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Nuclear Energy R&D Roadmap Hearing
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Chairman Gordon, Ranking Member Hall, and Members of the Committee, thank you for the opportunity to appear before you today to discuss the Office of Nuclear Energy's R&D Roadmap. We have been working hard for a long time to produce a document that will guide the Department of Energy's nuclear energy activities for many years to come, and I think the resulting plan meets that criterion.

Nuclear energy is a key component of a portfolio of technologies that can be used to help meet the nation's goals of energy security and greenhouse gas reductions. This roadmap will guide research, development, and demonstration activities to help ensure that nuclear energy remains a viable option for the United States.

Our planning for developing the FY2012 budget request will be informed by this report, and our proposed FY2011 budget for the Office of Nuclear Energy is also consistent with the R&D objectives outlined in this roadmap. Earlier in the development process, we had been calling the objectives "imperatives", and in my December 15 testimony to the Senate Energy and Natural Resources Committee, I described five of them. We have since merged two of those areas of R&D into one (R&D Objective 2).

There are several challenges to the increased use of nuclear energy:

- The capital cost of new large plants is high and can challenge the ability of electric utilities to deploy new nuclear power plants.
- The exemplary safety performance of the U.S. nuclear industry over the past thirty years must be maintained by an expanding reactor fleet.
- There is currently no integrated and permanent solution to high-level nuclear waste management.
- International expansion of the use of nuclear energy raises concerns about the proliferation of nuclear weapons stemming from potential access to special nuclear materials and technologies.

The four R&D objectives outlined in the roadmap will address these challenges.

R&D OBJECTIVE 1: Develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors

The existing U.S. nuclear fleet has a remarkable safety and performance record, and today these reactors account for 70 percent of the low greenhouse gas (GHG)-emitting domestic electricity production. Extending the operating lifetimes of current plants beyond sixty years and, where possible, making further improvements in their productivity will generate near-term benefits. Industry has a significant financial incentive to extend the life of existing plants, and as such, R&D activities related to life extension of nuclear facilities will be cost shared. Federal R&D investments are appropriate to answer fundamental scientific questions and, where private investment is insufficient, to help make progress on broadly applicable technology issues that can generate public benefits. The DOE role in this R&D objective is to work in conjunction with industry and where appropriate the Nuclear Regulatory Commission (NRC) to support and conduct the long-term research needed to inform major component refurbishment and replacement strategies, performance enhancements, plant license extensions, and age-related regulatory oversight decisions. DOE will focus on aging phenomena and issues that require long-term research and are common to multiple reactor types.

R&D OBJECTIVE 2: Develop improvements in the affordability of new reactors to enable nuclear energy to help meet the Administration's energy security and climate change goals

If nuclear energy is to be a strong component of the nation’s future energy portfolio, barriers to the 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. Although subject to their own barriers for deployment, more advanced plant designs, such as small modular reactors (SMRs) and high-temperature reactors (HTRs), have characteristics that could make them more desirable than today’s technology. SMRs, for example, have the potential to achieve lower proliferation risks and more simplified construction than other designs. The development of next-generation reactors could present lower capital costs and improved efficiencies. These reactors may be based upon new designs that take advantage of the advances in high performance computing while leveraging capabilities afforded by improved structural materials. Industry plays a substantial role in overcoming the barriers in this area. DOE provides support through R&D ranging from fundamental nuclear phenomena to the development of advanced fuels that could improve the economic and safety performance of these advanced reactors. Nuclear power can help reduce GHG emissions from electricity production and possibly in co-generation by displacing fossil fuels in the generation of process heat for applications including refining and the production of fertilizers and other chemical products.

R&D OBJECTIVE 3: Develop Sustainable Nuclear Fuel Cycles

Sustainable fuel cycle options are those that improve uranium resource utilization, maximize energy generation, minimize waste generation, improve safety, and limit proliferation risk. The key challenge is to develop a suite of options that will enable future decision makers to make informed choices about how best to manage the used fuel from reactors. The Administration has established the Blue Ribbon Commission on America's Nuclear Future to inform this waste-management decision-making process. DOE will conduct R&D in this area to investigate technical challenges involved with three potential strategies for used fuel management:

- *Once-Through* – Develop fuels for use in reactors that would increase the efficient use of uranium resources and reduce the amount of used fuel requiring direct disposal for each megawatt-hour (MWh) of electricity produced. Additionally, evaluate the inclusion of non-uranium materials (*e.g.*, thorium) as reactor fuel options that may reduce the long-lived radiotoxic elements in the used fuel that would go into a repository.
- *Modified Open Cycle* – Investigate fuel forms and reactors that would increase fuel resource utilization and reduce the quantity of long-lived radiotoxic elements in the used fuel to be disposed (per MWh), with limited separations steps using technologies that substantially lower proliferation risk.
- *Full Recycling* – Develop techniques that will enable the long-lived actinide elements to be repeatedly recycled rather than disposed. The ultimate goal is to develop a cost-effective and low proliferation risk approach that would dramatically decrease the long-term danger posed by the waste, reducing uncertainties associated with its disposal.

DOE will work to develop the best approaches within each of these tracks to inform waste management strategies and decision making.

R&D OBJECTIVE 4: Understand and minimize the risks of nuclear proliferation and terrorism

It is important to assure that the benefits of nuclear power can be obtained in a manner that limits nuclear proliferation and security risks. These risks include the related but distinctly separate possibilities that nations may attempt to use nuclear technologies in pursuit of a nuclear weapon and that terrorists might seek to steal material that could be used in a nuclear explosive device. Addressing these concerns requires an integrated approach that incorporates the simultaneous development of nuclear technologies, including safeguards and security technologies and systems, and the maintenance and strengthening of non-proliferation frameworks and protocols. Technological advances can only provide part of an effective response to proliferation risks, as institutional measures such as export controls and safeguards are also essential to addressing proliferation concerns. These activities must be informed by robust assessments developed for understanding, limiting, and managing the risks of nation-state proliferation and physical security for nuclear technologies. NE will focus on assessments required to inform choices for domestic fuel cycle technology. These analyses would complement those assessments performed by the National Nuclear Security Administration (NNSA) to evaluate nation state proliferation and the international nonproliferation regime. NE will work with other organizations including the NNSA, the Department of State, the NRC, and others in further defining, implementing and executing this integrated approach.

R&D Areas

The Department expects to undertake R&D in a variety of areas to support its role in the objectives outlined above. Examples include:

- Structural materials
- Nuclear fuels
- Reactor systems
- Instrumentation and controls
- Power conversion systems
- Process heat transport systems
- Dry heat rejection
- Separations processes
- Waste forms
- Risk assessment methods
- Computational modeling and simulation

R&D Approach

A goal-driven, science-based approach is essential to achieving the stated objectives while exploring new technologies and seeking transformational advances. This science-based approach combines theory, experimentation, and high-performance modeling and simulation to develop the fundamental understanding that will facilitate advancements in nuclear technologies. Advanced modeling and simulation tools will be used in conjunction with smaller-scale, phenomenon-specific experiments informed by theory to reduce the need for large, expensive integrated experiments. Insights gained by advanced modeling and simulation can lead to new theoretical understanding and, in turn, can improve models and experimental design. This R&D performed by NE must be informed by the basic research capabilities in the DOE Office of Science (SC).

The Modeling and Simulation Hub led by NE, for which proposals are currently under review, will integrate existing nuclear energy modeling and simulation capabilities with relevant capabilities developed by the Office of Science, the NNSA, and others. Existing advanced modeling and simulation capabilities (e.g., computational fluid dynamics) will be applied through a new multi-physics computational capability to provide predictive capability for life extension and power uprates calculations. After five years, the Hub is intended to produce a multi-physics computational environment that can be used by a wide range of practitioners to conduct predictive calculations of the performance of reactors in the future for both normal and off-normal conditions. The results will be used to communicate the potential role of science-based modeling and simulation to address technology issues concerning nuclear energy in the near, mid, and long terms.

NE maintains access to a broad range of facilities to support its research activities. Hot cells and test reactors are at the top of the hierarchy, followed by smaller-scale radiological facilities, specialty engineering facilities, and small non-radiological laboratories. NE employs a multi-pronged approach to having these capabilities available when needed. The core capabilities rely on DOE-owned irradiation, examination, chemical processing and waste form development facilities. These are supplemented by university capabilities ranging from research reactors to materials science laboratories. In the course of conducting this science-based R&D, infrastructure needs will be evaluated and considered through the established planning and budget development processes.

There is potential to leverage and amplify effective U.S. R&D through collaboration with other nations via multilateral and bilateral agreements, including the Generation IV International Forum. DOE is also a participant in Organization of Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA) and International Atomic Energy Agency (IAEA) initiatives that bear directly on the development and deployment of new reactor systems. In addition to these R&D activities, international interaction supported by NE and other government agencies will be essential in establishment of international norms and control regimes to address and mitigate proliferation concerns.

Conclusion

Thank you, Mr. Chairman, that concludes my written testimony. I would be pleased to take any questions at this time.