Testimony of
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Introduction

Good morning Chairman Bingaman, Ranking Member Domenici, and distinguished members of the Committee. It is an honor to appear before you today to discuss the Global Nuclear Energy Partnership, or GNEP. I will focus my remarks on the R&D challenges related to nuclear energy, and the capabilities that the Department of Energy's national laboratories provide to address these challenges.

I am Terry Wallace, the Principal Associate Director for Science, Technology and Engineering at Los Alamos National Laboratory. Los Alamos' mission is to develop and apply science and technology to ensure the safety, security and reliability of the U.S. nuclear deterrent; reduce global threats; and solve other emerging national security challenges. No emerging challenge is greater than that of energy.

Energy is the cornerstone of our nation's prosperity and the global demand is extraordinary. If the rest of the world's population enjoyed the U.S. standard of living today, it would require an immediate six-fold increase in energy production. This tremendous demand for energy will have many consequences, including unfathomable increases in greenhouse gases. Nuclear energy is, and must be, an important component of the global energy supply. It can provide reliable, clean energy without generating additional CO_2. However, a global renaissance in nuclear energy also generates concerns about proliferation and waste. GNEP provides a global vision that addresses these concerns. A key component of the GNEP plan is to offer international partners a secure fuel cycle, leasing fresh fuel and taking back of spent fuel.

GNEP Research and Development

DOE introduced GNEP as an international and holistic approach to managing the demand for nuclear power. Within the GNEP plan there are two research and development objectives: commercial deployment of existing technologies in the near-term, and a robust long-term research and development program to facilitate a closed fuel cycle. The recent review of GNEP by the National Academies endorsed closed fuel cycle technology and a more cautious approach to major facility implementation. The nation has the intellectual resource in its national laboratories and universities to solve the technological challenges of a new closed fuel cycle.

However, there is significant research and development required to achieve an integrated fuel cycle. In particular, research is required in the following five areas:

1.) Fuels Development: The advanced nuclear fuels in a closed fuel cycle approach will contain transuranic elements which will be transmuted (burned) in an advanced burner reactor (ABR). This will require development of new fuel fabrication techniques. The new fuels will have combinations of elements which have never been assembled in fuels before, and the performance of the ensemble is a rich topic for research. For much of GNEP's R&D experimentation needs, the national laboratories already have the required specialized facilities. One exception is a source of fast neutrons to test and certify new fuels. At the direction of Congress and the DOE, Los Alamos is working to build the Materials Test Station, an enhancement at the Los Alamos Neutron Science Center (LANSCE), which will enable testing of new fuels in a very cost effective fashion.

2.) Separations: The main GNEP objectives for separations of spent reactor fuel are to reduce both the proliferation risk associated with next-generation processing plants, and the volume of waste to be stored in geological repositories. The UREX+ technology, developed within DOE's Advanced Fuel Cycle Initiative (AFCI), is one option being investigated to provide these benefits. These processes are being demonstrated with Light Water Reactor (LWR) spent fuel at small scale (e.g., the level of kilograms per test run). Substantial improvements are possible with further development work including the baseline extraction systems and product and waste form preparation. The next step is for the processes to be run at much larger scales and for extended periods to provide industry with the information required to design commercial-scale facilities. Separation methods beyond the aqueous UREX+ extraction system are also under development in the AFCI program, for example, electrochemical processes in molten salts for recycle of fast reactor spent fuels.

3.) Waste: One of the primary goals of the GNEP effort is to reduce the quantity and radiotoxicity of waste produced during nuclear power generation and to simplify the disposition of those wastes. It is important to note that this longer-term GNEP effort is complementary to the current initiative to license the Yucca Mountain repository. Los Alamos scientists are also actively participating in the DOE's effort to prepare the license application for Yucca Mountain for consideration by the Nuclear Regulatory Commission. Whereas Yucca Mountain is a permanent solution for the commercial spent nuclear fuel currently awaiting disposal, as well as defense high-level waste, the GNEP research addresses the important issue of how to further optimize the long-term management of nuclear waste in a way that enables the global expansion of nuclear power in a safe and secure manner throughout the 21st century.

The radiotoxicity and heat-generating characteristics of nuclear waste pose significant technical challenges. In contrast to the "once-through" open fuel cycle, in which spent nuclear fuel rods are sent to a geologic repository, the separations and reprocessing steps of the closed fuel cycle being pursued in the GNEP program would lead to separated waste streams containing individual or groups of radionuclides. This approach, though more complex from a chemical processing perspective, leads to exciting potential advantages. Both the waste form (the solid form in which a radionuclide is incorporated) and the geologic repository for which that waste is destined can be tailored to optimize the safety and economics of the process. A particular waste form for isolating one or more radionuclides can in principle be optimized for the geologic and geochemical conditions of a particular repository setting. Considering that a variety of geologic environments are currently being considered worldwide, including granite, clay, and salt, long-term R&D investigating the suitability in a wide range of host environments seems prudent.

Los Alamos and other DOE laboratories, in collaboration with universities, stand ready to embark on a new, leading-edge effort to tackle the considerable scientific and engineering challenges posed by the waste issue. Radionuclides in waste streams from a closed fuel cycle could be stabilized in either solid glass, metal, or ceramic waste forms that would be disposed of in mined geologic repositories, or otherwise stored for a time sufficient to allow the radiotoxicity to be reduced to safe levels. R&D and engineering studies are being conducted to guide the selection of the solid matrix and waste loadings.

The goal of this effort is to design waste forms that are resistant to radiation damage and dissolution and mobilization of the waste in the selected environment. A long-term experimental and modeling program is required to achieve an ability to understand and ultimately predict the long-term behavior of these new waste forms in a geologic environment. Fundamental understanding of the reactive dissolution of the waste, as affected by self-irradiation and elemental transformations due to radioactive decay, is required to predict the long-term durability of a given waste form exposed to a given set of physical and geochemical conditions.

4.) Safeguards: Advanced material control and safeguards technologies to support national nonproliferation objectives can enable the safe and secure expansion of nuclear energy in the U.S. and globally. Research on an enhanced system will build on existing safeguards technologies, many of which were created at Los Alamos, to enable near-real time *knowledge* extraction of facility operations and global nuclear material management. These technologies will include development of high reliability, remote and unattended surveillance systems.

It is important to note that the United States leads the world in developing safeguard technologies. As an example, the International Atomic Energy Agency sends every new inspector to LANL for required training. Inspectors who have responsibility for advanced fuel cycle facilities return to LANL for advanced training. The experimental facilities at the Los Alamos Neutron Science Center can provide data to enable new instrumental techniques. Hot cell facilities at the Chemistry and Metallurgy Research building can provide an integrated material control & accountability and safeguards R&D test bed in an environment where iterative development can occur in an uncontaminated environment. In addition, computational capabilities developed under the stockpile stewardship program can be brought to bear to bring new levels of modeling and simulation to this area.

5.) Modeling and Simulation: The advanced modeling and simulation tools developed for the nuclear weapons program at the national labs by NNSA’s Advanced Simulation and Computing (ASC) program are now being applied to GNEP. Systems analysis studies help define and quantify the benefits and disadvantages of various deployment options for an expanded nuclear energy system, from uranium mining, to fuel fabrication, to reactor construction, to emplacement of wastes in a repository.

The modeling and simulation tools take advantage of the tremendous computer power and computational physics approaches that were developed for ASC. Several simulation tools required minimal modifications to address the needs of nuclear fuel manufacturing. As an example, the same tools used for simulations of plutonium alloy casting (TELLURIDE at LANL) are now employed for optimizing the casting of plutonium-based metal fuels. A number of ASC codes (CHAD at LANL and DIABLO at Lawrence Livermore National Laboratory) are currently being updated to include the models and numerical methods necessary for simulations of coupled phenomena in the nuclear fuel element, such as heat transport, diffusion of fission products, and thermo-mechanical deformation. This effort is aimed at developing an advanced fuel performance code.

In parallel, fundamental studies are being carried out at national laboratories to advance the understanding of irradiation effects on nuclear fuels and reactor structural materials. The studies are focused on predicting the changes in the thermal, mechanical, and chemical properties of the materials as a function of burnup (cumulative radiation) to determine the most probable causes of fuel element failure as well as the most probable time when the failure will occur. The fundamental studies are also critical in evaluating and optimizing new fuel types, such as the multi-component, transuranic oxide fuels (U-Pu-Np-Am-O).

Similar efforts are directed at simulating coupled phenomena in the nuclear reactor core. The complexity of these studies is increased by the necessity to incorporate neutron fluxes and their effect on the properties of the fuel and structural materials. LANL gained international recognition for developing one of the most advanced Monte Carlo simulations tools, the MCNP (Monte Carlo N-Particle Transport) program. Building on that, the simulations of the thermal-hydraulics in thermal and fast reactors revealed the necessity for new, advanced algorithms and high performance computational platforms. Recent simulations of ASC codes performed on the first components of the Roadrunner supercomputer at LANL demonstrated an important increase in computational capability. Besides benefiting the traditional LANL core programs, the increase in computational speed will benefit the complex, large- scale nuclear reactor simulations and lead to truly predictive accident scenario capabilities.

Although the thermo-chemistry of traditional actinide and fission products separation methods (UREX and PUREX) is well established, there are no advanced computational tools able to simulate the entire separation process. This area would benefit from intense research aimed at optimizing the separation process and reducing the risk of nuclear proliferation. A similar thermo-chemical approach is used in assessing the behavior of nuclear waste at the main US repositories. Comprehensive, fundamental models of chemical reactions between the waste and the environment have been developed at LANL and will serve as the basis for advanced simulation tools, able to predict the behavior of the waste over long periods of time.

Conclusion

In conclusion, the GNEP technology development program lays out a reasonable approach for closing the fuel cycle. With adequate R&D and critical investments in laboratory infrastructure, basic processes and systems can be demonstrated at reasonable scale and on a timetable consistent with the GNEP plan. Much of the infrastructure exists within national laboratories; for example the large hot cells in LANL's Chemistry and Metallurgy Research facility are perfectly suited for investigations of materials that have experienced radiation fatigue. There are no technological show stoppers to closing the fuel cycle, and providing a global approach to a major expansion of nuclear energy.

Thank you, and I look forward to your questions.