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Chairman Alexander, Ranking Member Feinstein, and Members of the Subcommittee, I am very pleased to appear before you today to discuss the profoundly important matter of advanced nuclear technology development.

As the major source of reliable, resilient and clean baseload electricity, nuclear energy is a very important strategic national asset for the United States. It is an essential element of our Nation's diverse energy portfolio helping to sustain the U.S. economy and support our national goals. A strong domestic nuclear industry enabled by the existing nuclear fleet and enhanced by game-changing advanced nuclear technologies is critical to our Nation's energy security, national security, environmental sustainability and economic prosperity.

Today, nuclear energy is the third largest source of domestic electricity generation and is the largest source of clean energy. As baseload electricity sources, nuclear power plants also contribute to the reliability and resilience of the electric grid and can provide price stability. From an energy attributes perspective, nuclear energy is utterly unique. No other energy source provides 24/7, 365-day, 18-24 month full-power generation without stoppages for refueling than nuclear power; and no other energy source has the density of power provided by nuclear. To put the density of power in perspective, there are approximately 8652 electricity generating plants, of all types, in the United States providing electricity to our citizens and only 59 of these plants are nuclear – less than 1% of the plants and only 10% of installed capacity; yet, providing 20% of all of our Nation's electricity and almost 60% of our clean non-carbon-emitting generation.

Nuclear power plants also serve as bedrocks and anchors to communities across the country According to a Nuclear Energy Institute fact sheet, nuclear energy supports almost half a million jobs. That factsheet also indicates that the U.S. nuclear energy fleet is a significant contributor to the U.S. economy, stating that it contributes over $60 billion to our gross domestic product (GDP), $10 billion in federal taxes and $2.2 billion in state taxes each year.[1] Nuclear power plants drive local economies as well, often serving as the largest employer and economic engine of small communities.

The first commercial nuclear power plants came on-line in 1969 and the average age of the nuclear fleet is now 38 years. Almost all of the operating plants have received approval to conduct at least one capacity uprate and to date; these uprates have contributed 8 gigawatts electric (GWe) of additional nuclear capacity. Efficiency improvements have also significantly increased the total amount of nuclear generation, helping to keep nuclear energy at 20 percent of the Nation's total electricity generation even though the total number of

[1] https://www.nei.org/CorporateSite/media/filefolder/resources/fact-sheets/nuclear-by-the-numbers-20180412.pdf

nuclear units has decreased. This is a true testament of our Nation's world-class plant operators, which consistently demonstrate the highest capacity factors of any nuclear fleet in the world.

Of the operating nuclear reactors, 87 have received license extensions to 60 years and another three have applications currently under review or pending. Three plants (six reactors), Florida Power and Light's Turkey Point (two reactors), Exelon's Peach Bottom (two reactors) and Dominion's Surry (two reactors), have applied for a subsequent license renewal to 80 years. The Nuclear Regulatory Commission (NRC) is currently reviewing these applications. Dominion has also announced its intention to seek subsequent license renewal for its North Anna plant (two reactors) in Virginia.

Unfortunately, since 2013, 7 reactors have retired prematurely (i.e., prior to license expiration) and 12 more are scheduled to retire as a result of historically low natural gas prices, and flat or declining demand. While premature retirements have generally been driven by market conditions, in other instances, state policies contribute to the retirement of plants, such as in California (Diablo Canyon), New York (Indian Point), and New Jersey (Oyster Creek). An additional 7 reactors would be slated to retire prematurely had New York and Illinois not included nuclear energy in their clean energy policies. New Jersey and Connecticut have also taken similar steps to ensure the continued operation of their nuclear power plants. It would be incredibly harmful to U.S. energy security, economic prosperity, and environmental sustainability if this shutdown trend were to grow. To put the magnitude of this last point into perspective, a recent Brattle Group study noted that the total generation lost from the 4 nuclear power plants (5 reactors) that are scheduled to retire prematurely in Pennsylvania and Ohio is considerably greater than all of the solar and wind generation combined in PJM in 2017 (39 million Megawatt hour (MWh) nuclear vs. 26 million MWh renewable in 2017).[2] If we do not stop this downward trajectory now, it may be too late to recover and realize the benefits of advanced nuclear technologies in the future.

Sustaining the current fleet of operating nuclear power plants is a priority for the nation because without a robust nuclear industry, we will not be able to reestablish a strong pipeline of advanced nuclear technologies and associated U.S.-based supply chains, nor maintain the fuel cycle infrastructure and workforce necessary for a vibrant civilian nuclear industry.

Even with all of these benefits, the nuclear energy sector is undergoing a major transformative period of time due to a variety of factors that include changing and very challenging market conditions, an aging fleet of reactors, and an absence of nuclear energy product choices and innovative business/technology deployment models available to customers. The industry needs to identify and implement solutions that enable nuclear power to maintain its critical role in the Nation's energy mix in the future. We are literally at a cross-roads with our Nation's nuclear energy sector, and what happens in the next few years will be determinative for not just us, but for our children and their children from an economic, energy, environmental, and national security standpoint. Having led the Department of Energy's (DOE) international nuclear energy cooperation for 11 years and served approximately 10 years prior to that working on global nuclear nonproliferation matters, I can assure you that Russia and China are determined to become the dominant

[2] https://www.nei.org/CorporateSite/media/filefolder/resources/reports-and-briefs/Impacts_of_Premature_Nuclear_Retirements_in_Ohio_and_Pennsylvania.pdf

nuclear suppliers in the world. This is far, far more than just electrons on the grid, I can assure you.

We are down in the fourth quarter, but thanks to an incredible bow-wave of highly innovative and disruptive U.S. nuclear technology developers and game changing manufacturing approaches, the industry it in the red zone and in a position to take the lead in a dramatic, disruptive and transformational manner; not unlike what we have seen with reusable rockets in aerospace, hydraulic fracturing and directional drilling in the oil and gas sector, and smart phones in the personal telecommunications sector.

Today, utility customers and communities around the United States, who may be interested in acquiring nuclear energy's long-term clean and reliable source of power for their communities, are faced with a rather startling limited choice of only large or larger nuclear reactors designed to produce over 1,000 megawatts (MW). These large reactors can require more than 10 years to build before generating revenue from power production. Additionally, many U.S. utilities and international markets find these GW class reactors simply too large for their electricity grids. As long as there are only large and larger reactors, nuclear energy will remain constrained relative to its true market potential.

So what do we see happening to respond to this lack of product choice by those who otherwise would very much like to have the unique attributes offered by nuclear energy? We see the market respond through the emergence of dozens of U.S. nuclear reactor design companies looking to seize this opportunity by advancing highly innovative small, scalable, flexible, versatile and more financeable nuclear reactors. These innovative concepts include small modular reactors (SMRs), micro reactors, high temperature gas reactors, molten salt reactors, and liquid metal fast reactors.

The flexibility offered by SMRs and many other advanced reactors also enhance the ability to load follow and integrate with renewables as integrated, or hybrid, energy systems. This is an important evolution of nuclear energy as the grid continues to rely on higher concentrations of variable and intermittent generation.

The innovative design features of advanced reactors also enable new opportunities for power plant siting. SMRs and micro reactors are being considered for microgrids, remote locations, or even data centers and military bases. It is envisioned that many of these reactors could also be placed near or in population centers, with little to no emergency-planning zone (EPZ) – something the NRC is currently evaluating. In fact, the NRC staff is already reviewing one major innovation that would exempt the NuScale design from the requirement to have safety-related electrical power for its primary safety systems. In the event of a loss of offsite power or loss of coolant, the reactor is designed to not need such power and to passively shut down safely on its own. This advancement has the added advantage of allowing this type of reactor to provide black start capability. The implications to distributed generation and resiliency are frankly enormous.

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Another class of reactors that is really generating considerable interest are micro reactors which typically range from approximately 1-10 MW. Both stationary and transportable designs are being developed. Due to their unique designs, micro reactors may well be the first advanced non-light water reactors to be commercially available. And if we think a 1 MW reactor is insignificant, we should think again. A 1 MW micro reactor can provide round-the-clock clean electricity for up to 10 years to over a 1,000 homes.

We are not only seeing game changing and highly disruptive advancements in the U.S. nuclear reactor design space, but also in the advanced manufacturing area as well. For instance, Oak Ridge National Laboratory (ORNL) is working with INL and private industry to build the world's first 3-D printed barrel sized micro reactor. This project, which we call the Transformational Challenge Reactor (TCR), aims to demonstrate the use of additive manufacturing as a viable route to faster, cheaper, and better components in nuclear applications. If we can demonstrate its use by printing an entire reactor that achieves criticality and produces power, we will have positioned ourselves to truly leap frog current manufacturing methods! This is what I call a game changer.

Finally, the U.S. industry is leading multiple advanced nuclear fuels development efforts with some of the design components already being tested in U.S. commercial reactors. These designs offer real potential for substantially improved economics and safety margins for our existing fleet and advanced reactors as well.

I hope what I have said thus far gives the Subcommittee a sense of the tremendous opportunity facing the United States due to the bow-wave of U.S. advanced nuclear companies, and the historic demand and need for new and innovative nuclear energy products and services. Now I'd like to shift the discussion a bit to discuss the role the Office of Nuclear Energy plays in supporting the development of these concepts.

Government support through early-stage R&D can help stimulate the nuclear industry as it works to address particularly high-risk fundamental technical challenges. Utilizing our greatest strengths, the Department is mobilizing its world-class capabilities, and supporting targeted early-stage research and development (R&D) partnerships between academia, the national laboratories and the U.S. nuclear industry.

One recent action we have undertaken to better support innovative technology developers was the release of a multi-year funding opportunity announcement (FOA) to support early-stage R&D of advanced nuclear energy technologies for application in the existing fleet and also advanced reactor designs. This industry FOA is intended to provide efficient, versatile and flexible ways by which DOE can effectively implement R&D partnerships to support our U.S. nuclear industry. This FOA is a key element of the Gateway for Accelerated Innovation in Nuclear (GAIN), providing cost-shared support to the domestic nuclear industry for early-stage nuclear R&D. In only its first year, 15 awards have been made under this innovative FOA, totaling approximately $80 million in DOE investment.

GAIN was launched a couple of years ago and has revolutionized the way my office works with industry. Through GAIN, NE is working closely with the private sector to establish effective private-public partnerships focused on accelerating the development innovative nuclear technologies. The support of the Department of Energy and its world-class laboratories is essential to the U.S. nuclear industry as it works to bring forth new innovative technologies and approaches.

The Department is also focusing on infrastructure needs to develop advanced nuclear technologies. We have assessed our national infrastructure across our national laboratory complex, universities and industrial research centers and have taken action to provide our technology developers with the capabilities they need. For example, in November, 2017, the Department restarted the Transient Reactor Test Facility (TREAT) at INL. This facility is needed as part of the material and fuels qualification processes. Furthermore, we are working to address the need for a fast test reactor. Such a reactor would accelerate innovation in advanced fuels and materials for U.S. nuclear vendors and pave the path to U.S. global leadership in advanced nuclear R&D by reestablishing this capability. Requirements have been developed and an R&D plan has been created. The fiscal year 2019 appropriation of $65 million will help us continue to move forward with this project to regain a necessary capability to test and validate advanced fuels and materials so that American innovators can develop cutting edge technology here in the United States.

Furthermore, many advanced reactor concepts currently under development, will need high-assay low-enriched uranium (HALEU), for which there is currently no commercially available supply in the world. HALEU is uranium that is enriched between 5 to 20% U-235. NE is very familiar with this issue and is now working to demonstrate domestic HALEU production capability. The Department believes that it is particularly important at this moment in time for the new class of U.S. advanced reactors, including micro reactors, attempting to get to market that a domestic demonstrated HALEU production capability be demonstrated, given there is no domestic HALEU production capability and many of the advanced reactors will require HALEU fuel.

The Department is also exploring other innovative and collaborative approaches to support our Nation’s evolving electricity grid. One such area is our collaborative work with the Office of Energy Efficiency and Renewable Energy on integrated energy systems, also referred to as hybrid energy systems. Optimization of nuclear and variable renewables could be a very important way to meet clean electricity needs, and it could also prove to be a disruptive step-change improvement for non-electric markets as well. By integrating with variable generation, nuclear plants can increase operational flexibility and provide process heat for industrial applications, hydrogen production, or desalination and wastewater treatment, thereby increasing revenue generation and the overall economics of nuclear power.

There are other actions the Federal government and industry can take to enable first movers and help create market opportunities. Federal, state and private sector policies and mandates helped create market opportunity for early deployment of renewable energy technologies. The benefits of that market creation are now being realized in the form of cost reductions and increased penetration. Google’s recent decision to include nuclear in their 100% clean energy goal is definitely a step in the right direction. DOE is also working with the Department of Defense to develop requirements for, and components of, a pilot program for micro reactors to provide resilience for national security infrastructure.

The Administration is fully committed to nuclear energy as a vital component of our Nation's energy system. I firmly believe that with a focused and sustained collaborative private-public partnership approach to support early-stage R&D, and by working closely and thoughtfully together with key U.S. stakeholders, this Committee and all of Congress, we can indeed revive, revitalize, and expand our Nation’s nuclear energy sector and restore our global nuclear energy leadership. By leveraging our national laboratory system, and enabling innovative thinking across academia and the private sector, we can support industry's development of a new and highly innovative class of U.S. advanced nuclear reactors, an innovative and responsive nuclear energy supply chain, and advanced nuclear energy fuel cycle technologies, positioning the U.S. for continued energy dominance in the 21st century. By taking these actions, we can help ensure that future American generations continue to benefit, as we have, from this emission-free, reliable, and secure power source for our Nation.

Thank you very much and I look forward to answering your questions.