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"Full Committee Hearing to Examine the Opportunities and Challenges associated with Advanced Reactor Commercialization."
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Chairman Manchin, Ranking Member Barrasso, and members of the committee, it is an honor and privilege to be here today. My name is John Wagner, and I am the director of Idaho National Laboratory (INL), the nation's nuclear energy research and development center. In this role, I lead a United States (U.S.) Department of Energy (DOE) national laboratory with more than 6,000 scientists, engineers and support staff, multiple nuclear and nonnuclear experimental facilities, and an annual budget of more than $1.8 billion, with a mission focused on nuclear energy, national and homeland security, and energy and environmental science and technology.

I hold a Bachelor of Science degree in nuclear engineering from the Missouri University of Science and Technology and Master of Science and Doctorate degrees in nuclear engineering from Penn State. Throughout my career, I have been intimately involved in technical issues related to the nuclear fuel cycle. My first position following graduate school was with a private company designing and licensing spent nuclear fuel storage and transportation systems. Later, during my employment at Oak Ridge National Laboratory (ORNL), I supported the U.S. DOE and the Nuclear Regulatory Commission (NRC) on a variety of technical issues related to long-term storage, transportation, and disposal of spent nuclear fuel, including serving as the national technical director of the DOE's Nuclear Fuels Storage and Transportation Planning Project—a project established to implement the recommended near-term actions in the Blue Ribbon Commission (BRC) on America's Nuclear Future report, and to lay the groundwork for implementing interim storage, including associated transportation. While at ORNL, I held various positions of increasing responsibility, ultimately the director of the Reactor and Nuclear Systems Division. In February 2016, I joined INL as the chief scientist for the Materials and Fuels Complex before becoming the associate laboratory director for the Nuclear Science and Technology Directorate (NSTD). I am the author and co-author of more than 170 refereed journal and conference articles, technical reports, and conference summaries, some of which have more than one hundred citations. I am a fellow of the American Nuclear Society and the American Association for the Advancement of Science.

Thank you for this opportunity to discuss an issue of great importance to our nation: the opportunities and challenges associated with advanced nuclear reactor commercialization.

I want to thank members of this committee, including our own Sen. Risch of Idaho, for their longstanding and unwavering support for the U.S. commercial nuclear industry and for maintaining and expanding our global leadership in nuclear technology. Sen. Risch and I recently co-authored an op-ed piece on the need for advanced nuclear technologies in our nation and around the world.

Background

Some have for many years debated the need for nuclear energy. Over the past few years, however, this discussion has shifted. Public opinion polls show broad public support for nuclear energy as part of our nation's effort to produce resilient and cost-effective electricity for our grid while also protecting the environment and powering our economy.

Nuclear energy also enjoys bipartisan support in Congress and in statehouses throughout the nation. This is evident in policies adopted by Congress and signed into law by the last two presidents. The Nuclear Energy Innovation Capabilities Act (NEICA) and Nuclear Energy Innovation and Modernization Act (NEIMA) passed both houses of Congress with overwhelming majorities. The bipartisan Infrastructure law and investments in research and development at our national labs have us on the cusp of achievements that could usher in a new era of nuclear energy and re-establish the United States as the world leader in nuclear energy development and deployment.

That's important for several reasons: the stability of our power grid, bolstering the national economy, national security, and meeting the nation's clean energy goals.

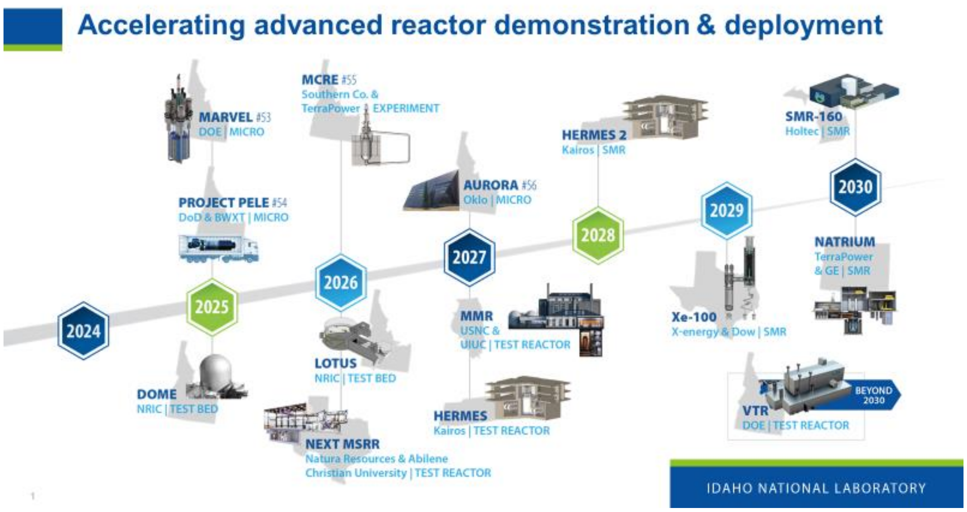
And so, it's no longer a matter of whether we need advanced nuclear technologies. It's a matter of how much firm, dispatchable, non-carbon emitting nuclear power we need, how we address past experiences associated with cost and schedule, and how quickly we can develop and deploy new reactors.

We know our nation needs more nuclear energy. A lot more. Earlier this year, a U.S. Department of Energy "Liftoff" report identified the need to triple our current nuclear generation to 300 gigawatts by 2050. Right now, the U.S. has 93 reactors in our fleet, another coming online soon. producing nearly 20% of American electricity and roughly half our nation's zero-carbon-emitting electricity.

The need outlined in the "Liftoff" report is consistent with what the Nuclear Energy Institute (NEI) found when it polled member utilities. NEI utilities see a need for approximately 100 GWe of new nuclear by 2050 to support their decarbonization goals. That's more than double the current U.S. nuclear capacity. Finally, analysis from the Nuclear Energy Agency and others points to the need to triple global nuclear capacity by 2050.

This presents a profound challenge and opportunity for clean, firm, secure, and flexible nuclear energy to address this domestic and global need.

That's why the nation's nuclear energy research and development center is working with such urgency. We know the clock is ticking. We know industry needs advanced nuclear technologies to meet domestic and global demand. That's why, with support from Congress, DOE, and our industry partners, we have laid out an aggressive advanced reactor demonstration timeline.



That begins as early as 2025 with MARVEL, an 85 kW DOE test reactor that will reestablish our ability to execute reactor demonstrations. MARVEL will provide an important research and development platform for researchers and industry to understand the use of microreactors for a variety of potential applications while providing information to support licensing, environmental assessments, improved performance, and deployments.

Next up, also in 2025, will be Pele, a partnership with the U.S. Department of Defense (DoD) and BWXT that will help our armed forces reduce their dependance on diesel fuel. Pele will pave the way for small, advanced reactors for other military applications, as well as for private-sector applications. It is worth noting that Pele will utilize TRi-structural ISOtropic (TRISO) particle fuel, enabled through collaborative research and development at the national laboratories in partnership with private industry.

Following MARVEL and Pele, INL, working with Southern Company and TerraPower, will conduct the Molten Chloride Reactor Experiment (MCRE), which will become the world's first fast-spectrum salt reactor experiment to achieve criticality.

These first three systems will be authorized for operation under DOE authority, as opposed to NRC licensing. The first planned NRC-licensed reactor on the INL site is the Oklo Aurora microreactor in 2027.

A key aspect of our strategy is to use existing reactor facilities at INL as test beds for reactor demonstrations and commercial innovators, via the National Reactor Innovation Center (NRIC). The decommissioned Experimental Breeder Reactor II, which is being repurposed for Demonstration and Operation of Microreactor Experiments, or DOME, is scheduled to be completed by 2025. Another test bed, LOTUS, will repurpose the Zero Power Physics Reactor facility to facilitate additional reactor tests and experiments, including MCRE. These test beds will streamline testing, demonstration, and, ultimately, deployment of advanced reactors into the market, showcasing the collaborative relationship between the national labs and the private sector at its best.

Many reactor projects will follow, demonstrating a variety of technologies for a variety of applications. These include the TerraPower Natrium reactor in Wyoming, which will be located at a coal generation site, the X-energy reactor in Texas that will support decarbonization of the energy-intensive industrial sector, and the Kairos Hermes reactor demonstration in Tennessee. Further, many additional reactor demonstration projects have not yet reached the level of maturity to satisfy our criteria for inclusion on our timeline, but will in time.

As a nation, we are moving forward. We are making steady progress. But we cannot rest easy, as the recent ending of the Utah Associated Municipal Power Systems (UAMPS) Carbon Free Power Project shows. The era of constructing paper reactors must end. We have to identify our challenges, address, and overcome them. We need to accelerate the systems and build the supply chains needed to rapidly develop and deploy advanced technologies at scale, in our nation and around the world.

How do we do this? I believe we begin with Congress addressing the following questions as it develops policies to enable deployment of advanced nuclear technologies:

1) *How can we address the cost of new nuclear plants and make sure that nuclear energy is appropriately valued for its contribution to the resiliency of our power grid, the U.S. economy, national security, and environment?*

The UAMPS/NuScale Carbon Free Power Project would have provided tremendous value for communities throughout the west, as well as INL, which was set to host the SMR plant on our site.

The project did not end because of technical flaws. The NRC approved the NuScale design, which will likely be used to generate electricity in other countries, such as Romania. The Carbon Free Power Project was suspended because of economics. A lack of subscriptions was directly related to the cost issues surrounding deployment of first-of-its-kind technologies.

And that leads to two questions:

1) Who should be the first movers on these advanced nuclear technologies?
2) Is nuclear energy being properly valued for its contributions?

Let's address that second question first. The answer is unquestionably "No." Nuclear energy contributes so much to our nation—and the world—in many vital areas. These include:

Ensuring Power Grid Resiliency

In 2017, Hurricane Harvey ripped through Louisiana and Texas, causing $125 billion in damages. Wind and solar plants shut down. A chemical plant exploded, and natural gas futures hit a two-year high, as did gasoline prices at the pump. Throughout this tumultuous time, there was one constant: nuclear power. Built specifically to withstand natural and man-made disasters, two nuclear reactors at the South Texas Project near Houston operated at full capacity despite 130 mile per hour winds. Those plants provided 2,700 megawatts of power to 2 million customers during their time of need.

We know what happens when it gets cold, especially in places not used to it. Folks turn up the heat. During the 2014 polar vortex in New England, the regional grid administration had to bring up coal and oil plants to meet demand. They even burned garbage. Electricity prices went through the roof. Nuclear? The plants that remained in New England operated flawlessly.

That is not unusual. Even though one reactor was closed for precautionary reasons prior to Hurricane Irma slamming into the Florida coast, customers were not affected because a second nuclear reactor didn't miss a beat.

There is—and this is key—no good way to store large amounts of electricity today. It must be produced where it is needed. That's a problem for wind and solar, which can only produce power under the right circumstances. It's an issue for natural gas, which requires a constant on-demand supply of gas to continue producing electricity.

Nuclear power plants always maintain two years of fuel. They operate on average at 93% capacity, in all varieties of conditions. At a time when weather patterns are changing, and extreme conditions become more normal, it is vital for power grid stability, and the health and safety of all Americans, that we increase nuclear capacity across our nation.

Bolstering the national economy and creating international opportunities for American companies and high-paying careers in communities across our nation.

The U.S. nuclear energy industry directly employs nearly 100,000 people. These are high-paying, long-term jobs that support families and sustain communities. When you include secondary jobs, that number climbs to nearly half a million.

Deployment of advanced nuclear technologies would positively impact every community fortunate enough to host a plant. We see that with projected job numbers and economic impact for the coal town of Kemmerer, Wyoming, which will host the TerraPower Natrium reactor's beginning operation in 2030.

Construction of a nuclear power plant means high-paying jobs for thousands of workers. Once operational, nuclear power plants employ hundreds of workers. They will operate for decades, providing jobs for generations of employees, at salaries well above other energy-generation sources. And these aren't just engineers. The nuclear energy industry creates careers for people from a wide range of fields and backgrounds, recruiting from universities, community colleges, the military, and the trades.

National Security

American ingenuity created the nuclear energy industry. The majority of reactors around the world are based on U.S. technology. As a result, our safety and nonproliferation standards are the world's standards. But as the U.S. nuclear energy industry has been stuck in neutral for decades, other nations have moved forward. That includes Russia and China, which has plans to develop approximately 30 reactors around the world.

The world needs American experience, expertise, and values. It needs the U.S. to set safety and nonproliferation standards as we enter a new era of nuclear energy production.

We cannot abdicate our world leadership in nuclear energy development and deployment. When we build new systems—and export our technologies, materials, and services—we also export our values. A nuclear power plant is designed to operate for six to eight decades. When a country sells a nuclear reactor to another nation, it begins what can be a century-long relationship that encompasses many areas. There are fuel purchases, maintenance, technical support, and other supply and service contracts. There also is cooperation between buyer and seller nations in the areas of education, research and development, training, cyber and physical security, environmental protection, and safety and nonproliferation.

We know that more nations in Asia, Africa, South America, and the Middle East are interested in nuclear energy, to generate clean, reliable and secure electricity, desalinate water, produce hydrogen, power remote communities, and more. These nations will look for developers who can quickly, safely, affordably, and effectively develop a reactor and get it deployed.

And because U.S. developers are not competing on equal terms, too many of these nations will turn to China, Russia or our friends in South Korea. This presents not just a missed opportunity, but in the case of Russian and Chinese expansion, a danger to U.S. national security.

Nobody should feel good about the Russians setting world standards for safety and nonproliferation. Nor should the U.S. cede world leadership to China in this crucial area.

Nuclear energy offers our nation a strategic advantage over our adversaries. Projects such as the Pele Reactor in development at INL in partnership with the DoD will enable us to power remote military bases and other operations while allowing these technologies to become commercially viable as costs come down. This is how advanced reactors can be developed and deployed by DoD and contribute to our national defense, leading to commercialization. This follows the path that out nation has taken in the past, from Navy submarine reactors to commercial light-water reactors.

Meeting the nation's clean energy goals

We need deep decarbonization to hit our climate goals. Nuclear energy must play a primary role in getting us there. America's 93 nuclear power plants, operating in 30 states, prevent the release of 470 million metric tons of carbon dioxide emissions that would otherwise come from fossil fuels. That's the equivalent of removing nearly 100 million passenger vehicles from our roadways. America's high-performing nuclear-reactor fleet produces roughly half our nation's carbon-free electricity. That's more than all other energy sources combined. Nuclear can complement clean energy sources such as wind, solar, and geothermal to reduce greenhouse gases and address climate change.

To meet our nations' clean energy goals, we need to expand our nuclear energy capacity. And we need to do it quickly. That DOE "Liftoff" report referenced earlier makes clear that we do not have the luxury of time. It concluded that waiting until the mid-2030s to deploy advanced nuclear technologies at scale could lead to our nation missing decarbonization targets.

Understanding and appreciating the true value of nuclear energy by enacting policies that help ensure completion of advanced reactor projects would help make our nation prosperous and safe, while building greater resiliency into the power grid.

That brings us back to our first question: Who should be the first movers on these advanced nuclear technologies?

INL is working with a variety of partners to develop and deploy advanced technologies. That includes DOE, DoD, universities, and private-sector companies such as TerraPower, X-energy, Oklo, and others.

Before we talk about advanced reactors, however, it is imperative that we ensure that the current fleet continues to provide nearly 20% of our nation's electricity and half our zero-carbon-emitting electricity. We must ensure that our plants are not subject to economic variations that can result in their being shut down prematurely. Thanks to recent state actions and legislation that provided the Civil Nuclear Credit Program, there are resources to keep the plants operating.

Additional legislation leveled the playing field for energy by enabling tax credits for expanded operations, including a nuclear-power production tax credit to support existing nuclear generators and delay potential retirements that would increase greenhouse gas emissions.

This support for existing nuclear generation expands on the Civil Nuclear Credit Program established in the bipartisan infrastructure law.

Another consideration is to lengthen the time of power-purchase agreements. We could look for opportunities for federal entities such as military installations and national laboratories to leverage premium power-purchase agreements to meet clean energy goals through nuclear energy.

We also should encourage and incentivize projects that repurpose existing infrastructure. A great example of this is TerraPower's Wyoming Natrium reactor project.

The federal government's energy needs represent an opportunity for first movers. This includes a range of government and defense installations, national laboratories, remote power needs, and more.

These could be executed through a range of operations, including power-purchase agreements that can match the long lifetimes of nuclear reactors.

We also need to consider emerging areas for the expanded use of nuclear energy, the “behind the meter applications,” that can provide reliable and clean energy to meet the exploding deployment of data centers, semiconductor production, and industrial-heat applications.

The DOE “Liftoff report” said: “A committed orderbook, e.g., signed contracts, for 5–10 deployments of at least one reactor design by 2025 is required to catalyze commercial liftoff in the U.S.”

The report went on to say that: “Given expressed U.S. utility risk tolerances, it is likely that the first design to reach a critical mass of orders may be a Gen III+ SMR, which could be followed in parallel or sequence by Gen IV reactors.”

Finally, the report offered the following potential mechanisms for consideration to enable a committed orderbook: cost overrun insurance, tiered grant financial assistance, government ownership, and government-enabled off-take certainty.

2) *How do we address the fuel cycle from development of the nuclear fuels needed to run our current fleet and advanced technologies, to safe disposition of spent fuel?*

In March, I had the honor of testifying before this committee for a hearing on the nuclear fuel cycle. Much of what I will say here was part of my presentation in that hearing. But the fuel cycle—from mining to disposition—is so important that I believe these points are worth repeating.

Currently, 93 high-performing reactors make up the U.S. domestic fleet. This is soon to increase to 94 with the completion and startup of Unit 4 at the Vogtle site in Georgia. Our current reactors run on low enriched uranium, or LEU, uranium fuel that is enriched up to 5% with uranium-235. The United States is highly reliant on other nations for uranium needed to operate our reactor fleet.

Our nation imports over 90% of the uranium needed for our reactor fleet. In the United States, uranium mining has decreased 92% since 1980. In 2021, the United States domestically produced only 5% of the uranium purchased, according to the U.S. government’s Energy Information Administration.

This uranium must be enriched to fuel our reactors, and currently we have limited ability to perform this enrichment in the U.S. Only one enrichment facility operates domestically, the Urenco USA plant in New Mexico, with the capacity to support about one third of the current reactor fleet with LEU, according to information compiled by the Urenco Group. The remainder is obtained by importing enriched uranium.

Developing new domestic mining, conversion, and enrichment capabilities, with urgency, will ensure the availability of a domestic supply of fuel, provide certainty to our existing fleet of nuclear power plants, and help ensure our domestic energy security.

Advanced-reactor development requires high-assay, low-enriched uranium, called HALEU, with enrichments up to 20% U-235. As announced by DOE, Centrus Energy Corp. recently produced the nation's first 20 kilograms of HALEU. This production is the first of its kind in the U.S. in more than 70 years. This is the only licensed HALEU production facility in the United States.

At INL, we are working to supply HALEU from DOE-owned materials, including processing Experimental Breeder Reactor-II spent fuel, to recover the highly enriched uranium and down-blend it to HALEU to create a limited supply. This material is not the only existing spent fuel in the DOE system that could be applied for HALEU production, and we should invest in recovering these materials to provide a bridge until a commercial HALEU supply is available.

But our lack of domestic fuel cycle capabilities is already hurting efforts to deploy the next generation of technologies needed to allow our commercial fleet to produce 24/7, carbon-free power more than 93% of the time—more reliably than any other source of generation. TerraPower recently extended the timetable on its Wyoming-based Natrium reactor because of concerns about HALEU fuel availability.

DOE said it projects that more than 40 metric tons of HALEU will be needed before the end of this decade to deploy a new fleet of advanced reactors and support the Administration's goal of 100% clean electricity by 2035.

The Russian invasion of Ukraine puts the United States, and many other nations, in a precarious situation. We know that being dependent on foreign nations, including those that do not have our best interests at heart, is both a national security and economic risk. We also know the national security benefits that come with a strong civil nuclear-energy industry.

Addressing these issues and continuing to operate our current fleet of reactors benefits our nation beyond the energy that these plants provide. We also need to address the back end of the fuel cycle.

The Nuclear Waste Policy Act (NWPA of 1982), and as amended in 1987, reflects the national priorities and concerns of the time. Various attempts have been made to further amend the NWPA to better reflect the nuclear-waste management realities, policies, and needs of today, but none have yet succeeded. Simply put, the present framework for interim storage and disposal of the U.S. spent fuel inventory, as set forth in the NWPA, is inadequate to meet the challenges of today or tomorrow, and a new policy framework is needed.

The near-term deployment of consolidated interim storage would be a useful component of an integrated waste-management system, but the need for deep geologic disposal capacity remains. Congress has directed DOE the use of a consent-based siting approach in the pursuit of federal consolidated interim storage for the nation's spent-nuclear-fuel inventory. However, federal interim-storage facilities of sufficient capacity cannot be constructed without first revising the NWPA to remove the prerequisite for repository construction authorization and inadequate capacity limits.

While recycling of advanced reactor spent fuels is certainly possible, and even anticipated for some designs, the fact remains that there will always be a need for deep geologic disposal capacity. In the United States, as in the rest of the world, deep geologic disposal of spent nuclear fuel and/or high-level waste is the long-term endpoint, and the time has come to revisit our approach.

To provide for the fulfillment of our legacy spent-fuel management responsibilities, and to fully realize the potential of our existing and future nuclear-energy systems, we must have a nuclear-waste management policy framework that addresses the issues of today.

3) *How can the regulatory process be improved to accelerate deployment of advanced nuclear technologies?*

Earlier this year, Congress asked INL for its thoughts on the NRC process. In response, we developed a report titled *Recommendations to Improve the Nuclear Regulatory Commission Reactor Licensing and Approval Process,* which was submitted to Congress and is part of the public record. The points made below are part of that white paper and were developed from our Laboratory's long experience working both with private-sector reactor developers and regulators.

Our nation benefits from the NRC, which is the world leader in nuclear-safety licensing and regulation. While acknowledging the important nuclear-safety role satisfied by the NRC, the licensing process has proven to be a significant hurdle and source of cost and uncertainty for new reactor developers.

To enable timely demonstrations and support large-scale deployment, we need an effective and efficient licensing process. The challenge is particularly acute for advanced reactors, which may raise unique regulatory questions and be smaller in size, resulting in a much-higher proportional impact from regulatory and cost challenges. This situation presents a risk given the urgency with which utilities are working to transition to clean, noncarbon-emitting nuclear energy.

The NRC is undertaking rulemaking to provide a risk-informed, technology-inclusive framework for commercial nuclear plants that can be used for future advanced-reactor licensing. The NRC also is taking steps to enable a deployment of reactors in the areas of emergency planning and environmental reviews and is looking at licensing fees.

What else can be done?

- Regulatory timeframes could be sped up by reviewing requirements for mandatory hearings and the alignment of hearings and by simplifying legislative hearing processes. Reviews could be expedited by specifically including objectives for timely and efficient reviews similar to other safety-focused regulatory agencies, such as the Federal Aviation Administration and the Food and Drug Administration. And there could be specific provisions to accelerate National Energy Policy Act (NEPA) reviews for noncommercial reactor projects on DOE sites.

- Roles of bodies within the NRC, including the Advisory Committee on Reactor Safeguards, should be clarified to ensure that they are focused and not onerous.
- The NRC licensing process could provide more schedule certainty by strengthening the requirements for milestones for new reactor-licensing activities by including shorter timelines and more-rigid reporting requirements and accounting for the full duration of licensing activities. This could be enabled by having an independent review team shadow an entire NRC-licensing review, start to finish, and provide recommendations to accelerate the licensing process.
- The schedules and fee structures should also be reflective of the scale and complexity of the reactor designs being licensed.
- Finally, there are areas that could provide financial benefits to encourage reactor demonstrations, such as eliminating fees for pre-licensing activities and early site permits, as well as changes that could encourage international investment. In addition, we should indefinitely extend the Price-Anderson Act coverage for nuclear-hazard indemnification for covered DOE contractors and NRC licenses. The Accelerating Deployment of Versatile, Advanced Nuclear for Clean Energy (ADVANCE) Act introduced in the Senate recently includes these points.

The NRC is going to encounter a growing number of applications for new reactors, of all sizes, designs, and fuel types. If our nation is going to build these reactors, develop the supply chains needed to operate them, and export these technologies, we need a more modern and efficient NRC process. This can be done without compromising safety or transparency. Regulators must be given the ability to process new licenses and approve construction so these new technologies can be brought online as quickly as possible.

Conclusion

I want to conclude by saying that I am incredibly optimistic about nuclear energy in our nation and across the world. As I said earlier, we are no longer debating the need for nuclear energy. Instead, we have moved onto discussions about how much nuclear energy we require and how we can address and overcome challenges to deployment.

The U.S. has more operating nuclear reactors than any other nation. Nuclear energy is our creation. Our nation must address these challenges and deploy the advanced nuclear technologies needed to create high-paying jobs in communities across the country, ensure national security, make our power grid more resilient, protect our troops in the field, and bolster national security.

At INL, we are conducting the science needed to usher in a new era of nuclear energy. Just as we did in the past, with 52 test reactors on the INL Site, we will work with industry to demonstrate and deploy these advanced technologies. The future of nuclear energy is small, medium, and large. It is flexible, resilient, and reliable. Microreactors will be used to power small remote communities and isolated industries, such as mining operations, as well as military bases and mobile operations. Small modular reactors will be used to power industrial operations, including data centers and semiconductor fabrication facilities vital to our nation's economy and security. Reactors of all sizes and fuel types will be used to stabilize the grid with 24-7-365 electricity and produce hydrogen to power clean industrial, transportation, and manufacturing processes.

I appreciate the opportunity to be a part of this important process, and I want to thank the committee again for its attention to this important issue for our nation. I look forward to your questions.