U.S. Senate Committee on Energy and Natural Resources
July 25, 2019 Hearing: ***The Importance of Energy Innovation to Economic Growth and Competitiveness***

Response to Questions for the Record
Dr. David M. Hart

Questions from Chairman Lisa Murkowski

Question 1, Part 1: One important aspect of creating economic prosperity here at home is ensuring American exports are internationally competitive. What are some ways that DOE can improve advanced manufacturing programs to keep the United States competitive?

Response: *The federal government should expand investment in use-inspired R&D and cluster-deepening programs.* ITIF recommends expanding investment in use-inspired R&D and cluster-deepening programs, such as Manufacturing USA. If the United States is to win its fair share of highly competitive global markets for clean-energy goods, the public, private, and academic sectors must work together effectively. The Department of Energy's (DOE) Manufacturing USA institutes, such as PowerAmerica, foster the kind of collaboration the nation needs, accelerating innovation and building workforce skills. However, federal funding for the Manufacturing USA institutes is currently required to sunset after only a few years. DOE should be encouraged to lift this restriction, to the extent permitted by law, as long as private sector members of the institutes continue to put in the lion's share of the budget. That doesn't mean that Manufacturing USA institutes should have an entitlement to federal funds forever. Ongoing federal funding should cover only a quarter of their budgets, down from half during the first five years. The institutes should be required to raise the rest from private sector members and other sources. Their willingness to contribute remains the most important metric of an institute's success. In addition, every institute should be evaluated regularly.[1]

The federal government should intensify its effort to make advanced manufacturing "smarter." ITIF also calls for a more intensive effort to make advanced manufacturing "smarter" by encouraging the adoption of digital manufacturing technologies, such as sensors, data analytics, wireless technology, and the broader Industrial Internet of Things. Smart manufacturing is the most important opportunity for process innovation impacting energy and can provide U.S. industries with a competitive advantage by radically improving energy productivity. DOE should be encouraged to continue to support smart manufacturing RD&D, including the Clean Energy Smart Manufacturing Innovation Institute. Support for demonstration projects, in which manufacturers "kick the tires" of smart manufacturing systems to see how they actually work and understand what specific technologies are, would be particularly helpful. Such projects could be embedded at national laboratories as well as other R&D institutions. Innovation vouchers for small manufacturers could be offered to strengthen their participation in demonstration projects and accelerate their adoption of smart manufacturing technologies.[2]

[1] David M. Hart and Peter L. Singer, "Manufacturing USA at DOE: Supporting Energy Innovation," Information Technology and Innovation Foundation (ITIF), May 2018.

[2] Stephen Ezell, "Why "Smart" Manufacturing Matters and How Countries Are Supporting It," ITIF, April 2018; Stephen Ezell and David M. Hart, "Accelerating Energy Innovation with DOE Lab Vouchers for Business," *Crain's Cleveland Business*, July 2, 2018.

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Question 1, Part 2: Are there growth markets where the U.S. is underinvesting in energy technology development?

Response: *Congress should expand DOE's investment in energy research, development, and demonstration (RD&D).* The most important direct spending role played by DOE in clean energy innovation is support for energy research, development, and demonstration (RD&D). Many studies have found that such investment acts as a catalyst and accelerant for private RD&D. Unfortunately, the converse is also true: Reduced public funding will likely lead to fewer opportunities for private-sector investment in new energy technologies. Analysis by Matt Hourihan of the American Association for the Advancement of Science found that declining federal energy RD&D investment during the early 1980s contributed to decreased private RD&D in advanced energy technologies. Patent applications in clean energy have declined in recent years as well, suggesting public investment is too modest to "crowd in" private investors who would seek patent protection.[3]

DOE should place greater emphasis on RD&D on solutions for hard-to-abate sectors.
ITIF's April 2019 report "FY 2020 Energy Innovation Funding: Congress Should Push the Pedal to the Metal" provides a detailed program-level review of opportunities for enhanced energy RD&D investments. In particular, Congress and DOE should place greater emphasis on technology challenges for hard-to-abate sectors, for which there are currently no available solutions to reduce carbon emissions. These challenges include long-duration energy storage; advanced nuclear power; carbon capture, utilization, and storage; carbon neutral fuels; and carbon dioxide removal technology, along with the science underlying each of these domains. The global race to find these solutions is already underway, and the producers that make breakthroughs will have a head start to gain customers in huge and growing global markets.[4]

Question 1, Part 3: How can we connect advanced manufacturing with economic development?

Response: *Expansion of advanced manufacturing is a major form of economic development.* Expansion and deepening of advanced manufacturing is intimately linked with economic development in many regions. Manufacturing directly employs 12.6 million workers in the United States. Taking into account indirect effects such as supply-chain purchasing, that number more than triples to nearly 39 million jobs. Workers employed by manufacturers, particularly those without college degrees, typically earn better wages than their peers in other sectors. Workers in the most innovative manufacturing industries earn 40 to 50 percent more than their peers.[5]

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[3] Matt Hourihan, "If Government Scales Back Technology Research, Should We Expect Industry to Step In?," American Association for the Advancement of Science, October 2017; Devashree Saha and Mark Muro, "Patenting Invention: Clean Energy Innovation Trends and Priorities for the Trump Administration and Congress," Brookings Institution, April 2017.

[4] Colin Cunliff, "An Innovation Agenda for a Low-Carbon Energy Future: Bridging Gaps in the Federal Energy RD&D Portfolio," ITIF, November 2018

[5] Charles S. Gascon and Andrew Spewak, "Advanced Manufacturing is Vital across Nation, Including Eighth District," *The Regional Economist,* Fourth Quarter 2017.

Federal agencies should enhance support for state and regional clean-energy-related advanced manufacturing strategies. With more than $300 billion in investment flowing into clean energy globally, it is not surprising that advanced manufacturing to support this sector has emerged as a focus for U.S. state and regional economic development strategies. The best of these strategies take a long-term, asset-building perspective that leverages the region's existing strengths. They include investments that fill the gaps in the innovation chain between federally-funded research and privately-funded commercialization, particularly through targeted R&D and technology transfer programs. Federal policy can enhance state and regional strategies by providing financial and technical support and encouraging national laboratories and other federal institutions to contribute to them as well as by expanding and reforming federal RD&D investments.[6]

Question 2: In addition to CCUS technology, are there other technologies that can keep the U.S. industrial sector competitive while reducing emissions? Is the DOE currently funding alternative feedstocks and pathways to the level needed for supporting the private sector?

Response: *The industrial sector will be very challenging to decarbonize.* The industrial sector is generally recognized as more challenging to decarbonize than the transportation and buildings sectors. There are two major obstacles to achieving a carbon-neutral industrial sector.
Some emissions result directly from industrial processes and are independent of the source of energy used to drive the process. For example, the calcination of limestone to make cement produces carbon dioxide as a byproduct. These emissions can only be reduced by changing feedstocks or processes, and cannot be eliminated by switching to low-carbon energy sources. Second, high-temperature heat used in many industrial processes is primarily generated by combusting fossil fuels. Melting iron ore to produce steel and steam cracking to produce ethylene are two high-volume examples.

Significantly expanded federal and private support will be needed to bring technologies for industrial decarbonization to maturity. In addition to CCUS, potential solutions to these industrial challenges include biomass combustion for heat; advanced nuclear energy, which could be designed to provide high-temperature heat as well as power; and chemical forms of long-duration energy storage, such as hydrogen and ammonia, which can be produced with zero-carbon electricity and combusted without emissions. All of these innovation pathways will require a significantly expanded level of federal and private effort to reach maturity. For instance, new electrocatalytic, photocatalytic, and solar thermochemical looping techniques must be developed to reduce energy consumption in ammonia production, while the use of ammonia in combustion turbines remains far from commercial application.[7]

[6] David M. Hart, "Clean Energy Based Regional Economic Development: Multiple Tracks for State and Local Policies in a Federal System," ITIF, February 2019.

[7] Cunliff, "Innovation Agenda."

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Question 3: One problem with government funding of innovative pilot programs is that after the pilot project ends, the government leaves, and there's not always support left behind. What are some ways to resolve this issue and ensure pilot projects are able be self-sustaining?

Response: *Government participation in energy technology pilot and demonstration projects is often essential.* Government participation in energy technology pilot and demonstration projects is often essential. The risks of such projects are typically so high as to deter full private sector support, particularly for very large projects. A recent study of 511 demonstration projects by Gregory Nemet of the University of Wisconsin and his colleagues, which spanned decarbonization in the energy and industrial sectors, found that almost all of those for which data could be found involved a financial contribution from the public sector.[8]

Smart policies for publicly-funded demonstration projects can increase the odds of privately-funded follow-on projects. These projects can only be considered successful, however, if they lead to privately-funded follow-on projects. One important way to enhance the odds of such follow-on projects is to engage private sector partners, especially technology end users, in leadership roles in the pilot and demonstration phases. The operational experience gained by these partners is a key benefit that can enable full commercialization of the technology. Second, pilot and demonstration projects should make information sharing among all potential users of the demonstrated technology a high priority. Information sharing accelerates diffusion and enhances competition as the technology is being commercialized. Third, pilot and demonstration projects should avoid excessively rapid scale-up of unproven technologies. They should only proceed when smaller-scale trials have proven that they are warranted. Finally, potential early adopters of many energy technologies may still need indirect support from public policies, such as tax incentives and loan guarantees, to surmount the risk threshold for investment.[9]

[8] Gregory F. Nemet, Martina Kraus, and Vera Zipperer, "The Valley of Death, the Technology Pork Barrel, and Public Support for Large Demonstration Projects," *Energy Policy* 119:154-167 (2018).

[9] David M. Hart, "Across the 'Second Valley of Death": Designing Successful Energy Demonstration Projects," ITIF report, July 2017.

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Questions from Ranking Member Joe Manchin III

Question 1: It has become clear that clean energy will play a major role in the future of our energy economy, particularly for rural areas, including West Virginia. However, many new technologies face a mixed set of federal and state policies regarding deployment and commercialization. What are the top policies you see as helpful to overcoming challenges to deploying more clean energy demonstration projects and building up our manufacturing base in rural areas?

Response: *The federal government should adopt a robust energy technology demonstration strategy.* The United States should build a robust and diverse portfolio of energy technology demonstration projects as part of a comprehensive clean-energy innovation policy, but it has not been investing in such projects for the past seven years. The federal government should co-invest with private partners in such projects, because they yield public benefits and because private investors lack adequate incentives to bear their full costs. Private sector partners, especially technology end users, should take leadership roles in implementing clean-energy demonstration projects, so that they gain operational experience, which will aid them in moving to full commercialization. Federal policy for private co-investment in demonstration projects should become more flexible in order to accommodate varying risk profiles, resulting in a wider range of cost-sharing ratios across projects. Although DOE improved its performance in designing and managing demonstration projects compared to the 1970s and 1980s, a continuing effort should be made to explore the viability of establishing alternative funding and management approaches, such as the proposed Energy Technology Corporation and Regional Innovation Demonstration Funds. Federal agencies other than DOE, such as the Departments of Defense and Transportation, as well as regions and states, should consider making their own co-investments in clean-energy demonstration projects.[10]

The federal government should strengthen its support for state and regional clean-energy-related advanced manufacturing strategies. Energy technology demonstration projects involving a variety of public and private participants may contribute to regional growth, particularly in rural areas, and lay the foundation for further economic development. Advanced manufacturing can also contribute to rural economic development. State and regional entities should take the lead, in collaboration with the private sector, in developing economic development strategies that best leverage the state or region's economic strengths in these key sectors. Federal policy can enhance advanced manufacturing and clean-energy-based economic development strategies by providing financial and technical support and encouraging national laboratories and other federal institutions to contribute to them as well as by expanding and reforming federal RD&D investments, particularly use-inspired R&D and cluster-deepening programs, such as ARPA-E and Manufacturing USA. Federal funding for the Manufacturing USA institutes, specifically, should be sustained as long as private sector members of the institutes continue to put in the lion's share of their budgets, rather than being cut off,

[10] David M. Hart, "Across the 'Second Valley of Death.'"

as is currently planned. ARPA-E's budget should grow significantly and its purview extended to support scale-up of promising energy hardware technologies.[11]

Question 2: High labor standards improve the quality of work and the wages that workers earn, as we've seen throughout West Virginia's history. A key element of this is the apprenticeship and training programs run by unions, which translate directly to skills needed to advance new projects in the energy sector. As the U.S. energy workforce ages, what opportunities do you see in the types of apprenticeship and training provided by labor unions to pass along skills and expertise from one generation to the next? In the context of energy innovation, what need do you see for the quality of work those apprenticeships develop?

Response: *The United States needs a high-quality employment and training system that draws on global best practices.* The United States needs a comprehensive, high-quality, and flexible employment and training system, along the lines that world leaders such as Scandinavian nations and Singapore have put in place. Policymakers should embrace the concept of "flexicurity," as Scandinavian nations have, which minimizes the number of workers at risk of layoffs and provides support for those who do get laid off to make successful and expeditious transitions. Policymakers also should learn four lessons from Singapore. First, federal policy needs to make a major commitment to skill development and workforce transition. Second, such efforts need to be closely linked to employers and markets (e.g., through vouchers and credits). Third, such efforts need to be much more flexible and less bureaucratic than existing efforts and take full advantage of advanced information technology tools. Finally, incremental changes in existing institutional arrangements are not enough. If policymakers are to respond effectively to the challenges of a more turbulent labor market, they will need to drive significant institutional reform. For example, Congress should increase the federal unemployment insurance tax rate and dedicate funding to support industry-led skills initiatives, including union-run training and apprenticeship programs, and expand adjustment assistance to include workers losing their jobs due to technological change associated with the transition to clean energy.[12]

[11] Hart, "Clean Energy Based Economic Development;" Hart and Singer, "Manufacturing USA at DOE;" David M. Hart and Michael Kearney, "ARPA-E: Versatile Catalyst for U.S. Energy Innovation," ITIF, November 2017; David M. Hart, "Response to ARPA-E RFI Regarding Pre-Pilot and Pilot R&D Projects," May 29, 2019.

[12] Robert D. Atkinson, "How to Reform Worker-Training and Adjustment Policies for an Era of Technological Change," ITIF, February 2018.

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Questions from Senator John Hoeven

Question 1: You mention in your testimony how the International Energy Agency (IEA) has identified 45 critical energy emission reducing technologies, but only seven of these technologies are on track to meet the Sustainable Development Scenario. One of these technologies that is not on track – CCUS – carries great promise at home and abroad but clearly more efforts are needed to promote the feasibility of these projects. What role do tax credits – such as the 45Q tax credit – play in the commercial development of these projects?

Response: *45Q will lead to expanded investments in some applications of CCUS.* Congress's 2018 expansion and extension of the 45Q tax credit created a stronger incentive to capture, utilize, and permanently store carbon dioxide, which would otherwise contribute to climate change. Tax incentives like 45Q work well for innovations that are mature enough to respond quickly to the market signals that they provide. CCUS applications like natural gas processing, biomass-to-ethanol, and fertilizer plants, appear likely to fall into this zone, and we expect 45Q to lead to expanded investments in them.[13]

Other major applications of CCUS will remain too expensive, even with 45Q in place. However, even with this new policy, current state-of-the-art technologies for CCUS are still too expensive to spur widespread deployment in the largest emitting sectors, particularly power plants and cement and steel production. A number of additional "supply-push" policies would be helpful to complement 45Q to accelerate CCUS technology development. For instance, DOE should establish a single carbon capture R&D program—outside the coal program office—that includes emissions sources such as natural gas power plants and industrial plants. Congress should also direct DOE to establish a demonstration program for carbon capture at natural gas, steel, concrete, and other industrial facilities and expand the Title XVII Loan Program to cover these applications as well. DOE and NSF should expand investment in basic and applied R&D on carbon utilization and implement the recommendations of the recent National Academies report. Finally, DOE, in collaboration with the United States Geological Survey (USGS), should continue to support R&D in the safe geologic sequestration of carbon dioxide.[14]

[13] Cunliff, "Innovation Agenda;" David M. Hart, "Two Tools for Two Jobs: Carbon Taxes and Energy Technology Tax Incentives," ITIF, July 2019.

[14] Cunliff, "Innovation Agenda;" National Academy of Sciences, Engineering, and Medicine (NASEM), "Gaseous Carbon Waste Streams Utilization: Status and Research Needs," October 2018.

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Question 2: Are you aware of any projects currently planned or in development that plan to take advantage of the 45Q tax credit? If so, what are they?

Response: *It is too soon to judge the impact of 45Q.* ITIF does not track carbon capture facilities. The most comprehensive effort in this regard that we are aware of is the Global CCS Institute, which maintains a global, on-line data base. The Clean Air Task Force commissioned a modeling study of the impact of 45Q on the electric power sector. The study found that 45 fossil-powered units totaling 10.8 gigawatts of generating capacity could be retrofitted as a result of this incentive. All of these plants are close to enhanced oil recovery basins, which would provide an additional revenue stream to the projects. News media reports have indicated that some firm commitments utilizing 45Q are being made; for instance, a subsidiary of Occidental Petroleum recently announced plans to design the world's largest plant to remove carbon dioxide from the air in West Texas. The Internal Revenue Service recently closed the comment period on implementing regulations for 45Q. The Carbon Capture Coalition, which represents more than 60 energy, industrial and technology companies, labor unions and environmental, clean energy and agricultural organizations, has urged the IRS to move quickly in finalizing these regulations, so that potential users of it have the maximum time to develop projects before the provision expires in 2023.[15]

[15] Global CCS Institute, "Facilities Database," on-line resource; Clean Air Task Force, "Carbon Capture & Storage in the United States Power Sector: The Impact of 45Q Federal Tax Credits," February 2019; Christa Marshall, "World's Largest Trap for Airborne CO2 Planned for West Texas," *Energywire*, May 22, 2019; Carbon Capture Coalition, "Comments on Section 45Q Credit for Carbon Oxide Sequestration," June 28, 2019.