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Nuclear Energy Innovation - The Path Forward for Small Modular Reactors and Advanced Nuclear Reactors

Introduction

Thank you Chairwoman Murkowski and Ranking Member Cantwell, and members of the Committee, for this opportunity to speak to you today. I am Dr. Mark Peters, Director of the DOE Idaho National Laboratory (INL) since October 1. I most recently served as Associate Laboratory Director at Argonne National Laboratory (ANL) in Illinois. I am pleased to participate in this most distinguished panel before the Committee. I request that my written testimony be made part of the record.

Before I begin my testimony, I would like to thank Idaho Senator Risch for his continuing support of INL and the research conducted at the national laboratories and for becoming a cosponsor of the Nuclear Energy Innovation Capabilities (NEICA) Act, S. 2461, authored by Idaho Senator Crapo, Senator Booker (D-New Jersey), and Senator Whitehouse (D-Rhode Island), which, on an 87-4 vote, was included as a bi-partisan amendment to the Senate Energy Bill last month.

The legislation is the companion to the House measure of the same name, H.R. 4084, offered by Representatives Lamar Smith (R-Texas), Eddie Bernice Johnson (D-Texas), and Randy Weber (R-Texas). It passed the House Science Committee and was recently added to H.R. 4909, the National Defense Authorization Act. The House and Senate legislation are important enablers to much of what I will discuss today.

Laying the Groundwork for a New Nuclear Innovation Paradigm

INL has a vision for the vital role nuclear energy must play as part of the future global energy system. The U.S. is widely recognized as a world leader in the development of advanced nuclear reactors, as demonstrated by the numerous cooperative research agreements and partnerships in place between DOE and foreign partners. However, leadership is earned, not granted, and other nations are investing to develop the facilities, capabilities, and people necessary to excel.

Light-water small modular reactors (SMR) and advanced reactors also provide the opportunity to re-establish the domestic nuclear industry (entire value chain) – a key to global leadership. The U.S. has the opportunity to regain domestic manufacturing and supply chain capabilities lost when we did not build new reactors during the last 30 years. SMRs and advanced nuclear reactors can be entirely sourced in the U.S. creating new advanced manufacturing facilities vital for economic growth. The proposed NuScale SMR, which could be built on the INL Site, would create thousands of jobs during the construction phase and hundreds of permanent jobs with annual incomes far above the regional, state, and national averages. According to the Idaho Department of Labor, this project would infuse millions of dollars annually into the local and state economies. This is but one example of why the U.S. cannot afford to fall behind and lose a competitive advantage to other nations.

The value proposition for U.S. nuclear energy has never been stronger. Recognizing safe, secure, reliable, and affordable energy as the engine for economic growth, prosperity, and quality of life, there is strong global and domestic interest in nuclear energy. Concerns about climate change and the associated need to limit the GHG emissions, and reliability of clean energy supply, also drive the increasing interest in this technology. During the recent international negotiations on greenhouse gas emissions, the White House declared nuclear energy a key component of U.S. strategy to achieve carbon reduction goals. The U.S. cannot safely, securely, and affordably meet increasing electricity demand and stringent clean air goals with renewable energy alone. In this effort, nuclear energy and renewables become complementary. Safe and reliable nuclear energy provides 19 percent of total electricity and 63 percent of U.S. electricity sector's carbon-free generation today. Nuclear energy's contribution to clean air must be maintained and even grow into the future.

We have immediate challenges and opportunities before us to enable SMRs and advanced reactors. We set about determining what could be done last March. With our partner national laboratories and the nation's universities, we hosted a set of six simultaneous workshops - the Nuclear Innovation Workshops - aimed at developing creative solutions to accelerate innovation in nuclear energy. We asked the private sector: what are your needs?

Our conversations with advanced reactor developers indicated challenges in two main areas: resolving technical and licensing challenges at an early stage and addressing remaining technical, licensing, and economic questions at the demonstration and deployment phase. In fact, one of the top recommendations to come out of the workshops was the need for a national test bed – or test beds – where the developers working on advanced nuclear technologies can mature the design of their system and associated components.

Then, in November, the Administration announced formation of the Gateway for Accelerated Innovation in Nuclear (GAIN). As the nation's lead nuclear energy laboratory with distinctive capabilities, expertise, and facilities, INL, in collaboration with ANL and Oak Ridge National Laboratory (ORNL), will play a leadership and integration role in the multi-lab and university implementation of GAIN.

GAIN, as a research, development, and demonstration platform through public-private partnership, will provide the people and facilities to develop and test key components and mitigate uncertainty while allowing developers to fine-tune their design. Resolving technological risks can give investors the confidence to move forward with increased financing for an advanced reactor design. Building on the success of national user facilities across its nationwide national laboratory complex, DOE has made great strides in making its unique facilities, capabilities, and people available to university and industry research partners, and GAIN will take this effort to a new level.

As a core part of GAIN, INL and our partners is the portal for designers and developers interested in a wide range of DOE nuclear-energy related capabilities and expertise. We are developing a detailed execution plan for GAIN with input from investors and industry. The execution plan will include streamlined contracting processes with industry, a communication plan, and describe the organizing principle for the DOE Office of Nuclear Energy (DOE-NE) sponsored relevant R&D programs. We have already made considerable progress in putting a number of critical elements of GAIN in place. We have established a National GAIN organization, including an executive advisory committee comprised of leaders from industry and the national laboratories. Technology specific workshops with various stakeholders are planned in the near future with the objective of streamlining the base DOE R&D programs informed by industry and investor needs. We have developed and proposed to DOE-NE, a five-year DOE-NE funding plan consistent with GAIN strategic objectives.

In late January, the Third Way with INL and partner national laboratories hosted an advanced nuclear energy summit to engage the private sector in regard to creation of new opportunities for collaborative research and development in light-water SMRs and advanced, non-light water reactor technologies. I would like to thank Chairwoman Murkowski for her remarks, which were heard by the hundreds of people attending the event. Advanced reactors may be suitable for micro grids like those found in Alaska. In many communities around the world, where there are impediments to building large-grid infrastructure, there continues to be great enthusiasm for the development of innovative nuclear energy technologies to achieve the full benefits of this clean energy source.

Light water reactors have achieved unparalleled safety and environmental milestones. However, in the light of growing demand for clean energy nationally and globally, there is an urgent need to develop and deploy significant new and flexible nuclear energy capacity, starting now and ramping up significantly in the 2030-2040 timeframe. The next generation of reactors will provide enhanced passive safety features, while increasing efficiency and reducing environmental impact. They will also prove to be more economical and reduce the proliferation risk. This requires accelerated innovation, and commercialization of SMRs and advanced reactors.

Gateway for Accelerated Innovation in Nuclear (GAIN)

The Administration's GAIN proposal has four components: 1) access to capabilities (test facilities, high performance computing, national experts, and demonstration capabilities); 2) a nuclear energy infrastructure database; 3) small business vouchers; and, 4) assistance in navigation of the regulatory process.

INL, with partner universities and other national laboratories, will facilitate an R&D test bed for industry to access laboratory expertise and nuclear facilities and capabilities. Resolving technological risks can provide confidence to investors to move forward with increased financing for a reactor design. For the later-stage commercialization, companies may access INL and other government sites for demonstration and deployment capabilities, which can reduce costs and improve performance of their design as it moves to full commercialization. An early example of this is the recent announcements related to potential siting of a NuScale SMR on the INL Site. The new cost of future reactor technologies has been notoriously difficult to predict. One function of the GAIN initiative is to remove engineering uncertainty for the construction process and allow developers to provide a better estimate of costs. Through GAIN, we will address different models for partnerships and incorporate what has been proven to work well into our new paradigm for advanced reactor development and deployment.

DOE continues to invest in maintaining and developing state-of-the art research capabilities to more effectively and efficiently develop innovative nuclear energy technologies. Recent examples include improved world-leading post-irradiation examination capabilities, the restart of transient testing capabilities, and high-fidelity modeling and simulation capabilities. These, and other capabilities, will be made available through GAIN for retirement of technical, licensing, and financial risk associated with the critical components of innovative designs.

DOE continues to invest in the experimental and computation capabilities in support of nuclear technologies. This includes the added capabilities at the Office of Science User Facilities, such as Spallation Neutron Source (SNS), National Synchrotron Light Source (NSLS-II), Advanced Photon Source (APS), and Linac Coherent Light Source (LCLS) to conduct experiments with nuclear materials. One major missing capability in the complex is a fast-spectrum test reactor needed for accelerated irradiation effect studies for fission and fusion systems, and the development and qualification of fuels and materials to be used in future advanced reactors. DOE is evaluating the needs for such a facility. Addressing the needs for a new fast-spectrum irradiation testing capability is also included in the recent House and Senate energy authorization bills, H.R. 4084 and S. 2461, respectively.

DOE is publishing the Nuclear Energy Infrastructure Database (NEID), which provides a catalogue of existing nuclear energy related experimental and computing infrastructure that will enhance transparency and support nuclear community engagement through GAIN. According to DOE, “NEID currently includes information on 802 research and development instruments in 377 facilities at 84 institutions in the United States and abroad. Nuclear technology developers can access the database to identify resources available to support development and implementation of their technology, as well as contacts, availability, and the process for accessing the capability."

DOE also announced a small business voucher (SBV) program to support the strong interest in nuclear energy from a significant number of new companies who are working to develop advanced nuclear energy technologies. According to DOE, the government plans to make funding "available in the form of vouchers to provide assistance to small business applicants (including entrepreneur-led start-ups) seeking to access the knowledge and capabilities available across the DOE complex." This program is modeled after the successful SBV program at the DOE Office of Energy Efficiency and Renewable Energy, but tailored to the unique needs of the nuclear industry. In 2016, a small pilot program is being executed for a total of $2 million in funding. The technical reviews for the many applications have been completed, and DOE soon will be making the final decisions for the awards.

DOE will work through GAIN with prospective applicants for advanced nuclear technology to better understand and navigate the NRC regulatory process for licensing new reactor technology. At the September 2015 workshop on advanced non-light water reactors, the NRC said it would: 1) consider whether a "staged" licensing process is possible; 2) clarify some targeted guidance of particular interest to designers, such as prototype guidance; and 3) continue progress on identified policy issues. A staged licensing process, in particular, would inform further investments by the private sector as technical and licensing risks are retired. The second DOE/NRC workshop is scheduled next month to address these issues further.

We are creating a new paradigm in nuclear innovation and nuclear energy. This paradigm involves new ways of working with a diverse nuclear community that includes utilities, startups, large nuclear suppliers, government entities, non-profits, and everyone on this Committee. We are your national laboratories, and we are open for business.

DOE's Lead Laboratory for Nuclear Energy: Idaho National Laboratory

For more than 60 years, INL has played an important leadership role in the development and deployment of nuclear energy and more recently the development of next generation nuclear reactors. It is an exciting time for nuclear energy as the world looks at this essential component to address energy security and the risks presented by a changing climate. Nuclear energy plays a vital role as part of the future global energy system. The value proposition for nuclear energy has never been stronger.

INL is an applied research and development laboratory. We work to enable innovation to ensure that secure and reliable advanced nuclear energy technologies are available to the U.S. and a global energy market. The laboratory is working with federal agencies (including the NRC), universities, and other national laboratories to establish and maintain a domestic nuclear energy capability. This work is anticipated to culminate in the U.S. providing global leadership and reestablishing a supply chain for advanced nuclear energy systems development and deployment.

INL is in a prime position to take on national challenges and seize opportunities in supporting nuclear energy. The work INL conducts in safety, nonproliferation, and the economics of nuclear energy supports the global nuclear energy market. INL researchers work to develop technology solutions to address climate change, ensure secure and resilient energy infrastructure, enable nuclear material security, and sustain U.S. leadership in a competitive environment.

INL has formed advanced reactor partnerships with the private sector. Currently the laboratory is working on: 1) advanced reactor design evaluation; 2) hybrid nuclear energy systems development; 3) digital instrumentation and control work; 4) innovative fuels and materials design development, fabrication and demonstration; and 5) modern and creative risk analysis techniques.

One of the most important projects undertaken recently by INL, and authorized by the 2005 Energy Policy Act, was the Next Generation Nuclear Plant (NGNP). This high-temperature gas reactor was under development as part of the GENIV nuclear energy program. From 2005-2013, the NGNP program worked to address and resolve critical technical and licensing issues. In 2014, the NRC staff released an assessment report that found the NGNP technical approach on fuel qualification was reasonable. The laboratory is still working with the NRC to qualify the fuel.

However, the (NGNP) experience also showed us some of the challenges associated with licensing advanced reactor technologies. We strongly believe INL's engagement with the NRC and industry on a non-light water reactor technology licensing effort will be a valuable part of enabling commercialization of advanced reactors.

The Transient Reactor Test Facility (TREAT) was specifically built at the INL site to conduct transient reactor tests where the test material is subjected to neutron pulses that can simulate conditions ranging from mild upsets to severe reactor accidents. The reactor was constructed to test fast reactor fuels, but has also been used for light-water reactor fuels testing as well as other special purpose fuels (i.e. space reactors). Renewed interest in this facility was sparked by the nuclear accident in Japan in 2011 when Congress directed DOE to renew efforts to develop more accident-tolerant nuclear fuel. We are on track to restart this important test facility by 2018.

In the last 10 years, we have made considerable progress in upgrading the capabilities at the Materials and Fuels (MFC) complex. Now, the facility includes state-of-the-art capabilities for laboratory-scale fuel fabrication, fuels and materials characterization, post-irradiation examination and analytical chemistry. The research output continues to improve. Likewise, we are making considerable progress in managing the Advanced Test Reactor (ATR) reliability and preventive maintenance issues, and increasing the efficiency of this world-class test reactor. We look forward to operating the ATR until 2050 and beyond. The reactor is operating on a much more predictable schedule, compared to previous years. We are also investing considerable R&D dollars for in-pile instrumentation for state-of-the-art measurements during irradiation experiments.

INL also is leading the way in a promising application of advanced reactors as part of hybrid energy systems that use heat from fission to power industrial processes that would otherwise rely on fossil fuel/natural gas to provide heat. Another potential use is hydrogen production. Large quantities of feedstock are being used in the petrochemical industry to upgrade heavy crude oil and produce fertilizers. We are working cooperatively with the National Renewable Energy Laboratory (NREL) to examine new ways to integrate renewable energy with nuclear energy systems. In addition, we have established a 91,000-square-foot Energy Systems Laboratory (ESL), located on the INL's Idaho Falls Research and

Education Campus, for research and development in bioenergy, hybrid energy systems, and advanced vehicle and battery testing programs.

INL also leads a robust DOE program in collaboration with industry in support of Light Water Reactor (LWR) technology - the Light-Water Reactor Sustainability (LWRS) program. For example, the laboratory has partnered with Arizona Public Service's Palo Verde Nuclear Generating Station to design a modernized control room for operating commercial reactors. This work supports the long-term sustainability and efficiency of the nation's existing nuclear reactor fleet by assisting nuclear utilities to address reliability and obsolescence issues of legacy analog control rooms.

Finally, INL and partner national laboratories support the ongoing and important efforts by DOE and the nuclear industry to develop and commercialize SMRs. We are providing direct technical support to companies such as NuScale as part of their design and licensing process and also are looking to provide technical support and infrastructure to deploy SMRs in the United States. We are a proud partner with NuScale and are working together with DOE and the Utah Associated Municipal Power Systems (UAMPS) to build the nation's first SMR at the INL.

Nuclear Energy Innovation is Strengthened at Idaho National Laboratory

The new nuclear energy innovation paradigm is driving new types of partnerships between national laboratories, universities, and industry. The laboratory is becoming an entry point, or portal, for utilities, large nuclear suppliers, entrepreneurs, and small businesses to access the national laboratory facilities and staff expertise. The idea for user facilities originated with the concept that exceptional research capabilities and expertise developed to meet national challenges should also be made available to non-government users. Idaho National Laboratory's Nuclear Science User Facilities (NSUF) is one of a number of DOE user facilities in the United States and the nation's only designated nuclear energy user facility. As the only DOE nuclear energy user facility with partner facilities, the NSUF is the hub that connects a broad range of exceptional nuclear research capabilities spanning the U.S.

The nuclear innovation test bed concept is a promising development in advanced reactor research and development. In a recent example, INL is working cooperatively with TerraPower to build new capabilities and provide support for the Traveling Wave Reactor (TWR) concept, a new type of fast reactor, under multiple cooperative research and development agreements (CRADA). In fact, the Experimental Fuels Facility (EFF) at INL's Materials and Fuels Complex has undergone a transformation in recent years to expand capabilities for the TWR. In addition to the extrusion press, the EFF has been newly equipped with a billet-casting furnace, inert glove box, draw bench, annealing furnace, and several other types of machining equipment.

INL is also partnering with other national laboratories to expand the capabilities of pre-existing DOE research programs. In December, DOE's Consortium for Advanced Simulation of Light Water Reactors (CASL), led by Oak Ridge National Laboratory (ORNL), agreed to help NuScale establish new cost-shared modeling and simulation tools for its SMR design. Through this agreement, CASL tools will be expanded to better simulate SMR operations and inform design decisions. This research will allow for a more efficient reactor design that will enable better operation lifetime.

In another recently formed public-private partnership, on January 15, DOE announced INL would partner with X-energy to address fuel development challenges of the Xe-100 Pebble Bed Advanced Reactor. Other partners include: BWX Technology, Oregon State University, Teledyne-Brown Engineering, SGL Group, and ORNL. This award provides an example of the public-private partnerships envisioned under the recently launched GAIN initiative. DOE's investment will be $6 million this year. The possible multi-year cost-share value for this research is as much as $80 million.

Summary

The outstanding safety record of the U.S. nuclear power industry is a direct result of the groundbreaking research, development, and demonstration of the technologies and safety systems developed in the last century. This leadership position enabled the U.S. to set the terms and act as a key resource for other nations as they developed reactors for power and research, and to ensure the security and eventual return of fuels and materials that could otherwise have been diverted.

We are on the cusp of another fundamental transformation in nuclear energy. The existing light water reactor fleet will serve as a bridge to SMRs and advanced reactor technologies. We have developed tremendous expertise in operating LWRs at the highest levels of safety and efficiency and much of that expertise will be relevant to advanced reactor design and operations.

We will see today's light-water reactors, SMRs, and advanced non-light-water reactors operating side-by-side. When looking at siting nuclear reactors, it may make sense to prioritize existing sites that have the infrastructure and workforce in place to support a new reactor and, moreover, a good deal of site characterization has already been performed. One key role that INL and the national laboratories can play is to provide the technical foundation for those siting decisions and platforms for demonstration (as part of GAIN).

I am very pleased to be at the helm of INL, the lead national laboratory for nuclear energy, with more than 4,000 employees devoted to science and innovation in advanced nuclear energy technologies. Recent White House and DOE initiatives, as well as Congressional legislation, are setting the stage for research, development, and deployment of new and advanced nuclear energy systems. The end result will mean cleaner, more plentiful energy with the potential for lifting billions out of energy poverty.

Thank you for inviting me today to testify, and I look forward to your questions.