

Statement of Dr. Peter Lyons, Assistant Secretary for Nuclear Energy
U.S. Department of Energy
Before the
Committee on Science, Space and Technology
Subcommittee on Energy
U.S. House of Representatives
December 11, 2014

Chairman Lummis, Ranking Member Swalwell, and members of the Committee, thank you for your invitation to testify at today's hearing on "The Future of Nuclear Energy." Nuclear energy continues to play a vital role in President Obama's "all-of-the-above" energy strategy for a sustainable, clean energy future. Nuclear energy has provided nearly 20 percent of electrical generation in the United States over the past two decades and now produces over 60 percent of America's zero-carbon electricity. As a deployable power source with a high capacity factor, nuclear power fits the needs for baseload power – and does it with today's technologies. A prerequisite for nuclear power continuing as a vital part of the nation's clean energy portfolio is public confidence in the safety of nuclear plants and commercial confidence that the plants can be operated safely, reliably, and economically. In order to ensure that nuclear energy continues to provide affordable, carbon-free power, the Office of Nuclear Energy (NE) focuses its programs to: improve the reliability and performance, sustain the safety and security, and extend the life of current reactors by developing advanced technological solutions; meet the Nation's energy security and climate change goals by developing technologies to support the deployment of affordable advanced reactors; improve energy generation, waste management, safety, and nonproliferation attributes by developing sustainable nuclear fuel cycles; maintain key infrastructure to support cutting edge research on nuclear technologies; and advance U.S. civil nuclear energy priorities and objectives through international collaboration.

The Current Fleet

NE works in conjunction with industry and, where appropriate, with the Nuclear Regulatory Commission (NRC) to support and conduct the long-term research needed to inform major component refurbishment and replacement strategies for the current fleet. These areas include performance, cyber security, and safety; long-term operations through plant license extensions; and age-related regulatory oversight decisions.

One of NE's key programs, the Light Water Reactor Sustainability (LWRS) program, addresses challenges facing the continued safe and economic operation of the current fleet. The LWRS program focuses research on material aging issues. Its findings will inform license renewal applications for operation beyond 60 years, which may be submitted by industry starting in the 2016 to 2018 time period. Extending the operating lifetimes of current plants beyond 60 years and, where possible, making further improvements in their productivity will generate near-term benefits. Activities in this area have been expanded to address lessons learned from the Fukushima Daiichi accident, particularly in understanding and managing Severe Accident (SA) events. These include evaluation of instrumentation to better monitor and manage SAs, computer analysis of SA progression, and preparation and planning efforts in

support of eventual examination of the damaged reactors. The LWRS program has partnered with industry to closely coordinate research needs and share costs. The program also coordinates with the NRC to improve the utility of research results.

Technical questions are not the only issues facing the current reactor fleet. Adverse economic conditions contributed to the early closure of four reactors in 2013 and are a factor in the imminent retirement of the Vermont Yankee plant. Complex market factors, falling alternative generations costs, and lower electricity demand forecasts have made operating nuclear power plants uneconomical in some parts of the country. Several more reactors may be at risk of early closure due to these economic forces and the increasing costs of operation. The shutdown of these power plants is a significant blow to zero-carbon electricity generation as well as a considerable loss of baseload electricity supply and energy diversity. America's nuclear power fleet is a national asset on many fronts, and our programs work to ensure nuclear remains a key player in America's clean energy future.

Licensing and Construction of Nuclear Reactors in the United States

Although the United States has experienced a reduction in nuclear capacity with these plant closings, we see cause for optimism with the current construction of five nuclear reactors. Tennessee Valley Authority's (TVA) Watts Bar Unit 2 in Tennessee is about 90 percent complete and, with a targeted in-service date of December 2015, will be the first U.S. reactor to be completed this century. Construction of the first new nuclear plants in this country in more than 30 years continues for two new units at VC Summer in South Carolina and two new units at Plant Vogtle in Georgia. Both projects are deploying the NRC-certified, Generation III+ Westinghouse AP1000, a new generation of passively safe reactors. Earlier this year, the Department of Energy's Loan Programs Office announced that two of the owners of Plant Vogtle received a \$6.5 billion loan guarantee to support construction of the Vogtle facility. Together, these newly constructed units will provide enough reliable, zero-emission, baseload electricity to power three million homes in the Southeastern United States, with current estimates for completion projected in the 2017 to 2019 timeframe.

Further headway has been made with the recent certification by the NRC of the GE-Hitachi Nuclear Energy's Economic Simplified Boiling Water Reactor (ESBWR). The ESBWR is a 1,600 megawatt reactor, which includes passive safety features that would cool the reactor after an accident without the need for human intervention. The design is currently being considered for deployment in Virginia and Michigan.

If nuclear energy is to continue to be a strong component of the Nation's energy portfolio, barriers to the further deployment of new nuclear plants must be overcome. Impediments to new plant deployment, even for those designs based on familiar Light Water Reactor (LWR) technology, include the substantial capital cost of new plants and the uncertainties in the time required to license and construct those plants.

A high priority of the Department has been to accelerate the timelines for the commercialization and deployment of small modular reactor (SMR) technologies through the SMR Licensing Technical Support (LTS) program. The SMR LTS program is a six-year, \$452 million initiative focused on first-of-a-kind

engineering support for design certification and licensing activities for SMR designs through cost-shared arrangements with industry partners to promote accelerated commercialization of the nascent technology. SMRs have the potential to achieve lower upfront capital cost, modular power additions, and simpler, predictable and faster construction than other designs. The Department believes strongly that SMRs can promote American competitiveness, create manufacturing jobs here at home, and reduce CO₂ emissions through clean, safe, and reliable nuclear power.

These new SMRs, as well as the AP1000 and ESBWR reactors, are designed with passive safety features to minimize any requirement for prompt operator action and to prevent auxiliary system failures from contributing to future accidents. These attributes further enhance the safety of nuclear power plants. Overall, the SMR Program supports the licensing of innovative designs that improve safety, operations and economics. We expect these SMRs to have lower core damage frequencies, longer post-accident coping periods, enhanced resistance to natural phenomena, and potentially smaller emergency preparedness zones than currently licensed reactors.

The Department has entered into two cost-shared agreements with industry. In November 2012, DOE announced the selection of the mPower America team, consisting of Babcock & Wilcox (B&W), Bechtel International and the Tennessee Valley Authority, for cost-shared investment to support the design development, certification, and licensing activities of B&W's mPower reactor to be sited at TVA's Clinch River site in Tennessee by 2022. In May 2014, the Department of Energy signed a cooperative agreement with NuScale Power, providing \$217M in DOE funds to support design development and NRC design certification with deployment scheduled for the 2025 timeframe.

The Department also recognizes the challenge of constructing large capital nuclear projects. The Department issued a loan guarantee for the Vogtle project, which represented an important step in deploying advanced nuclear technology. However, other innovative nuclear projects may be unable to obtain full commercial financing due to the perceived risks associated with technology that has never been deployed at commercial scale in the United States. To that end, in September 2014, the Department's Loan Programs Office released a draft \$12.6 billion loan guarantee solicitation for advanced nuclear energy projects. The loan guarantees from this draft solicitation would support advanced nuclear energy technologies including advanced nuclear reactors, SMRs, uprates and upgrades at existing facilities, and front-end nuclear projects. The Department accepted public comments for 30-days following publication of the draft solicitation; those comments are currently under review.

Research and Development for Advanced Reactor Technologies

Future-generation reactor systems may employ advanced technologies and designs to improve performance beyond what is currently attainable. More advanced reactor designs with coolants other than light water, often referred to as Generation IV designs, may enable reactors to operate at higher temperatures and with increased efficiencies resulting in improved economics. These designs may also provide expanded fuel cycle options that can inform future policy decisions. Generation IV reactor

designs are being developed in many countries, and research, development, and demonstration continues in the United States in support of a number of these concepts. Continued strong research and development in this area is essential for the long-term prospects of nuclear energy.

The Department's advanced reactor program performs research to develop technologies and subsystems that are critical for advanced concepts that could dramatically improve nuclear power performance through the achievement of goals on sustainability, economics, safety, and proliferation resistance. Advanced reactor technologies considered in this program reside at different maturity levels with research and development efforts mainly focused on three advanced concepts: liquid metal-cooled fast reactors, including sodium-cooled fast reactors (SFRs); fluoride salt-cooled high-temperature reactors (FHRs); and high-temperature gas-cooled reactors (HTGR). In addition, research and development addresses qualification of tristructural-isotropic (TRISO) coated particle fuel and graphite used in both FHRs and HTGRs.

The Department of Energy has issued several awards over the last two years to support industry's research and development activities through cost-share agreements totaling \$16.5 million in government funding. These projects will help address significant technical challenges to the design, construction, and operation of next generation nuclear reactors, based upon the research and development needs identified by industry designers and technical experts. In many cases, new technologies will be needed to enable advanced reactor designs.

To further support the development of advanced reactor technologies, the Department has undertaken a joint initiative with the NRC to support development of General Design Criteria (GDC) for Nuclear Power Plants for advanced reactor designs. The current GDC were initially developed primarily for light water reactors. .

NE also continues to leverage international experience through the Generation IV International Forum (GIF) where the United States collaborates on important research for HTGRs and SFRs. Over the past ten years, GIF has served as a unique multilateral mechanism for coordinating research and development on advanced reactors, resulting in the completion of hundreds of research deliverables and milestones in such areas as irradiation and fuel development, materials, chemistry, safety, and reactor operations.

The Department has also begun to study how to optimize nuclear energy with variable renewable energy sources through collaboration between the Offices of Nuclear Energy and Energy Efficiency and Renewable Energy. These studies will not only examine integration of current light water reactor technology, but also advanced reactor technologies that have the potential to provide high temperature process heat in addition to higher efficiency electricity. This can theoretically be accomplished by installing a combination of additional nuclear and renewable energy production technologies, improving or developing new energy storage capacity, and using excess capacity in the electric sector to provide clean thermal and/or electrical energy to the manufacturing and fuels industries. For the past ten years, NE has conducted research on supercritical carbon dioxide (sCO₂) Brayton cycles for use - with advanced reactor concepts. Recent efforts to accelerate the commercialization of this transformational energy conversion technology have been proposed in the Supercritical Transformational Electric Power

Generation initiative. This proposed initiative, which would build upon program research and development efforts by the Offices of Nuclear Energy, Fossil Energy, and Energy Efficiency and Renewable Energy, intends to build a 10 megawatt demonstration facility under a 50/50 cost-share with industry. This technology is suitable for a variety of applications including concentrating solar power, geothermal, advanced nuclear technologies (HTGR and SFR), and fossil fuels with efficiencies higher than traditional steam cycles using Rankine cycle technology currently used in those applications.

Sustainable Fuel Cycle

Finding a long-term, consent-based solution to managing the nation's nuclear waste and used nuclear fuel (UNF) is a long standing challenge. Such a solution, however, is necessary to assure the future viability of this important carbon-free energy supply and further strengthen America's standing as a global leader on issues of nuclear safety and nonproliferation.

In January 2013, the Administration released its *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*, which lays out plans to implement a long-term program that includes development of a pilot interim storage facility, a larger consolidated interim storage facility, and a geologic repository. The Strategy fully endorses the need for a consent-based process for siting facilities and highlights the need for both a new waste management and disposal organization and mechanisms to assure adequate and timely funding. The Administration continues to believe that these elements are necessary to provide the stability, focus, and credibility to build public trust and confidence and to assure overall success of the nuclear waste mission.

The Administration, through NE, is undertaking activities within its existing authority to plan for the eventual transportation, storage, and disposal of used nuclear fuel. To support the evolution of the domestic UNF inventory, special emphasis is placed on confirmatory research to provide further understanding of the long-term behavior of high-burnup fuels.

NE's Used Nuclear Fuel Disposition subprogram conducts scientific research and technology development to enable storage, transportation, and disposal of UNF and wastes generated by existing and future nuclear fuel cycles.

For disposal research and development, activities continue to further the understanding of long-term performance of disposal systems in three main geologic rock types: clay/shale, salt, and crystalline rock. In addition to focusing on mined geologic repositories, the Department is evaluating the possibility of disposal of certain radioactive waste in deep boreholes. The Department has initiated a process to identify a volunteer site for the core research and development activity related to the deep borehole (DBH) disposal concept, the DBH Field Test. t.

For Storage and Transportation research and development, because of the evolution of the domestic UNF inventory, special emphasis is placed on confirming and increasing our understanding the behavior of high-burnup fuels. In addition to laboratory testing, modeling, and observations at existing storage installations, a key R&D activity is the Full-Scale Storage Cask Demonstration, in the process of being implemented on a cost-share basis at a commercial nuclear utility. This Demonstration will be beneficial

by 1) benchmarking the predictive models and empirical conclusions developed from short-term laboratory testing and 2) building further confidence in the ability to predict the performance of these systems over extended time periods.

Another important initiative within NE involves the development of accident tolerant fuels, a next-generation nuclear fuel with higher performance and greater tolerance for extreme, beyond design basis events. . These fuels would give operators additional time to respond to unforeseen conditions, such as those experienced at Fukushima-Daiichi. The program is framed on a three phase approach from feasibility to qualification to commercialization and is executed through strong partnerships with national laboratories, universities, and the nuclear industry. The industrial research teams, led by AREVA, Westinghouse, and General Electric, plan to begin irradiation of their proposed fuels in the Idaho National Laboratory (INL) Advanced Test Reactor next year. DOE has also expanded collaboration with our international partners, including France, Japan, and the United Kingdom, as well as multi-lateral programs under the leadership of the OECD-Nuclear Energy Agency and the International Atomic Energy Agency.

Investing in Research and Development Infrastructure

Research, development, and demonstration programs are dependent on an infrastructure of experimental facilities, computational facilities, and highly trained scientists and engineers dedicated to meeting the needs of the Nation. The Nation's nuclear research, development, and demonstration infrastructure incorporates a broad range of facilities, from small-scale laboratories to hot cells and test reactors, up to full prototype demonstrations. Computing facilities ranging from desktop workstations to highly parallel supercomputers at the national laboratories are routinely employed to gain new insights and guide experiment design. The high cost of creating and maintaining physical infrastructure for nuclear research, development, and demonstration, including the necessary safety and security infrastructure, requires close alignment of infrastructure planning with programmatic needs to ensure capabilities are planned, maintained and available to support NE missions. To enable and facilitate research and development activities, NE's Idaho Facility Management program maximizes the utility of existing facilities and capabilities through focused sustainment activities and cost-effective rehabilitation. Activities focus on safe and compliant operation of the Idaho National Lab's (INL) nuclear research reactor and non-reactor research facilities, while conducting corrective and cost-effective preventative maintenance activities necessary to sustain this core infrastructure.

In spite of these efforts to maximize the effectiveness of the established infrastructure, additional investments are needed to achieve further progress in advanced nuclear technologies. In its FY 2015 budget request, NE proposed to focus investments on reestablishing a domestic transient testing capability with the TREAT reactor at INL. This capability will enable the NE research and development programs to understand fuel performance phenomenology at the millisecond to second time scale as well as provide a capability to screen advanced fuel concepts, including accident tolerant fuels, which allows for early identification of the limits of fuel performance.

Moving forward, the Department will continue to assess infrastructure capabilities to ensure the U.S. maintains a key leadership position in the international development of advanced nuclear technologies. By staying at the forefront of nuclear technology, we are able to ensure that the U.S. safety and non-proliferation standards are adopted internationally while providing clean, affordable, baseload power globally.

Conclusion

In conclusion, the programs of the Office of Nuclear Energy support the many aspects of this important energy source, from reactors, to used fuel management, to infrastructure. NE's programs strive to ensure both the current fleet and advanced light-water technologies are available to meet the Nation's energy security and clean energy needs. As we look further into the future, we recognize that reactors using coolants other than water appear to offer important attributes. NE supports research on these advanced reactor concepts and seeks international cooperation through the Generation IV International Forum. The current generation of modern plants and the development of the passively safe SMR designs, both using light water coolant, serve as a vital bridge between the reactors of today and the potential for non-light water reactors in the future. In the United States we now have immense knowledge of light water reactor systems and can design and regulate them with the highest confidence for safe operations. Research today should focus on providing that level of confidence for these new concepts for tomorrow.