the Council and the Department of Energy look forward to hearing the perspectives of decision makers on the best methods to accelerate the use of advanced materials.

The dialogue on May 8, 2015 at the Oregon State University allows the Department of Energy to gather feedback from the community of stakeholders in advanced materials. The Department of Energy will consider this feedback as it moves forward in the creation of a Materials Manufacturing Accelerator initiative with organizations across the innovation ecosystem.