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## Introduction

Senator King, thank you for the opportunity to join you here today for a field hearing in Maine to share the important role that new energy-related advanced manufacturing technologies, and combined heat and power in particular, play in the economy.

Within the Office of Energy Efficiency and Renewable Energy, as Director of the Advanced Manufacturing Office (AMO), I oversee a program that has a specific mission to make the U.S. more competitive through the support of research and development of new technologies related to energy and manufacturing as well as building partnerships with the private sector to ensure technologies get out of the lab and into manufacturing. Topics AMO works on include new energy efficient processes, new materials, and information technologies related to manufacturing. To accomplish this work, we partner with universities, laboratories, companies (both for profit and not-for profit), state and local governments, and other stakeholders across the nation.

Working through these partnerships with the private sector, new technologies for manufacturing represent transformational opportunities to leverage affordable and reliable domestic energy resources into a competitive advantage that enhances U.S. economic growth and energy security. This is a transformation currently underway across the United States. There are two issues I hope to cover today: first is the importance of technology innovation in areas related to energy and manufacturing, second is how the specific new technologies of combined heat and power and microgrids can impact manufacturing, particularly in energy and resource intensive manufacturing processes like wood products, which represents an opportunity for economic growth in communities across the nation overall and here in Maine specifically.

The new technology-enabled transformation in manufacturing by the private sector is on display right here in Searsmont, Maine, for example, with state-of-the-art combined heat and power system, or CHP for short. This 8.5 MW biomass CHP system is enabling Robbins Lumber to reinvent itself by turning its wood residuals – chips, sawdust and bark that was previously sold to paper mills – into steam for heating its buildings and drying lumber, as well as electricity for itself and that it can sell back to Central Maine Power. In doing so, Robbins lowers costs, reduces waste and emissions, and can be a foundation for the local economy.

## National Manufacturing Day

As we get started, let me mention that today is National Manufacturing Day—an annual opportunity to recognize the important role manufacturing plays in both the history and future of our country. Highlighting the importance of manufacturing to our nation, we can quote Treasury Secretary Alexander Hamilton from his Report to Congress on Manufactures 226 years ago that

"Not only the wealth; but the independence and security of a Country, appear to be materially connected with the prosperity of manufactures." Today for Manufacturing Day, over two thousand firms—small and large, across the country—open their doors to the public in a celebration of modern manufacturing meant to inspire the next generation, including an event down the road in Belfast, Maine where Front Street Shipyard is hosting tours of its manufacturing facilities.

Innovation in manufacturing and energy is a foundation of our economic growth and jobs for the future. This growth has and will continue to require a strong commitment to the advancement of both new technologies and a skilled workforce. According to analysis by the industry trade association, the National Association of Manufacturers of data from the US Department of Commerce Bureau of Economic Analysis and the US Department of Labor Bureau of Labor Statistics, manufacturers contribute almost $2.2 trillion per year to the U.S. GDP and represent 9% of the nation's workforce.[1] The sector also accounts for 30% of U.S. energy consumption.[2] New domestic energy sources and other natural resources, combined with new energy efficient technologies and processes, represent a significant competitive advantage for the U.S. manufacturing sector.

On Manufacturing Day, it is also worth noting that manufacturing is vital to rural communities. According to data from the U.S. Department of Agriculture, manufacturing provides a higher share of jobs and earnings in rural areas than in urban areas, and was responsible for 21% of rural private nonfarm earnings and 14% of jobs in 2015.[3] Data collected from 2010-2012 by the Bureau of Economic Analysis showed that 501 counties that were "manufacturing-dependent", meaning at least 23% of earnings or 16% of jobs were in the manufacturing sector. Of those, 348 were rural or micropolitan.[4]

## Maine, Manufacturing, and DOE Collaboration

Maine has a proud history of manufacturing. According to analysis by the National Association of Manufacturers, Maine's manufacturing sector generated almost $5.3 billion in output in 2015, supporting over 51,000 jobs.[5] While forest products led that total with $829 million, Maine manufacturers also produce food, transportation equipment, metal products, computers and electronics, chemicals, and a wide range of other goods.

The Department of Energy is partnering with manufacturers to ensure that— through continued technological innovation—Maine manufacturers stay competitive in a dynamic modern economy. For example, in January of this year, I joined with Senator King in Orono to announce the launch of an innovation partnership between Oak Ridge National Lab and the University of Maine. That meeting was the first step in a long-term effort to explore new uses for forest

[1] Top 20 Facts about U.S. Manufacturing: http://www.nam.org/Newsroom/Top-20-Facts-About-Manufacturing/
https://www.bea.gov/iTable/iTable.cfm?ReqID=51&step=1#reqid=51&step=51&isuri=1&5114=a&5102=1
https://data.bls.gov/timeseries/CES3000000001

[2] EIA energy consumption by sector: http://www.eia.gov/totalenergy/data/annual/

[3] https://www.ers.usda.gov/webdocs/publications/84758/eib177%20-%20print.pdf?v=42962

[4] https://www.ers.usda.gov/webdocs/charts/62740/manufacturingdependent.png?v=42345

[5] http://www.nam.org/Data-and-Reports/State-Manufacturing-Data/State-Manufacturing-Data/April-2017/Manufacturing-Facts---Maine/

products, for instance 3D printing using composite materials for tooling and structures used in things like aviation, boat manufacturing and construction, with a focus on forest product biological feedstocks.

The new bio-based composite materials will be low-cost, energy-efficient, and recyclable – and will be developed using expertise with the University of Maine's Advanced Structures and Composites Center in Orono. This effort will open new avenues for the Maine economy through technological innovation in the global composites tooling market, which was valued at $316M in 2015—of which 30% is represented by North America[6]. By combining expertise at Oak Ridge in additive manufacturing with the University of Maine's expertise in bio-based materials technology, new applications for Maine's forest products are being investigated and developed.

To give an idea of the progress the university-lab team is already making, a research project kicked off two months ago and has worked to identify a range of thermoplastic resin materials with different amounts of wood flour, and micro and nano-cellulose content. These composite materials are undergoing mechanical testing at the University of Maine and thermal and print testing at Oak Ridge. Representatives from the team have also met with industry partners like Hodgson, Houghton Marine, Sabre Yacht, and Hinckley to explore collaboration potential on downstream composite applications for the marine industry. Next steps include testing paint coating material adhesion and exploring types of tooling components for industry relevant prototype and test.

This partnership with a national lab on bio-based composites highlights just one cross-cutting technology with the potential to positively impact manufacturing. Others include advanced sensor based industrial process controls, high-performance computing simulation, roll-to-roll manufacturing of membranes, additive materials processed, advanced materials manufacturing, chemical process intensification and sustainable materials manufacturing, all of which are new technologies with the potential to positively impact the use of forest products in manufactured goods. Technical information on these areas for research and development was published this year by the Department of Energy's Advanced Manufacturing Office in a draft multi-year program plan, and has been available for comment and feedback by researchers, the private sector and the manufacturing community.

## Combined Heat and Power (CHP)

As noted earlier, a specific advanced technology for manufacturing and energy is Combined Heat and Power, like the system at our host site for the day, Robbins Lumber.

Combined Heat and Power (CHP) systems represent an important opportunity for manufacturers as they can provide reliable, flexible, cost-effective, energy efficient power to a variety of industrial, commercial, and institutional energy consumers in our communities. Moreover, the U.S. is well-positioned to be a manufacturer and an exporter of advanced CHP equipment to the rest of the world.

AMO's role in CHP is to support early stage research and development of advanced CHP systems and components that can better integrate and interact with the electric power grid and

[6] Market and Markets, 2015. Composite Tooling Market Report. http://www.marketsandmarkets.com/Market-Reports/composite-tooling-market-63004871.html

microgrids, and provide resilient and efficient energy resources to our communities. In coordination with the Department of Energy's Office of Technology Transitions, AMO enables partnerships between National Labs, universities and industry to improve the transition of innovative technologies from the lab bench to commercial application.

CHP is helping meet Maine's energy needs, but has significant room to grow. As of the beginning of 2017, Maine had 934 MW of capacity across 38 separate installations. Of that, 906 MW were installed at 16 industrial facilities – pulp and paper, and the wood sector; while 26 MW were installed across 19 commercial and institutional facilities[7] including such diverse applications as St Mary's d'Youville Pavilion nursing home, Augusta City Center, Lewiston Auburn waste water treatment plant, the Cumberland County Jail, and Togus Veteran's Affairs (VA) Medical Center. These systems, including the commercial installations, are fueled by a variety of sources including natural gas, biomass and biogas. Recent DOE-supported studies estimate the technical potential for additional CHP in Maine at about 3,400 MW, with much of it in emerging commercial/institutional applications for CHP.

CHP can continue to help transform manufacturing in large part due to, low cost domestic fuels including natural gas, biogas and biomass while delivering a number of key advantages, many of which facilities around the country area already experiencing:

- *Energy Security.* On-site and microgrid-based CHP generation also provides localized, autonomous systems that eliminate transmission line power losses and enable the integration of generation and storage from a variety of sources, providing greater security against power interruptions for industrial and commercial users, and a stronger, more resilient grid for the nation as a whole. In 2009 a major ice storm hit Fort Knox in Kentucky with severe effects. The post lost its connection to the local utility and several buildings went without power for as long as 10 days. Energy security and reliability being a concern, an 8.2 MW CHP was installed in 2014 to provide power, cooling and heating not only on a day-to-day basis, but also to serve as reliable backup power in case of future outages.

- *Lower costs.* CHP lowers operating costs for industry and businesses by reducing energy costs and increase power reliability and resiliency. CHP technologies offer flexibility in terms of fuel sources and energy output, providing protection against risks from power outages, loss of critical heating or cooling services, or volatility in fuel prices. O'Hair Shutters, the largest domestic shutter manufacturer in the U.S., uses CHP to reduce energy costs at its headquarters and manufacturing facility in Lubbock, Texas. The CEO has cited the $480,000 saved annually on energy costs as a key determinant in their ability to compete with Chinese imports.

- *Efficiency.* CHP offers efficient flexible power generation technologies to meet America's energy needs reliably and safely. These systems simultaneously produce power, heating, and cooling services from a single fuel source at the point of use, providing critical energy services with up to 80% efficiency—compared to about 50% for conventional power plants and on-site boilers. As an example, the Eight Flags CHP system owned by Florida Public Utilities and Chesapeake Energy at the Rayonier

[7] http://www.northeastchptap.org/

Advanced Materials softwood cellulous specialty mill in Amelia Island, Florida allowed the facility to reduce costs, increase production, and optimize its operations, while enhancing resiliency in its steam supply and the power supply for both itself and the island. The system operates at 78% HHV efficiency, and has achieved an operating availably of 98.5% since it was commissioned in July 2016. The economic performance of the CHP system was a key part of the selection of the Florida mill for a recently announced $115 million capacity expansion.

- *Cleaner Air.* Efficient power generation systems, such as CHP, lower emissions by reducing overall fuel usage, utilizing domestic fuel resources and incorporating the latest low-emissions technologies. This technology helps ensure clean air and clean water for generations to follow.

- *Resiliency.* Natural and man-made disasters, such as hurricanes and system-wide power blackouts, highlight the need for securing critical infrastructure (CI) for national or regional security, economic continuity, and public health and safety. CHP has proven effective in providing uninterrupted electric service and heating/cooling through multiple major disasters in hospitals, prisons, waste water treatment plants, schools, places of refuge, factories and other critical facilities. CHP systems simultaneously generate electricity and produce thermal energy, maintaining needed power, process heating, and space conditioning services on-site at high efficiency and high reliability. A great example is related to the recent flooding from Hurricane Harvey in Texas at the University of Texas Medical Branch (UTMB): In 2008, Hurricane Ike devastated the UTMB campus in Galveston with eight feet of floodwater. Subsequently they developed and implemented a plan to ensure UTMB would remain resilient during similar floods. As a result, the site elevated its utility infrastructure and in 2016 began operation of a newly installed 7.5 MW CHP system in the new East Plant, which remained fully operational without interruption when Hurricane Harvey struck on August 25, 2017, even with the rising flood level in the Brays Bayou area around UTMB. So while much of Houston, Texas and the surrounding areas were faced with uncertainty as Hurricane Harvey made landfall, the Texas Medical Center – the largest medical center in the world – was able to sustain its air conditioning, refrigeration, heating, sterilization, laundry, and hot water needs throughout the storm thanks to CHP installation.

  Closer to Maine in the Northeast, the 10 MW CHP system at the Sikorsky Aircraft facility in Connecticut enabled the plant to remain open and operational during and after Hurricane Sandy. Moreover, the facility was able to service its 9,000 employees with food and amenities, even while many local communities were without power.

- *Microgrids.* Microgrids are localized grids that can disconnect from the traditional grid to operate autonomously. Because they are able to operate while the main grid is down, microgrids can strengthen grid resilience and help mitigate grid disturbances as well as function as a grid resource for faster system response and recovery. CHP can be an ideal anchor for sustainable and resilient microgrid systems because of its ability to withstand heavy storms and long outages, while also serving as an enabling technology for integrating variable renewable energy. The City of Woodbridge, Connecticut and United Illuminating are constructing a microgrid that connects seven critical facilities around Woodbridge Town Center - public works building, town hall, police station/senior center,

library, new fire station, old fire station, and high school – anchored by a 2.8 MW fuel cell CHP system at Amityville High School. Designed to keep the lights on in these critical facilities during sustained outages, the microgrid and CHP system are owned and operated by the utility, United Illuminating.

The U.S. is also in a position to lead the world in manufacturing of CHP. America's abundant energy supply is a strategic advantage that positions U.S. companies to be global leaders in the manufacturing of energy related technologies of tomorrow. One example is Capstone, an American microturbine CHP manufacturer located in California, a leading exporter of microturbines to the oil and gas industry and for CHP applications around the world. Almost 60% of Capstone's existing sales in terms of capacity have been outside of North America.

AMO continues to support research into advanced CHP technologies – in particular the components needed to better integrate CHP systems in to the national electric grid, resulting in greater resiliency and efficiency. AMO held a research workshop last year to convene industry partners and other stakeholders to identify key R&D challenges that, if addressed, would both accelerate the adoption of as well as expand the technical capabilities of CHP. While the core CHP technology is mature, its relative lack of deployment has left a number of technology gaps, particularly around grid integration, flexibility, and rampability. Based on this and other feedback, new early-stage research in technical areas like new semiconductor-based power electronic switching as well as new materials that enable high heat rates and fast ramping in CHP are being supported.

Further, DOE continues to explore fundamental knowledge gaps that hinder opportunities for new applications and designs for CHP, and that can work hand in hand with the evolution of the power system. Going forward we hope to be able to continue to work with Maine and other states to take advantage of this efficient, resilient and affordable technology in hospitals, waste water treatment plants, and universities, as well as CHP in manufacturing sites including chemicals, primary metals, paper, wood products and food processing.

In conclusion, I thank the committee for the opportunity to meet with you today and we look forward to partnerships in which these advanced technologies have positive impact on U.S. manufacturing.