Testimony of

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Introduction

Chairman Lamb, Chairwoman Stevens, Ranking Members Weber and Baird and Members of the Subcommittees on Energy and Research and Technology, thank you for the opportunity to testify today on behalf of the Department of Energy's (DOE) Advanced Manufacturing Office.

The Advanced Manufacturing Office (AMO), within DOE's Office of Energy Efficiency and Renewable Energy (EERE), conducts research and development (R&D) to improve energy efficiency across the manufacturing sector. Greater energy efficiency saves industry money and improves their economic competitiveness while also reducing emissions, including carbon dioxide. A number of AMO and Administration priorities were incorporated in the National Science and Technology Council's recent *Strategy for American Leadership in Advanced Manufacturing*.[1]

Manufacturing is vital to the United States economy. The sector generates roughly 11.4% of U.S. gross domestic product (GDP)[2] and employs more than 12.8 million Americans according to the most recent data from the Bureau of Labor Statistics.[3] Energy is a central input into the production of goods, so it is no surprise that the sector has an annual energy bill of about $150 billion.[4] Although it varies by industry, the energy intensity of manufacturing makes the sector highly sensitive to energy costs.

The industrial sector consumes approximately one-third of total U.S. energy consumption.[5] Improving the industrial sector's energy productivity drives overall U.S. economic competitiveness. It aligns with the Department's science and technology mission and our priority for affordable energy.

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[1] https://www.whitehouse.gov/wp-content/uploads/2018/10/Advanced-Manufacturing-Strategic-Plan-2018.pdf

[2] U.S. Bureau of Economic Analysis, Value Added by Private Industries: Manufacturing as a Percentage of GDP [VAPGDPMA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/VAPGDPMA, March 8, 2019.

[3] U.S. Bureau of Labor Statistics, All Employees: Manufacturing [MANEMP], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/MANEMP, March 8, 2019.

[4] U.S. Energy Information Administration, Office of Energy Consumption and Efficiency Statistics, Form EIA-846, 2014 Manufacturing Energy Consumption Survey, Table 7.9. This figure includes expenditures for energy used as feedstock as well as fuel.

[5] U.S. Energy Information Administration, Office of Survey Development and Statistical Integration, Monthly Energy Review February 2019, Energy Consumption by Sector; https://www.eia.gov/totalenergy/data/monthly/pdf/sec2.pdf.

DOE's industrial energy efficiency program stems from the Department of Energy Organization Acts of 1977 and the Energy Policy Act of 1992.[6] DOE investments in industrial energy efficiency have helped reduce energy intensity of the industrial sector by over 30% since 1970.[7] Natural gas is used more than any other fuel source in the manufacturing sector.[8] Reliance on natural gas has helped make the industrial sector the least carbon dioxide-intense end-use sector.[9] Even though the sector's energy consumption is projected to rise 31% by 2050, according to projections from the Energy Information Administration, [10] the sector's energy intensity is projected to decrease by 0.9% annually during the same time frame due to energy efficiency gains and a shift to less energy-intensive manufacturing.[11] This corresponds to a decrease of carbon dioxide intensity of 11%.[12]

Overview of the Advanced Manufacturing Office

The AMO funds early-stage R&D to catalyze industry investment and adoption of energy efficiency-related advanced manufacturing technologies. Success reduces energy intensity within existing manufacturing processes and promotes domestic manufacturing growth in emerging energy technology fields. Leveraging the world-class scientific capabilities of DOE's network of 17 National Laboratories, our R&D ranges from using cutting-edge supercomputers to solve industry-defined manufacturing challenges, to advancing processing technologies for next-generation 3-D printing, to connecting the National Labs' top-tier technical talent with the next generation of energy entrepreneurs, and more. We also partner with the nation's premier research universities to conduct early-stage research projects, as well as community colleges to address the sector's skilled workforce needs. By actively partnering with industry to further lower technology risk, we lay the foundation for manufacturers to be competitive in existing and new technologies, which can result in new opportunities and job growth.

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[6] Pub. L. 95-91 and Pub. L. 102-486

[7] A Comprehensive System of Energy Intensity Indicators for the U.S.: Methods, Data and Key Trends (found at https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22267.pdf)

[8] U.S. Energy Information Administration, Office of Energy Consumption and Efficiency Statistics, Form EIA-846, 2014 Manufacturing Energy Consumption Survey, Table 5.4.

[9] U.S. Energy Information Administration, Office of Energy Consumption and Efficiency Analysis, Annual Energy Outlook 2019, Slide 21; https://www.eia.gov/outlooks/aeo/ppt/aeo2019.pptx.

[10] Ibid., Slide 137.

[11] Ibid., Slide 141.

[12] Ibid., Slide 22, as measured by CO2 emissions per British thermal unit (Btu) of energy consumed

We have identified 14 key technology areas with a high potential to improve energy productivity in U.S. industry. These areas were determined through multiple rounds of intensive stakeholder input beginning in 2013. A few examples are: critical materials that are essential to a wide range of energy technologies, new materials that can operate in harsh environments, cost-effective production of carbon fiber composites, and development of additive manufacturing technologies. What these diverse technology areas have in common is that, by solving key manufacturing-related R&D challenges, multiple industries can achieve transformational impact by their advancement.

AMO employs a three-pronged approach to executing its mission: investments in targeted R&D projects, support of consortia activities centered on key technical focus areas, and technical partnerships that validate R&D results in production-relevant environments.

Of particular interest to the Committee is our consortia subprogram, which the Department executes under statutory authority from the Energy Policy Act of 2005.[13] Current consortia include the Critical Materials Institute and the upcoming Energy-Water Desalination Hub, Oak Ridge National Laboratory's Manufacturing Demonstration Facility (MDF) and Carbon Fiber Test Facility (CFTF), and the Department's five Clean Energy Manufacturing Innovation (CEMI) Institutes.

Manufacturing Innovation Institutes and Program Impact

AMO manages the Department's five current CEMI Institutes, which are led by independent organizations. The institutes are formally recognized as part of the Manufacturing USA network, on which my colleague from the Department of Commerce may speak.

The institutes are large-scale public-private partnerships that are catalyzed by federal investment totaling $70 million, plus industry matching cost share, over five years. Through shared facilities and leveraging multidisciplinary teams from industry, academia, National Labs and state and local governments, the institutes create innovation ecosystems that aim to accelerate the transfer of technology from the labs to the private sector. The Institutes, with support from Federal partner agencies, also provide guidance, education, and workforce development activities that increase and improve workforce preparedness for the advanced manufacturing jobs of the future. After the initial five-year funding phase, institutes are expected to transition to a self-sustaining model.

[13] 42 U.S.C. § 16191(a)(2)(C).

Since the inception of the Department's manufacturing institutes, AMO has maintained a strong working relationship with our federal agency partners at the Department of Defense (DOD), the Department of Commerce, and other agencies. This includes strong interagency coordination on the network itself, led by the Advanced Manufacturing National Program Office (AMNPO) at the National Institute of Standards and Technology (NIST), as well as coordination around best practices for institute management. Through network meetings with agency leads, institute directors, and members and constant communication between the federal partners, there has been considerable interagency effort to oversee the 14 federal agency-wide institutes.

The collaboration extends to the institutes themselves. A powerful example of this is an R&D facility outside of Detroit, in a space shared by DOE's Institute for Advanced Composite Manufacturing Innovation (IACMI), and DOD's Lightweight Innovations for Tomorrow (LIFT) Institute. With IACMI's work on carbon fiber composites and LIFT's work on lightweight metal alloys, both institutes focus on accelerating manufacturing processes for new components integral to the automotive supply chain. By co-locating tools and expertise, the engineering teams are able to shorten the innovation cycle and deliver impactful new prototypes for its industry partners on much quicker timescales. The facility itself represents nearly $50 million in joint investment, including $12.5 million from IACMI and almost $18 million from the state of Michigan and other partners.

DOE's first institute, PowerAmerica, is located at North Carolina State University and focuses on wide bandgap semi-conductor materials. The Institute for Advanced Composite Materials (IACMI) is located in Knoxville, TN, and works to drive down the cost and energy consumption of carbon fiber composite manufacturing. The Clean Energy Smart Manufacturing Innovation Institute (CESMII), led by UCLA, develops the sensors, controls, and technologies to drive energy productivity through real-time, integrated management of manufacturing processes. The Rapid Advancement in Process Intensification Deployment (RAPID) Institute, located in New York City and led by the American Institute of Chemical Engineers, focuses on decreasing energy consumption, capital costs, and waste in chemical manufacturing through modular chemical process intensification. Finally, the Reducing EMbodied-energy And Decreasing Emissions (REMADE) Institute, headquartered in Rochester, NY, focuses on recycling and the reduction of waste in industrial-scale materials processing.

Each of DOE's institutes is organized around technology areas identified earlier. The table below shows the funding appropriated for each institute by year[14] in millions of dollars:

[14] A Notice of Intent for the sixth Institute can be found here: https://www.energy.gov/articles/doe-announces-notice-intent-issue-funding-opportunity-establishing-cybersecurity-institute

	FY13	FY14	FY15	FY16	FY17	FY18	FY19
PowerAmerica	$14	$14	$14	$14	$14	-	-
IACMI		$14	$14	$14	$14	$14	-
CESMII		$14	$14	$14	$14	$14	-
RAPID			$14	$14	$14	$14	$14
REMADE				$14	$14	$14	$14
Institute #6					$14	$14	$14

Due to the lead-time necessary for competing an institute, award selection, and the negotiation process, AMO institutes begin operation 18 to 24 months after congressional appropriations begin. As a result PowerAmerica, whose last year of appropriations was FY17, ends its fourth of five years of operation in June 2019. IACMI will end its fourth year in May 2019, while, RAPID, REMADE, CESMII will end their second years in January, March, and June 2019, respectively.

The institutes have developed important technologies. I would like to take a moment to highlight two examples:

As previously mentioned, PowerAmerica is working to reduce the manufacturing cost of wide bandgap semiconductors for use in power electronic devices. Among other things, power electronics are a potential enabler of industrial electrification, which could yield significant energy productivity gains in manufacturing processes such as heating, which accounts for over 30% of all primary manufacturing energy use.[15]

PowerAmerica previously worked with the silicon semiconductor foundry X-FAB in Lubbock, TX, to integrate a foundry line for 6-inch silicon carbide wafers around its silicon line. The facility now has the capacity to produce 1,500 silicon carbide wafers per month, and, more recently, the institute's device manufacturing partners have used the facility to develop new products. For example, GeneSiC just produced its first batch of 6.5kV silicon carbide microchip components at the foundry.

IACMI, the institute that focuses on cost-effective carbon fiber composites, is aiming for a 25% reduction in overall production costs and a 50% reduction in the embodied energy – the energy consumed by all of the processes associated with the production of a material - of carbon fiber-reinforced polymers. These advanced materials have applications ranging from wind turbine

[15] U.S. Energy Information Administration, Office of Energy Consumption and Efficiency Statistics, Form EIA-846, 2014 Manufacturing Energy Consumption Survey, Table 5.2.

blades and automobiles to gas storage and aviation, and the cost-effective production of base materials will in turn drive the competitiveness of these diverse industries.

Recently, a group led by Ford, Dow, and DowAksa collaborated on an R&D project through IACMI to develop carbon fiber composites to replace a number of metal components in automobile bodies, reducing the overall weight of the vehicle and increasing fuel efficiency. The group is targeting the deployment of components on over 100,000 vehicles per year. While work is still ongoing, the group has demonstrated the novel chemistry and developed the automated processing technology needed to integrate the materials into Ford's production lines.

Through the first fiscal quarter of 2019, the Department's institutes:

- leveraged at least $350 million in non-federal funding;
- partnered with 106 manufacturers employing over 500 people, as well as 168 small and medium-sized businesses; and
- leveraged support from 11 states, including: California, Colorado, Indiana, Kentucky, Michigan, New York, North Carolina, Ohio, South Carolina, Tennessee, and Texas.

A more comprehensive look at institute activities can be found in the annual interagency Manufacturing USA reports.[16]

Finally, I would like to highlight that AMO has plans for a sixth institute. In February, DOE published a Notice of Intent to issue a Funding Opportunity Announcement entitled, "Clean Energy Manufacturing Innovation Institute: Cybersecurity in Energy Efficient Manufacturing." This Institute will focus on understanding the evolving cybersecurity threats to greater energy efficiency in manufacturing industries, developing new cybersecurity technologies and methods, and sharing information and expertise to the broader community of U.S. manufacturers.

A Lawrence Berkeley National Laboratory report identified an opportunity for 15% industrial energy efficiency improvements through secure process automation.[17] However, cybersecurity risks limit increased adoption and implementation of automation, advanced sensors, and controls necessary to improve energy efficiency. By improving cybersecurity protection, those risks can be reduced and catalyze adoption of more energy efficiency technologies in manufacturing. More cyber-secure, energy-efficient manufacturing processes will lead to a more competitive

[16] https://www.manufacturingusa.com/reports

[17] Granderson, J, Fernandes S, 2017. State of Advanced Measurement and Verification Technology and Industry Application the Electricity Journal 30 8-16. https://eta.lbl.gov/sites/default/files/publications/sam_fernandes_-_report_-_state_of_advanced_measurement_and_verification_technology_and_industry_application_0.pdf

U.S. manufacturing sector. This is an example of another area where we will work closely with DOD. As with our other Institutes, after five years the institute is expected to transition to a self-sustaining model.

DOE is committed to working in partnership with industry, academia, and other federal agencies to support greater energy efficiency and competitiveness in the manufacturing sector, while also working with Congress to ensure appropriate stewardship of taxpayer investments. I appreciate the opportunity to appear before this committee to discuss DOE's manufacturing institutes.