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Statement on the leading role of the Department of Energy in American energy innovation and how its research, development, demonstration, and deployment programs may be enhanced to further boost the economic competitiveness of the United States

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Chairman Manchin, Ranking Member Barrasso, and Members of the Senate Committee on Energy and Natural Resources, thank you for the opportunity to speak with you today regarding the Department of Energy and its crucial role in advancing American innovation and competitiveness.

I have devoted my career to energy and climate technology innovation and infrastructure deployment. I have done so from many different positions: first, from academia, where I modeled options for nuclear waste management under my Ph.D. advisor, former Energy Secretary Ernest Moniz. Next, I worked on nuclear energy, efficiency, storage, and energy finance issues for this committee, as a Science Fellow with Senator Wyden in 2013. In my next role, I administered grants, wrote policy proposals, and managed analysis on natural gas, coal, nuclear, and grid cybersecurity issues at the U.S. Department of Energy (DOE). Finally, I served as Director of Technology Strategy for Exelon, a Fortune 100 energy utility, where I ran the company's partnership R&D program and invested in early-stage technologies. While there, I helped the company leverage tens of millions of dollars in Federal and State funding to support its innovation agenda. Now, I helm the climate work at a new nonprofit called Actuate, working to break open new approaches to the scaleup and deployment of greenhouse gas-reducing infrastructure.

I have worked with the DOE as an academic, as an employee, and as part of a large corporation seeking to innovate. In the process, I have experienced first-hand DOE's greatest strengths and its biggest challenges in spurring innovation.

Effective innovation requires more than the right processes and resources. It requires a clear mission; a North Star that mobilizes and excites the best minds to serve our country. DOE has some of the most valuable assets to bring to bear in the global fight against climate change, and its work is crucial for creating sustainable energy solutions that enhance infrastructure resilience, in an equitable and cost-effective way. DOE's success contributes to fighting climate change, and enhances the nation's global economic standing. And these important missions are closely linked.

We are not here to debate climate science. I hope we can all acknowledge, however, the economic reality it creates, that global demand for sustainability-minded and greenhouse gas-reducing technologies and infrastructure is on the rise. The U.S. has a choice: lead in climate technology innovation, and make sustainability products here, or cede leadership, jobs, and manufacturing to the rest of the world.

Today, I will highlight how the DOE Office of Science and ARPA-E are contributing strongly to climate innovation and global leadership. This in no way diminishes the contributions of the DOE program offices; they include a wide variety of efforts that are critical to achieving our national goals. Second, I will offer suggestions on additional activities DOE should undertake to expand its impact, translating innovations to economic gains for our nation.

Celebrate Achievements: The Office of Science and ARPA-E

The DOE's Office of Science is a national treasure. It is the largest federal sponsor of physical science research, and it is a key reason why I stand before you today.[1] In college, I had the privilege of working with a team at Lawrence Berkeley National Laboratory on work at Brookhaven National Laboratory's Relativistic Heavy Ion Collider. We studied quark-gluon plasma, an esoteric form of matter that represents what the universe was made of when it was first born. The experience riveted me, and cemented my decision to pursue a career in science and engineering.

It may seem as though a fundamental understanding of the physics of matter is a long way from establishing manufacturing lines and boosting GDP. But there are many ways in which Office of Science programs are starting to bear fruit, and fusion is one example. When I started my graduate studies in 2005, fusion was "30 years away, and always would be." That is no longer true. In its report "Bringing Fusion to the U.S. Grid," the National Academies of Sciences, Engineering, and Medicine recommended building a pilot fusion facility, showing net energy production at low cost, between 2035 and 2040.[2]

That may still seem far away, but the fact that we have a pathway to an always-on, carbon-free, environmentally friendly source of energy in the next two decades is game-changing for the climate challenge and for our economy. At Exelon, when I described advancements in fusion with our senior leadership, I was concerned they would be dismissed as too far in the future. Instead, I was told that as a nuclear company, Exelon needed to track these developments. This is not the same as voting with corporate investment dollars, but it is an important step on that path, and a signal that we are on a different plane of readiness and excitement with respect to contributions from fusion energy.

[1] https://www.energy.gov/science/mission, April 12, 2021.
[2] National Academies of Sciences, Engineering, and Medicine. 2021. Bringing Fusion to the U.S. Grid. Washington, DC: The National Academies Press. https://doi.org/10.17226/25991.

ARPA-E represents one of the best examples of innovation machinery that DOE brings to bear on the climate challenge. ARPA-E programs range from open calls to focused efforts to develop technologies with certain characteristics, and they have resulted in, by ARPA-E's estimation, 88 new startups and $4.9 billion in follow-on funding.[3] Program managers, recruited and retained in the rotating style honed at DARPA, are some of the best minds in energy innovation work. ARPA-E demonstrates that DOE can find new and powerful ways to do business, and continues to evolve in important ways as an organization. One prime example includes ARPA-e implementing its SCALEUP program to support continued evolution of the technologies in its portfolio; DOE should do more of exactly this type of work. Furthermore, given ARPA-E's proven effectiveness, it is time for Congress to fund ARPA-E at a significantly higher level. ARPA-E receives far more excellent funding applications than it can support, and has proven its model.

Do More to Achieve Impact: Moving the Department of Energy Beyond the Technology Transfer Paradigm to Technology Impact Delivery

Just as important as supporting the early stages of the innovation pipeline is supporting the transition of technologies from laboratories into wide-scale use. The words "technology transfer" are actually somewhat a misnomer. They imply that the government does the hard work of basic science, early technology development, and proof, and then neatly hands the technology off to the private sector to turn it into a product, scale it, and deploy it. I can't think of a single example among energy and climate technologies where the process has worked that simply.

The Office of Technology Transitions was established at DOE in 2015 to work on these issues. It has done herculean work as it aims to expose national laboratory and other DOE-funded technologies to commercial partners and deploys its $30 million Technology Commercialization Fund created by this committee in the Energy Policy Act of 2005. For the last few decades, Congress has recognized the complicated nature of technology development and has provided guidance to DOE on how to improve the innovation process. I commend the committee for its work to officially authorize the Office of Technology Transitions and to elevate the role of its Director to Chief Commercialization Officer and Advisor to the Secretary in last year's Energy Act of 2020. The law provides important direction to DOE on commercialization and entrepreneurship activities of the office and to commercialization efforts across the Department.

But the gap between what DOE funds, through its energy offices and ARPA-E, and what the private sector will fund and build, is still far too wide. A very select few venture capitalists, philanthropists, and "hardtech incubators" are stepping up with some patient capital and some technology de-risking resources. But it is not nearly enough. At this moment, with fierce global competition, the urgent need to mitigate climate change, and major hurdles to be overcome for many of the most important energy and climate innovations we have, everyone in the innovation ecosystem must do more to help technologies emerge from labs and universities such that they can be quickly harnessed and deployed. DOE, with its user facilities and world-class expertise,

[3] https://arpa-e.energy.gov/about/our-impact, accessed April 11, 2021.

funding resources, and programmatic design, has the potential to play a much better catalytic role in translating climate and energy innovation into economic impact.

At Exelon, I oversaw a team of PhDs with a set of abilities and a mandate that remains unique in the utility industry. We had an explicit mission to source new technology ideas that could be beneficial to the company, and to invest through a variety of means. We created overarching research agreements with universities and funded projects at each, we signed a Cooperative Research and Development Agreement with Argonne National Laboratory and funded work there, we made early-stage equity investments, and we partnered on and received DOE grants. We did all this in support of a broad innovation community federated at each of Exelon's business units, with a strong innovation push from the highest levels of our company's leadership. Few utilities have similar resources, support, and vision.

Even with these remarkable assets, we struggled at times to find projects that matched our interest and criteria, and to realize value from the ones that did. Most universities and national laboratories have strong scientific missions, and reward systems for researchers are based on papers published and frontiers expanded. My team, however, sought something very different: we looked for a specific line of sight toward commercial value for our company with every project we funded. With some notable exceptions, we had a very difficult time finding individuals and institutions that could frame and conduct their research in that way. In addition, the time it took to sign research contracts with DOE and overarching research agreements with universities was far too long; it was often a year or more just to get started.

Most importantly, we struggled to identify a sensible pathway to support technologies as they emerged from the lab into commercial use. While we had some unique abilities to place "small bets" on relatively early-stage technologies, we found it much harder to consistently justify the extensive investments required to fully de-risk those technologies in the later stages of the commercialization pipeline. Some technologies, including some that we funded, are lucky enough to find patient venture capital or homes in incubators with an ability and willingness to help them develop and scale. But there are too few dollars and too few opportunities for worthy technologies in this space, and DOE can do more beyond loan guarantees and demonstration programs to fix this section of the innovation pipeline.

This is an especially challenging set of problems to address, because almost no two technologies or commercialization approaches are alike, and neither are the barriers they face. Sometimes, the next steps in technology de-risking are too expensive for the private sector to fund. Sometimes, it's not yet clear what the market demand is. In some cases, the approach is so novel that it requires regulatory changes that utilities justifiably expect will be slow. Sometimes, the reduction in financing costs afforded by the DOE loan programs is just what a project needs, but we need more tools in this toolkit. This is exactly the set of problems I am addressing at Actuate. If the United States is to be successful in our bid for global sustainability and American competitiveness, DOE, with its very different set of approaches and assets, needs to address them as well.

There are several things DOE can do to improve the ecosystem for technology transitions, increase the rate at which DOE laboratory-created technologies emerge into the private sector and begin to have impact, and ultimately improve our competitive posture.

First, DOE should narrow the daylight between its work and the private sector, by encouraging collaboration, and, ideally, by instituting a cultural shift toward an economic impact mindset. Over the last several years, many DOE funding opportunities have included helpful requirements for private sector collaboration. This meant that at Exelon, we benefited greatly from a steady stream of lab scientists, university researchers, and startups seeking our ideas and participation as they pursued federal funding. And we believe they benefited from our commercial perspective. Incrementally, DOE could encourage a range of collaborative activities, from encouraging private sector cost share, to prioritizing funding projects that set companies as formal advisors. Note that DOE should *not* be held to a blanket directive that all funding opportunities include private sector cost share requirements. There are many cases where ideas are valid but need more de-risking to attract private sector funding, or where other forms of contribution from the private sector are in fact more valuable.

Transformationally, DOE should overhaul the guidelines and incentives embedded in the funding it grants to labs and universities. While direct private sector partnering may not be relevant for all DOE programs, especially those in the Office of Science, the entire Department would benefit from changes in how it prioritizes funding and rewards success. More programs could explicitly set engineering and cost targets. Success metrics should expand from papers published to include patents pursued and transferred, private sector follow-on funding attracted, and companies created. The degree to which these changes are desirable is different for each laboratory and each technology area, and should not be applied in a manner that stifles very early-stage scientific creativity. But new criteria that foster a cultural shift within laboratories and universities toward climate and economic impact will strengthen the U.S. innovation and competitiveness posture.

Second, DOE should do much more to specifically foster entrepreneurship. New ideas like the “LabStart” concept piloted at the National Renewable Energy Laboratory last year help pair lab researchers and entrepreneurs, enabling the labs to bring technologies and “CTO services” to new companies. And Lawrence Livermore National Laboratory created an Impact Committee to advise its Carbon Initiative, on which I serve. The committee presents a unique opportunity for those of us with commercialization credentials to hear from lab scientists and help steer their work toward making a difference. Supporting these kinds of activities is feasible immediately, and will provide much-needed progress toward improving commercialization opportunities within the labs.

As another driver for transformational impact of innovation, DOE should dramatically deepen and expand its support for entrepreneurial R&D fellowships. Entrepreneurial fellowships, which originated at Lawrence Berkeley National Laboratory's Cyclotron Road, have proven to serve as a lifeline for nascent technologies as well as deliver an invigorating influx of new ideas to the lab itself. Further enhanced and scaled through the national non-profit Activate.org, the fellowship

program has already delivered extremely attractive results; by their analysis, they have nearly 100 new products and businesses and catalyzing hundreds of millions of dollars in follow-on private sector funding. The initial program has also been repeated, in locally tailored ways, by Argonne as Chain Reaction Innovations and Oak Ridge National Lab as Innovation Crossroads. The DOE should scale these programs like it across the Department and country. Doing so is inexpensive at the level of the DOE budget, and would have massive catalytic effects in transforming scientists into entrepreneurs, invigorating the laboratories, and accelerating the commercialization of the technologies we need to address climate change and strengthen our economy.

Third, DOE must overhaul its contracting and reporting processes. While some commercial entities, like Exelon, have time and staff to conduct year-long negotiations on collaborative research and then painstakingly report how every federal dollar is spent, there are far more commercial entities that do not. Goals like protecting intellectual property on behalf of the American people are laudable and important and should continue to receive due consideration. But China and the climate are not waiting while we negotiate with ourselves.

Furthermore, the American people benefit far more from the installation of clean infrastructure and the sale of real products than they do from lab or DOE ownership of intellectual property. Programs like the Office of Energy Efficiency and Renewable Energy's Small Business Voucher pilot are examples of how DOE can overhaul its contracting, making it easier to work with the DOE labs. Of the 114 small businesses in the pilot, 91 percent of awardees rated positively the speed with which they were able to sign contracts with a national lab. This was due to a concerted effort to streamline the contracting process and create a central application portal and consolidated access to lab resources and capabilities.[4] New funding and contracting rules should explicitly encourage and support commercialization rather than hinder it; should be designed to move at the speed of real innovation; and should emphasize outcomes-based reporting that clearly delineates what the taxpayer gets for dollars spent.

Fourth, DOE should expand on one of the greatest strengths it possesses within the national labs: its user facilities. The national laboratories have unique assets that should continue to support basic science research, but be available to commercial entities as well. Within the nuclear sector, the National Reactor Innovation Center (NRIC) and Gateway for Accelerated Innovation in Nuclear (GAIN) programs are offering valuable opportunities to the companies working to commercialize advanced reactors. Efforts like NRIC's creation of an advanced reactor testbed should be fully funded, in a manner that includes continued operational support so NRIC can serve the community in a predictable manner. DOE should do much more to assess private sector needs and build the testbeds that specifically meet them.

[4] Gretchen Jordan and Albert Link, Evaluation of U.S. DOE Small Business Vouchers Pilot (Washington, D.C.: DOE, November 2018), 37, https://www.energy.gov/sites/prod/files/2018/12/f58/eval-small-business-vouchers-pilot-112718.pdf.

Fifth, the Office of Technology Transitions needs to be prioritized and resourced appropriately. Its Technology Commercialization Fund (TCF), currently at $30 million per year, is not nearly enough to support the commercialization of the outcomes of nearly $9 billion in federal work across DOE's Office of Science and Energy Program offices at the national labs. In addition to more funding for the TCF, a tripling of the OTT budget from approximately $20 million in FY 2021 to $60 million would be a good start toward implementing the suggestions made above. The additional funding could go to additional investments outlined in the Energy Act of 2020, like commercialization activities, partnerships to ensure success of DOE demonstration programs, surveys and other engagement mechanisms to systematically identify commercialization challenges within the private sector, regional innovation, and a range of other activities in support of new contracting mechanisms and DOE program incentives.

A transformational step forward could include funding a DOE foundation focused on technology impact. A foundation might enable new sources of funding to work alongside DOE priorities, and could enable DOE to find creatively powerful new ways to partner with the private sector. The Increasing and Mobilizing Partnerships to Achieve Commercialization of Technologies for Energy Act" or the "IMPACT for Energy Act," S.2005 introduced in the 116th Congress by Senators Chris Coons (D-DE) and Lindsey Graham (R-SC) establishes such a foundation. Its companion bill, H.R. 3575, passed in the House of Representatives last year, is a bipartisan bill with strong support by private sector and philanthropic partners. The concept has also been thoroughly evaluated by the National Academy of Public Administration, which recommends the creation of a DOE Foundation in its recently released report, *An Innovation Foundation for DOE: Roles and Opportunities*.

Sixth, DOE, and ideally the entire government, should do all of this in a systems context, with more funding going toward cross-cutting projects and new players: not just universities and labs, but also nonprofits, equity-focused community organizations, and regulators. The truth is that the silos we have established in government, in corporations, and in our economy are not suited to the interconnected and global challenges we face. This is true for pandemics and it is especially true for climate change.

My organization, Actuate, aims to solve some of the thorny systems issues that bedevil climate change mitigation and defy the boundaries of our silos. We start by asking where the biggest levers are to reduce greenhouse gases. We then get very specific about what the barriers are to wide-scale, rapid deployment of those levers. If we see a bold goal tied to greenhouse gas reduction, paired with a unique opportunity to demonstrate something that might just barely be achievable, we have the core elements of an Actuate program. We are early in our journey, but we have nascent ideas that range from reducing nitrogen emissions from agriculture, to demonstrating deep, consistent demand response to backstop renewables. Over the coming year, we intend to explore these ideas, designing programs that will actively fund the full suite of actors that are needed to achieve scale. This includes universities, labs, and startups, but also community organizations, nonprofits, and the companies and financial institutions that will bring much of the infrastructure into reality. Our hope is that these actions will, among other things,

provide a working example of new ways in which federal agencies can support innovation in a systems context.

These recommendations are raw ideas that require further study before implementation. Collectively, they and other measures will not move DOE beyond the dated technology transfer paradigm, but they represent a start toward catalyzing more, faster impact-driven innovation and investment.

In conclusion, we should celebrate the incredible asset we have in DOE and the national laboratories in fighting climate change and promoting American competitiveness. DOE enabled one of my proudest moments at Exelon: my team's launching of a hydrogen electrolysis pilot project at a nuclear plant site, intended to demonstrate a pathway for regional supply of clean hydrogen. That project became possible thanks to Federal ingenuity and funding, and foresight by Exelon's leadership. We need many, many more examples like it up and down the innovation pipeline and across technologies. Doing so will enable us to claim American leadership in science and technology development as we deliver climate-preserving infrastructure to the world.

Chairman Manchin, Ranking Member Barrasso, and Members of the Senate Committee on Energy and Natural Resources, thank you for the opportunity to appear before you today to discuss the Department of Energy and its role in U.S. innovation and competitiveness. I look forward to your questions.