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# NUCLEAR ENERGY RESEARCH INITIATIVE

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## 2. Background

In January 1997, the President tasked his Committee of Advisors on Science and Technology (PCAST) to review the current national energy R&D portfolio and to provide a strategy to ensure that the United States has a program to address the Nation's energy and environmental needs for the next century.

In its November 1997 Report to the President, Federal Energy Research and Development for the Challenges of the Twenty-First Century, the PCAST panel on Energy Research and Development determined that it was important to establish nuclear energy as a viable and expandable option and that a properly focused R&D effort to address the potential long-term barriers to expanded use of nuclear power (e.g., nuclear waste, proliferation, safety and economics) was appropriate. The PCAST panel further recommended that DOE reinvigorate its nuclear energy R&D activities in order to address these potential barriers with a new nuclear energy research initiative. DOE would fund research through this new initiative, based on competitive selection of proposals from the national laboratories, universities, and industry.

DOE endorsed the PCAST recommendations and received Congressional appropriations in FY 1999, allowing NERI to sponsor innovative scientific and engineering R&D to address the key issues affecting the future use of nuclear energy and preserve the Nation's nuclear science and technology leadership.

In 1999, the PCAST report, The Federal Role in International Cooperation on Energy Innovation, recommended creation of an international component to NERI to promote "bilateral and multilateral research focused on advanced technologies for improving the cost, safety, waste management, and proliferation-resistance of nuclear fission energy systems." In FY 2001, the Department launched the new International Nuclear Energy Research Initiative (I-NERI), for bilateral and multilateral nuclear energy research. Approximately \$15 million has been appropriated for bilateral, cost-shared research work under the I-NERI program with South Korea and France. A third collaboration involves Argonne

National Laboratory and a consortium of ten international participants represented by the U.S. Nuclear Regulatory Commission (NRC) and the European Organization for Economic Co-operation and Development (OECD) with offices throughout the world. Similar international agreements with other countries are being considered. I-NERI allows DOE to leverage federal investment with international resources through cost-share arrangements with each participating country on a wide range of nuclear technology topics. I-NERI will further enhance the influence of the United States and DOE in international policy discussions on the future direction of nuclear energy. Similar to NERI, I-NERI features competitive, researcher-initiated R&D selected through an independent peer-review process by international experts from the United States and its partners. A separate report covering the research effort provided by I-NERI is expected to be published in early 2003.

### NERI Development

In order to determine the initial focus of the NERI research areas, DOE convened a workshop of nuclear community stakeholders in April 1998, representing national laboratories, universities, and industry. As a result of this NERI workshop<sup>1</sup>, DOE focused its initial scientific and engineering R&D in the following areas:

- Proliferation-resistant reactors and fuel technology
- New reactor designs to achieve improved performance, higher efficiency, and reduced cost, including low-output power reactors for use where large reactors are not attractive
- Advanced nuclear fuels
- New technologies for management of nuclear waste
- Fundamental nuclear science

To encourage innovative R&D, a unique process for selecting new NERI projects has been employed since the program's inception. In response to the NERI solicitations,

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<sup>1</sup>Summary Report of the Nuclear Energy Research Initiative Workshop—An Assessment of Research Opportunities for Nuclear Energy, Technology and Education, June 1998.

principal investigators (PIs) select research topics of interest and define the scope and extent of the R&D in their proposals. DOE employs an independent, expert peer review process to judge the scientific and technical merit of the R&D proposals. For those proposals judged to have the highest scientific and technical merit, DOE conducts a programmatic review to ensure conformance of selected projects with DOE policy and programmatic requirements. The two reviews result in award-selection recommendations to DOE's Source Selection Official.

In the intervening years since the initiation of NERI a number of influencing events have occurred which have helped shape and focus NERI research activities.

- In 1998, DOE established the independent Nuclear Energy Research Advisory Committee (NERAC) to provide advice to the Secretary and to the Director, Office of Nuclear Energy, Science, and Technology (NE) on the DOE civilian nuclear technology program. In June 2000, NERAC issued the Long Term Nuclear Technology Research and Development Plan, which identifies the research and technology development necessary over the next 10-20 years to help ensure the long-term viability of nuclear energy as an electricity generation option. NERAC also established a task force to identify R&D needs related to nuclear non-proliferation issues associated with nuclear power production. Their recommendations for appropriate research in this area were provided to DOE in a January 2001 report titled, Technical Opportunities to Increase the Proliferation Resistance of Global Civilian Nuclear Power Systems (TOPS).
- The National Energy Policy, issued in May 2001 by the Vice President's National Energy Policy Development Group, supports the expansion of nuclear energy as one of its major initiatives for meeting the growing energy requirements of the United States. The National Energy Policy provides the core element in the planning for DOE's nuclear energy research programs addressing, among other areas, the research and development of advanced reactor and fuel cycle concepts, hydrogen production from nuclear energy, and the associated enabling sciences and technologies.
- In September 2002, NERAC issued the Draft Technology Roadmap for Generation IV Nuclear Energy Systems. In coordination with the ten-member country Generation IV International Forum

(GIF) six reactor system concepts were selected for further research and development. These include the Very-High-Temperature Reactor System, the Gas-Cooled Fast Reactor System, the Supercritical Water-Cooled Reactor System, the Lead-Cooled Fast Reactor System, the Sodium-Cooled Fast Reactor System, and the Molten Salt Reactor System.

### **NERI Mission**

The importance of nuclear power to the World's future energy supply requires that DOE apply its unique resources, specialized expertise, and national leadership to address key issues affecting the future of nuclear energy. NERI is a national research-oriented initiative focused on innovation and competitiveness that brings together national laboratories, universities, and industry to explore and develop new nuclear power technology. In so doing, NERI advances the state of scientific knowledge and promotes an enhanced domestic nuclear energy research and science infrastructure at universities, national laboratories, and industry that directly supports DOE's energy mission—a Secretarial priority.

The NERI program also supports the National Energy Policy by conducting research to advance the state of nuclear science and technology in the United States. This research addresses the key technical issues impacting the expanded use of nuclear energy. NERI is essential to helping DOE foster innovative ideas in such areas as advanced nuclear energy systems, hydrogen production from nuclear power, advanced nuclear fuels and fuel cycles, and fundamental science. This research enhances the ability of nuclear energy to help meet the Nation's future energy needs and environmental goals. To achieve these long-range goals, NERI has the following objectives:

- Address and help overcome the potential technical and scientific obstacles to the long-term future use of nuclear energy in the United States, including those involving nonproliferation, economics, and nuclear waste disposition.
- Advance the state of U.S. nuclear technology so that it can maintain a competitive position in overseas markets and a future domestic market.
- Promote and maintain a nuclear science and engineering infrastructure to meet future technical challenges.

Working in tandem with the Nuclear Power 2010 program<sup>2</sup>, the Generation IV Nuclear Energy Systems Initiative<sup>3</sup>, and I-NERI, the NERI program supports the following NE programmatic goals:

- Facilitate an additional 50,000 megawatts (MW) of electricity by 2020, saving the consumer \$500 million annually in comparison to producing the same electricity using fossil fuel.
- Avoid the emissions of 82 million metric tons of carbon, 2.5 million tons of sulfur dioxide, and 1.2 million tons of nitrogen oxide into the Earth's atmosphere each year.

This latter activity will make a significant contribution towards achieving the President's Global Climate Change goal of reducing greenhouse gas intensity by 18 percent by 2012.

### **NERI Work Scope**

In FY 2002, NERI expanded its R&D focus to address new research requirements introduced in the National Energy Policy. The following paragraphs defined the NERI research areas:

Advanced Nuclear Energy Systems: This program element includes the investigation and preliminary development of advanced concepts for reactor and power conversion systems. These systems offer the prospect of improved performance and operation, design simplification, enhanced safety, and reduced overall cost. Projects involve innovative reactors, system and component designs, alternative power conversion cycles for terrestrial applications, new research in advanced digital instrumentation and control and automation technologies, and other important design features and characteristics.

Hydrogen Production from Nuclear Power: This program element includes research and development to identify

and evaluate new and innovative concepts for producing hydrogen using nuclear reactors. This research includes investigation of hydrogen generation processes compatible with advanced reactor systems, and the integrating parameters needed to develop systems that are efficient and cost-effective overall.

Advanced Nuclear Fuels/Fuel Cycles: This element includes research and development to provide measurable improvements in the understanding and performance of nuclear fuel and fuel cycles with respect to safety, waste production, proliferation resistance, and economics, to enhance the long-term viability of nuclear energy systems. This research includes improvements in the performance of fuels for advanced systems, and development of fuels capable of withstanding the conditions in the supercritical light water reactor (LWR) regime and of advanced proliferation resistant-fuels capable of high burn-up such as those needed in support of the Generation IV concepts.

Fundamental Science: This element includes research and development in the fields of materials science and fundamental chemistry. Fundamental science research funded by NERI applies to and supports one or more of the preceding program elements in advanced nuclear engineering technology. Material sciences applications include research and development on materials for use in advanced nuclear reactor systems, structures, and components, including fuel cladding that may perform in high-radiation fields, high-temperatures and pressures, and/or in highly corrosive environments (i.e., lead-bismuth). Chemical science research may focus on development and improvement of primary and secondary coolant chemistry in advanced reactors. Other research subjects include the investigation of nuclear isomers that could prove beneficial in civilian applications.

In general, it should be noted that safety, nonproliferation, and waste management are considerations intrinsic to the above research topics, especially for the advanced nuclear energy systems and advanced fuels/fuel cycles. Thus, they become selection criteria across all four focus areas, and do not in themselves constitute focus areas.

The full-page graphic on the following page summarizes the key features of the NERI program.

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<sup>2</sup> The Nuclear Power 2010 program was implemented in FY 2002 to address nuclear regulatory, technical, and institutional issues to enable one or more orders to be placed for new commercial nuclear power plants in the United States by 2005 for deployment by 2010.

<sup>3</sup> The Generation IV Nuclear Energy Systems Initiative was implemented in FY 2000 to focus on the development and demonstration of one or more Generation IV nuclear energy systems that offer advantages in the areas of economics, safety and reliability, and sustainability, and that could be deployed commercially by 2030.

# An Overview of the NERI Program

