

Good morning, Chairman Foster, Chairman Bowman, Ranking Member Weber, Ranking Member Obernolte, and other distinguished members of the Subcommittees. Thank you for the invitation to provide testimony on the importance of Judicious Spending to Enable Success at the Office of Nuclear Energy.

My testimony today represents my own views and not those of my employer or any other organization with which I am affiliated.

I will focus on the pressing need for the creation of strategic and coordinated private-public pathways for the development of nuclear energy technologies.

Where are we in the history of nuclear power development

Currently, approximately 50 American entrepreneurial companies are working to rapidly bring the next generation of advanced reactor technologies to the market, with an emphasis on new energy applications and business models beyond large electricity production. The most advanced of these companies are in discussions with the US Nuclear Regulatory Commission aiming to build their first plants in the next 5 to 10 years. Others are actively working with the National Reactor Innovation Center to demonstrate their novel technologies on a similar time scale. This is an exciting time for nuclear energy.

The Pivot of 2015-2020

Congress has noted this emerging new commercial activity and responded in a timely and positive bi-partisan manner with many legislative actions that provided access to testing capabilities, streamlined the regulatory environment, established a demonstration program, and established a strong private-public partnership program.

During this period, Congress has also increased overall budgets to provide more opportunities at universities and laboratories to not only support this first generation of advanced reactor deployments, but also to innovate towards future generations of advanced nuclear energy systems.

The need to structure RDD&D program management for success

While Congress' support for nuclear energy has been strong and many new important program elements have been established, these program elements still often appear to operate independently rather than as an integrated whole. The sophistication of the research, development, demonstration, and deployment program elements have increased thanks to Congressional support, but the sophistication of the integrated program execution and project management have not yet caught up.

The Department of Energy programs need to simultaneously coordinate and support many things: a national research infrastructure program, early innovation, concept development, demonstrations, and ultimately commercial deployment. Historically, the

federally funded U.S. nuclear research programs have not consistently balanced all five of these elements. Continued and future success requires finding this balance.

One of the consequences of past insufficient program integration and lack of programmatic consistency is the limited results from previous nuclear technology development and deployment efforts. Though these programs have received significant investments (~\$2 billion since the late 1990s), they struggled to transition from programmatic success to commercial development and use (Appendix B). Therefore, a framework of principles and policies needs to be established that guides the programs and drives technologies from new ideas to deployment. What might some of these principles include (Appendix B, D)? A larger set is submitted with my written testimony, but I will highlight two examples:

1. We should encourage early-stage research that pushes the envelope (Appendix C) but which might not yield near-term results. Such research drives innovation for decades. Early-stage research should be daring! We should decide which early-stage research should be continued based on success of the research and not pre-determined time frames as has become the inclination at the DOE.
2. We should support well-structured private-public cost sharing as an important element in accelerating innovative technology development. Commercial deployment of new technologies is more likely to succeed if led by industry rather than by research institutions. The continued funding of these partnerships

should depend on the success in meeting specific measurable technical and financial milestones. The private-public partnerships should evolve based on performance rather than follow a fixed multi-year plan.

Programs, from infrastructure to early innovation to deployment, need to connect to ensure the best new ideas are developed and deployed in a timely manner.

Operationalizing these principles may require re-thinking program structures and interfaces. It is important to engage the academic, laboratory, and practitioner communities broadly to provide independent advice on these principles.

There are also tremendous opportunities for the Office of Nuclear Energy to achieve its goals through collaboration and synergy with other programs and offices across DOE, such as the Loan Programs Office, the DOE NNSA to integrate safeguards into the design principles of advanced reactors, and cross-cutting hydrogen programs.

Additionally, it is important to provide the Office of Nuclear Energy sufficient staffing to evolve and support their management programs and to support collaborative work across DOE. The funds provided to staff the Office of Nuclear Energy have not increased sufficiently even as the R&D budgets have grown approximately 60% over the past 5 years.

Conclusion

We are currently in an exciting and ambitious time for nuclear energy. Over the past three administrations, Congress has provided increased funding and legislative support for nuclear energy, recognizing the importance of nuclear energy for providing clean reliable energy and supporting good jobs. A number of new, critical programs have been initiated and a few more are needed. The principles and structures upon which these programs are executed need to be established to ensure the funding is best used as we build 21st century energy systems.

I look forward to this dialogue as well as to supporting the Committee as it considers how to enable success at the Office of Nuclear Energy.

Appendix A

Where are we in the trajectory of nuclear power development: past and present practices and the need for an equity-centering future

Currently, 93 large light water reactors provide roughly 20% of the U.S. electricity. This is over 50% of the U.S. zero carbon electricity.

These reactors were built primarily during the 1960s through 1990s at a rate of about 30 GW per decade, proving we can build nuclear power at a rapid rate through the strategic coordination of private and public efforts. Many first-generation plants are now working with the Nuclear Regulatory Commission to extend their licenses to 60 years and 80 years. Other first-generation plants have started to shut down, often due to financial pressures based on the design of deregulated electricity market rules where the plant operates.

At the same time, approximately 50 entrepreneurial companies are working to rapidly bring the next generation of advanced reactor technologies to the market, with an emphasis on new energy applications and business models beyond large electricity production – including as examples, the provision of community scale heat and electricity to U.S. and international markets and direct heat to industry. The emerging low carbon energy systems – which combine firm sources of energy such as nuclear

reactors with variable sources such as renewables -- are more complex than those of the 20th century.

The most advanced of these companies are in discussions with the US Nuclear Regulatory Commission aiming to build first plants towards the end of this decade. Still others are actively working with the National Reactor Innovation Center to demonstrate their novel technologies on a similar time scale.

As we create these low carbon energy systems of the near future, we need to build new energy technologies that are simultaneously clean, affordable, resilient, and equitable. This last consideration is especially important for the energy sector writ large and the nuclear sector specifically because historic efforts to develop nuclear technologies -- energy and weapons -- have created inequities disproportionately borne by communities of color -- especially indigenous communities. (These communities are sometimes referred to as environmental justice communities.) These legacies of inequity require that special care and attention be paid, and reparative measures be undertaken, as the industry considers the development and use of a new generation of technologies.

Indeed, the DOE's Office of Nuclear Energy recognizes the importance of these considerations as it has called for centering principles of equity and justice and pursuing a sociotechnical approach to reactor development in its most recent Consolidated Innovative Nuclear Research Funding Opportunity Announcement. As discussed in

Appendix D, an overarching equity-centering principle is needed to guide research, development, demonstration, and deployment efforts across the nuclear sector. Such an approach should be pursued because it is the right thing to do and also because it is likely to lead to the development of technologies that will successfully be put to use in service of society.

Appendix B

The following reference documents are suggested

- The U.S. Nuclear R&D Imperative, A Report of the American Nuclear Society Task Force on Public Investment in Nuclear Research and Development, February 2021. Chapter 4 on research structures is relevant.
- A Abdulla, M J Ford, MGMorgan, and D G Victor, "A retrospective analysis of funding and focus in US advanced fission innovation," Environ. Res. Lett. 12 (2017) 084016
- Enabling Nuclear Innovation, In Search of A SpaceX for Nuclear Energy: A report by the Nuclear Innovation Alliance, May 2019

Appendix C

Illustrative examples

Major databases that require continuous modernization

- Nuclear cross sections
- Material and fuel properties
- Thermo-physical properties
- Public sentiment
- Multi-physics codes

Examples of early stage research

- Quantum computing
- Development of novel materials for applications in radiation intensive environments
- New manufacturing approaches such as additive manufacturing
- Artificial intelligence and sensing networks
- Automation
- Integrated Energy Systems
- Cybersecurity of interconnected systems
- Socially-engaged complex system design
- Consent-based processes

Appendix D

Example principles and policies to guide RDD&D programs

1. We should continually protect and modernize key national infrastructure and make it available to many innovators, from universities to laboratories to companies. This includes traditional infrastructure like test reactors and supercomputers, but also critical data sources and the educational infrastructure. Making critical research infrastructure widely available is essential because innovators and reactor developers today, unlike in the past, are carrying out technology design and development work in a variety of settings including startups, large companies, national labs, and universities. Increasing the availability of critical infrastructure ensures that novel ideas, wherever they emerge, will be pursued towards full development and commercialization.
2. We should encourage early-stage research that pushes the envelope but which might not yield near-term results. Such research drives innovation for decades. Early-stage research should be daring! We should decide which early-stage research should be continued based on success of the research and not pre-determined time frames as has become the inclination at the DOE.
3. We should decrease the time to make research funding decisions. The current lead time between concept development, proposal writing and funding is

over 18 months, which is effectively several years when you include uncertainty of funding, where several proposals are revised multiple times before successfully receiving research funding. When you include the time to perform the research, the period may exceed 5 years. This is one of the reasons why there is a disconnect between industry needs and the work of the research community.

4. We should support well-structured private-public cost sharing as an important element in accelerating innovative technology development. Commercial deployment of new technologies is more likely to succeed if led by industry rather than by research institutions. The continued funding of these partnerships should depend on the success in meeting specific measurable technical and financial milestones. The private-public partnerships should evolve based on performance rather than follow a fixed multi-year plan.

5. We should seek community input and engagement from the earliest stages of technology design and development towards ensuring that technologies being developed will ultimately be adopted by communities. Such an approach is especially important in light of historic inequities created by the development and use of nuclear energy, as well as the distributed and community-scale nature of new nuclear energy technologies. There is an unprecedented and urgent need to emphasize principles of equity and environmental justice in technology design and development.

Appendix E

Statement on Participation in a National Academy of Science, Engineering, and Medicine Consensus Committee

I am a member of a National Academies consensus committee whose task is to assess the opportunities and barriers to commercializing new and advanced nuclear technologies within the next 30 years, and in the context of decarbonization. The committee has made no findings, recommendations, or conclusions. Such results will only appear after the committee's final report has been written, reviewed, and formally released in the summer of 2022. The views expressed in this testimony are my own and do not reflect the thinking of that committee.

Appendix F

Examples of Recent Congressional Support for Nuclear Energy

- Passing the 2018 Nuclear Energy Innovation Capabilities Act to enable the testing and demonstration of reactor concepts proposed and funded by the private sector.
- Passing the 2019 Nuclear Energy Innovation and Modernization Act requiring the Nuclear Regulatory Commission to develop a regulatory framework for America's innovators who seek to deploy advanced nuclear technologies
- Funding the 2019 Nuclear Reactor Innovation Center, providing access to U.S. Government resources, facilities, sites, infrastructure, and expertise and
- Funding the Advanced Reactor Demonstration Program in 2020 to help the next generation of American nuclear reactors make the transition from concept to technology demonstration as a precursor to commercial development

Appendix G Personal History

My perspective on nuclear energy technology development comes from a diverse career working in the U.S. submarine fleet, as an academic at the University of Wisconsin and now at The University of Michigan, as a senior leader at the Idaho National Laboratory, and with the think tank Third Way. I also gain perspective as a Board member of the Nuclear Innovation Alliance and the Nuclear Energy Institute, as well as being the Chair of the Nuclear Engineering Department Heads Organization.