REVITALIZING AMERICAN LEADERSHIP IN ADVANCED MANUFACTURING

JOINT HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

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C O N T E N T S

March 26, 2019

REVITALIZING AMERICAN LEADERSHIP IN ADVANCED MANUFACTURING

TUESDAY, MARCH 26, 2019

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY,
JOINT WITH THE SUBCOMMITTEE ON ENERGY,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittees met, pursuant to notice, at 10:01 a.m., in room 2318 of the Rayburn House Office Building, Hon. Haley Stevens [Chairwoman of the Subcommittee on Research and Technology] presiding.

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH & TECHNOLOGY AND
SUBCOMMITTEE ON ENERGY
U.S. HOUSE OF REPRESENTATIVES
HEARING CHARTER

Revitalizing American Leadership in Advanced Manufacturing
Tuesday, March 26, 2019
10:00 AM EST
2318 Rayburn House Office Building

PURPOSE

The purpose of this hearing is to review the successes and further opportunities for the Manufacturing USA Institutes to achieve the goal of improving the competitiveness of U.S. manufacturing. In particular, we will discuss the long-term sustainability of the Institutes and explore how the Institutes are working to accelerate the development of an advanced manufacturing workforce; leverage the existing national network of small and medium manufacturers; and develop local and regional economic opportunities in advanced manufacturing across America. An additional purpose of this hearing is to examine ways to enable decarbonization of the manufacturing sector in an effort to transition to a carbon-free future, and the role of the Manufacturing USA Institutes in achieving this goal.

WITNESSES

- **Mr. Ryan Myers** is the Director of Business Development, DoD for Hexagon Manufacturing Intelligence (Hexagon MI). Hexagon MI is a member of three Manufacturing USA Institutes: America Makes, Manufacturing times Digital (MxD), and the Lightweight Institute for Tomorrow (LIFT).
- **Mr. Mike Molnar** is the Director of the Office of Advanced Manufacturing at the National Institute of Standards and Technology (NIST), the headquarters for the interagency Advanced Manufacturing National Program Office that oversees coordination for the Manufacturing USA Institutes.
- **Dr. John Hopkins** is the CEO of the Institute for Advanced Composites Manufacturing Innovation (IACMI), a Manufacturing USA Institute.
- **Ms. Valri Lightner** is the Acting Director of the Advanced Manufacturing Office under the Office of Energy Efficiency and Renewable Energy at the U.S. Department of Energy (DOE), the office that oversees the five DOE-funded Manufacturing USA Institutes.
- **Dr. Mitchell Dibbs** is the Associate R&D Director for External Technology - Government Programs at the Dow Chemical Company.

MANUFACTURING USA

Background

The Manufacturing USA Institutes are a national network of institutes focused on accelerating innovation in industry-relevant manufacturing technologies to support the commercialization of these technologies.[1] Each Institute is a public-private partnership that leverages industry, academic, and federal resources to solve non-competitive/pre-competitive technical challenges in select advanced manufacturing sectors.[2] The federal share of costs for each Institute is equal to or less than the nonfederal share. The Institutes started as an initiative of the Obama Administration in 2012 and were authorized by Congress in 2014 through passage of the Revitalizing American Manufacturing and Innovation (RAMI) Act, included in the FY15 Appropriations Act.[3] Technology areas for the fourteen Institutes vary widely, and include 3D printing, advanced robotics, smart manufacturing, and advanced composites.[4]

The Institutes have many purposes, including: "to improve the competitiveness of United States manufacturing and to increase the production of goods manufactured predominantly within the United States; to stimulate United States leadership in advanced manufacturing research, innovation, and technology;…[and] to accelerate the development of an advanced manufacturing workforce."[2] The RAMI Act also establishes a national program office at NIST to oversee the Manufacturing USA Institutes and serve as a convener of the Institutes. Of the existing fourteen Institutes, eight have been established by the Department of Defense, five by the Department of Energy, and one by the Department of Commerce.

Current performance and future prospects

General consensus from formal reviews of the Manufacturing USA Institutes is that the Institutes are successfully leveraging the public-private partnership model to convene industry and academic partners to make joint R&D investments in technologies essential to commercializing cutting-edge advanced manufacturing techniques.[5] An independent review conducted by Deloitte concluded that the Institutes "deliver greater return on R&D spending for members than they could achieve on their own," which is enabled by the Institutes "providing access to expensive equipment, pooling project costs, creating technology roadmaps, and promoting knowledge exchange" to industry members.[6]

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[1] CRS Report R44371, *The National Network for Manufacturing Innovation*, John F. Sargent, Updated January 2017
[2] GAO report 17-320, *Advanced Manufacturing: Commerce Could Strengthen Collaboration with Other Agencies on Innovation Institutes*, April 2017
[3] Title VII, Division B, *Consolidated and Further Continuing Appropriations Act, 2015* (P.L. 113-235)
[4] *Manufacturing USA Institutes*, https://www.manufacturingusa.com/institutes, accessed 20 March 2019
[5] National Academies Proceedings of a Workshop, *Securing Advanced Manufacturing in the United States: The Role of Manufacturing USA*, 2017
[6] Deloitte report, *Manufacturing USA: A Third-Party Evaluation of Program Design and Progress*, January 2017

However, these reviews have found that there is still room for improvement for the Institutes to deliver on some of the identified purposes. Some suggestions for improvement include:

- Increasing the involvement of small and medium-sized manufacturers (SMMs) to ensure that Manufacturing USA R&D results in implementation by manufacturers[5,6];
- Strengthening and scaling workforce development programs at the Institutes by leveraging existing federal programs[5,6]; and
- Improving the effectiveness of the Institutes in delivering regional economic benefits to state and local areas[5].

This hearing will examine the successes of the Manufacturing USA Institutes and the potential for implementing these and other improvements within the existing Manufacturing USA framework.

DECARBONIZATION OF THE MANUFACTURING SECTOR

The five Manufacturing USA Institutes that are funded by the DOE focus on different ways to decarbonize the manufacturing sector. According to a draft report from the Environmental Protection Agency (EPA), the industrial sector is the third largest source of greenhouse gas (GHG) emissions at 22%, behind electricity (28%) and transportation (28%).[7] Efforts to achieve economy-wide decarbonization in the U.S. have focused primarily on reducing GHG emissions from the electricity sector, despite projections that GHG emissions from the industrial sector will increase in the next thirty years.[8]

Industrial emissions come from a variety of manufacturing sectors and processes, including cement, steel, and iron production; heating processes; and chemical processes. In order to address this issue, research and development (R&D) is needed on technologies that will help reduce and eliminate GHG emissions from these sectors, as well as R&D on new materials that have structural properties similar to cement and steel, but can be manufactured in more sustainable and energy efficient ways.[9]

The Advanced Manufacturing Office (AMO) at DOE engages in a number of R&D efforts to address these issues, including efforts in combined heat and power, high performance computing

[7] EPA report 430-P-19-001, *Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2017*, 2019
[8] C2ES report, *Decarbonizing U.S. Industry*, July 2018
[9] Science journal article, *Net-zero emissions energy systems*, June 2018

for manufacturing, and advanced materials. AMO is also the office responsible for overseeing the five DOE-funded Manufacturing USA Institutes. These Institutes include[10]:

- *Clean Energy Smart Manufacturing Innovation Institute (CESMII)*, focused on developing smart manufacturing capabilities (e.g. sensors, automation, big data) to enable more energy-efficient manufacturing processes;

- *Institute for Advanced Composites Manufacturing Innovation (IACMI),* focused on developing lower-cost, more energy efficient manufacturing and recycling for composite materials, i.e. materials made from two or more very different constituent materials, whose CEO is represented on the witness panel;

- *Rapid Advancement in Process Intensification Deployment (RAPID) Institute*, focused on breakthrough manufacturing processes to increase energy efficiency in several areas, including chemicals, natural gas, and renewable bioproducts;

- *Reducing Embodied-Energy and Decreasing Emissions (REMADE)*, focused on innovations in material recovery, reuse, recycling, remanufacturing, and optimization to improve overall manufacturing energy efficiency; and

- *PowerAmerica*, focused on developing advanced manufacturing processes for power electronics made from advanced materials beyond the conventionally-used silicon.

This hearing will explore the current role and future opportunities for DOE in R&D into reducing GHG emissions from manufacturing processes and the contributions of the DOE-funded Manufacturing USA Institutes to achieving this goal.

[10] DOE Advanced Manufacturing Office, R&D Consortia, https://www.energy.gov/eere/amo/research-development-consortia, accessed 20 March 2019

Chairwoman STEVENS. This hearing will come to order.

Without objection, the Chair is authorized to declare a recess at any time.

Good morning, and welcome to this joint hearing with the Research and Technology Subcommittee and the Energy Subcommittee. A warm welcome as well to our distinguished group of witnesses. Today is dedicated to every student, researcher, engineer, line worker, product manager, and American family wondering about the future of the United States' industrial place and our limitless potential for innovation and the strength of our workforce. This hearing is inspired by the motivation and desire for American excellence where software engineers meet assembly workers to deliver unprecedented quality, where and how we innovate the future.

It is particularly significant to welcome former colleagues, a constituent from Michigan's 11th District, Mr. Ryan Myers from Hexagon Manufacturing Intelligence located in Wixom and in Troy.

Manufacturing USA is a network of institutes that bring together multiple Federal agencies, large and small manufacturers, universities, community colleges, and nonprofits to catalyze new technologies, meet research needs, and train the workforce of the future. This initiative bore out of a policy prescription to answer the question we as a Nation faced in the post-recession era: How do we foster a competitive innovation agenda and ensure that the research and technology happens in our communities, in partnership with inclusive and necessary stakeholders?

It is a sincere and tremendous honor to recognize the achievement of our revitalized approach to advanced manufacturing innovation and what so many have dedicated the last decade toward achieving. Beginning with a pilot institute in Youngstown, led by the National Center for Defense Manufacturing and Machining, America Makes has invested in the development of 3D printing technologies and supply chain adoption. In addition, they have developed a workforce training roadmap for the Nation, including a veteran training program.

The Manufacturing USA Institutes are a critical part of U.S. global leadership in advanced manufacturing. The institutes provide a unique, collaborative platform for U.S. industry and academia to exchange best-in-class expertise to solve challenges and push the bounds of innovation. They also create a valuable opportunity for industry partners of all sizes to network, share data, exchange technology, and generate new business.

Small and medium-size companies make up 98 percent of all manufacturing firms in the United States, and the institutes provide unique access to research and innovation critical to keeping their businesses competitive, work that they could not do alone.

As we'll hear today, the private sector has been overwhelmingly supportive of the Manufacturing USA Institutes. Commitments of support over the program's life have grown to more than $3 billion, $1 billion of Federal funds matched by over $2 billion of non-Federal investment. The role of the Federal Government to catalyze new approaches to research and development (R&D) remains imperative and defines the value of the Manufacturing USA Institutes. It requires Federal leadership to bring all stakeholders to the

table to tackle large problems, develop new innovation, and address large as well as acute workforce training needs. This has proven successful, and it has been encouraged by dozens of manufacturing executives, university presidents, and experts such as the Advanced Manufacturing Partnership Steering Committee and the President's Council of Advisors on Science and Technology.

Heated global competition and the race to win the future is most certainly upon us. We acknowledge governments in free-market economies around the world have stepped up their investments in converting basic research into new manufacturing goods and processes. Today, Japan spends about 7 percent of its government R&D budget on this translational research. Germany spends about 12 percent. South Korea spends about 30 percent. The U.S., in contrast, spends just 0.5 percent.

We also today recognize the need to develop and elevate the priority of a skilled advanced manufacturing workforce by empowering Manufacturing USA to work with its partners. The demand for manufacturing jobs is met with a gulf of a readily available workforce. Currently, the skills gap for advanced technology jobs is projected to leave nearly 2.4 million positions unfilled between today and 2028, with a potential economic impact of $2.5 trillion.

In this hearing, we will learn how the Manufacturing USA Institutes have been successful, and consider opportunities to improve the work that they do either through the transfer of new technologies throughout the supply chain, or in workforce development, or by way of other regional economic development goals that have been articulated by the communities where the institutes exist.

I welcome your expert and exciting testimony, and I look forward to working together with my great and passionate colleagues on both sides of the aisle to make sure that the state of advanced manufacturing in the United States of America remains strong and is supported by the full faculties of the Federal Government.

And with that, I yield back.

[The prepared statement of Chairwoman Stevens follows:]

U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY

Opening Statement

Chairwoman Haley Stevens (D-MI)
Subcommittee on Research and Technology

Joint Subcommittee Hearing:
Revitalizing American Leadership in Advanced Manufacturing
March 26, 2019

Good morning and welcome to this joint hearing with the Research & Technology Subcommittee and the Energy Subcommittee. A warm welcome as well to our distinguished group of witnesses. Today is dedicated to every student, researcher, engineer, line worker, product manager, and American family wondering about the future of the United States industrial base, our limitless potential for innovation and the strength of our workforce.

This hearing is inspired by the motivation and desire for American excellence, where the software engineers meet the assembly workers to deliver unprecedented quality.

It is particularly significant to welcome my former colleague – Mike Molnar, with whom I worked closely on Manufacturing USA initiatives and Mr. Ryan Myers from Hexagon Manufacturing Intelligence, located in right in the heart of Michigan's 11th district.

Manufacturing USA is a network of institutes that bring together multiple federal agencies, large and small manufacturers, universities, community colleges, and nonprofits to catalyze new technologies, meet research needs and train the workforce of the future. This initiative bore out of policy prescription to answer the question we as a nation faced in the post-recession era: How can we foster a competitive innovation agenda and ensure that the research and technology happens in our communities, in partnership with a wide range of stakeholders?

It is a tremendous honor to recognize the achievement of our revitalized approach to advanced manufacturing innovation and what so many have dedicated the last decade towards achieving. Beginning with a pilot institute in Youngstown, led by the National Center for Defense Manufacturing and Machining, America Makes has invested in the development of 3D printing technologies and supply chain adoption. They have developed a workforce training roadmap for the nation, including veterans training programs.

Manufacturing USA now supports the co-investment of 14 Institutes supporting various research concentration from digital manufacturing to flexible electronics to remanufacturing to battery lifespan.

The Manufacturing USA Institutes are a critical part of U.S. global leadership in advanced manufacturing. The Institutes provide a unique collaborative platform for U.S. industry and academia to exchange best-in-class expertise to solve challenges and push the bounds of innovation.

They also create a valuable opportunity for industry partners of all sizes to network, share data, exchange technology and generate new business. Small and medium companies make up 98% of all manufacturing firms in the United States, and the Institutes can provide unique access to research and innovation critical to keeping their businesses competitive but work they could not do alone.

As we'll hear today, the private sector has been overwhelmingly supportive of the Institutes. Commitments of support over the program's life have grown to more than $3 billion: $1 billion of federal funds matched by over $2 billion of nonfederal investment.

The role of the federal government to catalyze new approaches to research and development remains imperative and defines the value of the Manufacturing USA Institutes. It requires federal leadership to bring all stakeholders to the table to tackle large problems, develop new innovation and address large and acute workforce training needs. This has proven successful and it has been encouraged by dozens of manufacturing executives, university presidents and experts such as the Advanced Manufacturing Partnership Steering Committee and the President's Council of Advisors on Science and Technology.

Heated global competition and the race to win the future is always at our heels. We acknowledge, governments in free-market economies around the world have stepped up their investments in converting basic research into new manufacturing goods and processes. Today, Japan spends about 7% of its government R&D budget on this translational research. Germany spends about 12%. South Korea spends about 30%. The U.S., in contrast, spends just 0.5%.

We also recognize the need to develop and elevate the priority of a skilled advanced manufacturing workforce by empowering Manufacturing USA to work with its partners. The demand for manufacturing jobs is met with a gulf of readily available workers -- Currently, the skills gap for advanced technology jobs is projected to leave nearly 2.4 million positions unfilled between today and 2028, with a potential economic impact of $2.5 trillion.

In this hearing, we will learn how the Manufacturing USA Institutes have been successful and consider opportunities to improve the work they do either through the transfer of new technologies throughout the supply chain, or in workforce development, or by way of other regional economic development goals that have been articulated by the communities where the institutes exist.

I welcome your expert and exciting testimony, and I greatly look forward to working together with my great and passionate colleagues on both sides of the aisle to make sure the state of advanced manufacturing in the United States of America remains strong and is supported by the full faculties of the federal government.

And with that, I yield back.

Chairwoman STEVENS. The Chair now recognizes Mr. Baird for an opening statement.

Mr. BAIRD. Well, good morning, and thank you, Chairwoman Stevens and Chairman Lamb, for holding this hearing today on this important topic which impacts almost everyone in all of our districts.

U.S. manufacturing plays a central role in the Nation's economic security and in our competitiveness. Manufacturing accounts for nearly 12 percent of the Nation's gross domestic product (GDP) and directly employs over 12 million U.S. workers. In my home State of Indiana, manufacturing accounts for almost 29 percent of the State's GDP and 17 percent of its workforce is employed in manufacturing, the highest percentage in the Nation.

While U.S. manufacturing has seen some ups and downs over the last century, it is clear there are significant opportunities for growth through the development and utilization of advanced technologies in manufacturing, as well as advanced technologies such as additive manufacturing, advanced materials, and cloud computing that are starting to be used by manufacturers to speed up and improve development, drive efficiencies in production, and enable new business models.

Federal agencies play a key role in fostering the growth of advancing manufacturing through investments in research and development, education and workforce development, and in supporting commercialization through technology transfer activities. We must also maximize these investments to ensure the greatest return for the hardworking taxpayers' dollars.

The National Institute for Standards and Technology (NIST) is working with the industry and universities to develop essential measurement capabilities and to forge collaborations that help U.S. manufacturers overcome shared technical obstacles. I look forward to hearing our witnesses through the measurement science conducted at NIST laboratories, the Hollings Manufacturing Extension Partnership, and the Manufacturing USA program. With the shared expertise and cooperation of our excellent universities, research agencies like NIST, and private industry, the U.S. can lead the world in advanced manufacturing.

I want to thank our witnesses for being here today, and I look forward to your testimony. Thank you, Madam Chairwoman. I yield back.

[The prepared statement of Mr. Baird follows:]

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
REPUBLICANS Frank Lucas, Ranking Member

Opening Statement of Research and Technology Subcommittee Ranking Member Jim Baird, PhD

Subcommittee on Research & Technology and Subcommittee on Energy Hearing - Revitalizing American Leadership in Advanced Manufacturing

March 26, 2019

Thank you, Chairwoman Stevens and Chairman Lamb for holding this hearing today on this important topic which impacts every one of our districts. U.S. manufacturing plays a central role in the nation's economic security and competitiveness. Manufacturing accounts for nearly twelve percent of the nation's gross domestic product (GDP) and directly employs over twelve million U.S. workers. In my home state of Indiana, manufacturing accounts for almost twenty-nine percent of the state's GDP and seventeen percent of its workforce is employed in manufacturing, the highest percentage in the nation.

While U.S. manufacturing has seen some ups and downs over the last century, it is clear there are significant opportunities for growth through the development and utilization of advanced technologies in manufacturing. Advanced technologies, such as additive manufacturing, advanced materials and cloud computing, are starting to be used by manufacturers to speed up and improve development, drive efficiencies in production, and enable new business models.

Federal agencies play a key role in fostering the growth of advanced manufacturing through investments in research and development, education and workforce development, and in supporting commercialization through technology transfer activities. We must also maximize these investments to ensure the greatest return for our hardworking taxpayers' dollars.

The National Institute of Standards and Technology (NIST) is working with industry and universities to develop essential measurement capabilities and to forge collaborations that help U.S. manufacturers overcome shared technical obstacles. I look forward to hearing our witnesses' thoughts on the measurement science conducted at NIST laboratories, the Hollings Manufacturing Extension Partnership, and the Manufacturing USA Program.

With the shared expertise and cooperation of our excellent universities, research agencies like NIST, and private industry, the U.S. can lead the world in advanced manufacturing.

I want to thank our witnesses for being here today and I look forward to your testimony. Thank you Madam Chairwoman, I yield back.

Chairwoman STEVENS. The Chair now recognizes the Chairman of the Subcommittee on Energy, Mr. Lamb, for an opening statement.

Mr. LAMB. Thank you, Madam Chairwoman. Good morning to all, and thank you for being here. I am thrilled that we're holding this hearing. Manufacturing is crucial not only to the country but to those of us in Pennsylvania. I'm also fortunate enough to serve as the Chairman of the Steel Caucus, which I mention only because we're having our State of Steel Hearing tomorrow at 8 a.m., bright and early if anyone wants to join us.

But I am happy that the Chairwoman noted the competitive situation in which we find ourselves because both in the steel industry and in manufacturing overall, we are coming under increased pressure from other countries around the world every year, and we have to respond.

More than half a million Pennsylvanians, people in my State, work in manufacturing. This has an $87 billion impact for us alone. But to me the more striking number is that we lost 5 million manufacturing jobs between 2000 and 2014, so, in other words, there are 10 Americans—for every one in my State that are currently working in manufacturing, there are 10 Americans who no longer have a job in manufacturing. This is an urgent problem. It's not just something we need to work on because it sounds good or because it's exciting or interesting or scientific. People's livelihoods are at stake, and I think we need to approach it that way.

I think that the work that the Manufacturing USA Institutes do just plays a key role in all of this and is really heroic. I think it's going to help us maintain a strong manufacturing base, and I think it's going to help us make gains in biotechnology and chemical and materials processing, even in robotics.

In my district, we've seen a great collaboration between Robert Morris University and the America Makes Institute. In fact, they just opened a 3D printing and additive manufacturing laboratory last month, which will allow them to do research and testing in some of these areas. And to me it reinforces that we really are at the start of something new here in manufacturing. Advanced manufacturing seems to be in its infancy, which means that someone around the world will develop the technology to win this game or at least to make some really big gains, and I would like that to be us here in the United States.

The research and work done by the five institutes sponsored by the Department of Energy (DOE) will help us on the energy efficiency side of the equation and making sure that we can reduce the environmental impacts and lower the electricity bills that come with manufacturing. Again, it's a place where the U.S. should lead the way. And this work I know extends across many programs in DOE. In fact, just last week ARPA-E (Advanced Research Projects Agency - Energy), which is a program we're very proud of and supportive of here, announced $36 million in awards to develop high temperature and high pressure heat exchangers, which is absolutely essential to increasing energy efficiency in this area.

So the institutes that we're highlighting today are impressive. They are working to leverage private investment, which is something we all know we need to work on. And we do believe that we

can create about 3.5 million more manufacturing jobs in the next decade. As the Chairwoman rightly noted, some of these are at risk of going unfilled because we haven't done the same work on the other side of the ledger to prepare our workforce, but to me that's not an outcome that we have to accept, and it's something that we can work together on to do in the years ahead. Investments like this are essential to developing the technologies that will help us lead the world and lead this industry for long into the future, and that's what I look forward to learning about here today.

So thank you all for being here, and I yield back.

[The prepared statement of Mr. Lamb follows:]

U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY

Opening Statement

Chairman Conor Lamb (D-PA)
Subcommittee on Energy

Joint Subcommittee Hearing:
Revitalizing American Leadership in Advanced Manufacturing
March 26, 2019

Good morning and thank you all for being here. I am pleased we're holding a hearing this morning about an industry critical to our country and especially in Pennsylvania: manufacturing. Our factories built the Golden Gate Bridge, the Hoover Dam, and powered the Allied Forces in World War II. And as some of you may know, I am fortunate to also serve as Chairman of the Steel Caucus – for which I'll throw a quick plug - our annual State of Steel Hearing will be held tomorrow morning and you all are welcome to attend.

More than half a million Pennsylvanians work in manufacturing; the sector has an economic impact of $87 billion in my home state alone. But the industry is changing. Our country lost over 5 million manufacturing jobs between 2000 and 2014. It is an absolute imperative that we renew our leadership in this industry – we cannot sacrifice these future opportunities for rising generations of American workers.

I believe the Manufacturing USA Institutes play a key role to that end. These Institutes are essential in helping our nation maintain a robust manufacturing base in forward-looking sectors such as biotechnology, chemical and materials processing, and robotics. These fourteen Institutes help form a national network that convenes industrial, academic, and federal partners invested in continuing U.S. leadership in advanced manufacturing.

Take, for example, the new partnership in my district between Robert Morris University and the America Makes Institute. Through a collaboration with America Makes, RMU just opened a 3D Printing and Additive Manufacturing Laboratory last month, which will serve as both a research and teaching facility and launch a manufacturing engineering certificate program to help meet our region's workforce needs in this growing field. This is just one example of the many ways in which Manufacturing USA brings together a diverse set of partners to revitalize manufacturing in America.

The research and work done by the five institutes sponsored by the Department of Energy, will help develop technologies that can increase the energy efficiency of manufacturing processes and reduce their environmental impacts. This, in turn, could lower electricity bills for manufacturers and present new economic opportunities for the U.S. to lead the way in developing novel manufacturing processes and advanced materials.

This work extends across many programs in DOE – in fact, just last week, ARPA-E announced thirty-six million dollars in awards to develop high-temperature, high-pressure heat exchangers, essential to increasing the energy efficiency of a variety of applications involving thermal energy, such as manufacturing and waste heat recovery.

The institutes we are highlighting today are impressive. They are clearly working to leverage private investment and develop new technologies, and they play a key role in not just advancing science but strengthening our economy. Accordingly, I believe our committee needs to explore bolstering this critical program.

As Mr. Molnar's testimony highlights, industry will create the potential for 3.5 million manufacturing jobs coming in the next decade, and more than half will go unfilled due to the shortage of skilled workers. If that potential lost opportunity, coupled with the millions of previously lost manufacturing jobs, is not a clarion call for dramatically increasing our investments and partnerships, I don't know what is.
Investments like these are essential to developing technologies that can help us lead the world in the evolving manufacturing industry for the years to come. I look forward to hearing more about these institutes and the recommendations of this excellent panel of witnesses assembled here today.

Thank you and I yield back.

Chairwoman STEVENS. The Chair now recognizes the Ranking Member of the Subcommittee on Energy, Mr. Weber, for an opening statement.

Mr. WEBER. Thank you, Madam Chair.

Today, we will hear from a panel of experts on advanced manufacturing technology development and discuss the Department of Energy's (DOE's) and the National Institute of Standards and Technology's (NIST's) roles in enabling fundamental research and development in support of this rapidly evolving field.

Advanced manufacturing covers a wide range of applications from additive manufacturing and creating advanced controls and sensors, to developing those waste heat recovery systems that Representative Lamb referred to, and wide bandgap semiconductors for power electronics.

Innovation in advanced manufacturing is critical to America's continued international competitiveness and I will add national security as well. Today's hearing is yet another opportunity to evaluate whether we are effectively targeting Federal efforts to ensure that the United States remains a leader in science and technology.

DOE primarily funds advanced manufacturing research through its Office of Energy Efficiency and Renewable Energy Advanced Manufacturing Office (AMO) as well. AMO funds R&D projects at the DOE national labs and enables early-stage, technical partnerships with American universities and industry stakeholders in order to improve the energy efficiency and effectiveness of those manufacturing processes. For example, the DOE-managed Institute for Advanced Composites Manufacturing Innovation (IACMI)—lots of acronyms—works with national labs and university partners to accelerate R&D in manufacturing advanced polymer composites for use in vehicles and wind turbines. And let me hasten to add, Conor, that Texas leads the Nation in wind energy. I'm just saying, just for the record.

Similarly, at the Oak Ridge National Lab Manufacturing Demonstration Facility, researchers host partners from industry to apply advanced manufacturing technologies in order to lower their production costs, create new products, and reduce lifecycle energy needs. Today, we will hear from one of these industry partners, Dow Chemical Company. And I will say that Dow Chemical Company happens to have a fairly sizable footprint in District 14 in Texas.

Dow Chemical is a diversified chemical company that leverages advanced manufacturing R&D to drive innovation over a broad range of chemical products and services, some of which are produced by the over 6,000 Dow Chemical employees and contractors in my 14th District of Texas. That's a sizable footprint. We're very proud of Dow. Dow Chemical relies on the deep bench of basic research capabilities that only the Federal Government can provide. Since 2015, Dow Chemical has entered into 26 different collaborations with DOE and 10 collaborations with NIST on complex research challenges. Partnerships like this between the Federal Government, the national labs, academia, and industry on advanced manufacturing can modernize and transform many U.S. sectors.

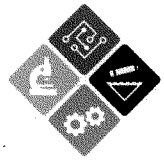
But in our search for breakthroughs, we must focus on the taxpayer's investments on the things the Federal Government is good

at doing, which we all know is not everything. With that in mind, DOE should continue to prioritize investments in user facilities and the basic and early-stage research that provides the critical data and analytical tools industry needs to commercialize groundbreaking technologies.

I want to thank the Chairwoman for holding this hearing and the witnesses for their testimony, and I'm looking forward to learning more about the right priorities for Federal investments in advanced manufacturing today.

And, Madam Chair, I yield back.

[The prepared statement of Mr. Weber follows:]



COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
REPUBLICANS Frank Lucas, Ranking Member

Opening Statement of Energy Subcommittee Ranking Member Randy Weber

Subcommittee on Research & Technology and Subcommittee on Energy
Hearing - Revitalizing American Leadership in Advanced Manufacturing
March 26, 2019

Today, we will hear from a panel of experts on advanced manufacturing technology development and discuss the Department of Energy (DOE)'s and the National Institute of Standards and Technology (NIST)'s roles in enabling fundamental research and development in support of this rapidly evolving field.

Advanced manufacturing covers a wide range of applications – from additive manufacturing and creating advanced controls and sensors, to developing waste heat recovery systems and wide bandgap semiconductors for power electronics.

Innovation in advanced manufacturing is critical to America's continued international competitiveness. Today's hearing is another opportunity to evaluate whether we are effectively targeting federal efforts to ensure that the United States remains a leader in science and technology.

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Today we will hear from one of these industry partners – Dow Chemical Company.

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Partnerships like this between the federal government, the national labs, academia, and industry on advanced manufacturing can modernize and transform many U.S. sectors.

But in our search for breakthroughs, we must focus the taxpayer's investments on the things the federal government is good at doing – which we all know isn't everything. With that in mind, DOE should continue to prioritize investments in user facilities, and the basic and early stage research that provides the critical data and analytical tools industry needs to commercialize ground breaking technologies.

I want to thank the Chairman for holding this hearing and the witnesses for their testimony, and I'm looking forward to learning more about the right priorities for federal investment in advanced manufacturing today.

Chairwoman STEVENS. If there are Members who wish to submit additional opening statements, your statements will be added to the record at this point.

[The prepared statement of Chairwoman Johnson follows:]

U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON
SCIENCE, SPACE, & TECHNOLOGY

Opening Statement

Chairwoman Eddie Bernice Johnson (D-TX)

Joint Subcommittee Hearing:
Revitalizing American Leadership in Advanced Manufacturing
March 26, 2019

Good morning and welcome to our witnesses. Thank you, Chairwoman Stevens and Chairman Lamb, for holding this timely hearing to draw attention to the role the Manufacturing USA Institutes play in promoting a strong domestic manufacturing base.

Manufacturing is foundational to the national security and economy of the United States, which is why I was one of one hundred bipartisan co-sponsors of the original Revitalize American Manufacturing and Innovation Act that established the Manufacturing USA program, signed into law by President Obama in 2014. Since the program's creation and ensuing growth, the fourteen Manufacturing USA Institutes have led transformational innovations with a variety of applications.

Not only do these Institutes play an important role in developing next-generation technologies, they also foster networks built upon public-private partnerships that maximize the impact of government investment. The Institutes engage with manufacturers of all sizes to build a robust national manufacturing network and to train a workforce of tomorrow that meets the demands of emerging manufacturing sectors.

Manufacturing USA Institutes are also an important tool in our fight against climate change. The Department of Energy funds five Institutes that focus broadly on developing technologies that reduce energy consumption in manufacturing processes. This focus is vital considering that the manufacturing sector is the third-largest emitter of greenhouse gases in the U.S. economy, behind transportation and power generation.

For this reason, we must ensure that Congress gives the Manufacturing USA program the resources and tools it needs to continue to innovate. That is why I am excited to discuss today how we can best harness the Manufacturing USA Institutes to improve U.S. competitiveness, decarbonize our economy, and train the next-generation's workforce.

With that, I yield back.

Chairwoman STEVENS. Thank you. Well, as you can tell, we are delighted to have you all here today, and at this time, I'd like to introduce our witnesses. Our first witness—oh, excuse me, important. If there any Members who wish to submit additional opening statements, your statements will be added to the record at this point.

At this time I'd also like to introduce our witnesses. We're eager to hear from you. Our first witness is Mr. Ryan Myers. Mr. Myers is the Director of Business Development - Department of Defense at Hexagon Manufacturing Intelligence. In this role, he also manages a number of strategic relationships for Hexagon in the advanced manufacturing sphere. He has a bachelor's degree in mechanical engineering from Michigan Technological University, a master's in engineering management from Long Beach State, and both an MBA and master's in finance as part of that.

Our next witness is a friend of mine, Mr. Mike Molnar. I say he's a friend because he's a former collaborator through the Manufacturing USA network where I worked. Mr. Molnar is the founding Director of the Office of Advanced Manufacturing at the National Institute of Standards and Technology, NIST. And in this capacity he is responsible for NIST's extramural advanced manufacturing programs, and he serves as a liaison to academia and industry. Mr. Molnar has earned a bachelor's degree in mechanical engineering and a master's degree in manufacturing systems from the University of Wisconsin, as well as an executive MBA from the University of Notre Dame.

After Mr. Molnar is Dr. John Hopkins. Dr. Hopkins is the Chief Executive Officer of the Institute for Advanced Composites Innovation, IACMI. As CEO, Dr. Hopkins leads this advanced Manufacturing USA Institute funded by the Department of Energy to develop advanced composites with novel material properties that are incredibly strong and very lightweight. Dr. Hopkins holds a bachelor's and a master's degree in mechanical engineering from the University of Tennessee, a Ph.D. in mechanical engineering from the University of Tennessee, and an MBA from Vanderbilt University.

Our fourth witness is Ms. Valri Lightner. Ms. Lightner is Acting Director of the Advanced Manufacturing Office, Office of Energy Efficiency and Renewable Energy at the Department of Energy. Ms. Lightner's team manages research, development, and the adoption of energy-related advanced manufacturing technologies and practices. She holds a bachelor's degree in chemical engineering from Villanova University.

And our final witness is Dr. Mitchell Dibbs. Dr. Dibbs is an Associate R&D Director for External Technology Government Programs at the Dow Chemical Company, which also has a great presence in Michigan, and so we are delighted to have you here today. We all recognize what a profound role that Dow has played in the creation of Manufacturing USA. In your role at Dow you're leading global efforts for government-related R&D. Dr. Dibbs has received a bachelor's in chemistry and math from the University of Wisconsin - Superior and a Ph.D. in analytical polymer chemistry from the University of Wisconsin - Madison.

As our witnesses should know, you will each have 5 minutes for your spoken testimony. Your written testimony will be included in the record for hearing. When you have all completed your spoken testimony, we will begin the questions. And each Member will have 5 minutes to question the panel.

And so today we will start with Mr. Myers.

TESTIMONY OF RYAN MYERS,
DIRECTOR OF BUSINESS DEVELOPMENT - DOD,
HEXAGON MANUFACTURING INTELLIGENCE

Mr. MYERS. Thank you, Chairwoman Stevens and Chairman Lamb, Ranking Member Baird, Ranking Member Weber, and other Committee Members. It's an honor to be here today to speak before the House of Representatives Committee on Space—on Science, Space, and Technology, Subcommittees on Research and Technology and Energy on topics so critical to national defense, advanced manufacturing.

I am Ryan Myers, Director of Business Development for Hexagon Manufacturing Intelligence, North America. We do have an office in Wixom, which is in Chairman Stevens' district—Chairwoman Stevens, sorry. We also have headquarters in Rhode Island, the 2nd District there under Chairman Langevin. We have a total of 13 offices spread throughout the country and centered around manufacturing hubs, which are critical to the growth of our business and supporting the network of manufacturers local to those areas. Larger Hexagon is a company headquartered out of Stockholm, Sweden, with about $4.5 billion in revenue and 20,000 employees globally with many different divisions from imaging from space, terrain mapping, and down to the industrial side, which I work on the industrial metrology side.

Hexagon is a global leader in digital solutions, creates autonomous-connected systems where data is seamlessly connected through converging the physical and digital worlds, building on intelligence into all process. We digitally transform the manufacturing process by converging design and engineering, production, and metrology solutions to make factories smarter. We use our design and engineering solutions to ensure computer-aided techniques to simulate reality and ensure quality is embedded into the design right up front. Production solutions and CNC simulations that computer-aided manufacturing software ensure the design intent is maintained through the production process. Our metrology centers then capture real-world data for inspection, and our metrology software provides actionable information through advanced analytics and intuitive reporting.

We have memberships in three of the institutes, LIFT (Lightweight Innovations for Tomorrow), America Makes, and MxD (Manufacturing times Digital). I was going to say DMDII, but they changed their name recently. We have provided equipment to LIFT and to America Makes in terms of inspection equipment. We have provided software to MxD through one of our companies that we acquired 2 years ago, MSC Software Solutions, to model how 3D printing was made and how to optimize the design for 3D parts—3D printed parts.

We have seen benefits by being part of the manufacturing institutes, and I've been a strong supporter of it because I've chartered with DOD business development and, given that eight of the institutes are DOD-funded, it seemed like a good fit. And we have had some purchases come through that. The networking is also very beneficial for a midsize company like ours. Several of the larger customers are our customers as well, and it's good to work with them on additional projects that are coming through the institutes to advance manufacturing.

There are some suggestions for improvement. One in particular that comes to mind, I'd like to see how we can leverage the network of the institutes, as well as OSD ManTech (Office of the Secretary of Defense Manufacturing Technology) and the MEPs (Manufacturing Extension Partnerships) through some integrated process to advance. I think the infrastructure is there to really move forward to make the United States a leader in advanced manufacturing, but I think there's some communication and some integration that has to happen between the two, and I don't know—I wrote in my testimony that I think the institutes can come up with a brand—you know, the broad new manufacturing technologies, and the ManTech programs can productize those and through the MEPs they can focus on education and training and scale of those new technologies to the small and midsize manufacturers, which is the largest base of manufacturers in this country.

Along with that, there's some workforce, but I see I've run out of time. I'll probably say that a little bit later. Thank you, Chairwoman Stevens.

[The prepared statement of Mr. Myers follows:]

Statement of

Ryan Myers, MBA

before the

House Subcommittee on Space, Science, and Technology

"Revitalizing American Leadership in Advanced Manufacturing"

Introduction

Chairwoman Stevens, Chairman Lamb, Committee members, it is an honor to be here today to speak before the House of Representatives' Committee on Science Space and Technology's Subcommittee on Research and Technology and Subcommittee on Energy about a topic so critical to the U.S. economy and national defense – advanced manufacturing.

I am Ryan Myers, Director of Business Development for DoD at Hexagon Manufacturing Intelligence, North America. We have an office in Wixom, Michigan, which sits in Michigan's 11th Congressional District and our North American headquarters is in North Kingstown, Rhode Island which sits in the 2nd Congressional District. In addition, we have a total of 13 offices centered around manufacturing hubs through-out the country. We employ roughly 750 people in North America, and about 650 in the U.S. Our parent company, Hexagon AB, is out of Stockholm, Sweden. Globally, Hexagon AB generates about $4.5 billion in revenue with over 20,000 employees. I have worked in this role for Hexagon for the past two and a half years. I also serve our nation as a Lieutenant Colonel in the United States Army Reserve.

Hexagon Manufacturing Intelligence is a global leader in digital solutions that create Autonomous Connected Ecosystems...where data is connected seamlessly, converging the physical and digital worlds, and building intelligence into all processes. We digitally transform the manufacturing process, by converging...design and engineering, production, and metrology solutions to make smart factories, while ensuring speed and accuracy in the production process. Our design and engineering solutions use computer-aided engineering techniques to simulate reality, so quality is embedded in design and manufacturability is guaranteed. Our production solutions include CNC simulation and computer aided manufacturing software that ensure design intent is maintained through the production process, improving throughput and delivering high quality components. Our metrology sensors capture real-world data very quickly and accurately for inspection, and our metrology software provides actionable information through advanced analytics and intuitive reporting.

We have memberships in three of the Manufacturing USA Institutes; America Makes, Lightweight Innovations For Tomorrow, LIFT, and Manufacturing times Digital MxD (formally DMDII). We came onboard with the Institutes, all about the same time, approximately three years ago. We have provided hardware and software to America Makes and LIFT, and software only to MxD. I personally have been most engaged with LIFT which is based in Detroit, Michigan, and focused on lightweight materials. To a lesser extent, I have also been involved with America Makes and MxD.

Benefits of Membership with Manufacturing USA Institutes

Our rationale for joining the Manufacturing USA Institutes was rooted in supporting the advancement of manufacturing and manufacturing technologies in the U.S. We immediately saw the value that it would bring to our DoD customers, but also to the broader manufacturing industry and national defense preparedness. This was coupled with the fact that I was hired for DoD business development for Hexagon, and these institutes are DoD funded, so it was a good strategic fit. While LIFT has been focused on important work in lightweight metals across the Defense and commercial transportation sectors, the Institute also is playing a leading role in developing and implementing smart manufacturing processes and systems. Together, Hexagon and the Manufacturing USA Institutes can advance manufacturing processes for other Institute members, Michigan manufacturers and advanced manufacturers across the nation. To support the research into those new processes, we have housed a Coordinate Measuring Machine (or CMM) at the LIFT Headquarters' Metrology Lab, which provides other members and partners accuracy, repeatability and automated dimensional inspection of manufactured parts.

Since Hexagon also has been aggressively pursuing a merger and acquisition strategy, going forward, and has done so over the past 20 years, membership in these institutes would help communicate our brand name recognition as we grow and acquire new capabilities. We have consigned metrology equipment to both America Makes and LIFT, and provided Design and Engineering software to America Makes, LIFT, and MxD as part of our membership cost-share agreements. Our economic benefits have been a purchase from LIFT for a Coordinate Measurement Machine (CMM) and the indirect influence through America Makes of a laser tracker purchase from Oak Ridge National Labs. Various software purchases have also stemmed from the Manufacturing Institute memberships. Other benefits are the networking opportunities provided by membership meetings with the large OEMs on relevant projects, both inside and outside, the scope of the Institutes. On the software side of our business we have supported collaborative projects to enhance digital file transfer between suppliers and OEMs in the Model-Based Enterprise.

Suggestions for Improvement

Though we have supported the cost share agreements and attended the Institute meetings and networking events, there is always room to improve. Since the larger companies can afford larger cost share they end up driving the Institute projects and activities, which is working exactly as the model is supposed to work. To further enhance small and mid-size business participation, perhaps a consistent stream of government funding could level out the playing field among the tiered membership, allowing the small and mid-sized businesses have a stronger voice in the Institutes activities.

Even though there is a Strategy for American Leadership in Advanced Manufacturing, by the Subcommittee on Advanced Manufacturing under the Committee on Technology of the National Science & Technology Council, October 2018, integration and alignments need to occur between the Manufacturing USA Institutes, the OSD Manufacturing Technology Programs (ManTech), and the Manufacturing Extension Partnerships (MEPs). To truly grow and strengthen America's posture in Advanced Manufacturing, we need to leverage this entire network to move forward. An example might be that the Institutes development the new manufacturing technology, the ManTech program then develops the new manufacturing technology into a product, then the MEPs take over and train and scale the new product to small, medium, and large manufacturers. The Manufacturing USA Institutes are a step to help recreate innovation transition structure that was inherent in a robust manufacturing

ecosystem, which has since been lost. The pace of disruptive innovation in manufacturing has slowed in the U.S. Working the Institutes, ManTech, and MEPs together appears to be a way to revitalize and recreate US manufacturing robustness, on a local level and nationally.

Workforce Development

While we are advancing new technologies, processes, and systems, we also recognize the importance of developing the talent needed in advanced manufacturing. The most important activity to the successful implementation of the Digital Thread and Advanced Manufacturing Technologies is the need for employee skill development, specifically in the areas of in-process quality monitoring, and advanced inspection capability. These skills are expanding, but are not yet broadly available in the workforce. Consequently, training and skill development in specific topics will be necessary for acceptance and successful implementation of the Digital Thread on a large scale.

Education and commitment of manufacturing management will also be essential: first to understand and advocate for the recommended Digital Thread activities, and then to ensure early and continuous commitment of required resources. Increased use of computational modeling, the integration of process development and process-monitoring data, NDE results, automated data collection and analysis for feedback will necessitate investment in equipment, data bases, personnel, and software.

Collectively, a commitment to Advanced Manufacturing activities offers enormous potential for benefits in time, cost, and risk for Digital Thread development and implementation: but achieving these benefits will require that manufacturing management understand and support the infrastructure and workforce requirements.

More specifically, the Metrology Lab is also a key component of the LIFT Learning Lab, which will open later this summer. The LIFT Learning Lab is the only immersive learning venue to focus on building the pipeline of advanced manufacturing technicians with skills related to these Digital Thread emerging technologies. I believe this will help fill the future need for Hexagon's applications engineers needed to fulfill economic growth in this critical area.

Local Economic Benefits

Both the LIFT high-bay and LIFT Learning Lab are key assets in the Michigan regional economy and nationally, helping to strengthen our defense industrial base and our manufacturers' leadership in the global economy.

At Hexagon, we believe these institutes can only succeed and have the desired impact of repositioning the United States as the global leader in advanced manufacturing with continued commitment of both industry and government acting together in harmony and long term.

While the first institutes, including LIFT, are just now completing their initial start-up phase and initial contracts with the Department of Defense, they are poised to make even greater contributions to both our economic and national security.

Thank you.

Ryan Myers' expansive background includes over 25 years of combined experience in Executive Leadership, Corporate Strategy and Finance, Business Development & Sales, Entrepreneurship, and Aerospace and Defense M&A.

Currently, Mr. Myers works as Director, Business Development – DoD for Hexagon Manufacturing Intelligence. He has led the quadrupling of Hexagon's sales to the Department of Defense in a matter of 3 years. He is also instrumental in managing key strategic relationships for Hexagon in the Advanced Manufacturing space; America Makes, National Center for Defense Machining & Manufacturing, Light Weight Institute for Tomorrow (LIFT), Manufacturing times Digital (formally DMDII), Commonwealth Center for Advanced Manufacturing (CCAM), National Defense Industry Association (NDIA) Manufacturing Committee, National Center Manufacturing Sciences (NCMS), and Workshop for Warriors.

Mr. Myers has founded, built and successfully exited two of his own companies and raised capital the in the manufacturing and construction business segments. Additionally, he has worked corporate strategic buyer M&A in executed transactions totaling over $1.2 billion and has developed deep understanding of both perspectives from the buyer and seller.

Mr. Myers is very experienced in strategic planning and business development, mergers and acquisitions, joint ventures, developing strategic alliances, business valuations, raising capital, due diligence analysis, negotiating and structuring transactions.

Ryan's career started in the U.S. Air Force on classified space program acquisitions at Los Angeles AFB, where he held a DoD Top Secret Security Clearance. Mr. Myers still maintains his Top Secret Security Clearance with his position in the Army Reserve, as Commander of the 3100 Strategic Intelligence Detachment. He also held various command and leadership positions within United States Special Operations Command and United States European Command.

Mr. Myers is a graduate of Michigan Technological University with a B.S. in Mechanical Engineering. He also obtained a M.S. in Engineering Management from Long Beach State, and both an MBA and M.S. in Finance. He is married and lives in South Lyon, MI with his three daughters.

Chairwoman STEVENS. Thank you. Now, we will hear from Mr. Molnar.

TESTIMONY OF MIKE MOLNAR,
DIRECTOR OF THE OFFICE OF ADVANCED MANUFACTURING,
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

Mr. MOLNAR. Thank you, Chairwoman Stevens, Chairman Lamb, Ranking Member Baird, Ranking Member Weber, and Members of the Subcommittees. I'm Mike Molnar, Director of the Office of Advanced Manufacturing at the National Institute of Standards and Technology in the Department of Commerce. Thank you for the opportunity to testify about Manufacturing USA.

I'd like to begin with some background on U.S. manufacturing, which frames the need for Manufacturing USA. A strong U.S. manufacturing sector is essential to our economic security and our national security. American manufacturers contribute over $2 trillion to the U.S. economy and drives more than 60 percent of our exports. Moreover, manufacturing plays a critical role in our innovation ecosystem, representing over 70 percent of private-sector R&D.

Especially for the emerging technologies in advanced manufacturing, industry faces a critical workforce skills gap. Another worrisome trend is that the U.S. has been a net importer of advanced technology products since 2002. Innovation is an American strength, but inventing here, while other nations benefit from new jobs and products, is not sustainable. Competitor nations have increased their efforts in applied research, often leveraging discoveries made by U.S. researchers. U.S. investments in manufacturing innovation can help restore our competitive edge in manufacturing, ensuring that what's invented here is made here. Addressing this disparity is the purpose of Manufacturing USA.

Manufacturing USA uses a public-private partnership approach to create an effective innovation space for U.S. manufacturers. It is how industry can collaborate with each other—and with academia—to solve challenging industry-relevant problems. Manufacturing USA Institutes have two main, complementary activities: Applied research and workforce skills. On research: the key is focused on bridging the "valley of death," applied research to de-risk and scale up technologies. Simply put, moving ideas into production here in the United States. Institutes provide the neutral convening ground for collaborations.

The activities are "pre-competitive"; product commercialization happens in industry, so even direct competitors can collaborate on issues that no single company can solve by themselves. On workforce: The key is collaboration with educational partners, including universities and community colleges, to develop workforce training for these emerging technologies. With passage of the bipartisan *Revitalize American Manufacturing and Innovation Act*, or *RAMI*, Congress established the Manufacturing USA network.

The Manufacturing USA Institutes are sponsored by the Department of Defense, Department of Energy, and the Department of Commerce. The program is coordinated by the National Program Office, working with eight other agencies. It's important to note that the RAMI requirements are only applicable to institutes established by Commerce. Institutes sponsored by DOD and DOE were

established under other authorities, and NIST has no role in the management of these institutes.

NIST does have the responsibility to convene the network of institutes, facilitate information and knowledge sharing, communicate with the public, and report on the network's performance to Congress each year. NIST laboratory programs have technical collaborations and provide subject-matter experts with all 14 Manufacturing USA Institutes. RAMI also directed NIST to work with the Manufacturing Extension Partnership to ensure the program reaches small and medium-sized companies—the critical U.S. supply chain.

Collectively in the past year, Manufacturing USA Institutes engaged nearly 1,300 member organizations with two-thirds of these being manufacturers and two-thirds of those being small manufacturers. These members work on hundreds of major research and development projects, projects of priority to broad industry sectors. Institutes and their members have also trained close to 200,000 people in the past year with advanced manufacturing skills. Institutes partner with educational organizations of industry to train students, existing workers, and military veterans in advanced manufacturing.

In looking ahead, global competition is fierce and has accelerated since the passage of RAMI. On National Manufacturing Day, the White House released the Strategy for American Leadership in Advanced Manufacturing. Manufacturing USA is working to support the goals of our national strategic plan and is the delivery vehicle for a number of national initiatives.

In closing, I'd like to thank you again for the opportunity to testify about Manufacturing USA. This is a team effort involving agency partners from DOD and DOE in sponsoring the institutes, along with the Departments of Agriculture, Education, Labor, HHS (Health and Human Services), NASA (National Aeronautics and Space Administration), and NSF (National Science Foundation) in the broader interagency team. I look forward to your questions. Thank you.

[The prepared statement of Mr. Molnar follows:]

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Testimony of

Michael F. Molnar

Director
Office of Advanced Manufacturing
National Institute of Standards and Technology
United States Department of Commerce

Before the
United States House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Energy
Subcommittee on Research and Technology

"Revitalizing American Leadership in Advanced Manufacturing"

March 26, 2019

Thank you, Chairwoman Stevens, Chairman Lamb, Ranking Member Baird, Ranking Member Weber, and members of the Subcommittees. I am Mike Molnar, Director of the Office of Advanced Manufacturing at the U.S. Department of Commerce's National Institute of Standards and Technology (NIST). In this capacity, I also serve as the Director for the interagency Advanced Manufacturing National Program Office (AMNPO). Thank you for the opportunity to testify today about the Manufacturing USA initiative, early successes, and opportunities for even greater impact for U.S. manufacturing and the nation's competitiveness.

Background Need and Origin of Manufacturing USA

A strong U.S. manufacturing sector is essential to our economic and national security. American manufacturers contribute more than $2.4 trillion to the U.S. economy.[1] Manufacturing also makes up 8.5 percent of U.S. nonfarm employment[2] and 11.4 percent of U.S. GDP[3] yet drives 60 percent of exports[4] and an astounding 70 percent of private-sector research and development (R&D).[5] Manufacturing and the strength of the U.S. manufacturing supply chain also are critical to national security.[6]

There are not enough workers with the right skills to fill current and future manufacturing jobs. Deloitte and the Manufacturing Institute report that, over the next decade, nearly 3.5 million new manufacturing jobs will be needed;[7] with 2 million of those jobs expected to go unfilled due to the shortage of skilled workers.

In addition, the United States has been a net importer of advanced technology products since 2002.[8] This trade deficit in advnaced manufacturing is historically unprecedented for a nation that leads the world in science and technology research. Our country has a great culture of discovery and innovation. And manufacturing is where innovation happens. While the United States leads the world in invention and discovery, other nations have focused on developing these emerging technologies for production. Capitalizing on U.S. inventions and promoting the training of an effective workforce is Manufacturing USA's mission.

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[1] Bureau of Economic Analysis, U.S. Department of Commerce, https://apps.bea.gov/iTable/iTable.cfm?reqid=51&step=51&isuri=1&startyear=2018&table_list=1&series=q&endyear=2018&valuationtype=b&thetable=1&codelist=31gva

[2] U.S. Department of Labor, Bureau of Labor Statistics, (2019), https://data.bls.gov/timeseries/CES0000000001 and https://data.bls.gov/timeseries/CES3000000001.

[3] Bureau of Economic Analysis, U.S. Department of Commerce https://apps.bea.gov/iTable/iTable.cfm?reqid=51&step=51&isuri=1&startyear=2018&table_list=5&series=q&endyear=2018&valuationtype=b&thetable=1&codelist=31gva

[4] International Trade Administration, U.S. Department of Commerce (2017), http://tse.export.gov/tse/TSEOptions.aspx?ReportID=2&Referrer=TSEReports.aspx&DataSource=NTD.

[5] McKinsey Global institute, Making it in America: Revitalizing U.S. Manufacturing, S. Ramaswamy, J. Mayika, G. Pinkus, K. George, J. Law, T. Gambell, and A. Serafino, McKinsey Global Institute pgs. 75 (2017), https://www.mckinsey.com/~/media/McKinsey/Global%20Themes/Americas/Making%20it%20in%20America%20Revitalizing%20US%20manufacturing/Making-it-in-America-Revitalizing-US-manufacturing-Full-report.ashx. Nov 2017

[6] *National Security Strategy of the United States of America*, Executive Office of the President, pgs. 55 (2017), https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905-2.pdf.

[7] Deloitte and the Manufacturing Institute, The skills gap in US manufacturing: 2015 and beyond, C. Giffi, J. McNelly, B Dollar, G. Carrick, M. Drew, and B. Gangula, Deloitte Development LLC, p. 5, (2015) http://www.themanufacturinginstitute.org/~/media/827DBC76533942679A15EF7067A704CD.ashx

[8] Producing Prosperity: Why America Needs a Manufacturing Renaissance; Harvard Business Review Press 2012

Advanced manufacturing is a top priority for this Administration and is included as one of four Industries of the Future. The race for leadership in advanced manufacturing hinges on innovation, and transitioning those innovations into production, which both creates and requires good jobs. Innovation is an American strength. Competitor nations have significantly increased their efforts in and support of applied research, often leveraging discoveries originally made by U.S. researchers. Our investments in production innovation can help restore our technological competitive edge in manufacturing and promote the manufacture of U.S. technological innovations in the United States.

The Role of Our Network

With passage of the bipartisan Revitalize American Manufacturing and Innovation (RAMI) Act,[9] Congress authorized the establishment of the National Network for Manufacturing Innovation Program, or Manufacturing USA. This law authorizes the Secretary of Commerce to establish and coordinate manufacturing innovation institutes and to collaborate with federal departments and agencies whose missions contribute to, or are affected by, advanced manufacturing.

The Manufacturing USA program is about helping industry move discoveries from the Nation's universities and research laboratories to the domestic production floors that are equipped with the necessary skilled workforce.

The federal role in these public-private partnerships serves to create a "neutral convening ground" where industry and academia collaborate on applied research, addressing the most important opportunities facing U.S. manufacturers. Manufacturing USA institutes have a mission to develop both game-changing manufacturing technology and to train workers with the skills needed for future U.S. manufacturing.

As shown in Table 1, 14 Manufacturing USA institutes are sponsored by the Department of Defense (DOD), the Department of Energy (DOE), and NIST at the Department of Commerce. The program is coordinated by the Advanced Manufacturing National Program Office, located at NIST, which works with the other two institute-sponsoring agencies, DOD and DOE, along with the Departments of Agriculture, Education, Labor, and Health and Human Services, the National Aeronautics and Space Administration, and the National Science Foundation in the broader interagency team. This is truly a team effort.

It is important to note that the RAMI requirements are applicable only to institutes established by DOC/NIST; institutes sponsored by DOD and DOE were established under separate legal authorities and NIST has no role in the management of the institutes sponsored by other agencies. NIST does have the responsibility to convene the network of institutes, communicate about the work of the network to the public, facilitate information and knowledge-sharing among the network, scale workforce efforts, and deliver a report on the network's performance to Congress each year.

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[9] Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. 113-235, Title VII – Revitalize American Manufacturing and Innovation Act of 2014, codified at 15 U.S.C. § 278s, http://uscode.house.gov/view.xhtml?req=(title:15 section:278s edition:prelim).

What the Institutes Do and Why it Matters

There are currently 14 Manufacturing USA institutes. Collectively, the institutes:[10]

- Reach 1,291 member organizations (of which 844 are manufacturing firms and 65 percent are small- and medium-sized manufacturers);
- Work on over 270 major research and development collaboration projects of priority to broad industry sectors;
- Attract $2 billion in private investment;
- Leverage $1 billion in federal funds; and
- Equip more than 200,000 people with advanced manufacturing skills.

Key goals of the Manufacturing USA institutes are to: 1) increase the competitiveness of U.S. manufacturing; 2) facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing capabilities; and 3) accelerate the development of a skilled advanced manufacturing workforce.

The institutes focus on developing a broad range of manufacturing capabilities in promising new advanced technologies that have the potential for high impact on the economy, on national security, and on the workforce of the future. Bringing together the best minds from industry, academia, and government to tackle tough manufacturing challenges helps to strengthen and expand the manufacturing base of the nation.

Serving Small- and Medium-Sized Manufacturers

Manufacturing USA also works with the NIST Manufacturing Extension Partnership Program to serve small and medium-sized manufacturers, which are 99 percent of all manufacturers, critical to local economies, and an integral part of the U.S. supply chain. MEP equips small- and medium-sized manufacturers with the resources needed to grow and thrive—working side-by-side with manufacturers to reduce costs, improve efficiencies, develop the next generation workforce, create new products, and find new markets.

Federal Agency Connections

Each institute has a sponsoring federal agency working in partnership with the institute consortia on direction and management. Through our interagency approach, other federal agencies are engaged with Manufacturing USA institutes in significant supporting roles. For example, NIST laboratory programs have technical collaborations with, and provide subject-matter experts to, all 14 Manufacturing USA institutes. NIST has a senior scientist acting as a technical lead for each institute, who coordinates with NIST laboratory resources and aids in standards and technical roadmapping activities.

Industry Advances in Technology Enabled by Manufacturing USA Institutes

The collaborative innovation enabled by the Manufacturing USA institutes has resulted in products that assist workers, make buildings safer, consume less energy, and save lives. Some examples of the hundreds of ways in which Manufacturing USA institutes create research

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[10] Manufacturing USA Annual Report, Fiscal Year 2017, Advanced Manufacturing National Program Office, National Institute of Standards and Technology, Department of Commerce (2018), https://doi.org/10.6028/NIST.AMS.600-3.

collaborations that enable member companies and their partners to produce innovative products in the United States include:

- **Modernizing Factories by Digitizing Legacy Equipment at Low Cost:** Manufacturers seeking to digitize their operations often need to incorporate data from expensive legacy manufacturing equipment into new, innovative processes without disrupting production, creating failure points, or voiding equipment warranties. A project with the Digital Manufacturing and Design Innovation Institute (DMDII), led by the University of Cincinnati, is developing an open source framework for computer vision-enabled cameras to recognize and read a variety of legacy digital displays and analog dials to produce information in the increasingly accepted MTConnect format. The final software and hardware toolkit will cost less than $1,000 per machine, enabling even the smallest manufacturing company to update its processes without replacing costly legacy equipment. Other project participants include Raytheon, Faurecia, ITI, and TechSolve (part of the Ohio MEP Center).

- **Comfortable, Wearable Medical Devices Provide Continuous Real-Time Information to Healthcare Providers:** GE Global Research partners with NextFlex to make it easier for patients to get the care they need by creating comfortable, wearable medical devices that provide continuous monitoring. NextFlex has enabled this technology, which promises to improve patient outcomes and bring down healthcare costs by allowing patients' health to be monitored from home rather than in the hospital.

- **Detecting Viral and Bacterial Contaminants:** Two National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL) projects led by Carnegie Mellon University and Accugenomics focus on advanced methods for rapid inline detection of bacterial or viral contaminants present during drug manufacturing to ensure safe, high-quality medicines for the U.S. public. These tests will replace laborious, off-line methods that can necessitate discarding up to three weeks of production due to the time they take to complete.

- **Gluten-free Cheerios:** General Mills worked with the Clean Energy Smart Manufacturing Innovation Institute (CESMII) to implement digital systems to monitor their supply chain, ensuring that their gluten-free products were truly gluten free—from the harvest field, to shipment containers, to various storage containers, and finally to the manufacturing of the Cheerios.

- **Delivering Life Saving Technology to Firefighters:** Lightweight Innovations for Tomorrow (LIFT) successfully aided Lifeline Firehose with the production of a state-of-the-art technology that makes it possible for a firehose to deliver both breathable air and water/foam simultaneously. The technology is being launched initially on a Grand Ledge Area Fire Department truck in Grand Ledge, Michigan, allowing firefighters to battle fires longer, as well as get critically needed air to downed personnel and victims. The Michigan fire department became the first-ever to deploy innovative firehoses helping first responders save lives and fight fires more efficiently. The groundbreaking technology uses a patented coupler system, which LIFT engineers helped prototype, to

deliver both air and fire suppressants to the end of the nozzle utilizing equipment firefighters are already trained on.

- **PowerAmerica Keeps the U.S. a Leader in LED Technology:** John Palmour, CTO and Founder of CREE, a leading company in LED lighting and power electronics, shared that "*PowerAmerica creates an ecosystem where technology can thrive and shows that the impossible is possible.*" CREE started when a small group working on semiconductor material, silicon carbide, commercialized the new technology. His company has grown into a large, international manufacturing company with over 4,500 workers in the United States, with products that focus on saving energy. He joined PowerAmerica because the institute helps de-risk innovative technology that companies cannot support on their own because the market is too far away. The work members are doing together in this space shows the viability of manufacturing that technology in the United States.

Developing an Advanced Manufacturing Workforce for the Future
In a healthy economy, workers are trained for new, higher-paying, advanced manufacturing jobs in emerging technology-driven manufacturing sectors. Advanced manufacturing has been the cornerstone of a robust economy and a solid middle class in the United States over the past century.

These new jobs require a workforce with new skills suitable for advanced manufacturing, so workforce development and education is a priority for Manufacturing USA and directly support's the Administration's priorities in science, technology, engineeirng, and mathmatics (STEM) education. Institutes partner with educational organizations and industry partners to teach advanced manufacturing technologies through workshops, courses, internships, and apprenticeships in order to create the workforce of the future.

The Manufacturing USA Education and Workforce Development Team has more than 50 members, including institute education and workforce directors, human capital and STEM-educational experts, and representatives from seven participating federal agencies.[11] The group develops partnerships and shares lessons learned, success stories, and initiative updates. It provides a cohesive platform for newer institutes to partner with older institutes and to develop processes based on proven models. The team's sharing of roadmapping models has led to project partnerships and to the creation of advisory committees across many of the institutes. The team's collaborative online portal, provided by AMNPO, allows for knowledge management, including sharing of hundreds of items, such as institute workforce assessment reports, project call guides, presentations, meeting reports, and industry reports.

Last year, we saw tremendous growth in institute-led workforce efforts in advanced manufacturing, educator and trainer instruction, and STEM activities, resulting in over 191,000 workers, students, and educators participating in Manufacturing USA-led workforce efforts. Education and workforce development initiatives include: summer internships for high school, vocational, community college, and university-based students; educational resources for K-12 educators; career workshops for middle and high school students; technology specific workshops

[11] The Departments of Commerce, Defense, Energy, Labor, and Education; the National Science Foundation, and the National Aeronautics and Space Administration.

for manufacturing employees; and programming for upcoming funding opportunities on manufacturing jobs training.

Institutes and national partners are creating programs to train new workers and to retrain existing workers and military veterans, as well as to educate and train students to equip them with the skills they need for high-paying jobs in the modern manufacturing sector. Some of these projects include:

- **Leading Companies Turn to Manufacturing USA to Ensure their Workers are Trained in the Latest Technologies:** Lockheed Martin works with the AIM Photonics institute and its AIM Academy to train its next-generation integrated photonics workforce. Lockheed is a member of many institutes and finds that the project work being done is critical because workers can learn by collaborating on hands-on projects.

- **Inspiring Students to Build a National Talent Pipeline in Advanced Manufacturing:** NextFlex's FlexFactor® program is overcoming common misconceptions among youth about manufacturing careers. FlexFactor uses a project-based learning approach that is integrated into an existing classroom, regardless of subject, incorporating a month of research, product design, and customer discovery work, culminating in students pitching their product and business models to a group of industry professionals in a "shark tank" style setting. Students also participate in two field trips: first to a manufacturing company where they discover what it is like to work in the sector, and then to a college or university where they learn about the education pathways that will help them build skills and experience that will prepare them for their careers.

  In Silicon Valley alone, FlexFactor has trained over 2,000 students. Early in 2018, FlexFactor launched with Lorain County Community College near Cleveland, Ohio, and has since grown from 17 students to over 700 participants in less than a year. The Boeing Company recently partnered with NextFlex and the Alabama Community College System to bring FlexFactor to schools in Northern Alabama where Boeing's manufacturing operations require a variety of technician and technologist talent.

- **Bringing Women into the Next Generation of Manufacturing: Girls of Steel Robotics®:** Girls of Steel Robotics was created at Carnegie Mellon University, which also runs the ARM institute. They offer educational programs, competitions such as FIRST Robotics, and camps for girls. They also bring summer camps to underserved areas to alleviate the transportation challenge for economically disadvantaged families. Girls of Steel has been successful at achieving its mission of "*Empowering women and girls in the pursuit of STEM by exemplifying female success in robotics.*" There have been 65 Girls of Steel alumnae, with 85 percent pursuing STEM fields in college.

- **Teaching Veterans 3D Printing for High-Paying Jobs:** 3D Veterans works with America Makes to expand a life-changing additive manufacturing training program for veterans by introducing new hands-on, projects-based additive manufacturing technology training pilot programs for U.S. veterans in Pittsburgh and Los Angeles. America Makes

provided critical support, linkages with corporate and university sponsors, technical expertise, and curriculum guidance for the training to ensure that veterans gained the 3D printing job skills needed by employers today. Veterans completing the training have gone on to high-paying, high-skill advanced manufacturing jobs.

Global Competition—What Other Countries Are Doing

The United States leads the world in innovation and inventions, yet many U.S. research discoveries are incorporated into manufacturing capabilities and cutting-edge products made in other countries. Global competition has made it unaffordable for most individual companies to transition inventions from the lab to mass production. In countries known for their manufacturing strength, such as China and Germany, this transition is facilitated by coordinated planning and national investments in advanced manufacturing programs, supporting the private sector's push to develop new manufacturing processes and products.[12]

Although the United States has established 14 Institutes, that is many fewer than the German counterpart, Fraunhofer, which has 69 institutes and China's planned 40 institutes. In 2018, Canada awarded $950 million for five innovation "advanced manufacturing superclusters," which are like our consortia of small and large business, academia, and others.[13]

China Manufacturing 2025 is one of China's key policies to reach the goal of "a strong country in manufacturing" or "a global manufacturing power." China Manufacturing 2025 is one of six key national policies that include: Reforming the One-Child Policy; National Defense; Establishing Rule of Law in the Economy; Encouraging Entrepreneurship; and Urbanization. The significance of each of the other policies underscores the importance which China attaches to its manufacturing initiative. The United States is taking strong actions to address the problematic Chinese policies implementing this initiative, which are designed to promote the development of Chinese industry in large part by restricting, taking advantage of, discriminating against or otherwise creating disadvantages for foreign enteprises.

Just last month, the German government announced a "National Industry Strategy 2030" in which, among other things, the German government may review and reform existing subsidy and competition law, allowing for time-limited subsidies in areas of innovation having a high impact on the economy, as well as company mergers in sectors where size is an absolute necessity for future global economic success.[14]

The Path Forward

In closing, I like to highlight what we often use as somewhat of a Manufacturing USA tagline: "Securing America's Future."

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[12] See Invented in America, Scaled Up Overseas, E. Reynolds and H. Samel, Mechanical Engineering Magazine (2013), https://www.asme.org/engineering-topics/articles/manufacturing-processing/invented-america-scaled-up-overseas and Restoring American Competitiveness, G. Pisano, and W. Shih, Harvard Business Review (2009). https://hbr.org/2009/07/restoring-american-competitiveness.

[13] https://business.financialpost.com/technology/canadas-950-million-bet-on-innovation-gets-set-to-take-the-next-step

[14] https://www.insidesources.com/the-global-emergence-of-national-industrial-strategy-and-americas-response/

In October, the White House released the quadrennial *Strategy for American Leadership in Advanced Manufacturing*, which is based on a vision for American leadership in advanced manufacturing across industrial sectors to ensure national security and economic prosperity.

To achieve this vision, the strategy defines three goals:

1) Develop and Transition New Manufacturing Technologies
2) Educate, Train, and Connect the Manufacturing Workforce
3) Expand the Capabilities of the Domestic Manufacturing Supply Chain

The Manufacturing USA program is working in support of all three of these goals. Collectively, the Manufacturing USA institutes are moving ideas into production and are training workers in the skills needed for tomorrow's high-paying, high-skill advanced manufacturing jobs.

Thank you for the opportunity to testify about NIST's role in coordinating the Manufacturing USA program and the large-scale, collaborative innovations happening across the country at the Manufacturing USA institutes. I will be pleased to answer any questions you may have.

Table 1. Manufacturing USA Institutes cover a broad range of critical technology areas.

Technology	Institute	Lead Funding Agency	Headquarters	Established
Additive manufacturing	America Makes — The National Additive Manufacturing Innovation Institute	DOD	Youngstown, Ohio	August 2012
Digital manufacturing and design	DMDII — Digital Manufacturing and Design Innovation Institute	DOD	Chicago, Illinois	February 2014
Lightweight metals manufacturing	LIFT — Lightweight Innovations for Tomorrow	DOD	Detroit, Michigan	February 2014
Wide bandgap power electronics manufacturing	PowerAmerica — The Next Generation Power Electronics Manufacturing Innovation Institute	DOE	Raleigh, North Carolina	January 2015
Fiber-reinforced polymer composites	IACMI — Institute for Advanced Composites Manufacturing Innovation	DOE	Knoxville, Tennessee	June 2015
Integrated photonics manufacturing	AIM Photonics — American Institute for Manufacturing Integrated Photonics	DOD	Rochester and Albany, New York	July 2015
Manufacturing thin flexible electronics devices and sensors	NextFlex —America's Flexible Hybrid Electronics Manufacturing Institute	DOD	San Jose, California	August 2015
Fiber materials and manufacturing processes	AFFOA — Advanced Functional Fabrics of America Institute	DOD	Cambridge, Massachusetts	April 2016
Smart manufacturing	CESMII — Clean Energy Smart Manufacturing Innovation Institute	DOE	Los Angeles, California	December 2016
Biofabrication and manufacturing	BioFabUSA — Advanced Regenerative Manufacturing Institute	DOD	Manchester, New Hampshire	February 2017
Robotic manufacturing	ARM — Advanced Robotics for Manufacturing Institute	DOD	Pittsburgh, Pennsylvania	January 2017
Biopharmaceutical manufacturing	NIIMBL — The National Institute for Innovation in Manufacturing Biopharmaceuticals	DOC	Newark, Delaware	March 2017
Modular chemical process intensification for clean manufacturing	RAPID — Rapid Advancement in Process Intensification Deployment Institute	DOE	New York, New York	March 2017
Sustainable manufacturing with clean energy and carbon emission reduction	REMADE — Reducing EMbodied-energy And Decreasing Emissions	DOE	Rochester, New York	May 2017

Mike Molnar is the founding director of the Office of Advanced Manufacturing (OAM) at the National Institute of Standards and Technology (NIST). In this capacity he is responsible for NIST extramural advanced manufacturing programs and liaison to industry and academia. Mike is also the founding director of the Advanced Manufacturing National Program Office (AMNPO), an interagency team with core staff hosted at NIST. This interagency team works to coordinate federal activities in advanced manufacturing, and is the Congressionally designated National Program Office for Manufacturing USA—the National Network for Manufacturing Innovation.

Mike joined NIST in 2011. Prior to federal service Mike had a 30-year industry career in advanced manufacturing, with leadership roles in manufacturing technology development, corporate manufacturing engineering, capital planning, metrology, quality systems, automation, computer integrated manufacturing, and industrial controls for manufacturing competitiveness. Mid-career Mike served as the manufacturing policy Fellow in the White House Office of Science and Technology Policy.

Mike is well known in industry and academia, with over thirty years of leadership roles in manufacturing professional societies and associations—most recently as the President of the Society of Manufacturing Engineers. He is a licensed Professional Engineer, Certified Manufacturing Engineer, and was elected Fellow of both the American Society of Mechanical Engineers and the Society of Manufacturing Engineers. Mike earned an Executive MBA from the University of Notre Dame, and a Bachelors in Mechanical Engineering and Masters in Manufacturing Systems Engineers from the University of Wisconsin.

Chairwoman STEVENS. Thank you. Dr. Hopkins.

TESTIMONY OF DR. JOHN HOPKINS,
CEO, INSTITUTE FOR ADVANCED COMPOSITES
MANUFACTURING INNOVATION

Dr. HOPKINS. Good morning, and thank you, Madam Chair, Chairman, Members of the Subcommittees. I'm John Hopkins, the Chief Executive Officer of the Institute for Advanced Composites Manufacturing Innovation, known as IACMI, the Composites Institute. IACMI is a public-private partnership comprised of more than 160 members from industry, academia, government agencies, and trade organizations. It leads innovation and workforce development initiatives to grow the adoption of advanced composites, strengthen U.S. manufacturing base, and support U.S. national security with the current focus on energy interests. As a Manufacturing USA Institute, IACMI is supported by the U.S. Department of Energy's Advance Manufacturing Office, as well as key State and industry partners, including the States of Indiana, Ohio, Colorado, Michigan, and Tennessee.

IACMI's technology impact is focused on the area of advanced composites, which combines strong fibers with tough polymers to provide strength and stiffness while being very lightweight, stronger than steel, lighter than aluminum, and corrosion-proof.

We have four primary goals under DOE: Reducing the cost of these materials, improving the recyclability, and providing a pathway for their greater adoption for energy efficiency and energy savings. IACMI and our partners have already achieved or are ahead of schedule for its technical goals. However, an even greater outcome is that the DOE-established goals have created a framework for IACMI to form a community for innovation. This community is addressing the energy-based challenges essential to our DOE program but is also targeting other key application areas in markets that support national security interests in not only energy but also in space defense and infrastructure.

IACMI provides a production-relevant environment for innovation through its founding partners, the University of Tennessee and Oak Ridge National Laboratory (ORNL), as well as through its other strategic university and national laboratory partners across the country. These local ecosystems leverage proximity for co-located place-based innovation while also connecting to the greater network innovation assets within IACMI. This builds on the successful model and Manufacturing Demonstration Facility at ORNL is used to support facility-based collaborations in support of advanced manufacturing.

Through that, we created a community of consortium members that span the composite supply chain and include specific emphasis on the engagement of small and medium enterprises. More than 50 percent of our 130 industry members are small and medium companies, and they are a critical part of the U.S. composites value chain.

IACMI R&D projects validate new technologies that can be adopted by the entire supply chain. These projects officially de-risk technology for critical decisionmaking within supply chain partners sets as necessary for large-scale adoption.

We have great examples of these SMEs (small and medium-sized enterprises) driving economic growth via collaboration. Just as an example, Techmer PM and Local Motors, two SMEs, have collaborated with several of our innovation partners to expand material options and manufacturing consistency for advanced composites. As a result, Techmer has expanded its catalog of new products and expects to double its sales of these products in 2019.

As innovation outcomes create and grow markets such as these, new workforce needs must also be met, and IACMI and its workforce partners have placed more than 100 interns in our internship program, trained more than 2,000 industry workers through composites training workshops and courses with our partners, and engaged more than 9,000 K through 12 students in science, technology, engineering, and math activities.

IACMI has created a nationally connected ecosystem for innovation that engages small and large companies, serves national security needs, supports innovation and technology validation at scales relevant for commercial adoption, and helps drive economic growth. IACMI's accomplishments directly support the goals and strategies outlined in the October 2018 report: Strategy for American Leadership in Advanced Manufacturing released by the White House. I see that Mike has brought a copy for our use.

And since IACMI's founding, the composites industry has announced more than $400 million in capital investments and 3,000 jobs in eight States. IACMI projects have led to more than 10 new products now commercially available. Through the institute's first 4 years, IACMI has worked with partners to make significant strides in not only reaching our DOE goals but also in establishing a foundation for manufacturing innovation and workforce development that can continue to serve into the future.

As an institute that's positioned to serve across key markets for both regional and national interests and is completing mission-specific objectives for DOE, IACMI will seek to create ongoing public-private co-investment opportunities and new forms of Federal and State participation that extend the value of DOE's initial investment of taxpayer dollars to grow a stronger, globally competitive, U.S. advanced composites industry.

Thank you for your time today, and I look forward to answering any questions.

[The prepared statement of Dr. Hopkins follows:]

Testimony of

John A. Hopkins

Chief Executive Officer
Institute for Advanced Composites Manufacturing Innovation
IACMI – The Composites Institute

Before the
United States House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Energy
Subcommittee on Research and Technology

"Revitalizing American Leadership in Advanced Manufacturing"

March 26, 2019

Introduction

Good morning Chairman, Madam Chair, and members of the subcommittees. It is my pleasure to speak with you on the impact that IACMI has made throughout its first four years of funding as a Department of Energy Manufacturing USA institute, as well as on the importance of leadership in manufacturing innovation to national interests. In addition to the testimony provided today, I would like to enter letters of support from the American Chemistry Council and Continental Structural Plastics and a recent IACMI outcomes report into the written record.

I am John Hopkins, the Chief Executive Officer of the Institute for Advanced Composites Manufacturing Innovation, known as IACMI – The Composites Institute. I have been with IACMI since its founding in 2015, and previously served in roles leading public-private partnerships for entrepreneurship, technology commercialization, and multi-institutional capacity building for innovation and workforce development. Throughout these experiences, I have witnessed the importance of public private partnerships in supporting regional ecosystems for innovation. In its four years since founding, IACMI has made significant progress creating local ecosystems of innovation and connecting them nationally to accelerate the path from idea to commercial adoption and economic growth. Thank you for the opportunity to testify today about IACMI, its early successes, and opportunities for future greater impact for both U.S. manufacturing and national security interests.

About IACMI and Advanced Composites

IACMI is a public-private partnership comprised of more than 160 members from industry, academia, government agencies, and trade organizations. It leads innovation and workforce development initiatives to grow the adoption of advanced composites, strengthen the U.S. manufacturing base and support U.S. national security, with a current focus on energy interests. As a Manufacturing USA institute, IACMI is supported by the U.S. Department of Energy's Advanced Manufacturing Office, as well as key state and industry partners including the states of Indiana, Ohio, Colorado, Michigan, and Tennessee. Collectively, these states have invested a comparable amount of taxpayer funds as the Department of Energy, and their support has been critical to effective implementation of The Composites Institute.

IACMI's technology impact is focused on the areas of advanced composites. Advanced composites combine strong fibers with tough polymers to provide strength and stiffness while being very lightweight: stronger than steel, lighter than aluminum, and corrosion proof. These characteristics provide advantages in many transportation, energy, and infrastructure applications. IACMI is working to make advanced composite materials more cost-competitive for large-scale adoption.

IACMI has three primary technical goals in support of the Department of Energy:

- reduce production costs of carbon fiber composites by over 25%
- demonstrate greater than 80% recyclability of polymer composites
- reduce embodied energy of carbon fiber composites by 50%

These goals address barriers to large-scale adoption for three key application areas that impact energy use and efficiency:

- lightweight vehicles with better safety, performance, and fuel economy or range
- high pressure compressed gas storage tanks to support greater use of more efficient alternative fuels such as natural gas and hydrogen
- lighter and longer wind turbine blades to increase power generation efficiency and capacity

IACMI and our partners have already achieved, or are ahead of schedule, for all of these technical goals. An even greater outcome is that the DOE-established goals created a framework for IACMI to form a community for innovation. This community is not only addressing the energy-based challenges central to our DOE program, but is also targeting other key application areas and markets that strengthen the U.S. manufacturing base, provide competitive advantages to our global peers, and support national security interests in not only energy, but also in space, defense, and infrastructure.

For example, IACMI is establishing a new paradigm for advanced composite price/performance through the validation of the first generation of textile carbon fiber developed at the U.S. Department of Energy's Carbon Fiber Technology Facility (CFTF) at Oak Ridge National Laboratory (ORNL). Substantial cost-savings can be realized using novel processing to reduce the embodied energy in manufacturing carbon fiber. This cost-saving innovation not only supports the path to adoption for vehicles and wind blades, but also opens new opportunities for infrastructure, defense, and non-traditional aerospace applications.

Additionally, the textile carbon fiber reduces the energy and carbon footprint for the production of these materials. When combined with the significant progress IACMI and partners such as ACMA are helping drive in advanced composite recyclability, it is possible to envision these materials providing an even greater global decarbonization impact by substituting lower cost, longer-lasting carbon fiber composites for steel and concrete in infrastructure.

I will speak to three areas in which IACMI is making significant impacts for the future of advanced composites: forming a consortium of members as a community, facilitating the formation of collaboration teams for innovation, and serving workforce needs.

IACMI Creates a community for innovation and validation

IACMI, through its founding partners the University of Tennessee and ORNL, and strategic university and national laboratory innovation partners across the country, provides production-relevant environments for innovation. Each innovation partner has fundamental composites R&D capacity while also providing a set of unique facilities and personnel capabilities specific to that location. These local ecosystems leverage proximity for co-located, place-based innovation, while also connecting to the greater network of innovation assets. This builds on the successful model the U.S. Department of Energy's Manufacturing Demonstration Facility (MDF) at ORNL has used to support facility-based collaborations and industry-informed innovation in support of advanced manufacturing.

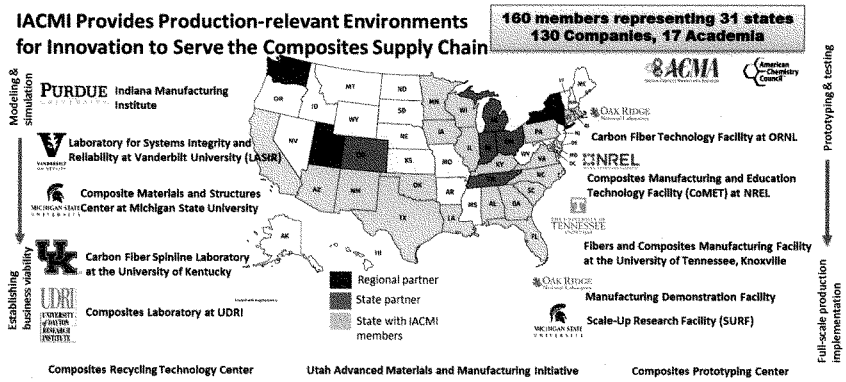


Figure 1: Illustration of IACMI membership and partner network

IACMI has created a community of consortium members that span the composites supply chain and includes specific emphasis on the engagement of small and medium enterprises (SMEs) and manufacturers. More than 50% of IACMI members are SMEs, and they are a critical part of the U.S. composites value chain. IACMI has a strong partnership with trade organizations including the American Chemistry Council (ACC) and the American Composites Manufacturers Association (ACMA). ACC represents the largest chemical companies in the United States. In addition, over 40% of ACC's approximately 200 member companies are SMEs. ACMA has more than 500 SME members, which are provided opportunities to engage with IACMI.

IACMI supports its membership through semi-annual Members Meetings and other workshops throughout the year. Some of the methods we have found effective in driving SME participation are:

- providing incentives for SMEs to participate in R&D projects
- delivering topical content directed to SME needs, including entrepreneurship, SBIR/STTR program overviews, and introduction to venture and other funding opportunities
- highlighting SME capabilities and interests to promote networking with both peers and large companies
- supporting state and regional coalitions such as the MEP network, the Utah Advanced Materials and Manufacturing Initiative, and the Tennessee Composites Coalition, to name just several. Many of these groups provide opportunities for SMEs to network with other companies and discuss common needs such as workforce development

These efforts have been successful in driving SME engagement. IACMI has more than 50 projects in its R&D portfolio, with more than 80 IACMI members participating on these projects.

IACMI Establishes supply chain-based collaborations for innovation

IACMI R&D projects validate new technologies that can then be adopted by the entire supply chain. IACMI's unique capability is to facilite collaboration among a variety of different members of the supply chain to solve a technology problem or foster new innovation. These projects sufficiently de-risk technology for critical decision-making necessary for large scale adoption. A supply chain-based approach for collaboration is an important part of the project teaming. Consortium members are encouraged to bring existing and potential supply chain partners into teaming so that innovation outcomes are achieved with participation of all the industry suppliers needed for rapid adoption and scale-up.

We have examples of project teams that include large companies such as Ford and Dow, which are driving some of our flagship projects. These projects have made great progress validating new low-cost, high-rate materials for automotive applications and wind turbine blades, and several new products are already for sale in their markets. We also have great examples of IACMI's membership community engaging SMEs to drive economic growth via collaboration.

One example is a project with two SMEs: Techmer PM and Local Motors. They collaborated with several partners, including ORNL, UT, Purdue University, and Vanderbilt University, to expand material options and consistency of printing processes for additive manufacturing (3D printing) of structural components. Project outcomes are supporting significant commercial growth for both companies. Techmer PM expanded its catalogue of additive manufacturing products, expects to double sales in 2019, and customer demand is driving the installation of a new multi-million dollar manufacturing line. Local Motors has installed the world's largest 3D printer, made by Thermwood (IN), at its Knoxville, TN microfactory and is planning to start production of its first autonomous people mover Olli beginning in July 2019. Beyond this project, Techmer PM is further benefiting from IACMI membership via launch of additional commercial projects with other industries, such as marine, aerospace, construction, and infrastructure. The use of these materials for tooling applications also provides a means to regain competitiveness in what once was a global strength for the U.S. manufacturing base.

These are examples of how IACMI is supporting supply chain based innovation teams, including SMEs, to drive the adoption of advanced composites technologies.

IACMI Serves industry's workforce needs

As innovation outcomes create and grow markets, new workforce needs must be met. IACMI is working with partners to systematically connect innovation and workforce assets across industries positioned for significant growth. IACMI and its workforce partners have:

- placed more than 100 interns through the IACMI Internship Program
- trained more than 2,000 industry workers through composites training workshops and courses, many of which are aimed at technician and apprentice levels
- engaged more than 9,000 K – 12 students in STEM activities.

Most of these programs directly leverage innovation partner facilities while connecting to IACMI industry consortium members. For example, immersive training events, such as the Closed Mold Alliance Workshops, offer opportunities for hands-on training utilizing technologies at IACMI partner facilities throughout the U.S. This not only provides impactful training, but also creates greater awareness and familiarity of capabilities across the consortium that can be leveraged for future innovation and workforce development collaborations.

An impact example in workforce development comes through the IACMI Internship Program. IACMI interns have a one hundred percent placement record for either a job offer or acceptance into a graduate program. The IACMI Internship Program provides hands-on learning experiences in national laboratories, academic labs, and industry facilities. Additionally, the interns gain networking and professional development skills through participation in poster presentations and professional development workshops. One former intern with an SME IACMI member, Vartega (CO), was hired full-time upon graduation and said the following about her experience: "IACMI and Vartega opened so many doors for me, allowing me to become a project leader, attend industry events, offer client-facing solutions, and present my work. I'm confident in my impact on the composites industry in a global capacity." The IACMI Internship Program provides depth and breadth of experiences that not only addresses current workforce development needs but is growing composites leadership for the future.

Closing and Path Forward

IACMI has created a nationally connected ecosystem for innovation that serves national security needs, supports innovation and technology validation at scales relevant for commercial adoption, and helps to drive national economic growth. IACMI's structure and accomplishments directly support the goals and strategies outlined in the October 2018 National Science & Technology report *Strategy for American Leadership in Advanced Manufacturing* released by the White House.

Since IACMI's founding, the composites industry has announced more than $400M in capital investments and 3,000 jobs in eight states. IACMI projects have led to more than 10 new products now commercially available. Through the Institute's first four years, IACMI has worked with partners to make significant strides in not only reaching our DOE goals, but also in establishing a foundation for manufacturing innovation that can continue to serve into the future.

The Department of Energy's investments in IACMI have already paid significant dividends in the Institute's areas of focus. As we look forward to the future, the physical capacity and network of thought-leaders we have developed can continue to serve the needs of Congress and the Administration in new areas, including strengthening our national defense and revitalizing the American infrastructure network.

As part of our DOE program, we have developed a sustainability plan that assumes future base operational funding will be provided by our industry consortium members. This sustainability plan provides a path for the Institute to continue operations and continue to convene and serve the consortium. However, the plan does not provide a ready means for maintaining and refreshing equipment and facilities, which creates challenges for maintaining competitive levels of capacity and expertise. As an institute that is positioned to serve across key markets for both regional and

national interests, we will seek to create ongoing public-private coinvestment opportunities by leveraging the strength of our industry consortium and innovation partners. Thus, as IACMI completes its mission-specific objectives for DOE, we will seek new forms of federal and state participation that extend the value of DOE's initial investment of taxpayer dollars to grow a stronger, globally competitive American advanced composites industry.

Thank you, again, for your time today and for allowing me the opportunity to testify. I will be happy to answer any of your questions.

American Chemistry Council

March 26, 2019

The House Committee on Science, Space and Technology
Subcommittees on Research and Technology/Subcommittee on Energy

Re: March 26, 2019 Hearing: *Revitalizing American Leadership in Advanced Manufacturing*

Dear Committee Members,

The American Chemistry Council (ACC), Plastics Division, is pleased to provide the following comments regarding the Institute for Advanced Composites Manufacturing Innovation (IACMI) and Revitalizing American Leadership in Advanced Manufacturing.

I. BACKGROUND

ACC is a national trade association representing the leading companies that sell and manufacture chemistry and polymers in the United States. American chemistry is an innovative $526 billion enterprise, providing 529,000 skilled american jobs. The business of chemistry plays a critical role in delivering a sustainable future through resource and fuel efficiency, material innovation, and continuous improvement in our products and operations. Every day, polymer composites help deliver cleaner air and water, safer living conditions, efficient and affordable energy sources, lifesaving medical treatments and innovative lightweight vehicle solutions. More than 96% of all manufactured goods are directly touched by the business of chemistry, including the automotive industry. Virtually every component of a lightweight vehicle, from the front bumper to the rear tail-lights, is made possible through chemistry.

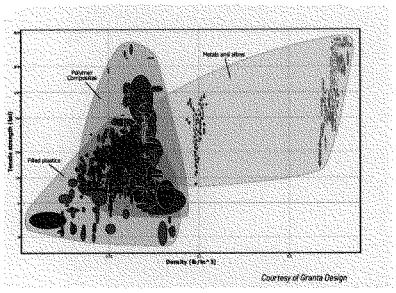
Automotive composites provide countless innovative lightweight solutions, including reconfigurable flexible interiors for autonomous vehicles, antimicrobial self-cleaning surfaces for fleet and ride share vehicles, interior and exterior lighting and important safety features such as back-up cameras and air-bags. Lightweight polymer composite auto parts comprise over 50 percent of a vehicle's material volume, but less than 10 percent of its weight.

Polymer composites are a combination of tough plastic resins that are reinforced with glass, carbon fibers and other materials. These materials often weigh far less than traditional automobile materials, yet maintain high levels of strength and a high resistance to corrosion. These materials provide an economical way to innovate and lightweight vehicles while preserving important safety features and consumer preference through improved design flexibility. Additional properties, including strength to weight ratio and excellent energy absorption, make these materials especially well-suited for the design and manufacture of light-duty vehicles.

The chart labeled "Figure 1" below provides data regarding the tensile strength and density of filled plastics, polymer composites, metals, and alloys. As shown in the chart, there are many polymer composites that are significantly less dense than most metals and alloys while offering

similar tensile strengths. This data illustrates a fundamental physical advantage that many polymers can offer over metallic automotive materials: higher strength-to-weight ratios enable automakers to lightweight while maintaining performance and innovative designs that consumers demand.[1]

Figure 1 Tensile strength versus density for filled plastics, polymer composites, and metals and metal alloys



II. THE ROLE OF IACMI IN U.S. LIGHT-DUTY VEHICLE MANUFACTURING

As a member of IACMI, ACC applauds the Committee for its efforts to maintain American leadership in advanced manufacturing and their recognition of the numerous investments made by U.S. companies in IACMI. Supporting advanced manufacturing has, and will, continue to spur innovation, growth and competition in the U.S., including within the automotive industry to meet consumer demands for innovative, stylish and safe vehicles. ACC supports these efforts and the Committee's recognition of America's leadership role in advanced polymer composite technologies. Among other numerous benefits, automotive composites play an important role in improved safety, improved design, mass reduction, aerodynamic improvement, electrification and autonomous deployment and optimized component integration.[2] Utilizing composites within the U.S. automotive industry follows well-documented trends of polymer usage to economically reduce mass, increase efficiency and realize innovative new technologies in the civilian and military aerospace industries. Choosing polymer composites to reduce mass in light-duty vehicles is a decision supported by science that can pay immediate and long term economic and environmental dividends.[3]

IACMI plays a critical role in ensuring the U.S. maintains leadership in advanced composite manufacturing. IACMI is making significant impacts for the future of advanced composites, including creating a network of members, fostering collaborative teams for innovation, and serving workforce needs across the nation. IACMI's primary goals and successes to date are helping remove significant technology barriers for advanced manufacturing of polymer composites.

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[1] American Chemistry Council, "Plastics and Polymer Composites for Automotive Markets Technology Roadmap", pp. 10-12, 36-40 and 58, (March 2014), *available at*: https://plastics-car.com/Tomorrows-Automobiles/Plastics-and-Polymer-Composites-Technology-Roadmap/Plastics-and-Polymer-Composites-Technology-Roadmap-for-Automotive-Markets-Full-Report.pdf.

[2] EPA, NHTSA and CARB, "Draft Technical Assessment Report: Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025, Appendix", pp. B-46-B-76 (July 2016), *available at* https://nepis.epa.gov/EPA/html/DLwait.htm?url=/Exe/ZyPDF.cgi/P100OYCH.PDF?Dockey=P100OYCH.PDF.

[3] Trucost, "Plastics and Sustainability: A Valuation of Environmental Benefits, Costs and Opportunities for Continuous Improvement" (July 2016), available at https://plastics-car.com/Resources/Resource-Library/A-Valuation-of-Environmental-Benefits-Costs-and-Opportunities.pdf.

III. U.S. ECONOMIC IMPACT OF AUTOMOTIVE POLYMER COMPOSITES

Developing technology to lightweight vehicles spurs advanced innovations and creates high-skilled manufacturing jobs in the United States. The $426 billion North American light vehicle industry represents an important sector of economy for the United States and is a large end-use customer market for chemistry. In 2017, the 16.88 million light vehicles assembled in North America required some 5.8 billion pounds of plastics and polymer composites valued at $7.0 billion, or $416 in every vehicle. These automotive plastic and polymer composite products are produced at 1,622 plants located in 45 states. These plants directly employ about 63,080 people and feature a payroll of $3.2 billion. Michigan is the leading state in terms of direct employment (more than 15,275) and is followed by Ohio (about 8,900), Indiana (8,280), Tennessee (nearly 4,120), Minnesota (nearly 3,155), Pennsylvania (more than 2,865), Wisconsin (2,320), Illinois (more than 2,160), North Carolina (nearly 1,720), and New York (nearly 1,515).[4]

Producers of automotive polymer composites typically purchase resins, additives, other materials, components and services from other parts of the economy. As a result, the contributions of polymers go well beyond their direct economic footprint. The automotive composites industry fosters economic activity indirectly through supply-chain purchases and through the payrolls paid both by the industry itself and its suppliers. This, in turn, leads to induced economic output as well. As a result, it is estimated that every job in the automotive polymer industry generates an additional job elsewhere in the United States' economy, totaling more than 119,000 jobs.[5] Innovation investments made by U.S. companies, as well as U.S. high-skilled manufacturing jobs, and indirect jobs, will be directly impacted if the U.S. is unable to maintain a leadership role in advanced manufacturing for automotive composites.

IV. CONCLUSION

We thank you for the opportunity to comment with regard to IACMI and its important role in maintaining American leadership in advanced manufacturing. We look forward to strengthening our partnership with IACMI, and other IACMI members, as we continue developing lightweight vehicle innovations that enable autonomous and electric vehicles, enhance fuel economy, improve safety and vehicle performance through the use of polymer composites.

Sincerely,

Gina Oliver

Sr. Director, Automotive Market Team
American Chemistry Council, Plastics Division
Gina-Marie_Oliver@americanchemistry.com
248-244-8920

[4] Economic and Statistics Department, American Chemistry Council, "Plastics and Polymer Composites in Light Vehicles", page 1, (July 2018), available at: https://plastics-car.com/Resources/Resource-Library/Plastics-and-Polymer-Composites-in-Light-Vehicles-Report.pdf
[5] *Id.*

March 20, 2019

To whom it may concern:

I am writing this letter in support of IACMI – The Composites Institute®, as I firmly believe it provides value to my organization and to the composites industry as a whole.

Continental Structural Plastics (CSP) originally joined as members of the Carbon Fiber Consortium based at Oak Ridge National Laboratory (ORNL). At the time, we were hedging that it was the best way to stay at the forefront of carbon fiber composites development. For us, I admit, it was largely a networking organization. Although we participated in a few minor projects and created some lasting collaborative relationships, that organization did not provide sustainable value.

When the CF Consortium was absorbed by the creation of IACMI, my initial expectations were that the new organization would provide opportunities comparable to the previous consortium experiences. In the past few years, the activity and productive work has increased exponentially. The creation of exceptional facilities in Corktown (Detroit, Michigan) and at Purdue University (West Lafayette, Indiana) and the resulting collaborations are extremely exciting. I feel that a lot of good work has been started and the vision is taking shape. I foresee continued growth and significant advancements for the composites industry through the resources and partnerships afforded by the IACMI network.

In addition, CSP has recently begun to participate in the IACMI Intern program. We have always found great value in employing interns in our laboratory and have had good success developing future employees. It is difficult finding students with specific interest and training in composites at regional universities. The IACMI program provides a direct connection to top students with a specific passion for our growing industry. We are excited to currently have our first IACMI student intern (who is working out very well), and intend to continue our involvement in the program moving forward.

I would be happy to discuss my experiences with IACMI in more detail if necessary. My contact information is detailed below.

Best regards,

Michael J. Siwajek, Ph.D.
Vice President, Research and Development
Continental Structural Plastics

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IACMI – The Composites Institute®

Institute Outcomes

March 2019

IACMI – The Composites Institute is a 160+ member community of industry, academia, and government agencies leading innovation and workforce development initiatives to drive the adoption of advanced composites to grow U.S. manufacturing and support national security. IACMI, a Manufacturing USA institute, is supported by the U.S. Department of Energy's Advanced Manufacturing Office, as well as key state and industry partners.

Advanced composites provide strength and stiffness while being very lightweight. These characteristics provide advantages in many transportation, energy, and infrastructure applications. Greater deployment of advanced composites can offer benefits, such as providing safer, more energy-efficient vehicles. IACMI is working to drive the large-scale adoption of advanced composites in diverse markets.

Connecting innovation and workforce development

IACMI is uniquely and systematically connecting innovation and workforce assets across multi-billion dollar industries positioned for significant future domestic and international growth. IACMI will make the U.S. a leader in the manufacture of these strategic materials and accelerate the growth of their markets.

Creating a collaborative ecosystem

IACMI is creating a community throughout the composites supply chain, including support for small and medium enterprises (SMEs). More than 50% of IACMI members are SMEs, leveraging their unique specializations to collaborate with one another, larger organizations, and technical experts.

Building supply chain-based frameworks for decision making

IACMI provides production-relevant environments for innovation, establishes supply-based frameworks for decision making, and trains the workforce in support of the needs of the composites industry.

Driving economic growth

Through IACMI projects, member companies have developed new, commercially available products. These products have helped lead to job creation, facility expansion, and economic growth for the companies, as well as their manufacturing partners. IACMI has created an ecosystem of innovation that meets commercial needs, serves national security, and drives national economic growth.

iacmi.org

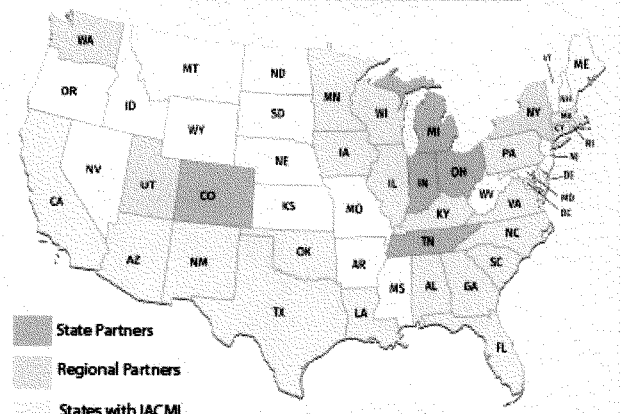
The IACMI consortium consists of more than 160 members and is a proven collaboration framework for catalyzing innovation and workforce development outcomes. IACMI projects are addressing national interests in energy and manufacturing competitiveness, training the next generation workforce, creating new commercial products and markets, and driving economic growth.

50+ IACMI technical projects

90 IACMI members participating on technical projects

$70M+ IACMI's R&D value to date

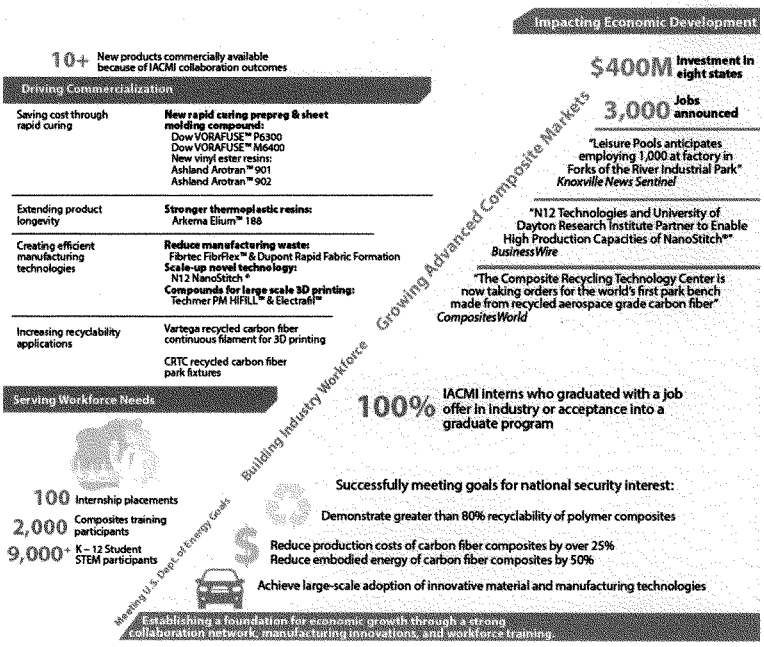
Creating an Innovation Network



160+ IACMI Members

- 130 industry members
- 53% of companies are SMEs

IACMI – The Composites Institute creates an ecosystem of innovation to drive commercial outcomes that lead to economic growth.



Overall Institute

10+ New products commercially available because of IACMI collaboration

$400M Investment in eight states

3,000 Jobs announced

Case Study

Techmer PM and Local Motors IACMI technical project example

"Our participation in IACMI allowed us to develop new technologies that have contributed to Techmer PM's growth in the additive manufacturing ecosystem."

Tom Drye, Vice President of Emerging Markets & Innovation and Application Development, **Techmer PM**

Challenge

Improve the material options and printing processes for additive manufacturing (3D printing) that enables Local Motors to commerically produce its 3D printed vehicles

Objectives

- Increase the variety of materials available for additive manufacturing
- Better understand 3D printed materials' properties to make reliable manufacturing decisions

Impact

Significant commercial growth for multiple companies involved in the project

Techmer PM

- Techmer PM has had significant sales of new 3D products and expects to double sales in 2019
- Techmer PM is helping lead the growth and acceptance of large part additive manufacturing through materials designed specifically for optimum performance and reliability in additive manufacturing
- Customer demand is driving installation of a new multi-million dollar manufacturing line to meet the increased 3D materials need of Techmer's customers

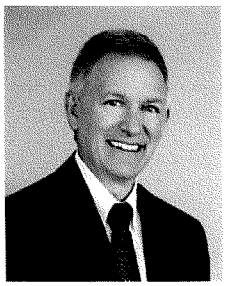
Local Motors

- Local Motors installed the world's largest 3D printer, made by Thermwood, at its Knoxville, TN microfactory
- Local Motors to commercially produce Olli 2.0 at Knoxville, TN microfactory beginning in July 2019

IACMI – The Composites Institute
www.iacmi.org
2360 Cherahala Blvd.
Knoxville, TN 27932

University, State, Regional, National Laboratory, & Association Partners

The Institute for Advanced Composites Manufacturing Innovation (IACMI), managed by the Collaborative Composite Solutions Corporation (CCS). CCS is a not-for-profit organization established by the University of Tennessee Research Foundation. As a Manufacturing USA institute, IACMI is supported the U.S. Department of Energy's Advanced Manufacturing Office in the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE).



John A. Hopkins is the Chief Executive Officer of The Institute for Advanced Composites Manufacturing Innovation, IACMI – The Composites Institute. A former senior leader for IACMI and the University of Tennessee (UT), Dr. Hopkins is credited with establishing IACMI's national technical advisory board and research and development project process.

As CEO, Dr. Hopkins leads the U.S. Department of Energy supported Manufacturing USA composites institute. This public-private partnership leads domestic production research and development knowledge, and catalyzes economic development across the U.S. advanced composites industry. The institute is supported by a $70 million commitment from the U.S. Department of Energy's Advanced Manufacturing Office, and over $180 million from other public and private partners.

Prior to his role with IACMI, Hopkins served as Director of Strategic Operations in the UT Office of the Executive Vice President. In this role, he led several statewide initiatives, including a National Science Foundation (NSF) program, TN-SCORE, consisting of more than 30 academic and industry partners focused on solar energy and energy storage research, as well as related K-12 outreach. In support of TN-SCORE and related NSF EPSCoR programs across the country, he chaired both a national conference and workshop series for innovation and entrepreneurship.

Dr. Hopkins served in several leadership roles at the UT Research Foundation, including Director of Technology Transfer, and led the organization through several restructurings to build capacity and improve processes in service of a growing the UT research enterprise. As faculty member at the University of Tennessee Space Institute, he managed funded research projects in laser materials processing sponsored by numerous industry partners and the U.S. Departments of Energy and Defense. Dr. Hopkins is a licensed engineer in Tennessee, author of 50 technical papers, and named inventor on 11 U.S. patents, which resulted in two start-up companies.

Dr. Hopkins earned his Ph.D. from the University of Tennessee, Knoxville while supporting flight experiments on the First International Microgravity Laboratory as a NASA pre-doctoral fellow. He has an MBA from Vanderbilt University's Owen Graduate School of Management.

Chairwoman STEVENS. Ms. Lightner?

TESTIMONY OF VALRI LIGHTNER, ACTING DIRECTOR OF THE ADVANCED MANUFACTURING OFFICE, OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Ms. LIGHTNER. Chairwoman Stevens, Chairman Lamb, Ranking Members Weber and Baird, and Subcommittees on Energy and Research and Technology, good morning, and thank you for the opportunity to testify today. My name is Valri Lightner, and I'm the Acting Director of the Department of Energy's Advanced Manufacturing Office within the Office of Energy Efficiency and Renewable Energy.

As you've heard, manufacturing is critical to the U.S. economy. The sector generates roughly 12 percent of the gross domestic product and employs more than 12 million Americans. It also consumes one-third of the country's energy and has an energy bill of $150 billion per year. Today, natural gas is used more than any other fuel source in the manufacturing sector, helping to make it the least carbon-intense end use sector according to the Energy Information Administration.

The Department's Advanced Manufacturing Office funds and manages research and development activities to improve energy efficiency across the manufacturing sector and reduce the energy impact of manufactured goods. Greater energy efficiency saves industry money and improves their economic competitiveness, while also reducing emissions. The Department's investments in industrial energy efficiency have contributed to a reduction in energy intensity in the industrial sector by over 30 percent since 1970.

Working with stakeholders, my office has identified 14 technology areas with high-energy impact potential in the United States' industry, including materials for harsh environments and process heating. Our balanced portfolio includes early-stage research projects, consortia, and technical partnerships. The focus of today's hearing is our Clean Energy Manufacturing Innovation Institutes executed as consortia under the authority from the *Energy Policy Act of 2005*.

My office manages five institutes, which are formally recognized as part of the Manufacturing USA network. These institutes are large-scale public-private partnerships catalyzed by Federal investment of $70 million over 5 years. Through collaborative multidisciplinary teams from industry, academia, and national labs, the institutes create innovation ecosystems that accelerate technology development. In addition to research and development activities, institutes provide shared research facilities that are particularly valuable to small and medium-sized businesses that can't afford facilities of their own.

Institutes also have a workforce development component to increase the country's preparedness for the manufacturing jobs of the future, including retraining the current workforce and training the next generation of workers.

Our institutes cover a wide range of technology areas. Our first institute, PowerAmerica in Raleigh, North Carolina, focuses on reducing the cost of wide bandgap semiconductors for use in power electronics devices.

The Institute for Advanced Composite Manufacturing Innovation located in Knoxville, Tennessee, works to drive down the cost and energy consumption of carbon fiber composite manufacturing for use in lightweight vehicle components, compressed gas storage tanks, and wind turbine blades.

The Clean Energy Smart Manufacturing Innovation Institute located in Los Angeles, California, is focused on smart manufacturing. That is using sensors, controls, data, and modeling with an opportunity to improve energy efficiency by 15 percent.

The Rapid Advancement and Process Intensification Deployment Institute located in New York City is driving the next generation of chemical manufacturing technologies with potential for orders-of-magnitude reduction in energy.

The Reducing Embodied Energy and Decreasing Admissions Institute headquartered in Rochester, New York, focuses on recycling and increasing the use of secondary materials with a focus on metals, electronics, polymers, and fibers.

Overall, the Department's institutes have leveraged $350 million in non-Federal support, partnered with 106 large manufacturers and 168 small and medium businesses and leveraged support from 11 States. Just this morning the Department issued a funding opportunity for a sixth institute on cybersecurity and energy efficient manufacturing.

With that, I'd like to thank the Committee, and I appreciate the opportunity to discuss the Department's manufacturing institutes.

[The prepared statement of Ms. Lightner follows:]

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Testimony of

Valri Lightner

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

Before the

House Space, Science, and Technology Subcommittees on Energy and Research and Technology
United States House of Representatives

March 26, 2019

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.

Ms. Valri Lightner
Director (Acting), Advanced Manufacturing Office
Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

Valri Lightner has been a technology development manager for the federal government for 35 years. Valri's team manages research, development and adoption of energy-related advanced manufacturing technologies and practices to drive U.S. economic competitiveness and energy productivity. The program is executed through collaborations of industry, academia, and government. Valri previously worked in the Loan Programs Office where her team provided the technical management of a portfolio including vehicle manufacturing and innovative energy projects. Valri also led public-private research and development partnerships in cellulosic biofuels, fuel cells for transportation, and pulp and paper energy efficiency.

Valri has a bachelor's degree in chemical engineering from Villanova University.

Chairwoman STEVENS. Thank you. Dr. Dibbs?

TESTIMONY OF DR. MITCHELL DIBBS,
ASSOCIATE R&D DIRECTOR,
EXTERNAL TECHNOLOGY-GOVERNMENT PROGRAMS,
THE DOW CHEMICAL COMPANY

Dr. DIBBS. Chairwoman Stevens, Chairman Lamb, Ranking Members Baird and Weber, and the Members of the Subcommittees, it is my privilege to address you on the topic of revitalizing American leadership in advanced manufacturing. My name is Mitchell Dibbs, and I am the Associate R&D Director of External Technology for the Dow Chemical Company. My organization oversees all of Dow's research collaborations with government agencies, government laboratories, universities, and independent laboratories around the world.

In 2018, Dow invested over $1.5 billion on research and development. The majority was expended on internal programs. However, Dow also supports a broad portfolio of external collaborations. Dow works with governmental institutions and agencies worldwide to advance the role of chemistry in solving the world's greatest challenges.

Dow has strongly supported the subject of today's hearing. Dow co-chaired the Advanced Manufacturing Partnership (AMP) effort in 2012 and 2014. I was personally involved with the AMP 2.0 team and helped develop the recommendations for structuring the manufacturing innovation institutes that are the foundation of Manufacturing USA. Dow strongly believes that a reinvigorated U.S. manufacturing sector has the potential to positively address many of the challenges facing this country, including maintaining technology leadership, promoting global competitiveness, and providing critical STEM (science, technology, engineering, and mathematics) workforce skills to sustain and grow an advanced technology economy.

Dow has experience with the Manufacturing USA Institutes having joined 3 of the 14 directly and one indirectly, as well as exploring several others. Dow is a member of the Digital Manufacturing and Design Innovation Institute that was recently rebranded as MxD, and the Rapid Advancement and Process Intensification Deployment Institute, RAPID. We have taken leadership roles in these two institutes and are active in multiple projects.

Dow is also an active member of the Institute for Advanced Composites Manufacturing Innovation, IACMI. Examples of projects, for instance, at IACMI, the next generation of high energy efficient automobiles must be lighter without sacrificing safety and reliability. The invention of unique chemistry and development of novel carbon fiber intermediates and ultrafast production methods led to the achievement of automotive OEM specifications.

At MxD, application of the integrated real-time optimization technology brought together large and small manufacturers, a process control supplier, and top academic computer specialists to develop a modeling framework that can simultaneously account for factors both in production scheduling and unit operation level and reduce the impact of disturbances both proactively and reactively.

Also at MxD, Dow, in collaboration with a small commercial drone company, developed a small tethered drone intended for use in inspecting confined areas either indoors or within industrial infrastructure, including tanks, conduits, and pipes. This will significantly reduce the safety risk of inspections by eliminating the need for confined-space entries.

Dow also works with the Federal and national laboratories under cooperative research and development agreements providing access to unique facilities and top-notch researchers to work side-by-side with Dow researchers to solve complex technical problems. For instance, working together with Dow and LBNL (Lawrence Berkeley National Lab) have made progress toward development of catalyst imaging techniques, and understanding the variation of catalyst sites in correlation with polymer properties enables researchers to better design the next generation of catalysts.

While the institutes provide a number of important benefits, Dow has observed several areas where improvement could enhance the institutes' goals. The institutes have shown a tendency to be slow to launch and slow to implement projects. This could be minimized through better communications and with well-written membership and project agreements. Each institute has put together its own membership agreement and project process. The institutes could benefit from shared practices and standardization of the agreement process. Such support was recommended in the AMP 2.0 report but not implemented.

Most of the institutes operate under cooperative agreements, which generally do not provide enough flexibility to develop a framework for the institutes that would allow the institutes to quickly implement approved projects. One way to improve this issue is for agreements using other transaction authority negotiated with appropriate terms and conditions. This approach is been utilized for MxD, which is reaching the end of its agreement with the Department of Defense. MxD secured follow-on funding and negotiated a technical investment agreement using OTA (other transaction authority).

Thank you, and I welcome your questions.

[The prepared statement of Dr. Dibbs follows:]

Testimony of Dr. Mitchell G. Dibbs
Associate R&D Director, External Technology - Government Programs
The Dow Chemical Company
Before the Joint Subcommittees on Energy and Research & Technology
Committee on Science, Space and Technology
U.S. House of Representatives
Revitalizing American Leadership in Advanced Manufacturing
March 26, 2019

Introduction

Chairwoman Stevens and Chairman Lamb, Ranking Members Baird and Weber, and the members of the Subcommittees, it is my privilege to address you on the topic of 'Revitalizing American Leadership in Advanced Manufacturing.' My name is Mitchell Dibbs and I am the Associate R&D Director of External Technology for The Dow Chemical Company (Dow). My organization oversees all of Dow's research collaboration with government agencies, government laboratories, universities and independent laboratories around the world. I am responsible for Dow's government research collaborations globally. I have 36 years of experience with Dow in research, product development & commercialization with considerable experience in external research collaborations both as a researcher and as a collaborations director.

Dow combines science and technology knowledge to develop premier materials science solutions that are essential to human progress. Dow has one of the strongest and broadest toolkits in the industry, with robust technology, asset integration, scale and competitive capabilities that enable it to address complex global issues. Dow's market-driven, industry-leading portfolio of advanced materials, industrial intermediates, and plastics businesses deliver a broad range of differentiated technology-based products and solutions for customers in high-growth markets such as packaging, infrastructure, and consumer care. Dow is a subsidiary of DowDuPont, Inc. but on April 1st will separate/emerge from DowDuPont, Inc. as an independent publicly traded material sciences company.

In 2018 Dow invested over $1.5 Billion on research and development. The majority was expended on internal programs; however, Dow also supports a broad portfolio of external R&D collaborations. Dow works with governmental institutions and agencies worldwide to advance the role of chemistry in solving the world's greatest challenges. Collaborations and research partnerships enable Dow to share information and insight into key scientific applications and combine strengths in pursuit of breakthrough solutions. Dow also supports the development of responsible, science-based laws, regulations, standards, practices and procedures that safeguard the community, workplace and environment. Another area of manufacturing innovation is sustainable

chemistry. Markets and regulations call for the development and use of chemicals with improved health and environmental profiles in all sorts of products, and along with our suppliers and customers, Dow is stepping up to this opportunity.

Dow's Partnership with the Advanced Manufacturing Institutes

Dow believes that manufacturing is the lifeblood of U.S. economic growth and has strongly supported the subject of today's hearing. Dow co-chaired the Advanced Manufacturing Partnership and the Advanced Manufacturing Partnership 2.0 that led to the 2012 report, *"Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing"* and the 2014 report, *"Report to the President on Accelerating U.S. Advanced Manufacturing"*. I was personally involved with the AMP 2.0 team and helped develop the recommendations for structuring the Manufacturing Innovation Institutes that are the foundation of Manufacturing USA. Dow strongly believes that a reinvigorated US manufacturing sector has the potential to positively address many of the challenges facing this country including maintaining technology leadership, promoting global competitiveness, and providing critical STEM workforce skills to sustain and grow an advanced technology economy.

Dow has had considerable experience with the Manufacturing USA Institutes having joined three of the fourteen directly and one indirectly as well as exploring several others. Dow is a member of the Digital Manufacturing & Design Innovation Institute (recently rebranded as MxD) and the Rapid Advancement in Process Intensification Deployment Institute (RAPID). We have taken leadership roles in these two institutes and are active in multiple projects. Dow is also an active member of the Institute for Advanced Composites Manufacturing Innovation (IACMI).

Examples of Dow's Institute collaborations include:

IACMI: Composite Products and Processes for high volume Automotive Parts

The next generation of high energy efficient automobiles must be lighter without sacrificing safety and reliability. A unique team consisting of a manufacturing OEM, suppliers, DOE national lab, and academic institutions are working together to develop the materials and processes for lightweight, low-cost, carbon fiber composite automotive components. The invention of unique chemistry and development of novel carbon fiber intermediates and ultrafast production methods led to achievement of OEM specifications and demonstrated viability for large-scale adoption by the OEM in its product lines. This collaboration enables Dow to work directly with customers, suppliers and top tier academic and lab researchers to solve the multitude of complex issues and bring these innovations to reality.

MxD: Scheduling and Control for Real-Time Optimization of Factory Operations

Application of the integrated real time optimization technology can greatly improve the efficiency of manufacturers by bringing automated and optimized decision-making to the shop floor. This project brought together large and small manufacturers, a process control supplier, and top academic computer specialists to develop a modelling framework that can simultaneously account for factors both in production scheduling and unit operation levels and reduce the impact of disturbances, both proactively and reactively. The technology also frees operators from repetitive tasks such as adjusting processing speed, minimizing the need of human interventions to the manufacturing process, and improving productivity.

MxD: Small Drone for Inspection in Confined Spaces

Dow, in collaboration with a small commercial drone company, developed a small, tethered drone, intended for use inspecting confined areas either indoors, or within industrial infrastructure, including tanks, conduits, and pipes. This will significantly reduce the safety risk of inspections by eliminating the need for confined space entries. The drone is an evolution of an existing technology, with the small size, and agility needed to carry a camera or sensor payload into difficult to reach or hazardous areas.

Dow also works closely with federal and national laboratories under Cooperative Research and Development Agreements (CRADAs) providing access to unique facilities and top notch researchers to work side by side with Dow researchers to solve complex technical problems. These labs include Lawrence Berkeley National Lab, Oak Ridge National Lab, National Institute of Standards & Technology, Sandia National Lab, National Renewable Energy Lab, Argonne National Lab, Brookhaven National Lab, Environmental Protection Agency National Risk Management Research Laboratory, Federal Aviation Administration William J. Hughes Technical Center, and Department of the Interior Bureau of Reclamation to name a few of the more recent collaborators.

Lawrence Berkeley National Lab: Electron Microscopy for Imaging of Catalysts

By working together Dow and LBNL have made significant progress toward the development of catalyst imaging techniques. The ability to image the structure of atomic surfaces allows for the studying of catalysts in a previously unexplored manner. This research direction had not been previously pursued because of the air and radiation sensitivity of the catalyst support. An understanding of the variations of catalyst sites and correlation with polymer properties enable researchers to a better design the next generation of catalysts allowing US industry to strengthen its leading edge position. The implications of this work to the broader electron microscopy community should not be over-looked.

Attached at the end of this written testimony is a list of Dow's external collaborations from 2015 to 2019, intended to demonstrate the breadth of Dow's collaborations. It is important to note this list is not fully inclusive of all of Dow's external collaborations

with government entities. Fourteen collaborations out of the 36 are with Manufacturing USA Institutes.

The Manufacturing Institutes and federal labs provide a number of unique benefits to the country as a whole through both workforce and technology development. Primary among these benefits is the unique research environment that Institutes and federal labs provide. The labs have a number of facilities and capabilities that are unique in the world. In many cases the costs of the facility investments are justifiable only on a national scale; industry alone could not support these types of facilities. Federal labs and universities are intellectual powerhouses, led by researchers, professors and students who think outside the box, are not encumbered by traditional approaches, and are filled with energy and enthusiasm to drive innovative solutions.

The Institute's Role in Commercialization New Technology

The commercialization of new technology can be impeded by many factors including: the cost and scale of the research, lack of critical expertise, lack of needed infrastructure, and high perceived technical and/or business risk. Since the Institutes along with universities and federal labs are not in the business of product commercialization, these environments are ideal for bringing together manufacturers, suppliers, and customers of all sizes in precompetitive ways. Convening these groups and facilitating discussion which otherwise would not occur is a great way to uncover new concepts, and develop new product idea and innovations.

Government involvement can play a vital role in helping to alleviate the barriers to commercialization. The benefits of such arrangements are shared by government, partners, and society as a whole – as well as the companies. There are many reasons why government support for innovation is of value:

- Funding for a research program that is of interest to society.
- Providing the framework for pre-competitive consortia or collaborations for projects that are beyond the scope of a single company.
- Providing a mechanism to develop working relationships with sources of innovation such as universities and Government Labs.
- Encouraging partnerships with customers and suppliers.
- Making possible projects where a company does not have all the required skills or technology.
- Allowing a company to explore areas beyond its core expertise.
- Providing early contact with future product specifiers/buyers.
- Outside confirmation of the value of a company's research direction.
- Objective analysis of a company's research plans.

However, the government support for research brings with it some obligations that are not typical of internally supported research:

- The company is contractually obligated to perform the research and report results to the government.
- The company must comply with government accounting and audit requirements.
- The research must be carried out within the border of the country that provides the financial support
- Restrictions on sale or licensing of the Intellectual Property.
- Require manufacturing substantially within the country.
- The government march-in rights to use the technology for the government's own use if the company does not commercialize.
- The timeline for the process from proposal to close-out of the research program can be quite long, often 5-7 years. A funded project that aligns with business needs today may not align in 2-3 years.

Suggestions for Improving the Efficiency and Effectiveness of the Institutes

While the Institutes provide a number of important benefits, Dow has observed several areas where improvements could enhance the Institutes' goals. The Institutes have shown a tendency to be slow to launch and slow to implement projects. This could be minimized through better communication and with well written membership and project agreements. Each Institute has put together its own membership agreement and project process. The Institutes could benefit from shared practices and standardization of the agreement process. Such support was recommended in the AMP 2.0 report but not implemented.

Most of the Institutes operate under Cooperative Agreements which generally do not provide enough flexibility to develop a framework for the Institute that would allow the Institute to quickly implement approved projects. One way to improve this issue is for agreements using Other Transaction Authority (OTA) negotiated with the appropriate terms and conditions. This approach has been utilized for MxD which is reaching the end of its original agreement with the Department of Defense. MxD secured follow-on funding and negotiated a Technology Investment Agreement using OTA.

Closing

Thank you for holding this hearing on Revitalizing American Leadership in Advanced Manufacturing.

Dow recognizes the business and societal value of collaborative innovation, where technological advancements can be leveraged to create societal benefit. Sustained and substantial investments in R&D are critical to accelerate the fundamental expansion of knowledge. In particular, government investment in R&D and support of facilities, such as the National Labs, allows for the creation of unique capabilities that could not be built without government involvement.

For Dow, public-private partnerships have proven to be the most effective way to maximize public investment, and drive innovation and commercialization. The Manufacturing Institutes demonstrate what is possible when public investment is aligned to the mutual priorities of industry and federal agencies. They combine the unique capabilities of government with the scale and sophistication of industry, the theoretical knowledge in our research universities, and the innovation culture that drives many start-ups. Success has come through a focus on the collaborative aspects of innovation, letting industry and government both do what it does best.

Attachment

Selected Dow US Government Collaborations (2015-2019)	Start Date	End Date
Data Aggregation Platform and Knowledge Base for Manufacturing Intelligence (MxD*)	30/Sep/16	31/Dec/18
Integrated Scheduling and Control for Real-Time Optimization of Factory Operations (MxD*)	1/May/17	15/Oct/18
An Analytics Based Supply Chain Risk and Event Management Decision Support Framework (MxD*)	9/Jul/17	12/Nov/19
Robotic confined entry inspection (MxD*)	1/Oct/17	31/Oct/18
Digital Manufacturing Roadshow (MxD*)	1/Feb/18	1/Jun/18
Dynamic Intensification of the Operation of Dividing Wall Column (RAPID)	1/Apr/17	1/Oct/20
Energy-efficient separation of olefins and paraffin through a membrane (RAPID)	1/Oct/17	1/Oct/21
Formation of Rapid Center for Process Modeling (RAPID)	1/Oct/17	9/Sep/99
Synthesis of Operable Process Intensification Systems (RAPID)	14/Aug/18	14/Aug/21
RAPID Multiscale Modeling Infrastructure (RAPID)	1/Nov/18	1/Nov/22
An experimentally verified physical properties database for absorbent selection (RAPID)	11/Dec/18	11/Dec/20
Optimization modeling for advanced syngas to olefin reactive systems (RAPID)	30/Jul/18	9/Sep/99
Efficient chemicals production via chemical looping (RAPID)	1/Sep/17	1/Sep/21
Novel Chemistry-Enabled Fast Processing of Carbon Fiber Composites for the Transportation Industry (IACMI)	22/Apr/14	22/Apr/19
Clean Energy Research Center Building Energy Efficiency (LBNL)	7/Oct/10	31/Dec/18
Energy Efficient Housing Research Partnerships (NREL)	23/Mar/11	23/Mar/15
Development of High VI High Fuel Efficient Lubricant (NETL-VTP)	1/Jan/12	1/Apr/15
Scale-up of novel low cost Carbon Fibers (EERE-IMI)	1/Sep/12	1/Sep/15
Residential Cool Roof (ORNL)	11/Mar/13	11/Mar/15
Development of a Long Life Cycle, Highly Water Resistant, Solar Reflective Retrofit Roof Coating (LBNL & ORNL)	15/Feb/13	14/Feb/15
Integrated Computation Materials Engineering Development of Carbon Fiber Composites for Lightweight Vehicles (EERE-VTO)	1/Apr/15	30/Sep/18
Ambient pressure XPS for in situ studies of heterogeneous catalysts (LBNL)	16/Feb/16	31/Aug/19
Imaging Model Ziegler Natta Catalysts with Single-Atom Sensitivity (LBNL)	16/Feb/16	31/Aug/19
Advancing PV material performance using nanoscale opto-electrical characterization (Atomic Force Microscopy) (LBNL)	16/Feb/16	15/Aug/17
Additive Manufacturing of Polyurethane Materials (ORNL)	1/Feb/16	1/Feb/17
Modeling the Effect of Film Morphology on the Performance of an OLED Device (LBNL)	16/Feb/16	15/Feb/17
3D Structure and Organization in Polymeric and Organic Thin Films (LBNL)	16/Feb/16	30/Jun/18

Selected Dow US Government Collaborations (2015-2019)	Start Date	End Date
Bio-Syngas fermentation to C6-C14 alcohol production (EERE-BETO)	1/Oct/16	31/May/19
Development of an oxidative dehydrogenation (ODH) of ethane to ethylene technology (ARPA-E)	10/May/17	30/Sep/17
HPC4M: Polyurethanes Modeling (Sandia NL)	3/Dec/18	3/Dec/19
Integrated Hydrogen Combustion with Energy-Efficient Ethylene Production (EERE-AMO)	1/Sep/18	31/Aug/19
NIST CRADA Development and Validation of Neutron-based Characterization Methods for Morphology and Topology of Soft Materials Consortium	5/Sep/12	30/Nov/19
NIST CRADA National Voluntary Laboratory Accreditation Program	1/Jan/15	31/Dec/18
NIST CRADA: Service Life Prediction Methodologies and Metrologies for Building Joint Sealant Consortium	1/Oct/17	1/Nov/20
NIST CRADA Characterization And Modeling of the Surface/Interface of Polymeric Materials and Systems Consortium	1/Aug/15	31/Mar/19
NIST CRADA: Materials Characterization Using Synchrotron Radiation	22/Dec/98	22/Dec/18

Dr. Mitchell G. Dibbs
Associate R&D Director
The Dow Chemical Company (a subsidiary of DowDupont, Inc.)

Mitchell Dibbs is an Associate R&D Director for External Technology Government Programs at The Dow Chemical Company.

He has been with Dow for 36 years, starting in the area of structure property relationships; performance/processing relationships; and optical/electrical properties of high performance polymers. He has over 25 years' experience as Project Manager/Principle Investigator and Project Administrator for a wide variety of university and government sponsored R&D including projects with DARPA, the Navy, NIST ATP, DOE, and European Framework, Horizon 2020, and other country program. He was active in the White House sponsored Advanced Manufacturing Partnership effort that lead to the creation of Manufacturing USA and their network of Innovation Institutes. In his current role he leads Dow's global efforts for government related R&D working with agencies, national labs, and institutes developing, negotiating and managing projects and agreements.

Mitch received a B.A. in chemistry & math from the University of Wisconsin-Superior and a Ph.D. in analytical polymer chemistry from the University of Wisconsin-Madison.

Chairwoman STEVENS. Thank you.

At this point we'll begin our first round of questions, and the Chair will recognize herself for 5 minutes.

Allow me to say we are just so proud of all of you. This interagency effort with the Department of Defense, Department of Energy, the Department of Commerce, with the National Institute of Standards and Technology being the spearhead there, this is a success story that the country will reflect on for years to come.

And, Dr. Hopkins, you're absolutely right about Local Motors and what you've been able to do with smaller companies.

And, Dr. Dibbs, you're spot on about some of the improvements. We'd certainly like government to move more at the speed and rate of business. And those comments are welcome.

I was just recently at MxD right before they rebranded, and it's incredible on the 5-year anniversary to see how far the institute has come, how many projects have proliferated, and phenomenal workforce development efforts.

So, Director Lightner, in your testimony you mentioned the 5-year funding phase of the Department of Energy's Manufacturing USA Institutes and the subsequent transition to a self-sustaining model. Does this mean that the Department of Energy does not plan to continue Federal funding for its current Manufacturing USA Institutes at the end of the 5-year funding phase?

Ms. LIGHTNER. Thank you for the question. And the initial $70 million investment from the Federal sector is to catalyze the collaboration amongst the institute members. And during that time, the institute works with its members to develop a plan for how they will operate in Year 6 and beyond. And these plans vary depending on the industry and the needs of the industry. But in general what we see in the plan is non-Federal sources to cover the maintenance, the management, and operations; strong partnerships with States continuing; and then the opportunity to compete for Federal research and development dollars in the future.

Chairwoman STEVENS. It's fair to say that the institutes began as a vision, part of an experiment so to speak. I remember one of the directors from Lockheed Martin rightly declaring that to be the case. And the experiment with robust funding, interagency partners, competitor OEMs, and suppliers all being at the table has certainly proven itself to be inspiring and successful.

So as we kind of explore the success of the public-private model, Ms. Lightner, Director Lightner, how do you think that the impending elimination of Federal funding will fundamentally change the Institutes as you have had the chance to see it?

Ms. LIGHTNER. Yes. I just want to clarify that we've had longstanding funding in many of the technology areas that the institute supports and so believe that there will be continued Federal funding for research and development dollars but that, you know, what the institutes will work with our members on during this current 5-year period is a plan that provides what the industry needs to continue collaboration in the future with various sources of resources coming in to pay for the management and operations.

And, you know, for the Department of Energy, our first two institutes are just moving into their 5th year of execution starting in the June/July timeframe.

Chairwoman STEVENS. We'll be keeping a close eye on it.

Mr. Myers, certainly with your experience working across a multitude of institutes, I was wondering if you could shed a little bit more light on opportunities for improvement regarding the M-E-Ps or MEPs, Manufacturing Extension Partnership centers, that the National Institute of Standards and Technology operates, your experience working with the institute on the MEPs and other supply chain activities. I'd love for you to extrapolate, please.

Mr. MYERS. Thank you, Chairwoman Stevens. Yes, we have our memberships in three—we're actually exploring a few more, ARM (Advanced Robotics for Manufacturing), for example, and I see it as beneficial to belong to the institutes to kind of drive the advancement of technology in manufacturing. And that's why—and I look at—took a look at where Hexagon is going strategically as a company and, you know, make sure that there's a good strategic fit, and so that's kind of how I evaluate where we join strategic partnerships with the institutes.

And there's some outside of that as well. Those work out well, the Commonwealth Center for Advanced Manufacturing being one example. OMIC is another example, the Oregon Manufacturing Innovation Center, but the manufacturing center up there in Portland that's being established.

Yes, being part of the network is valuable. It's, you know, kind of twofold for a commercial business like ours. It—you know, it helps us engage with our customers, first of all, the larger customers, and work with them exclusively on projects. The workforce development component I'm not too familiar with but I do know they have at LIFT, in particular, has a successful program run through Ms. DeRocco there. And in fact I'm supposed to be meeting with her sometime when we get a chance to connect on what Hexagon can do to help advance workforce development on the metrology side because there's the NIMH (National Institute of Mental Health)standards that's out there as well.

And we're working with AMT as well through advanced manufacturing technology programs for training the workforce to be able to use the digital thread because a lot of the smaller midsize manufacturers are using older and antiquated methods. But to get to scale, I think the education and technology has to expand through the MEPs because they're more regionalized, and they have the extension to a lot of the smaller local areas that where you have the institutes, they also are regional, but they also have a specialty. But that specialty that's developed, for example, in IACMI or in LIFT or in MxD has to flow—what's the mechanism to kind of flow the advancement of the technologies so that other U.S. manufacturers located in other regions can use those? I don't know off the top of my head but that's—I think something that working together though can be addressed.

Chairwoman STEVENS. I'll now recognize Mr. Baird for 5 minutes.

Mr. BAIRD. Thank you, Madam Chair.

Mr. Molnar, you indicated in your testimony that over the next decade, 3.5 million new manufacturing jobs will be generated with 2 million of those jobs expected to go unfilled due to a shortage of the skilled workers. The Purdue Manufacturing Extension Partner-

ship, which is in my district, has developed five skills for success, programs that address manufacturing skills gap in Indiana in the areas of manufacturing, quality, supply chain, and leadership. Would you care to elaborate on the work of NIST and the MEPs and the Manufacturing USA Institutes and what they're doing to address this skills gap in your opinion?

Mr. MOLNAR. Terrific. Thank you. It was in RAMI of course that we have the requirement to work with the Manufacturing Extension Partnership program. MEP is a 30-year network with a mission to engage small and medium-sized enterprises, a natural fit with our 4-year-old Manufacturing USA network.

As the institutes—they're focused on the development of technology and the identification of the skills gaps in those technologies. They seem like a natural partnership working with our other agency partners, including the Department of Education, to help identify these with our academic partners, universities such as Purdue, and community colleges such as Ivy Tech to identify, develop, and have these.

And then, finally, it's the old you don't know what you don't know in the supply base, and so this is where the MEP program really shines, in that folks in Indiana know about the Purdue Center, and so they know that here is where I can go to get advice and be made aware.

So we've seen that as with the NIST pilot over the past year and a half has been to have an embedding program to make sure that there is an MEP staff member involved with each one of the institutes to make sure that we have a two-way conduit between what do the small and medium-size enterprises need and want, and then what do the institutes have that could be a solution for those companies?

Mr. BAIRD. Thank you. And to kind of follow up on that, do you think there's any need to evaluate those initiatives and scale those up or add to them?

Mr. MOLNAR. Well, as RAMI also required, biannually we have an assessment by the Government Accountability Office (GAO), and we're just completing our second assessment there, so working with our colleagues at GAO, we have this biannual assessment. And one of the things that we've just received yesterday, their draft findings, and they noted about the connections with education and workforce. So we're always looking. Before public service, nearly 30 years in industry, continuous improvement is the way of manufacturing, and so we can always find ways to improve.

Mr. BAIRD. Thank you. I have one more question. Dr. Hopkins, I understand that your organization is a partnership of government–private industry and universities conducting research on new composite materials. Can you describe how these efforts could help companies in Indiana and how this research could improve the resiliency of our infrastructure?

Dr. HOPKINS. Yes, I'd be happy to. And Purdue University is one of our key partners. I'm looking at the Midwest in general and Indiana particularly. The composites industry has a pretty strong base in that area. A lot of that is attached to automotive but also in recreational vehicles.

One of the things that we're doing is trying to connect these—you know, these various sets of companies who have different markets that they're serving and provide a common place for them to innovate. A lot of these companies in Indiana and in the Midwest are smaller companies that don't have access or easy access to research and development facilities. And even though they're next door maybe at Purdue, it's challenging sometimes to find the right door, to find the assistance in getting—you know, getting help with innovation, and finding a way to help implement it.

We heard a little bit about the importance of digital. This is another important missing piece in the small-to-medium-sized enterprise landscape is the digital tools necessary to feed into the greater, you know, scaled-up production that your Fords and Dows just, you know, automatically have at hand. These are things that we're trying to do by connecting these dots and providing that service.

Mr. BAIRD. Thank you. I see I'm out of time, so I yield back.

Chairwoman STEVENS. I also at this time ask that the following statement from the Sustainable Chemistry Alliance to be placed in the record. Without objection, so ordered.

And now we will turn to Mr. Lamb for 5 minutes.

Mr. LAMB. Thank you very much.

Mr. Molnar, you highlighted the difference between our country's programs when it comes to advanced manufacturing, both in style and in amount that we invest and those being invested by some other countries. Could you—like an example that I saw was that Germany spends somewhere around €2.5 billion on its Fraunhofer model. Are you familiar with that? Could you just talk about the comparison between the United States' efforts in this regard and what we see from Germany or even from China in a little more detail and what the implications of that might be?

Mr. MOLNAR. It's really an excellent question because the gold standard, if you will, for focused applied research has been the Fraunhofer Institutes originally established in 1949 as a recovery strategy from World War II. Fraunhofer has grown into 69 major institutes with a number of satellite institutes in other countries, and the Germans have made this into their key part of their innovation ecosystem, so it's between the investment of the Federal Government, the Länder Government, and industry, it's been a partnership.

So when we were designing Manufacturing USA, of course, that was one of the role models. But the culture and the dynamic nature of the United States is different, so we were trying to pick the best of the best of different countries. So the leading characteristic of Fraunhofer that we wanted to ensure in Manufacturing USA is that it is the trusted entity. It is the place where this is something in my industry career which is so difficult. It was hard enough working with more than one university at a time, difficult to work with other companies, and impossible to work with competitors. So a key notion here is that Manufacturing USA with the Federal partnership there, it's the neutral convening ground where industry can really work together with academia. That's relatively new for the United States, but what it does is it augments what is really the envy of the world, this innovative, dynamic culture that we have in the United States.

So there are similarities, there are differences. I guess if imitation is the sincerest form of flattery, the Chinese Manufacturing 2025 program, they've taken a page from us and they've committed to launching 40 institutes by the year 2025. Actually, they've copied all of our institutes, and we've actually noted that within days of any public Manufacturing USA event things are translated and shown in China. So this is why we see that global competition has really stepped up as more and more countries have focused on the value of applied research. We think that Manufacturing USA really applies a valuable tool here, which is leveraging the dynamic nature of the United States.

Mr. LAMB. I agree. And, more importantly, it seems like many of the experts who have studied this whole model think that we are showing some initial signs of success and maybe would do better by investing a little bit more.

So I wanted to ask, maybe Dr. Hopkins. You mentioned that you get roughly $70 million in DOE funding for a year for IACMI. In your mind—without putting a specific number on it, but in your mind is there room to grow? Do you think you could do more with more resources? And can you maybe talk to us a little bit about what additional return on investment we could get through an institute like IACMI?

Dr. HOPKINS. Well, I think so. I mean, more is always, you know, better to the extent that you can scale effectively. The thing that we're seeing from our industry membership and our consortium is the importance of these other application areas. You know, as I mentioned, we are addressing, you know, mission-specific goals within the Department of Energy that are very important to them, very important to the country, but if we look at the composites marketplace and the consortium that we're managing and the industry element of it, it's broader than that.

And the capacity to leverage the institute I think is beyond the initial goals that were set out within the Department of Energy. We're looking at that as part of our sustainability plan, looking at how do we manage the consortium, work to provide a—an ROI (return on investment) for them as a convening organization. We can convene, aggregate, and focus attention on important innovation-seeking ideas and concepts that the companies individually can't do. We're seeing the value in that. In fact, we're seeing more and more of our industry counterparts seeing value in that. Even in Year 4, we're still recruiting big companies and important companies who are part of the composites landscape that give me I think a good idea that we do have the capacity to scale and do more with the consortium.

Mr. LAMB. That's great. Thank you. And I see I'm out of time. Madam Chairwoman, thank you.

Chairwoman STEVENS. Thank you. I will now recognize Mr. Weber for 5 minutes.

Mr. WEBER. Thank you, ma'am. Dr. Dibbs, you mentioned the need for more flexibility and cooperative research. You may be aware that the Science Committee had previously advanced legislation to give the Department of Energy's lab directors signature authority or the ability to approve research partnerships under $1 million. I don't know if you were aware of that or not. But nonethe-

less, you are now. Would this policy help encourage in your opinion more cooperative R&D within the industry?

Dr. DIBBS. Yes, it would, and I was aware of that, and that is something that we were working with—one of the things just to bring that up, we developed a—we have long—had a longstanding relationship with Lawrence Berkeley National Lab (LBNL) having worked very extensively at the Advanced Light Source there. Then what—we then a few years ago started looking at broadening that out into—into that type of a much broader collaboration around analytical techniques necessary to study the materials that Dow is developing.

In that process there were multiple meetings, yet when we got into doing agreements, everything had to be approved back at DOE even in changes, and as we were going through this, it took a significant amount of time to finalize not the statement of work and what we wanted to do but just the agreement and get those signed so that we could then proceed with the work.

Mr. WEBER. You might get Ms. Lightner's cell phone. You could probably get those approvals quicker that way. No pressure, Ms. Lightner.

And I appreciate that, Dr. Dibbs. Would you put a percentage on that? Would you say it would improve efficiency, increase 10 percent, 20 percent, 30 percent? Those million-dollar programs, what percentage of those would you say you all invested your time and effort in?

Dr. DIBBS. Every one of the programs we were doing was under $1 million.

Mr. WEBER. Is that right?

Dr. DIBBS. Yes.

Mr. WEBER. Woah.

Dr. DIBBS. When we finally got the agreements approved, we were able to launch five new CRADAs (cooperative research and development agreements) with LBNL very quickly.

Mr. WEBER. Very good. In your prepared testimony you state that, "The manufacturing institutes demonstrate what is possible when public investment is aligned to the mutual priorities of industry and Federal agencies." You also add that these partnerships are successful because of, "a focus on the collaborative aspects of innovation letting industry and government both do what it does best." Would you expand on that for us?

Dr. DIBBS. OK. When I—when you really talk about that, industry knows what the issues are in the marketplace. We know what customers want. We know what are the critical stumbling blocks in terms of bringing those things forward. So when you combine that knowledge——

Mr. WEBER. When you say stumbling blocks, you mean risk?

Dr. DIBBS. Risk. What I mean is risk. I mean what are the main technical challenges that we need to overcome. And one of them is always going to be cost in terms of a product, so what we have to do is we have to balance all those issues against what we're trying to achieve in the collaboration. And those—that is the knowledge that a company—that the industry brings into this.

What the government, the government agencies, the national labs, what they bring in that is the very in-depth technical knowl-

edge that then can be put toward those problems, and that's why I say what do we do best? We have the issues. What they have is they have the ability to actually address those issues.

Mr. WEBER. Thank you. I want to switch over to you, Dr. Hopkins. I'm fascinated by the composites and stuff. I mean, they build all kinds of things. And I was an air-conditioning contractor for 35 years and I sold my company a couple years ago actually with mixed emotions, joy and happiness. And so the things that they're building now just are unbelievable. And you say that IACMI has 160 members in the organization. Is there any other alike organization that has that many members in it that you're aware of in the manufacturing arena?

Dr. HOPKINS. I believe there are a few that have close to that number. You know, and certainly if I'm looking at, you know, the broader space with regards to even our trade organizations, you know, the American Chemistry Council, the American Composites Manufacturers Association are two of our key partners who are very much a part of our community of success. You know, they represent hundreds more members. But from a manufacturing institute perspective and the Manufacturing USA network, I think that we're, you know, probably at the top or we're near the top in terms of membership.

Mr. WEBER. All right. Very impressive. Thank you very much. I yield back.

Chairwoman STEVENS. Great. And now we'd like to recognize Mr. Lipinski for 5 minutes.

Mr. LIPINSKI. Thank you. I want to first say I noticed that the first three witnesses here all have bachelor's degree in mechanical engineering, which impressed me very much. Unfortunately, none of you went to Northwestern like I did, but, you know, as the Chairwoman was introducing everyone, I say, oh, three BSMEs, so good to have all of you here, but us engineers have to always stick together, and there aren't too many of us up on this side.

I want to ask Ms. Lightner, you know, I understand that the Department of Energy published a notice of intent regarding its plan to complete a sixth Manufacturing USA Institute that has the title, "Clean Energy Manufacturing Innovation Institute: Cybersecurity in Energy Efficient Manufacturing." Certainly cybersecurity is a major issue that we need to do more about. It's a threat that we face constantly, and it continues to increase.

I just wanted to ask. I know that the DOD has the Manufacturing times Digital Institute in Illinois, and so, you know, the National Center for Cybersecurity Manufacturing at MxD, I was just wondering how this DOE decision to launch a separate but overlapping manufacturing institute, what impact that would have? I don't want to see things be duplicated. I just want to see how you see any interaction there.

Ms. LIGHTNER. Sure. Thank you for that important question. So, as I mentioned, we actually issued the funding opportunity earlier this morning for the Cybersecurity and Energy Efficient Manufacturing Institute. And cybersecurity is a national priority, and both the DOD and DOE efforts are—need to be funded to ensure that the Nation's manufacturing sector remains competitive and is not compromised by cyber warfare.

For DOE's mission, automation and advances in automation are enabled by cybersecure-connected sensors and control, and that is really critical to being able to achieve that opportunity of a 15 percent energy efficiency improvement in manufacturing.

Prior to issuing our notice of intent, DOE and DOD met together to discuss both our intention to go out with a funding opportunity for the Cyber Institute and also other activities that DOE has related to cybersecurity and manufacturing to collaborate and discuss and ensure that the work that we are doing is coordinated and collaborative and not duplicative. And we are committed to continuing that dialog with the DOD to ensure that as we move forward, our efforts are collaborative.

Mr. LIPINSKI. Very good. That's good to hear. And I know the Chairwoman has an interest in MxD having worked there before, so that's great to—good to hear about the—it being a—you've had those discussions.

One thing I wanted to touch on very quickly, and I don't know if we have much time to get into it, I've been a longtime supporter of advanced manufacturing and also a longtime advocate for entrepreneur-in-training, mentorship training programs like I-Corps and Hacking for Defense. And Hacking for Defense brings in, you know, students to work on real-world national security problems. It brings together government, private sector, and the startup community, universities, nonprofit sector to solve real-world problems. And I think this could be a good model in manufacturing to do this, to go after some of the issues that we face in manufacturing. I don't know if anyone has enough knowledge and background. I don't know if, Mr. Myers, in Hacking for Defense or I-Corps you have any thoughts or opinions on bringing this into the manufacturing sector.

Mr. MYERS. Yes, I don't really have that extensive background to kind of answer that, but I know there's other folks within our company that I can reach back to and ask that same——

Mr. LIPINSKI. OK.

Mr. MYERS [continuing]. Question to.

Mr. LIPINSKI. I appreciate that.

Mr. MYERS. Yes.

Ms. LIGHTNER. I'd just like to add that the Department of Energy also has an energy I-Corps activity and a lab-embedded entrepreneur program that brings entrepreneurs into our laboratory systems under a fellowship program to further advance their technologies and work on their business plans. And it's hardware-based, so manufacturing-based.

Mr. LIPINSKI. And have you seen success?

Ms. LIGHTNER. We have. We've had—some of our entrepreneurs have made the, you know, 30 under 30 list in the first couple years of execution of the program.

Mr. LIPINSKI. Very good. Thank you. I yield back.

Chairwoman STEVENS. The Chair would now like to recognize Mr. Marshall.

Mr. MARSHALL. Thank you so much, Chairwoman.

I might take that conversation in a little different direction. You all have had a unique view of manufacturing since—well, since NAFTA (North American Free Trade Agreement) came about, and

I would think that would impact you. You know, as manufacturing jobs left the country, I would suppose maybe your business wasn't quite as busy either. I'm sure you keep track of USMCA (United States-Mexico-Canada Agreement) and that trade agreement. Do you think it'll be good for manufacturing jobs in this country? Does anybody wish to grab that one? Nobody? All right.

Mr. WEBER. I wonder why. The gentleman yields back.

Mr. MARSHALL. Let's talk about innovation and carbon recapture for a second. Who sees anything in that happening? What's happening out there in the world of carbon recapture or just what are we doing to decrease our carbon imprint? What's impacting the country right now? Ms. Lightner, I think you had some comments on some of the innovation things I heard earlier.

Ms. LIGHTNER. Yes, I do. So our—you know, our mission of our office is to reduce the energy intensity of the manufacturing sector, and by improving energy efficiency, there is an affiliated result of reducing emissions as well. So, you know, that comes along with the technologies that we're developing. Reducing emissions comes along with improving energy efficiency in the manufacturing sector.

Mr. MARSHALL. OK. Anybody just want to comment on innovations? Yes, Dr. Hopkins, go ahead.

Dr. HOPKINS. Yes, I'll do that because that's really at the core of what we're trying to accomplish within IACMI. The primary driver for cost is the carbon fiber itself. That's because of the energy, the embodied energy that is required to create it. We're trying to reduce that. That has kind of a trifold effect possibly. One is it reduces the cost of manufacturing, the carbon footprint for the manufacturer itself, the implementation of the materials that are now more readily adoptable because of the cost reduction due to the reduced energy, makes them beneficial with respect to use and applications like vehicles where then you reduce the energy footprint and the application of the products. And if we can reduce these costs sufficiently, then there's also even greater opportunity for deployment and infrastructure in which you are looking at displacing concrete and other materials that have a significant carbon footprint over their lifespans.

Mr. MARSHALL. Well, what can Congress do right, what can Congress do wrong to help or hurt innovation going forward in the world of carbon recapture and decreased carbon footprint?

Dr. HOPKINS. In the path that I just laid out IACMI has been working on the *IMAGINE Act* (Innovative Materials for America's Growth and Infrastructure Newly Expanded), which provides a readymade pathway for adoption of these materials. It's challenging for nascent new materials to find their way into use for these types of applications. And the *IMAGINE Act* provides a pathway for, you know, decisionmaking to, you know, have some incentive to look at, you know, new ideas and new materials that could provide advantage in the utilization.

Mr. MARSHALL. OK. Let's turn to community colleges and technical colleges. I suppose I have 12 or 13 of those in my district, and only one of them I know is actively advanced in any type of research going on. Any words of advice? Was it Mr. Molnar that mentioned something about community colleges, working with them?

What advice can I take back home to a community college or a technical college that wants to be involved with research?

Mr. MOLNAR. I think the answer lies in this misperception of what manufacturing is about, that people think it's the dirty, dark, dangerous, declining thing of a big factory making something, and that's this niche here, and really what's exciting today is that manufacturing is really about designing and making things. And so what I'm excited about is the fact that over the weekend my son was at a science fair where he was researching—and he's a high school student, and he's researching additive manufacturing. And so as long as they don't consider that as manufacturing, rather that it is an innovative thing.

So I'd say part of the notion is imagining that while community colleges or even high schools don't do manufacturing, and the fact is actually they do. And just having 3D printers is a way to interest people, and if you have an idea, then you can make it, and if you can make it, you're a manufacturer. And so it's an exciting new field of applying math and science and having it manifest itself in something that they can make. I think that's a big part of it.

What's exciting here is many of our projects at the institutes, is beneficially informed by having community colleges there because they provide the voice of the customer if you will for what youth are looking about, what youth need, and so that's part of the diversity of having these things on the project teams.

Mr. MARSHALL. Great. Thank you so much, and I yield back.

Chairwoman STEVENS. Thank you. The Chair would now like to recognize Mr. Tonko for 5 minutes.

Mr. TONKO. Thank you, Madam Chairwoman.

America's economy, millions of jobs, and our national security depend on manufacturing. Experience has taught us that our government can be a powerful partner in revitalizing and strengthening the U.S. manufacturing arena. For instance, we came together as a Nation and made a commitment to invest in manufacturing when we created the first-ever national network of manufacturing hubs. This achievement was the result of our overwhelming bipartisan passage of the *Revitalize American Manufacturing and Innovation, RAMI, Act*. Our gains in this area will need continued support and the kind of sustained long-term funding we see from our most productive allies and competitors around the world.

As a representative for New York's capital region, I've seen firsthand that moving toward an innovation economy can be the key to economic growth. Our region is home to robust and diverse manufacturing landscape. From small companies to large multinationals, our region produces some of the world's most advanced materials, power generation equipment, pharmaceuticals, industrial components, and semiconductors just to name a few.

AIM Photonics led by SUNY Polytechnic Institute applies lessons from 40 years of success in the electronics industry to drive photonic-integrated circuits. Rensselaer Polytechnic Institute in Troy, New York, runs the Northeast node for the Clean Energy Smart Manufacturing Innovation Institute or CESMII. CESMII is focused on making U.S. manufacturing more energy-efficient and more competitive across-the-board. And RIT leads the REMADE Institute in Rochester, which will enable early-stage applied re-

search and development of technologies that could dramatically reduce manufacturing energy and carbon emissions. These and other public-private partnerships across the State and the country have been incredibly successful and fill a needed role. I'm concerned that more long-term funding is needed to see the full benefits of these institutes if we're going to really make as much progress as we hope to.

So, Dr. Lightner, industrial greenhouse gas emissions remain a large, overlooked, and difficult-to-decarbonize piece in our climate solutions puzzle. Much more R&D must be done to develop ways to reduce process emissions, but we also need to make major improvements in industrial energy efficiency. Luckily, this Committee has a real expert in a colleague like that seated to my right in Mr. Casten who worked to deploy CHP and other industrial efficiency systems.

But I want you to focus on how DOE is promoting adoption of better energy management systems such as the ISO 50001. Can you explain a little bit about what ISO 50001 is and the benefits of a manufacturer implementing this standard or participating in its superior energy performance program?

Ms. LIGHTNER. Sure. Thank you. The Department, through our technical partnerships program, has a flagship program of Better Plants where we partner with the manufacturing sector to set aggressive energy management goals. And under that, that is—we asked them to at least commit to a 25 percent improvement in energy intensity over 10 years. The ISO 50001 framework provides an even more rigorous international standard to energy management, and what we've seen through superior energy performance is that when companies undergo that more rigorous evaluation on energy management, they can see up to, you know, a doubling, so, you know, whereas the standard goal is a 2.5 percent improvement per year, we've seen upwards of 5 percent improvement a year for companies that have taken on the superior energy performance.

Mr. TONKO. Thank you. And, you know, for us to stay competitive or ahead of the pack so to speak, we want to be innovative. Are other industrialized nations implementing ISO 50001 as part of their climate mitigation strategies and promotion of more sustainable manufacturing processes?

Ms. LIGHTNER. Other countries are implementing—now, Europe particularly is—has a more rigorous program in—I think tied to some regulatory framework regarding the implementation of ISO 50001. The U.S. program is more voluntary basis.

Mr. TONKO. And what else is your office doing to promote widespread awareness and adoption through the 50001-ready program?

Ms. LIGHTNER. Yes, so, you know, one of the things that we do in addition to trying to engage additional partners is get the word out about successes of our current partners so we're amplifying success stories and looking for opportunities to let people know how they can replicate some of those successes.

Mr. TONKO. Thank you. My time is up, but if you could share some of those success stories with the Subcommittee, that would be helpful.

Ms. LIGHTNER. Sure. Thank you.

Mr. TONKO. Thank you so much. And with that, I yield back, Madam Chairwoman.

Chairwoman STEVENS. Thank you. And the Chair would now like to recognize Mr. Gonzalez for 5 minutes.

Mr. GONZALEZ. Thank you, Chairwoman Stevens and Chairman Lamb, Ranking Members Baird and Weber, for having this hearing today. Thank you, witnesses, for your time and attention.

So I have the honor and privilege of representing a district in northeast Ohio, Ohio's 16th District, and obviously we rely heavily on manufacturing, always have. We're proud of it. And we employ roughly 41,000 people working directly in the industry, $2.2 billion in annual payroll, and it's just been an incredible gift to our region and our country.

But we share a lot of the frustrations that have been voiced here today. Team NEO, which is one of our business development groups in town, recently told us that advanced manufacturing has about 15,000 open jobs that haven't been filled due to the growing skills gap. And so we clearly have—if I want to break this into kind of two things, we clearly have workforce issues, but then I also believe we have investment issues.

I think, you know, in Washington, D.C., we do a good job—or I think we do a poor job I should say—but we like to spend a lot of money. I don't think we're particularly thoughtful about our investments. I think there's a difference between just spending versus investing. And when I think of this hearing and when I think of how important this is, I think we need to reprioritize our dollars, and we need to think about actually investing in advanced manufacturing, giving it the resources that it needs. And yes, we need to be more efficient, no question, but if we underinvest, then we're going to lose to Germany and China. And there's no reason why that has to be the case.

And so I want to start my first question focused specifically on China and Germany and the trends that they have on the investment side. So, Mr. Molnar, could you talk specifically about how those two countries have prioritized advanced manufacturing and the investments that they have made in that sector compared to us in the last 5 years let's say.

Mr. MOLNAR. Well, the German Fraunhofer network with the 69 institutes, they have a different model. It's much a more structured model. I believe it's €2.3 billion or €2.4 billion annual budget, and so this is funding their institutes. They also have a crosscutting program that encourages intra-institute activities. As I mentioned before, they've really built into their innovation ecosystem coming from their national labs and being an applied research conduit working closely with industry. We work with them. We talk with them. And again, there are many similarities.

One thing that we are proud of with Manufacturing USA is the innovative culture and the ability to identify, when technology changes, when you find something, we can stop nimbly and pivot and go with the voice of industry, so we always want to move a bit faster.

The question of China is more difficult. They do not publish budgets of what they have. From what we have been able to see,

they are very, very well-funded, and it really is a government-led initiative.

Mr. GONZALEZ. And then Germany you said was €2.4 billion. What is our dollar figure? You know, don't convert it to Euro if you don't want to but—unless you're really good at math but——

Mr. MOLNAR. Well, again, the Federal investment has been limited to the startup of the institutes——

Mr. GONZALEZ. Yes.

Mr. MOLNAR [continuing]. So I believe the—we're talking about from the last year about a $350 million——

Mr. GONZALEZ. Yes.

Mr. MOLNAR [continuing]. Collective investment.

Mr. GONZALEZ. So fair to say Germany is more focused and they commit more resources?

Mr. MOLNAR. Yes.

Mr. GONZALEZ. OK. And then when we're talking about the skills gap, you mentioned Purdue has done a really good job of what I would call advertising the program that they have in getting more folks into it. Could you talk more about that? Because when I hear about the skills gap in my district, I hear about a few things. One, there's definitely a skills gap, but there's also an awareness gap, there's a motivation gap if you will. I think you said it earlier. Folks think of manufacturing as heavy industry, and maybe it's not as cool quote/unquote, but obviously produce doing something different. Can you talk about what they've done that's been successful?

Mr. MOLNAR. Well, I think the success stories—we are working on our next year's annual report. I mentioned in the past year over 200,000 people were touched by programs with Manufacturing USA. We're anticipating that this number will be much higher for our next year. But I'd point to Lorain Community College——

Mr. GONZALEZ. Yes.

Mr. MOLNAR [continuing]. Working with students, so part of the piloting programs that we have with the institutes, we want to cascade it, and so community colleges like Lorain are important partners——

Mr. GONZALEZ. Great.

Mr. MOLNAR [continuing]. So I think that there will be a lot of interesting success stories coming up very soon.

Mr. GONZALEZ. Thank you. Thank you for your time. I think this is an amazing hearing. So with that, I'll yield back.

Chairwoman STEVENS. Thank you. And the Chair will now recognize Mr. Foster for 5 minutes.

Mr. FOSTER. Thank you. And I'd like to thank the Chairs and Ranking Members for organizing this very important hearing and as well as our panelists.

Several of you have mentioned the key contributions of the national labs and particularly the 17 Department of Energy national labs in seeding this technology and the transfer. First off, I should acknowledge I'm actually the Co-Chair of the National Labs Caucus along with Congressmen Fleischmann, Luján, and Zeldin. And we're actually going to be having our kickoff event tomorrow evening in the Rayburn Building here where there will be several directors of national labs and other representatives there. So my

colleagues that are, you know, interested in getting here, we're also going to be organizing visits to the individual national labs where I'm sure we'll be hearing about their technology transfer, including manufacturing, for many of these laboratories. So I want to thank you all for highlighting that.

Now, my question here has to do with sort of your vision for the future of manufacturing. You know, traditionally, we've had large systems integrators. You can think about, you know, the main contractors for the Apollo program or Boeing where you have a main system integrator and large numbers of ma-and-pa machine shops so to speak, you know, making individual components. And startups with a unique technology would start a little standalone business.

At the other end of the vision here is something I think a lot more that Mr. Myers described, which is sometimes described as cloud manufacturing. These are large contract manufacturers that can build anything. And so, you know, a lot of the startups with products in mind now just—they—oh, we're going to design the product and it's going to be mass-produced by a contract manufacturer typically in the east for many high-tech products.

And so I think if that is in fact the future of manufacturing, it's very different than the individual ma-and-pa businesses. I have to say this sort of breaks my heart. I'm best known as being the other Ph.D. scientist in Congress, but I also am a businessman. I started this company with my younger brother with $500 of my parents' money, and that company now manufactures about 70 percent of the theater lighting equipment in the U.S., over 1,000 workers, and we're all in suburban Wisconsin.

But, you know, if we restarted the business today, it is not clear that the contract manufacturing model is more attractive. And that really affects what your planning is. You know, are you trying to set up the technology and transferring it to what may be the future of manufacturing if these are—when you've got a bright idea, instead of planning a startup operation, you'd simply license it to one of the large contract manufacturers. And is that something that you wrestle with or do you have any words of wisdom on which way you think that is going to proceed in mass production of things? Mr. Myers, actually since you came close to describing your vision of the future would be a big digitally integrated manufacturing capability.

Mr. MYERS. Right, thank you for the question. I see it as an opportunity for entrepreneurs who would want to go into the manufacturing field without the need for a large capital investment because typically you would need to do that with that, but with—through autonomous connected ecosystems and knowing we're—if you had a design for a product and needed a manufacturer, you didn't really—you don't really need to own the asset through—you can——

Mr. FOSTER. Right.

Mr. MYERS [continuing]. Rent time on machines through one of the institutes and have a machine——

Mr. FOSTER. Cloud-based manufacturing——

Mr. MYERS. Right. I mean——

Mr. FOSTER [continuing]. And it is a very attractive model because if your product takes off, you can rapidly scale the same way a digital business can today. You know, you write an app, and if the world loves it, then you can rapidly scale the number of customers. But it's a very different version for, you know, the small-scale manufacturers, whether they'll end up going the way of the family farm. And this is something I struggle with, you know, all the time when I think about the future. It's going to be hard to compete with large integrated manufacturing. And if that is in fact the way things are going, we should be thinking about how to put our technology transfer in place for that.

So, anyone?

Mr. MOLNAR. Well, I'd like to say that it's a very exciting time for many people that think the golden age of manufacturing is ahead of us because in fact the rules are changing. And if a small manufacturer is aware of these changes and make use of them, then they have a greater opportunity for market exposure and a greater opportunity for capturing these trends called the democratization of manufacturing, which is why, again, we really wanted to see that manufacturers play a pivotal role in engagement of the institutes, and then two-thirds of the manufacturers are small institutes. So the rules are changing, and the exciting thing is if we're in the driver's seat in changing those rules, then the future can be very bright for our small and medium-size manufacturers.

Mr. FOSTER. But if—you just said they would exist as people who design products and then send it to a big contract manufacturer. My time's up here, but, you know, any thoughts that you had on that because this I think is the big challenge for, you know, the Mittelstand, which I am a proud—I guess I—my business qualifies as that. So, anyway, thank you for holding this hearing, and I'm out of time here.

Chairwoman STEVENS. Thank you. And the Chair will now recognize Mr. Balderson for 5 minutes.

Mr. BALDERSON. Thank you, Madam Chair. Good morning, everyone. Good afternoon almost. Thank you all for being here this morning.

A little background first. Wyandot Snacks, located in Marion, Ohio, is one of the largest snack food manufacturers in the U.S. They are a member of the Center for Innovation Food Technology (CIFT), which is part of the Manufacturing Extension Partnership network through NIST. Because of the research that CIFT has conducted, Wyandot has been able to leverage their own resources in pursuit of technologies that can improve the company's bottom line and increase wages for workers. In one project, Wyandot took advantage of CIFT's technology program to explore the use of rapid detection technology to uncover pathogens in a dry processing environment. Collaboration between public partners like NIST and private partners like Wyandot Snacks often leads to successful implementations of technologies.

My question for all of you is to weigh in on how valuable you believe these public-private partnerships can be to manufacturing innovation? And you may go in any order you wish.

Mr. MOLNAR. Well, as many have noted, when you have a difficult or challenging problem, there is no more effective means to

tackle it than creating a public-private partnership, a collaboration, and so that's really what the foundation of Manufacturing USA is about is partnering.

And I mentioned earlier the strength of diversity of having large, medium, and small companies, research universities, and community colleges. We've really seen the power of that in these collaborative projects. I think another Member said the role of government with the—with all of the agencies involved, we've really been able to connect with—if there is a national laboratory, if there is a Federal program. And, as I mentioned earlier, not because they have to but because—that there are laboratory programs at NIST that are beneficial that touch on it, all 14 institutes have engagement from the NIST laboratories. I really think public-private partnerships are an effective means of dealing with these challenging issues.

Ms. LIGHTNER. And I'll just weigh in from the Department of Energy as well. You know, that is how we execute our program is through public-private partnerships. And we feel that it's really important to engage with industry so that we're focusing the Federal research dollars on problems that industry is facing and that we continue to be able to direct research dollars to those broad and evolving changes in the manufacturing space through public-private partnerships. Thank you.

Mr. MYERS. Another way is on a particular project and focus for advancement of technology in a certain area in terms of scanning and also incorporating AI where you can teach and through machine learning certain defects on certain systems through scanning basically through algorithms developed through the—working with the institutes in combination with private and public funding can advance technologies where we could lead, you know, in this area again.

Dr. DIBBS. From the company perspective, a lot of the issues and problems that we are now dealing with are much larger and more complex than something that any company actually can deal with on their own. What the government provides is a framework that allows us to access both the technology and innovation capabilities of the universities and the national labs and other Federal agencies to address those issues, bring them to them, and then, in partnership, get solutions that will benefit the company, the society, and the public as a whole.

Mr. BALDERSON. Thank you all very much. Doctor, go ahead if you had an input. Thank you.

Dr. HOPKINS. Well, I just want to comment on the importance of the connectivity, you know, and the things that we're talking about to some extent aren't difficult to, you know, conceptually think of, but they are critical with regards to how you bring these dots together, how you bring the community together and providing environments where there's knowledge and awareness of capabilities, problems, and really creating an environment to support industry-informed innovation.

Mr. BALDERSON. Thank you very much. Madam Chair, thank you.

Chairwoman STEVENS. Thank you. The Chair would now like to recognize Ms. Horn for 5 minutes.

Ms. HORN. Thank you, Madam Chair, and thanks to all of you for being here today. This is a really important topic. I want to follow on a little bit more from the conversation about public-private partnerships to the importance and the role of workforce development and the role of our educational institutions and how that fits into this manufacturing sector because we know that one of the key parts as technologies continue to evolve in developing and manufacturing workforce is individuals that have a STEM background or some connection to STEM and technology.

And so I want to start with Dr. Hopkins. You mentioned in your testimony that IACMI has engaged over 9,000 K–12 students in STEM activities. And I want to ask you to expand on how this prepares them to move into STEM careers and their relationship between not only the 2- and 4-year institutions but also technical career techs and other technical programs.

Dr. HOPKINS. Right. And these, you know, interactions tend to be locally driven where we're working with partners at the community college and university level and in most cases where we have students at the community college and the universities involved in the delivery of these programs. We try to put them in the form of, you know, experiential type of programmatic activity where they're creating a composite snowboard or skateboard or something that they can relate to. And these are things that are really increasing awareness. We see the—you know, the benefit of making sure that high school students in particular know what options are available to them, that they have some introduction to composites and these advanced materials, as well as the—you know, the manufacturing careers that are associated with them. Both entry points into, you know, 4-year and community college pathways are important, and it's important to provide that in the context that relates to—you know, to those students. And I think that we've done a good job at doing that for those that we've engaged.

Ms. HORN. Thank you very much. And following onto that, the conversation around public-private partnerships I think is really important and about the framework that the government programs provide to make it possible to build these public-private partnerships with the R&D on the front end. But I wanted to follow up a little bit more, Dr. Dibbs, about this balance and where the incentive is for private sector to build onto public sector. And so what is a simple payback that Dow would be using and requires to invest their resources in, say, energy efficiency in your manufacturing operation? What would that take to promote that investment or to make it worthwhile?

Dr. DIBBS. Well, it would actually depend upon what the investment is. One of the things that Dow has always done is recognize that reduction in energy, reduction in waste is always—pays because those are the—those are elements that you're always going to have to deal with. We are constantly striving to reduce the energy intensity in our products and also reduce the waste, which means that anything that we would like to have I think the model where everything that comes in from a raw materials standpoint goes out as a product.

Ms. HORN. Thank you very much. And I think I just have about a minute left here, so finally, I want to talk for a moment about

when we're talking about technically skilled jobs and good-paying manufacturing jobs, how these sorts of partnerships—and I'm just going to open this up to everybody—can work to increase access and increase reaching out to underserved communities, especially communities where there's high poverty, communities that are historically underserved in these public-private partnerships, how we can leverage that, the partnerships between the universities, the colleges, the technical schools, and industry to work together to get people into these jobs?

Mr. MOLNAR. Well, I think the exciting part is you learn by doing, and so with exposure of the hands-on projects that IACMI does and NextFlex does is really impacting a lot of high school students and community college students. That's one aspect of it. But we know that we can do more, and this is why, as I said, we really benefit from a diverse set of participants, and one of the things that we like to see is more engagement by historically black colleges and universities. Our office is working with the National Science Foundation in a workshop later this year on how bringing together the 50 or more HBCUs (historically black colleges and universities) on how we can better engage HBCUs and other communities into the Manufacturing USA network. I should note that Johnathan Holifield, who leads the White House initiative on HBCUs, is also part of this initiative.

So we know that we can do more, but it's very exciting to see this outreach happen especially as the hands-on projects, nothing excites a student more about doing something than learning by actually doing.

Ms. HORN. Thank you very much. My time is expired. Thank you, Madam Chair.

Chairwoman STEVENS. Well, thank you.

And before we bring the hearing to a close, I want to thank our witnesses again for testifying before the Committee today. This was very intentional for us to have this hearing in the first 100 days of the 116th Congress on the heels of many of the original institutes reaching or cresting their 5-year milestone and showcasing success.

I'd also like to take a minute to recognize Ms. Tracy Frost, who has joined us here today in the audience, our Director of the OSD ManTech office within the Department of Defense. You don't know the Manufacturing USA without knowing Ms. Frost, who has been a dedicated and tireless leader and advocate for the success of our Institutes.

The record will remain open for 2 weeks for additional statements from Members and for any additional questions that the Committee may ask of our witnesses. The witnesses are excused at this time, and the hearing is now adjourned.

[Whereupon, at 11:52 a.m., the Subcommittees were adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Mr. Ryan Myers

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

Questions for the Record to:
Mr. Ryan Myers
Director of Business Development - DoD
Hexagon Manufacturing Intelligence
Submitted by Congressman Daniel Lipinski

As you may know, I am a long-time supporter of advanced manufacturing, and also a long-time advocate for of entrepreneurship mentoring through programs like I-Corps and Hacking for Defense. Programs like this are wildly successful – for example, the Hacking for Defense program has addressed 80 Department of Department of Defense and Intelligence Community programs to date.

- Do you believe that the success of Hacking for Defense within the DOD can be further leveraged to bolster the national security innovation base and be replicated to support broader 21st Century advanced manufacturing initiatives here in the U.S.?

Answer for Congressman Lipinski,

Do you believe the success of Hacking for Defense within the DOD can be further leveraged to bolster the national security innovation base and be replicated to support broader 21st Century advanced manufacturing initiatives here in the US?

- While I cannot speak on the Hacking for Defense Program specifically as I have not been involved in it. I believe that wherever there are successful programs that are benefitting our national security – much like the Manufacturing USA institutes – we should continue to support them and see where else they could be beneficial. In the advanced manufacturing economy, there is a need for "problem solvers," so if programs like "Hacking For Defense" are producing those individuals, we should explore how it might translate to industry and bringing more "problem solvers" to the workforce.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

"Revitalizing American Leadership in Advanced Manufacturing"

Questions for the Record to:
Mr. Ryan Myers
Director of Business Development - DoD
Hexagon Manufacturing Intelligence
Submitted by Congressman Anthony Gonzalez on behalf of Congressman Tom Reed

1. Will you compare and contrast the Manufacturing USA program to similar programs in other advanced industrial nations, including Germany, Korea, and China? Comment on the comparative investments made in those programs, the lifecycle of the programs in terms of transitioning results to the private sector, and the relationships between government and the private sector in supporting the programs.

2. The Nationally Security Strategy of the United States published by the White House in December 2017 states that "Economic security is national security" and calls out the need to lead in research, technology, invention, and innovation. Working with broad outreach to US stakeholders, NIST published the "Return on Investment Initiative Draft Green Paper" in December 2018 as part of the President's Management Agenda in support of that need. The report identifies strategies to transfer the results of Federal R&D investment to the benefit of our county's commercial, economic, and national security interests. This report is the most extensive of its kind to explore the value of Federal US research investments. The Manufacturing USA program is uniquely positioned to address these strategies. The strategies addressed are https://www.nist.gov/tpo/return-investment-roi-initiative/green-paper
   - Regulatory and administrative improvements
   - Private sector engagement
   - Entrepreneurial workforce
   - Tools and services for technology transfer
   - Understanding of global science and technology trends and benchmarks

   Which of those strategies, does the Manufacturing USA program directly address and provide examples of ways the program and/or the manufacturing centers contribute to the success of a vibrant US program to support the transition of our federal research programs to national manufacturing opportunities?

3. A stated purpose of the hearing was to examine ways to enable decarbonization of the manufacturing sector in an effort to transition to a carbon-free future, and the role of the Manufacturing USA Institutes in achieving this goal. The industrial sector's electricity production (excluding electricity purchases) is projected to increase by 39% by 2050, and carbon emissions from manufacturing of bulk chemicals and plastics, food products, construction, and fabricated metal products are projected to increase. (EIA, "Annual Energy Outlook," Table 19; Vine and Ye, "Decarbonizing U.S. Industry," 1–3.) The industrial sector includes two categories of emissions that cannot be eliminated through electrification, meaning that if clean sources of electricity were available these categories would still be carbon producers. "Process" emissions result directly from industrial processes (such as steam methane reforming to make ammonia) and are independent from the source of energy used to drive the process. And the high-temperature heat (i.e., temperatures greater than 750°F) used in many industrial processes is currently provided by fossil fuel combustion and cannot be easily electrified. A recent study published in Science quantifies these "difficult-to-eliminate" emissions. (https://science.sciencemag.org/content/360/6396/eaas9793.full)

   Do you see an opportunity for the Manufacturing USA Program to lead the way in addressing decarbonization in these fields in conjunction with the other stated objectives of strengthening the US manufacturing base? In other words, would decarbonization technologies for these sectors be an opportunity for US exports to existing and emerging manufacturing-based economies that need to control their carbon production? Is there a federal agency qualified to lead such an effort in collaboration with industry to develop these capabilities and would the Manufacturing US program be a constructive partnership program for implementing?

Answers for Congressman Gonzalez and Congressman Reed

Will you compare and contrast the Manufacturing USA program to similar programs in other advanced industrial nations……

- While there is tremendous value in the Manufacturing USA institutes, the United States is lagging behind some of the other industrialized nations in investing in similar programs. For example, according to information recently published by the National Academies of Sciences, Germany, United Kingdom, Belgium, Singapore, and Taiwan each invest significantly more as a comparison between the funding provided and the manufacturing portion of the GDP. The same data shows that the organizations in those countries have been in existence longer than the Manufacturing USA institutes, with a percentage of funding come from the federal government annually. For example, the Fraunhofer in Germany have been in existence since 1949 with 33% of its funding coming from the government annually.

Which of those strategies in the "Return on Investment Green Paper" does the MFG USA institutes directly address and how do they contribute to the success of a vibrant US program to support the transition of our federal research programs to national manufacturing opportunities?

- As the question states, the Manufacturing USA institutes are in a unique position to address many of the strategies in the Green Paper. They are well equipped to engage the private sector, the entrepreneurial workforce and providing tools and services for technology transfer. In fact, those three strategies are how and why we at Hexagon became involved in the institutes. We saw engaging with them as an opportunity to provide equipment that manufacturers – specifically small or medium-sized companies - could use to further iterate on their technology innovations and put them in a position to deliver to the market. It has also been our experience that the leadership in place at the institutes have tremendous industry backgrounds which provides them with a perspective to know what manufacturing trends are on the horizon and what is occurring globally.

Decarbonization…

- I don't have enough information on that as it is not in mine or Hexagon's expertise…

Responses by Mr. Mike Molnar

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY

"Revitalizing American Leadership in Advanced Manufacturing"

Questions for the Record to:
Mr. Mike Molnar
Director of the Office of Advanced Manufacturing,
National Institute of Standards and Technology
Submitted by Ranking Member Jim Baird

1. Many of the manufacturers in Indiana's 4th Congressional district are small to medium sized. Two years-ago Congress passed a law directing both the MEP and Manufacturing USA programs to focus their services to small and medium-sized manufacturers.
    a. What progress has your office made in meeting this directive?

NIST Response:
Smaller manufacturing establishments represent an increasing share of the manufacturing landscape and are critical to local economies and the U.S. supply chain. There are more than 291,000 manufacturing establishments in the United States, with 99 percent of them being small- and medium-sized manufacturers (SMMs) with fewer than 500 employees. These manufacturers are an integral part of the American economy and a critical part of the Nation's supply chain, yet often face significant challenges in adopting new manufacturing technologies.

The Revitalize American Manufacturing and Innovation Act of 2014 directed NIST's Advanced Manufacturing National Program Office (AMNPO) to incorporate the Hollings Manufacturing Extension Partnership (MEP)[1] into the Manufacturing USA program planning to ensure that the results of the program reach small and mid-sized companies. MEP helps SMMs to improve the competitiveness of U.S.-based manufacturing by making manufacturing technologies, processes, and services more accessible to SMMs. The MEP National Network™ includes 51 MEP Centers located in all 50 states and Puerto Rico.

MEP entered into memoranda of understanding with Department of Defense (DOD) and Department of Energy (DOE) in 2015 and 2017 respectively to define how institutes and MEP Centers should work together to: 1) facilitate awareness and outreach of institutes' technical areas to SMMs; 2) involve SMMs in institute R&D planning; 3) encourage SMMs to participate in institute R&D; and 4) implement institute R&D results.

In 2017, NIST MEP completed a competitive process to embed MEP Center staff within each Manufacturing USA institute. With this pilot project, these MEP staff are accelerating the transition of the latest and most compelling technological innovations into the manufactured goods produced by SMMs, as well as enabling the small manufacturers to contribute to technology development in the institutes.

[1] The FY 2020 President's Budget request continues the discontinuation of federal funding for the Hollings Manufacturing Extension Partnership Program (MEP). MEP is a federal-state-industry partnership. In FY 2020, no federal funding will be provided for MEP Centers and the Centers will be required to rely on non-Federal funding.

b. Can you please provide some examples of how these programs assist small and medium sized manufacturers, like those in my district, in adopting advanced technologies?

NIST Response:

The Indiana Manufacturing Extension Partnership (MEP), Purdue MEP, is a strong component of the MEP National Network and works closely with several Manufacturing USA institutes. These include engagements with NextFlex, the institute focused on Flexible Hybrid Electronics (FHE), and the MxD digital manufacturing institute (Manufacturing times Digital, the new brand of DMDII—the Digital Manufacturing and Design Innovation Institute). In fact, Purdue University has built a new building to accommodate projects dedicated to accelerating implementation of advanced manufacturing and engagements with Manufacturing USA institutes.

In the first case, Purdue MEP kicked off the NextFlex relationship by touring their facility to learn about flexible hybrid electronics substrates, FHE printing techniques, and FHE components. Purdue MEP identified potential applications for FHE technology, such as asset and environmental monitoring systems, human health and performance monitoring systems, and integrated array antennas. Purdue MEP conducted outreach activities across Indiana to identify and develop collaborative relationships with organizations in the state and region (such as trade organizations, economic development groups, Academia, and National Labs) that advance the transfer of FHE technologies. As a result, Purdue MEP conducted FHE-technology *readiness assessments* for 18 Indiana manufacturers and assisted six companies with FHE-themed technical assistance projects.

In addition, in partnership with MxD and the Illinois Manufacturing Excellence Center (Illinois MEP), Purdue MEP developed a Digital Manufacturing and Design readiness assessment program. Indiana manufacturers participated in five digital manufacturing readiness assessments, providing information on specific areas of where the use of digital manufacturing technology could add value and/or create a competitive advantage. Also, the partnership resulted in the co-facilitation of the rollout of an on-line training series for manufacturers, Digital Manufacturing and Design 101. Finally, the group co-developed and launched a Digital Manufacturing and Design "train-the-trainer" program for the MEP National Network. This resulted in more than half of all 51 MEP Centers being trained in digital manufacturing technology and best practices, as well as information in how to conduct digital manufacturing readiness assessments.

From January 2017 until the end of last year, the Indiana MEP Center completed 657 projects assisting small- and medium-sized manufacturers across Indiana. One hundred seventy-two projects (or 26 percent of the total) involved SMMs in the 4th district.

An example of this work is Calienté LLC, a company that provides high quality, innovative heating solutions to help businesses lower costs. The 25-employee company is based in Fort Wayne. Purdue MEP partnered with Purdue University Fort Wayne and the Indiana Next Generation Manufacturing Competitiveness (IN-Mac) program to identify new competitive technology for Calienté. The technology adoption project enabled automated data logging on the manufacturing floor, and integrated solutions for work-in-process to improve part tracking. It streamlined operations, improved quality control, and led to an increase in sales by $150,000. The company is using more automation without losing employees and is more efficient.

2. What is the one most important policy change you would make to the existing federal advanced manufacturing programs to make them more effective?

NIST Response:
The Revitalize American Manufacturing and Innovation (RAMI) Act of 2014 authorized the Manufacturing USA Program—the Network for Manufacturing Innovation Program. RAMI authorized the creation of a "program" under Department of Commerce (DOC) leadership, designated a National Program Office located at NIST, authorized DOC to sponsor new institutes under a competitive process open to topics proposed by industry, and enabled a "network" of institutes including those sponsored by other agencies.

Since establishment of the first manufacturing innovation institute in August 2012 (AmericaMakes), the network has grown to 14 institutes supported by over $1 billion in federal start-up funding matched by over $2 billion of non-federal co-investment. Five of the institutes are sponsored by DOE, eight by DOD, and one by DOC. The DOE and DOD institutes were established pursuant to existing authorities and appropriations, and the management of those institutes are not subject to the provisions of the RAMI legislation.

Third party evaluations of the program, for example by the National Academies, have confirmed the effectiveness of Manufacturing USA partnership program in advancing the manufacturing technology and workforce development.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
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"Revitalizing American Leadership in Advanced Manufacturing"

Questions for the Record to:
Mr. Mike Molnar
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Submitted by Congressman Anthony Gonzalez on behalf of Congressman Tom Reed

1. Will you compare and contrast the Manufacturing USA program to similar programs in other advanced industrial nations, including Germany, Korea, and China? Comment on the comparative investments made in those programs, the lifecycle of the programs in terms of transitioning results to the private sector, and the relationships between government and the private sector in supporting the programs.

NIST Response:
Programs similar to Manufacturing USA exist in other places, including the Fraunhofer Society in Germany, Catapult High Value Manufacturing in the United Kingdom, IMEC in Belgium, A*Star in Singapore, ITRI in Taiwan, and the MIC-Manufacturing Innovation Centers in China. The following table, adapted from the recently published study on Manufacturing USA by the National Academies Press[2], compares these programs.

Table. Characteristics of International Public-Private Partnerships

	Mfg USA	Fraunhofer	Catapult* HVM	IMEC	A*Star	ITRI	MIC
Country	USA	Germany	UK	Belgium	Singapore	Taiwan	China
Type of organization	Nonprofit	Nonprofit	Nonprofit	Nonprofit	Autonomous Govt	Nonprofit	Govt
Owner	Govt agencies	Fraunhofer Society	Innovate UK	Nonprofit	Govt	Nonprofit	Govt
Est. 2017 DGP ($B)	$19,417	$3,423	$2,496	$426	$292	$566	$11,795
%GDP from Mfg	12%	23%	10%	14$	20%	29%	23%
No. of institutes	14	69	7	9	18	6	8
Year started	2012	1949	2010	1964	1991	1973	2016
Estimated annual budget (US $M)	$330	$2,482	$287	$426	$163	$714	NA
Index: Investment per Mfg GDP	1.0	22.3	8.1	50.4	19.8	30.7	NA
Government direct support after 5 yrs	0%	33%	33%	15%	15%-100%	25%	NA
Government indirect support (projects)	NA	33%	33%	NA	NA	0%	NA

The National Academies Press report attempts to describe how level the playing field is among key industrial nations. The "normalized" investment relative to the United States is given in the line "Index: Investment per Mfg GDP."

[2] The National Academies Press, Strategic Long-Term Participation by DoD in Its Manufacturing USA Institutes (2019). ISBN 978-0-309-49138-0 DOI 10.17226/25417.

2. The Nationally Security Strategy of the United States published by the White House in December 2017 states that "Economic security is national security" and calls out the need to lead in research, technology, invention, and innovation. Working with broad outreach to U.S. stakeholders, NIST published the "Return on Investment Initiative Draft Green Paper" in December 2018 as part of the President's Management Agenda in support of that need. NIST drafted the Green Paper to inform, not prescribe, policy discussion. The paper is a method for NIST to communicate stakeholders' perspectives on today's lab-to-market system. Stakeholders identified a number of opportunities to improve that system including in areas such as regulatory and administrative improvements, private sector engagement, entrepreneurial workforce, tools and services for technology transfer, and global science and technology trends and benchmarks. The full report is available at: https://www.nist.gov/tpo/return-investment-roi-initiative/green-paper

   Which of those strategies, does the Manufacturing USA program directly address and provide examples of ways the program and/or the manufacturing centers contribute to the success of a vibrant US program to support the transition of our federal research programs to national manufacturing opportunities?

NIST Response:
The Manufacturing USA Program focuses on private sector engagement, entrepreneurial workforce, and tools and services for technology transfer.

Information about the Manufacturing USA Program can be found in the program annual report: https://www.manufacturingusa.com/reports/manufacturing-usa-annual-report-fiscal-year-2017

The Return on Investment Initiative Final Green Paper April 2019 is available at https://doi.org/10.6028/NIST.SP.1234

3. A stated purpose of the hearing was to examine ways to enable decarbonization of the manufacturing sector in an effort to transition to a carbon-free future, and the role of the Manufacturing USA Institutes in achieving this goal. The industrial sector's electricity production (excluding electricity purchases) is projected to increase by 39% by 2050, and carbon emissions from manufacturing of bulk chemicals and plastics, food products, construction, and fabricated metal products are projected to increase. (EIA, "Annual Energy Outlook," Table 19; Vine and Ye, "Decarbonizing U.S. Industry," 1-3.) The industrial sector includes two categories of emissions that cannot be eliminated through electrification, meaning that if clean sources of electricity were available these categories would still be carbon producers. "Process" emissions result directly from industrial processes (such as steam methane reforming to make ammonia) and are independent from the source of energy used to drive the process. And the high-temperature heat (i.e., temperatures greater than 750□)used in many industrial processes is currently provided by fossil fuel combustion and cannot be easily electrified. A recent study published in Science quantifies these "difficult-to-eliminate" emissions. (https://science.sciencemag.org/content/360/6396/eaas9793.full)

   Do you see an opportunity for the Manufacturing USA Program to lead the way in addressing decarbonization in these fields in conjunction with the other stated objectives of

strengthening the US manufacturing base? In other words, would decarbonization technologies for these sectors be an opportunity for US exports to existing and emerging manufacturing-based economies that need to control their carbon production? Is there a federal agency qualified to lead such an effort in collaboration with industry to develop these capabilities and would the Manufacturing US program be a constructive partnership program for implementing?

NIST Response:
A number of Manufacturing USA institutes have reduction of both industrial and commercial energy use as part of their missions, thus providing significant decarbonization. In particular, the five Department of Energy Clean Energy Manufacturing Institutes in the Manufacturing USA network have significant contributions. IACMI, the Institute for Advanced Composites Manufacturing Innovation, has reduction of energy in the manufacturing process as a primary goal—50 percent reduction in CFRP (carbon fiber reinforced polymer) embodied energy. Most of the institutes have reduction of energy in industrial processes as part of their role in bringing the Fourth Industrial Revolution to U.S. manufacturing.

Responses by Dr. John Hopkins

INSTITUTE FOR ADVANCED COMPOSITES MANUFACTURING INNOVATION

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY SUBCOMMITTEE ON ENERGY

Revitalizing American Leadership in Advanced Manufacturing

Questions for the Record to:

John A. Hopkins, PhD, PE
Chief Executive Officer
The Institute for Advanced Composites Innovation-The Composite Institute

Submitted by Congressman Anthony Gonzalez on behalf of Congressman Tom Reed

1. ***Will you compare and contrast the Manufacturing USA program to similar programs in other advanced industrial nations, including Germany, Korea, and China? Comment on the comparative investments made in those programs, the lifecycle of the programs in terms of transitioning results to the private sector, and the relationships between government and the private sector in supporting the programs.***

RESPONSE:

While the USA boasts 12% of its GDP from Manufacturing, the overall the Manufacturing USA program is significantly underfunded when comparing the percentage of research and development dollars allocated to the institutes and partners as compared to international peers. A 2017 analysis of non-US international manufacturing innovation centers projected between 15-100% of direct support after 5 years for most comparable international centers with Germany and the UK Innovation hubs expected to average 33% continued direct support. Information was not readily available for future Chinese investments. No U.S. investment in the Department of Energy Manufacturing USA institutes after 5 years is currently expected.

The collective $330M U.S. investment in research and development with the Manufacturing USA institutes reflects an investment rate of 0.014% U.S. investment dollars in the institutes as a percent of Manufacturing 2017 GDP dollars. This same comparison for international institutes reflects significantly stronger percentage of research investment as a percent of MFG GDP. For example, Germany effectively invests 20 times more, as it invests $2,5B a year in its manufacturing research centers, reflecting an investment rate of 0.29% for its total $787B GDP manufacturing dollars.

The information in the chart below was presented at a Spring 2018 Manufacturing USA network meeting in San Jose, California.

Attribute	Manufacturing USA	Fraunhofer	Catapult HVM	IMEC	A*Star	ITRI	MIC
Owner	Government Agencies	Fraunhofer Society	Innovate UK	Non Profit	Gov't Of Singapore	Non Profit	Government of China
Type of Governing Organization	Non Profit	Non Profit	Non Profit	Non Profit	Autonomous Government	Non Profit	Government
Country	USA	Germany	UK	Belgium	Singapore	Taiwan	China
EST 2017 GDP (US$Billions)	$ 19,417	$ 3,423	$ 2,496	$ 426	$ 292	$ 566	$ 11,795
EST 2017 GDP Actual Dollars	$ 19,417,000,000,000	$ 3,423,000,000,000	$ 2,496,000,000,000	$ 426,000,000,000	$ 292,000,000,000	$ 566,000,000,000	$ 11,795,000,000,000
Percent GDP from Mfg	12%	23%	10%	14%	20%	29%	23%
# of Institutes	14	69	7	9	18	6	2
Yr. Started	2012	1949	2010	1984	1991	1973	2016
Est Total Budget/Year (USD millions)	330	2482	287	426	163	570	NA
Research done by institute and partners**	Partners Only	Yes	Yes	Yes	Yes	Yes	NA
Index/Mfg GDP	1	22.3	8.1	50.4	19.8	24.5	NA
Government direct support after 5Y	0%	33%	33%	15%	15-100%	25%	NA
Government Indirect Support (Competitive Projects	NA	33%	33%	NA	0%	NA	

The U.S. based institutes have a strong co-investment model with FY 2016 matching funds cited as 2:1 and 66% of institute support coming from non-federal matching funds. Industry driven support of the institutes remains strong due to the strength of the supply chain ecosystems driven by the institutes and the innovations infrastructure assets in place. These collective resources help enable legislation such as the Bayh-Dole Act to encourage private industry to facilitate further development of federally funded research inventions.

Source: National Academies Presentation by Mike Molnar, Director of NIST Office of Advanced Manufacturing
http://sites.nationalacademies.org/cs/groups/pgasite/documents/webpage/pga_182911.pdf)

Although the specific investments of China are not confirmed, it is worth noting multiple sources highlight China's manufacturing prominence and provide a contrast for US manufacturing strategies compared to their future plans as outlined in *Made in China 2025*.

China's strong investment in manufacturing through its Made in China 2025 plan is projected to be a multi-billion dollar investment aimed at solidifying China's competitive industrial position.

Source: 2019 Council on Foreign Relations, https://www.cfr.org/backgrounder/made-china-2025-threat-global-trade

The importance of US manufacturing to national security is emphasized in President Trump's New National Security Strategy issued on December 18, 2017, wich aims to address key challenges and trends that affect the U.S. standing in the world. Protecting the Homeland is a fundamental responsibility and the strategy cites a commitment to "redouble our efforts to protect critical infrastructure and digital networks, because new technology and new adversaries create new vulnerabilities." Also referenced in the strategy is the goal of Promoting American Prosperity, as a strong economy protects the American people, supports our way of life, and sustains American power. The Manufacturing USA institutes catalyze economic development for Americans and help ensure the U.S. remains competitive its mission to lead innovations in technology.

Source: White House website, https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf

2. ***The National Security Strategy of the United States published by the White House in December 2017 states that "Economic security is national security" and calls out the need to lead in research, technology, invention, and innovation. Working with broad outreach to US stakeholders, NIST published the "Return on Investment Initiative Draft Green Paper" in December 2018 as part of the President's Management Agenda in support of that need. The report identifies strategies to transfer the results of Federal R&D investment to the benefit of our county's commercial, economic, and national security interests. This report is the most extensive of its kind to explore the value of Federal US research investments. The Manufacturing USA program is uniquely positioned to address these strategies. The strategies addressed are https://www.nist.gov/tpo/return-investment-roi-initiative/green-paper***
   - ***Regulatory and administrative improvements***
   - ***Private sector engagement***
   - ***Entrepreneurial workforce***
   - ***Tools and services for technology transfer***
   - ***Understanding of global science and technology trends and benchmarks***

   Which of those strategies, does the Manufacturing USA program directly address and provide examples of ways the program and/or the manufacturing centers contribute to the success of a vibrant US program to support the transition of our federal research programs to national manufacturing opportunities?

RESPONSE:

The Manufacturing USA institutes are well positioned to contribute to a vibrant US program to support the transition of federal research programs to national manufacturing opportunities.

Although institute activities overlap with most of the listed strategy elements, there are several they address directly. Specific impact opportunities for strategies addressed in the NIST ROI Green Paper are below:

Strategy 2: Increase engagement with private sector technology development experts and investors
Private sector engagement is catalyzing the impact of the Manufacturing USA program through its $2b in investment, over 1,300 member organizations engaged, and partnership to equip more than 200,000 people with advanced manufacturing skills. Through the private sector engagement, supply chain synergies and innovation assets are enabling faster speed to market.

As an example, below is a case study synopsis of a recent IACMI technical research and development project that has enabled significant commercial growth for multiple companies involved in the project.

Case Study

Techmer PM and Local Motors IACMI technical project example

"Our participation in IACMI allowed us to develop new technologies that have contributed to Techmer PM's growth in the additive manufacturing ecosystem."
Tom Drye, Vice President of Emerging Markets & Innovation and Application Development, Techmer PM

Challenge

Improve the material options and printing processes for additive manufacturing (3D printing) that enables Local Motors to commerically produce its 3D printed vehicles

Objectives

- Increase the variety of materials available for additive manufacturing
- Better understand 3D printed materials' properties to make reliable manufacturing decisions

Impact

Significant commercial growth for multiple companies involved in the project

Techmer PM

- Techmer PM has had significant sales of new 3D products and expects to double sales in 2019
- Techmer PM is helping lead the growth and acceptance of large part additive manufacturing through materials designed specifically for optimum performance and reliability in additive manufacturing
- Customer demand is driving installation of a new multi-million dollar manufacturing line to meet the increased 3D materials need of Techmer's customers

Local Motors

- Local Motors installed the world's largest 3D printer, made by Thermwood, at its Knoxville, TN microfactory
- Local Motors to commercially produce Olli 2.0 at Knoxville, TN microfactory beginning in July 2019

Strategy 3: Build a more entrepreneurial R&D workforce
Through the strong partnership with the NIST MEP and other partners, the Manufacturing USA ecosystem is collectively engaging with small and medium sized businesses through supply chain networking, workforce training, and business opportunities through local, regional, and national SBIR programs.

Over 50% of IACMI's 130 industry members represent small and medium sized companies. This segment of membership benefits strongly from engagement with the IACMI partners from academia, national laboratories, and larger companies as the organizations greatly increase their respective sphere of influence and innovation capacity that wouldn't be possible without the ecosystem exposure. Since fewer resources need to be allocated to individual ecosystem supply chain research, more effort is spent on entrepreneurial vision, research, and workforce development.

IACMI and other Manufacturing USA institutes have developed nationally recognized work and learn programs such as intern and apprenticeship initiatives that provide mutual benefit. Students receive the opportunity to work alongside industry increasing connections and connectivity to academic training and employers yield an opportunity to build their respective future employee pipeline.

Strategy 5: Improve understanding of global science and technology trends and benchmarks
The Manufacturing USA institute ecosystems of collaboration and innovation are enabling private industry to network with university and federal laboratory partners and develop technology roadmaps specific to market opportunities. This provides a new, cross-cutting framework for information sharing that supplements that of technical societies and trade organizations. The network also provides for information sharing within the context of supply chain partnerships and the technoeconomic decision-making required for investment in technology adoption and scale-up. Shared research and development and communication of outcomes and innovation best practices enables private industry to prioritize their respective demonstration and commercialization efforts.

3. ***A stated purpose of the hearing was to examine ways to enable decarbonization of the manufacturing sector in an effort to transition to a carbon-free future, and the role of the Manufacturing USA Institutes in achieving this goal. The industrial sector's electricity production (excluding electricity purchases) is projected to increase by 39% by 2050, and carbon emissions from manufacturing of bulk chemicals and plastics, food products, construction, and fabricated metal products are projected to increase. (EIA, "Annual Energy Outlook," Table 19; Vine and Ye, "Decarbonizing U.S. Industry," 1-3.) The industrial sector includes two categories of emissions that cannot be eliminated through electrification, meaning that if clean sources of electricity were available these categories would still be carbon producers. "Process" emissions result directly from industrial processes (such as steam methane reforming to make ammonia) and are independent from the source of energy***

used to drive the process. And the high-temperature heat (i.e., temperatures greater than 750□)used in many industrial processes is currently provided by fossil fuel combustion and cannot be easily electrified. A recent study published in Science quantifies these "difficult- to-eliminate" emissions.
(https://science.sciencemag.org/content/360/6396/eaas9793.full)

Do you see an opportunity for the Manufacturing USA Program to lead the way in addressing decarbonization in these fields in conjunction with the other stated objectives of strengthening the US manufacturing base? In other words, would decarbonization technologies for these sectors be an opportunity for US exports to existing and emerging manufacturing-based economies that need to control their carbon production? Is there a federal agency qualified to lead such an effort in collaboration with industry to develop these capabilities and would the Manufacturing US program be a constructive partnership program for implementing?

RESPONSE:

Yes, the Manufacturing USA program, through its networks of innovation leaders industry consortia can address decarbonization. The institutes have the capacity to address these challenges at both the process and product levels. For example, decarbonization can be driven through adoption of materials such as textile carbon fiber that uses process improvements to reduce the energy required for production and thus the carbon footprint of products made with these fibers. This also leads to a substantial cost reduction, as energy costs for the production of the fiber are a substantial portion of the total cost of carbon fiber composite parts. A reduction in cost makes the textile carbon fiber a more economically viable substitute for traditional materials, so that not only does textile carbon fiber provide a direct decarbonization benefit when substituted in existing carbon fiber applications, it also provides substantial potential benefit through large scale substitution in specific application spaces.

For example, greater use of carbon fiber composites in automobiles is a significant goal for IACMI, as lightweighting directly reduces energy use during its operating life. However, there are other application markets that are enabled by the lower cost of carbon fiber composites, and some of these have even more significant potential impact on decarbonization at a global scale. If carbonization and carbon footprint are considered within a holistic global system, the life cycle of infrastructure such as buildings, roadways, etc. represent a significant fraction of the total footprint. As the world population grows to its expected peak over the next twenty years, it will become increasingly important to consider carbon footprint for these applications. When lower cost carbon fiber is considered with the significant progress IACMI and partners such as ACMA are helping drive in advanced composite recyclability, it is possible to envision these materials providing an even greater global decarbonization impact by substituting lower cost, longer-lasting carbon fiber composites for steel and concrete in infrastructure.

The Manufacturing USA institutes and their industry consortia members have the opportunity to lead the development and implementation of novel materials and processes for decarbonization. This provides an advantage for the institutes serving national interests, and US companies leading related global markets. Leading such an initiative across institutes would best be served by inter-agency cooperation. Topically, many of the Department of Energy's mission objectives, including those in the Advanced Manufacturing Office, directly impact or touch on decarbonization. When the broader manufacturing and process development elements are considered, together with the question of how to facilitate inter-Manufacturing USA institute collaboration, both the Department of Commerce and Defense have existing roles that also serve this greater goal. If a single point of coordination is desirable for the Manufacturing Institutes to serve national interests that span agencies, Commerce's history of supporting broad manufacturing-related initiatives and programs could make them a candidate for serving that role.

Responses by Ms. Valri Lightner

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Questions for the Record Responses from Valri Lightner
"Revitalizing American Leadership in Advanced Manufacturing"
March 26, 2019

QUESTIONS FROM REPRESENTATIVE DANIEL LIPINSKI

Q1. I understand the Department of Energy published a Notice of Intent regarding its plans to compete a sixth Manufacturing USA Institute entitled "Clean Energy Manufacturing Innovation Institute: Cybersecurity in Energy Efficient Manufacturing." While I am in agreement that cybersecurity is a threat to the manufacturing sector and it is important to develop new cybersecurity technologies and share information with U.S. manufacturers, I am concerned that this new institute would significantly duplicate efforts with the DOD-sponsored Manufacturing Times Digital (MxD) institute in the state of Illinois. In 2018, the DOD established the National Center for Cybersecurity in Manufacturing at MxD, which was known as the Digital Manufacturing and Design Innovation Institute (DMDII) at the time. One of the core missions of the Cybersecurity Center at MxD is to work with small medium, and large manufacturers to enhance awareness of cybersecurity threats, and develop and implement technologies that increase the resilience of the manufacturing industrial base and supply chain.

Q1a. Would it be more efficient use of limited government resources for DOE to combine efforts with the Department of Defense institute, already competed, awarded, and executing research and development in cybersecurity?

A1a. The EERE Institute will focus on R&D to enable energy efficient manufacturing, which is an inherently different mission than MxD. Close coordination and collaboration between the DOE, DHS, and DOD efforts will ensure efficient and effective use of federal resources. It is also important to run an open and competitive solicitation to ensure the best applicant is selected. DOE has asked DOD personnel to serve on the proposal review teams to ensure that DOE and DOD efforts are integrated.

Members of existing DOE, DOD, and Department of Commerce Manufacturing USA Institutes may be eligible to apply as primes or sub-recipients to the funding opportunity announcement that was released on March 26, 2019, which includes specific eligibility requirements.

Q2. How do you intend to ensure the efforts of this new DOE institute would not conflict with or draw committed partners and resources away from the established DOD institute?

A2. DOE is committed to ensuring the Cybersecurity in Energy Efficient Manufacturing Institute (Institute) is coordinated with efforts across the federal government, including

but not limited to DOD, the Department of Homeland Security and the Department of Commerce. Within DOE, while the Institute is being funded and managed by EERE, it is in partnership with the Office of Cybersecurity, Energy Security and Emergency Response (CESER). DOE has already involved DOD in the review of the draft Institute FOA and DOE is committed to ongoing coordination with DOD during the award selection and performance period. For instance, DOE has asked DOD personnel to serve on the proposal review teams to ensure that DOE and DOD efforts are integrated.

Institutes in other complementary areas have strong membership without drawing members from other institutes. For example, MxD reports 324 members and CESMII (DOE smart manufacturing) reports 100 members. DOD LIFT (lightweight metals) reports 88, while DOE IACMI (lightweight composites) reports 153 members. The DOD additive manufacturing institute (America Makes) and Oak Ridge National Lab's Materials Demonstration Facility are both working well with complementary roles.

Q3. What is the unique vision for this DOE institute that is not yet addressed elsewhere?

A3. DOE has an important mission to improve the energy efficiency of manufacturing. Lawrence Berkeley National Laboratory estimates that the adoption of automated controls and sensors provide the potential for up to 15% improvement in manufacturing energy efficiency. However, cybersecurity risks limit increased adoption and implementation of automation, advanced sensors and controls necessary to achieve this potential. Our Cybersecurity in Energy Efficient Manufacturing Institute will focus on early-stage research to better understand the cybersecurity threats in advanced manufacturing and to develop innovative new technologies, such as cyber-secure sensors and controls, for manufacturing and catalyze their adoption. The DOE Institute is also expected to provide the framework for Coordinated Vulnerability Disclosures (CVD) to improve the safety and security of the advanced manufacturing and energy intensive industries.

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Q4. How are you coordinating with the Department of Defense and other federal agencies on this institute?

A4. Within DOE, the Cybersecurity in Energy Efficient Manufacturing Institute (Institute) is being funded and managed by EERE in partnership with Office of Cybersecurity, Energy Security and Emergency Response (CESER). One of CESER's key priorities is working closely with local, state, and federal agency partners, as well as energy sector industry partners.

To make sure the efforts of the Institute would not duplicate or overlap technical scope, DOE proactively provided the draft Funding Opportunity Announcement (FOA) to our DOD federal partners for input. DOE is committed to involving DOD in the review and selection of applications for the Institute. DOE will also coordinate with DOD during award negotiations to ensure the technical scope is not duplicative with the cybersecurity efforts of MxD (the DOD Institute). During the award performance period, DOD will be included in the governance board of the selected institute. DOE will also use program management milestones to ensure management coordination between the DOE and DOD efforts. DOE has used this approach to effectively coordinate complementary efforts within the Department previously (e.g., ARPA-E and EERE have utilized milestones requiring recipients to coordinate).

Additionally, the DOE Institute will use the National Institute of Standards and Technology (NIST) developed cyber security framework consisting of standards, guidelines, and best practices and coordinate with NIST on the cybersecurity efforts of the Manufacturing Extension Partnership Program.

As it does with the other five DOE-funded Manufacturing USA institutes, DOE will work with the Advanced Manufacturing National Program Office, headquartered at NIST, to coordinate this institute's efforts with the DOD and the Department of Commerce as funding agencies of institutes, as well as with other agencies, such as the Department of

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Labor (DOL), the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the U.S. Department of Agriculture (USDA).

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QUESTIONS FROM REPRESENTATIVE ANTHONY GONZALEZ ON BEHALF OF REPRESENTATIVE TOM REED

Q1. Will you compare and contrast the Manufacturing USA program to similar programs in other advanced industrial nations, including Germany, Korea, and China? Comment on the comparative investments made in those programs, the lifecycle of the programs in terms of transitioning results to the private sector, and the relationships between government and the private sector in supporting the programs.

A1. In his written testimony for the hearing, Mr. Molnar (Director of the Office of Advanced Manufacturing at the U.S. Department of Commerce's National Institute of Standards and Technology, summarized key investments other countries have made in programs similar to the Manufacturing USA program: "Although the United States has established 14 Institutes, that is many fewer than the German counterpart, Fraunhofer, which has 69 institutes and China's planned 40 institutes."

The Advanced Manufacturing Office (AMO), within the Office of Energy Efficiency and Renewable Energy, manages the DOE's Clean Energy Manufacturing Institutes, which are led by independent organizations. The institutes are large-scale, public-private partnerships that are formally recognized as part of the Manufacturing USA network. Leveraging shared research facilities, multidisciplinary teams from industry, academia, National Labs, and state and local governments, the institutes create innovation ecosystems to accelerate technology development. The institutes include education and workforce development activities to prepare the workforce for the advanced manufacturing jobs of the future.

The $70 million federal investment is to catalyze collaboration in the first five years. During that time the institutes work with their membership to develop a plan for Years 6 and beyond. Those plans vary depending on the needs of the industry and include non-federal resources for management and operations and a strategy to compete for federal and state research and development funding.

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The Korea Institute of Industrial Technology (KIIT) was established in 1989 and provides grants to mostly private small- and medium-sized companies, with a few exceptions to universities. In 2014, KIIT had a total budget of $291 million, of which 85% was received from the federal government and the rest from industrial or other sources, with funding going towards applied R&D projects.

Germany's Fraunhofer Society was established in 1949 and currently includes 72 institutes focused on applied research and development across various technology domains relevant to manufacturing. Each Fraunhofer institute is established with a university that has the unique capabilities and expertise in a specific technology area and contracts with German small- and medium-sized enterprises on a research and development portfolio. In 2017, the Fraunhofer Society had a total budget of about $2.6 billion, with about $2.25 billion in contract research. About 30% of the budget comes from the government (90:10, federal to state) with the remaining 70% from industry or indirect government funding. In addition to other review criteria, Fraunhofer institutes continue to exist as long as the institute does not incur financial losses over several consecutive years.

China has instituted a fully formed, broad government-run system to build specific, strategic, advanced technology manufacturing industries. While the Made in China 2025 industrial plan is the most well-known and discussed, China has numerous industrial plans at both the national and local levels that make up a state-led system with the Chinese government playing a central role. China's system is dependent upon government intervention and financial support, and promotes indigenous production. It aims to create 15 manufacturing innovation centers by 2020 and 40 by 2025. For a full description of Made in China 2025, *see* Office of the United States Trade Representative, Executive Office of the President (2018). "Findings of the Investigation into China's Acts, Policies, and Practices Related to Technology transfer, Intellectual Property, and Innovation Under Section 301 of the Trade Act of 1974". Washington, D.C. G.P.O.

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Q2. The Nationally Security Strategy of the United States published by the White House in December 2017 states that "Economic security is national security" and calls out the need to lead in research, technology, invention, and innovation. Working with broad outreach to US stakeholders, NIST published the "Return on Investment Initiative Draft Green Paper" in December 2018 as part of the President's Management Agenda in support of that need. The report identifies strategies to transfer the results of Federal R&D investment to the benefit of our country's commercial, economic, and national security interests. This report is the most extensive of its kind to explore the value of Federal US research investments. The Manufacturing USA program is uniquely positioned to address these strategies. The strategies addressed are https://www.nist.gov/tpo/return-investment-roi-initiative/green-paper

- Regulatory and administrative improvements
- Private sector engagement
- Entrepreneurial workforce
- Tools and services for technology transfer
- Understanding of global science and technology trends and benchmarks

Q2a. Which of those strategies, does the Manufacturing USA program directly address and provide examples of ways the program and/or the manufacturing centers contribute to the success of a vibrant US program to support the transition of our federal research programs to national manufacturing opportunities?

A2a. Manufacturing USA directly addresses four of these strategies: private sector engagement, entrepreneurial workforce, tools and services for technology transfer (for example, by providing small businesses with shared facilities to test prototype technologies), and understanding of global science and technology trends and benchmarks.

Manufacturing USA Institutes seek to address the complex technology transition challenges associated with advanced manufacturing that exist between early-stage research and technology adoption. To provide ongoing focus and guidance for its stakeholders, Manufacturing USA's vision, mission, and goals were documented in the program's first strategic plan. The program's four goals are to: 1) increase the competitiveness of U.S. manufacturing; 2) facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing

capabilities; 3) accelerate the development of an advanced manufacturing workforce; and 4) support business models that help the Manufacturing USA Institutes to become stable and sustainable after the initial federal startup funding period.

With respect to private sector engagement, DOE institutes have leveraged $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.

Each DOE institute has a dedicated effort in entrepreneurial workforce development. For example:

- The Institute for Advanced Composite Innovation (IACMI) has trained over 2,000 people via hands-on composite manufacturing workshops, has placed 100 students into internships, and educated over 9,000 students of all ages about composites.
- The Rapid Advancement in Process Intensification Deployment (RAPID) Institute trained over 1,000 participants via a 10-part webinar series on process intensification fundamentals, along with one additional webinar on Module Manufacturing.

Examples of technology transfer through DOE Institutes include:

- Through the use of IACMI's shared scale up research facility in Corktown, Michigan, a group led by Ford, Dow, and DowAksa collaborated on a project 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.

- PowerAmerica, focused on advancing wide bandgap power electronics, partnered with X-FAB in Lubbock, Texas, to modify a foundry line to process silicon carbide. X-FAB now has the capacity to process 1,500 six-inch wafers per month to device manufacturer specifications. Thirteen device manufacturers are using the facility to process wafers.

In order to stay on the cutting edge of innovation, each institute conducts analysis to understand global science and technology trends and benchmark technology development.

While Congressional report language calls for funding the manufacturing institutes, the FY2020 Budget favors a transition away from the institute model because the mortgaging of future appropriations reduces budgetary flexibility. Instead, the Budget proposes a set of smaller and more directly managed, early-stage, R&D consortia activities.

Q3. A stated purpose of the hearing was to examine ways to enable decarbonization of the manufacturing sector in an effort to transition to a carbon-free future, and the role of the Manufacturing USA Institutes in achieving this goal. The industrial sector's electricity production (excluding electricity purchases) is projected to increase by 39% by 2050, and carbon emissions from manufacturing of bulk chemicals and plastics, food products, construction, and fabricated metal products are projected to increase. (EIA, "Annual Energy Outlook," Table 19; Vine and Ye, "Decarbonizing U.S. Industry," 1-3.) The industrial sector includes two categories of emissions that cannot be eliminated through electrification, meaning that if clean sources of electricity were available these categories would still be carbon producers. "Process" emissions result directly from industrial processes (such as steam methane reforming to make ammonia) and are independent from the source of energy used to drive the process. And the high-temperature heat (i.e., temperatures greater than 750) used in many industrial processes is currently provided by fossil fuel combustion and cannot be easily electrified. A recent study published in Science quantifies these "difficult-to eliminate" emissions. (https://science.sciencemag.org/content/360/6396/eaas9793.full)

Q3a. Do you see an opportunity for the Manufacturing USA Program to lead the way in addressing decarbonization in these fields in conjunction with the other stated objectives of strengthening the US manufacturing base? In other words, would decarbonization

technologies for these sectors be an opportunity for US exports to existing and emerging manufacturing-based economies that need to control their carbon production? Is there a federal agency qualified to lead such an effort in collaboration with industry to develop these capabilities and would the Manufacturing US program be a constructive partnership program for implementing?

A3a. The DOE Manufacturing USA Institutes' mission space reflects the strategic goals of the Advanced Manufacturing Office, which include improving the productivity and energy efficiency of U.S. manufacturing and reducing the life cycle resource impacts of manufactured goods. Within that context, innovation and technology advancements being pursued through the current DOE-funded institutes will reduce carbon intensity. However, while Congressional report language calls for funding the manufacturing institutes, the FY2020 Budget favors a transition away from the institute model because the mortgaging of future appropriations reduces budgetary flexibility. Instead, the Budget proposes a set of smaller and more directly managed, early-stage, R&D consortia activities.

By pursuing a variety of technologies, product design choices, and operational approaches, industry, can cost-effectively reduce energy consumption and GHG (including carbon emissions) across a broad range of industries, and provide products with reduced environmental impacts. Additionally, technologies that can extend the useful lifetime of materials (e.g. via recovery of secondary materials), or extend the useful lifetime of products (e.g. via remanufacturing), can provide co-benefits to manufacturers via reduced energy and materials costs. Breakthroughs in areas such as additive manufacturing, chemical catalysis and intensification, and facility automation are transforming manufacturing. Techniques such as lightweighting and design for reuse offer ways to reduce material consumption while providing equivalent or improved services. These approaches also provide new domestic and export opportunities for U.S. manufacturers.

HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY
Questions for the Record Responses from Valri Lightner
"Revitalizing American Leadership in Advanced Manufacturing"
March 26, 2019

There are additional opportunities for technology development, which are needed to target non-energy process-related emissions, and emissions from thermal demands in energy intensive industrial subsectors. Some examples include renewable electricity-sourced hydrogen (i.e., via electrolysis) as a direct fuel and as a chemical feedstock for ammonia synthesis; electrotechnologies to augment or replace traditional process heating via combustion; and industrial carbon capture and use technologies that do not result in a net cost burden to manufacturers.

Responses by Dr. Mitchell Dibbs

April 24, 2019

Chairwoman Haley M. Stevens
Subcommittee on Research and Technology
Committee on Science, Space, and Technology

Conor Lamb
Chairman
Subcommittee on Energy
Committee on Science, Space, and Technology

To the attention of:

Subcommittee on Research and Technology
Committee on Science, Space, and Technology
U.S. House of Representatives
2321 Rayburn House Office Building
Washington, D.C. 20515

Re: March 26, 2019 hearing entitled *"Revitalizing American Leadership in Advanced Manufacturing"*

Answers to questions for the Record:

Submitted by Ranking Member Jim Baird

1. In your prepared testimony, you note your involvement with the Advanced Manufacturing Partnership 2.0, and in particular you highlight your recommendations for structuring the Manufacturing Innovation Institutes — the foundation for Manufacturing USA.
   a. In what way have the Institutes met your expectations?
      The potential of the Manufacturing Innovation Institutes as anticipated by AMP 2.0 was to provide a forum and framework for large, medium, and small manufacturers, equipment suppliers, federal labs, and academic researchers to work together to address the development and demonstration of manufacturing innovations. This has been realized.

b. What, if any, changes would you make to your recommendations today, based on their progress in the past five years or so?
The recommendations made in AMP 2.0 still stand today. However, not all recommendations were fully addressed. The institutes have been slow to launch and slow to implement projects. Each institute has experienced the same growing pains without broader network support. The AMP 2.0 report recommended the establishment of a network with shared guidelines for organization, operational structure, and intellectual property management, balancing consistency and individual institute autonomy. This body of shared communication and practices has not been fully realized.

Submitted by Congressman Anthony Gonzalez on behalf of Congressman Tom Reed

1. Will you compare and contrast the Manufacturing USA program to similar programs in other advanced industrial nations, including Germany, Korea, and China? Comment on the comparative investments made in those programs, the lifecycle of the programs in terms of transitioning results to the private sector, and the relationships between government and the private sector in supporting the programs.

   There has already been mention of the German Fraunhofer Institutes in this hearing.

   Unlike programs in U.S. and Europe, multinational manufacturers are not eligible for government funding in China, so we have no direct experience to provide a basis for comment.

   In Europe, Horizon 2020 is a research and innovation program with almost 80 billion euros in funding over 7 years and built off the long-standing precedent Framework Programs. Horizon 2020 is designed to make it easier for public and private sectors to collaborate on innovative research, development and demonstration. The follow-on program, Horizon Europe, is already under development. There is a misperception in the U.S. that industry will frequently fund demonstration projects for high risk technologies. For manufacturing the risk and investment is very high with the potential for total failure, leading to demonstrations being the exception rather than the rule. This has been recognized by EU which provides more funding for realistic pilot demonstrations at much higher Manufacturing Readiness Levels.

2. The Nationally Security Strategy of the United States published by the White House in December 2017 states that "Economic security is national security" and calls out the need to lead in research, technology, invention, and innovation. Working with broad outreach to US stakeholders, NIST published the "Return on Investment Initiative Draft Green Paper" in December 2018 as part of the President's Management Agenda in support of that need. The report identifies strategies to transfer the results of Federal R&D investment to the benefit of our county's commercial, economic, and national security interests. This report is the most extensive of its kind to explore the value of Federal US research investments. The Manufacturing USA program is uniquely positioned to address these strategies. The

strategies addressed are https://www.nist.gov/tpo/return-investment-roi-initiative/green-paper

- Regulatory and administrative improvements
- Private sector engagement
- Entrepreneurial workforce
- Tools and services for technology transfer
- Understanding of global science and technology trends and benchmarks

Which of those strategies, does the Manufacturing USA program directly address and provide examples of ways the program and/or the manufacturing centers contribute to the success of a vibrant US program to support the transition of our federal research programs to national manufacturing opportunities?

Dow provided input to the Draft Green Paper, with comments provided to the Request For Information and participation in the summit hosted by NIST. Many of our submitted comments address this question. Overall, the Manufacturing USA program plays an important role in the technology development ecosystem in the U.S. and has the potential to continue to evolve and increase its impact.

3. A stated purpose of the hearing was to examine ways to enable decarbonization of the manufacturing sector in an effort to transition to a carbon-free future, and the role of the Manufacturing USA Institutes in achieving this goal. The industrial sector's electricity production (excluding electricity purchases) is projected to increase by 39% by 2050, and carbon emissions from manufacturing of bulk chemicals and plastics, food products, construction, and fabricated metal products are projected to increase. (EIA, "Annual Energy Outlook," Table 19; Vine and Ye, "Decarbonizing U.S. Industry," 1-3.) The industrial sector includes two categories of emissions that cannot be eliminated through electrification, meaning that if clean sources of electricity were available these categories would still be carbon producers. "Process" emissions result directly from industrial processes (such as steam methane reforming to make ammonia) and are independent from the source of energy used to drive the process. And the high-temperature heat (i.e., temperatures greater than 750°F) used in many industrial processes is currently provided by fossil fuel combustion and cannot be easily electrified. A recent study published in Science quantifies these "difficult to-eliminate" emissions.
(https://science.sciencemag.org/content/360/6396/eaas9793.full)

Do you see an opportunity for the Manufacturing USA Program to lead the way in addressing decarbonization in these fields in conjunction with the other stated objectives of strengthening the US manufacturing base? In other words, would decarbonization technologies for these sectors be an opportunity for US exports to existing and emerging manufacturing-based economies that need to control their carbon production? Is there a federal agency qualified to lead such an effort in collaboration with industry to develop these capabilities and would the Manufacturing US program be a constructive partnership program for implementing?

Reducing the carbon intensity of the manufacturing sector is an important issue that will require collaboration between governments, academia, and the private sector to develop

lower carbon technologies. Public private partnerships such as Manufacturing USA have been an effective convening forum for these types of collaborations in the past. Dow is not aware of any ongoing work with Manufacturing USA on decarbonization; further questions on their capabilities in this area would be best answered by them.

Thank you for the opportunity to participate.

Sincerely,

Dr. Mitchell Dibbs
Associate Director, External Technology – Government Programs
1776 Building
Midland, Michigan 48674

Appendix II

Additional Material for the Record

STATEMENT SUBMITTED BY REPRESENTATIVE HALEY STEVENS

Statement of the GC3 Sustainable Chemistry Alliance
Regarding Revitalizing American Leadership in Advanced Manufacturing

March 26, 2019

The members of the GC3 Sustainable Chemistry Alliance believe sustainable chemistry is central to American innovation in advanced manufacturing. As chemical and biochemical developers and producers, commercial and consumer product makers and retailers, Alliance members are committed to accelerating development and use of more sustainable chemistry.

As chemistry is intrinsic to virtually all products, a very broad segment of the U.S. economy is implicated in sustainable chemistry development, including startups, chemical and biochemical producers, small to large commercial and consumer products companies and retailers. The GC3 Sustainable Chemistry Alliance represents this entire value chain and is focused on policies that can accelerate the pace of private sector investment in the development and scale of new sustainable chemistry processes and products and the high value jobs such development creates.

Companies throughout the value chain are seeking more sustainable chemicals to incorporate into products in response to growing market pressure and regulatory attention to chemistry used in everyday products. More sustainable chemicals can offer improved human health profiles, improved environmental health profiles, reduced environmental emissions and lower lifecycle energy consumption and greenhouse gas emissions. Global competition will be fierce for the development of the sustainable chemistry market, which is projected to exceed $100 billion worldwide by 2022.

There has been considerable effort within the private sector to drive US development of sustainable chemistry. The Green Chemistry and Commerce Council (GC3), the parent organization of the Sustainable Chemistry Alliance, has provided a business-to-business collaboration space to foster chemistry innovation for a decade. Despite progress, companies point to the lack of adequate sustainable chemical alternatives as a major barrier to timely adoption of more sustainable chemistry in their products. Sustainable alternatives must have the same functionality of the chemistry they are replacing, must have adequate economics and be free of undesirable health, environmental, energy or process safety attributes. These overlapping criteria present a significant challenge for chemical developers and developing more sustainable chemical alternatives can require extensive time and financial resources. For a more sustainable chemical

alternative to be viable in the market, it must also be manufactured at sufficient scale to allow companies to transition large product lines to the new chemistry. These challenges can be addressed through focused research, development and deployment incentives that encourages and de-risks private sector R&D investments in more sustainable chemistry and the subsequent scale up of the resulting innovations.

Given its robust chemical industry and inherent innovation strengths, the US has a natural competitive advantage in sustainable chemistry development. However, there is ample global competition for this exciting emerging market. Sound public policy can help accelerate the rate at which we seize this opportunity, and it will translate into growth in US advanced manufacturing and jobs.

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