3. NERI Accomplishments

This section discusses the program's progress in attracting research proposals, awarding annual R&D funding, facilitating the successful completion of the initial NERI-funded projects, and increasing the number of students participating in nuclear-related studies and research.

Project Awards

In FY 1999, DOE's NERI program received 308 R&D proposals from U.S. universities, national laboratories, and industry in response to its first solicitation. The initial FY 1999 procurement was completed with the awarding and issuing of grants, cooperative agreements, and laboratory work authorizations for 46 R&D projects. The proposed research represented participants from 45 institutions and organizations. Thirty-two of the projects involved collaborations of multiple organizations. Eleven foreign R&D organizations also participated in NERI collaborative projects. The duration of these annually funded projects was one to three years, with the majority lasting three years. The total cost of these 46 research projects for the three-year period was approximately $52 million.

Figure 1 depicts the number of research projects in each of the four R&D areas awarded in FY 1999. Proliferation-resistant technologies, though not considered separately, are incorporated in most of the research projects on advanced nuclear fuels and new reactor designs and technologies. In addition, the fundamental nuclear science area includes research projects in materials science, fundamental chemistry, computational and engineering science, and nuclear physics.

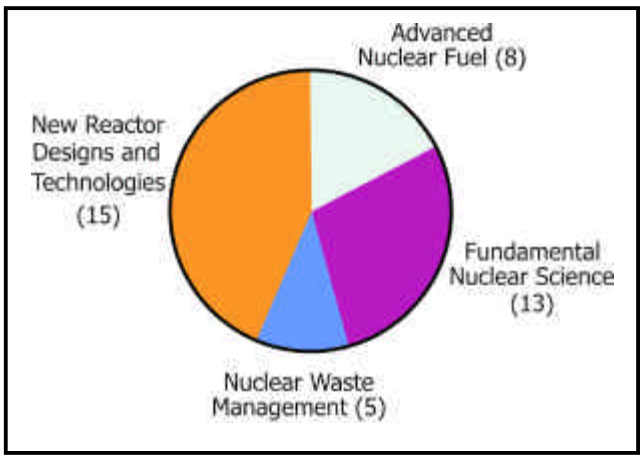

Figure 1. The graph illustrates FY 1999 NERI projects by R&D areas.

In FY 2000, FY 2001, and FY 2002, scientific and technical development advanced through the continuation of research efforts begun in FY 1999 as well as through the initiation of new awards.

- In FY 2000, 10 NERI R&D projects were awarded involving 18 U.S. and 6 foreign R&D organizations.
- In FY 2001, 13 NERI R&D projects were awarded involving 23 U.S. and 5 foreign R&D organizations.
- In FY 2002, 24 projects were awarded involving 32 U.S. and 5 foreign R&D organizations.

Figure 2 illustrates the cumulative total of research projects for FY 2000, FY 2001, and FY 2002 in each of the three major R&D areas. Nuclear Waste Management was discontinued as a focus research area for NERI after the FY 1999 award cycle.

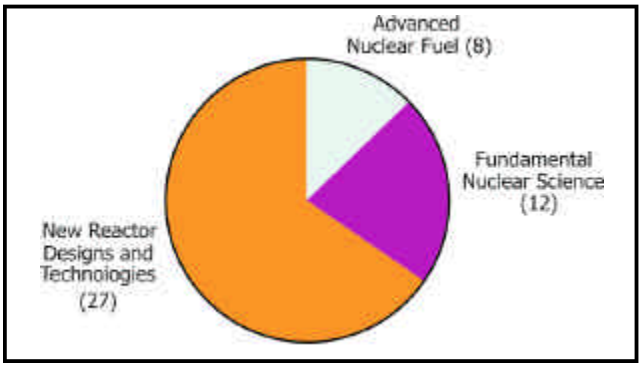

Figure 2. The graph indicates the division of NERI projects by R&D area for FY 2000, FY 2001, and FY 2002.

Funding for NERI is appropriated annually by Congress in the Energy and Water Development Appropriations Act.

- NERI funding for FY 1999 was a total of $19 million with $17.5 million available for new awards.
- Funding for FY 2000 was $21.5 million, which provided for Year 2 funding of FY 1999 awards in addition to approximately $2.7 million for new FY 2000 awards.

- FY 2001 funding was $26.5 million, which provided for Year 3 funding of FY 1999 awards, Year 2 funding for FY 2000 awards, and approximately $5.7 million for 13 new FY 2001 awards.
- In FY 2002, NERI project funding was $25.6 million with approximately $10 million allocated for the new awards and $9.3 million for continuing ongoing research projects begun in FY 2000 and FY 2001.

To date, over $110 million has been awarded to fund NERI research projects. Figure 3 shows the distribution of these funds among the national laboratories, U.S. universities, and industry.

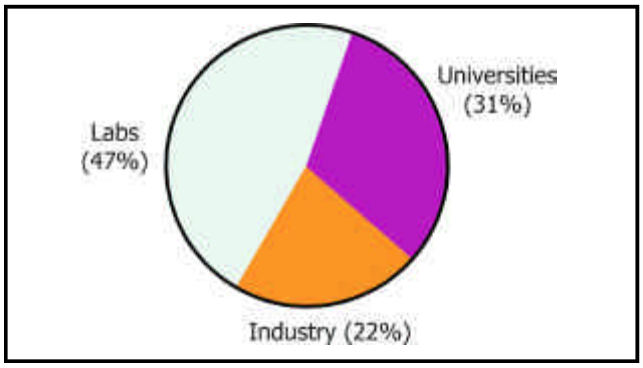

Figure 3. The chart illustrates the overall distribution of NERI funds for FY 1999 through FY 2002.

DOE has not funded foreign participants in existing projects as part of the NERI program. Rather, their participation has been supported by the foreign organizations interested in the research being conducted. Although the principal investigators have been responsible for soliciting such support, foreign participation in NERI projects is contingent upon DOE approval.

FY 1999 Project Completions

This year marked the scheduled completion of the initial 46 FY 1999 NERI projects. Based on reported accomplishments, it is clear that NERI's stated goals and objectives are being met. These collaborative efforts between the public and private sectors have resulted in significant enhancements in the U.S. nuclear science and engineering infrastructure, especially in the areas of human and physical resources and capabilities. This will allow the United States to better meet future technical challenges related to nuclear energy. NERI research includes collaboration with over 25 international organizations. These efforts, coupled with those of I-NERI and the Generation IV Nuclear Systems Initiative, have served to revive the Nation's leadership role in international nuclear R&D. Moreover, the technology advances will allow the United States to maintain a competitive position in overseas energy markets and a future domestic market.

Finally, through accomplishment of their stated research objectives, these NERI projects have addressed and helped to overcome a number of potential technical and scientific obstacles to the long-term future use of nuclear energy in the United States. A few examples of the FY 1999 project accomplishments in each area of emphasis are described below. Additional details on individual project accomplishments are contained in the project summaries located in the following chapters.

Designing a Low-Cost, Proliferation-Resistant Reactor

- Westinghouse led an international team that is developing an innovative proliferation-resistant, water-cooled reactor called IRIS (International Reactor Innovative and Secure). IRIS is a new modular, passively safe, natural circulation (i.e., with no active pumps) design that is based on proven light water reactor experience. Detailed reactor physics and heat transfer analyses have been performed. Preliminary fuel and materials selections have been made for the initial conceptual design. Component manufacturers, an architectural engineering firm, and engineering analysis teams have begun further development of a detailed design that enhances passive safety and proliferation-resistance and that can be built at a reduced cost. (Project No. 99-027)

Automating Future Nuclear Power Plants

- Oak Ridge National Laboratory (ORNL) led a team that is developing new advanced controls, diagnostic techniques, and information systems that could be used to automate future nuclear plants. The team is developing, testing, and implementing "adaptive" control strategies that recognize changes in operating data and use a decision-making module to detect system faults. (Project No. 99-119)
- Pacific Northwest National Laboratory (PNNL) focused on an on-line, intelligent, self-diagnostic monitoring system for next-generation nuclear plants, using wireless radio-frequency (RF) tagging technology. The wireless RF sensors, communication modules, and hardware and software allow RF sensors to be placed inside or near individual plant system components to provide fault detection and condition-monitoring information. (Project No. 99-168)

Bringing Advanced Ceramic Materials to Nuclear Power Applications

- The University of Florida has developed a silicon carbide (SiC) radiation-resistant material with excellent thermodynamic properties that will improve the economics of nuclear fuel. A SiC coating was applied to fuel cladding and several experiments have been completed that show how this SiC coating behaves in high-temperature environments. (Project No. 99-229)
- PNNL has explored how various ceramics behave in different thermal environments to determine whether SiC fibers, monolithic materials, and composite materials could be used in very high-temperature fission reactors under harsh irradiation environments. (Project No. 99-281)
- Gamma Engineering led a team to investigate the use of a continuous fiber ceramic composite cladding for commercial water reactor fuel. Researchers developed, tested, and irradiated the ceramic cladding material and demonstrated its ability to handle harsh accident conditions. This completed NERI project has served to demonstrate that new cladding concepts are possible. This new ceramic composite was further developed as part of a DOE-sponsored Phase I Small Business Innovation Research (SBIR) commercialization effort. (Project No. 99-224)

Developing New, Proliferation-Resistant Nuclear Fuels

- The Idaho National Engineering and Environmental Laboratory and eight research organizations investigated the feasibility of using thorium/uranium (Th/U) dioxide ceramic fuels to increase fuel utilization and proliferation-resistance in light water reactors. The team is developing Th/U core designs, fuel pellet fabrication methods, and temperature-dependent Th/U fuel property correlations, and is determining the corrosion and oxidation rate characteristics of the Th/U waste form. (Project No. 99-153)
- The Argonne National Laboratory (ANL) and Purdue University investigated the use of metallic Th/U fuel that has better thermal and proliferation-resistant properties and that can be disposed of directly. Initial physics and heat transfer calculations, laboratory experiments, and production of different Th/U fuel mixtures have been completed. Further research is focusing on the possible use of Th/U mixtures in new fuel designs in order to reduce the relative amount of plutonium isotopes produced in power reactors. (Project No. 99-095)

Developing Radiation-Resistant Alloys

- PNNL worked with General Electric (GE) and the University of Michigan to develop new alloys that are resistant to radiation damage. By doping common stainless steels with small amounts of platinum, hafnium, and other elements, it may be possible to reduce radiation-induced damage mechanisms, such as stress corrosion-cracking, which limit reactor component lifetimes. The team has irradiated materials with nickel ions and protons to simulate accelerated irradiation damage in reactor metals. Tests have been completed that show how these doped metals perform at different temperature and chemistry conditions. (Project No. 99-280)

Exploring Direct Energy Conversion Technologies for Nuclear Power

- Sandia National Laboratories (SNL) led a team investigating direct fission energy conversion concepts using reactor pumped lasers, pulsed power, space technology, solid state converters, magnetohydrodynamics, and direct radioactive isotope decay technologies. Three promising concepts have been selected for further development. Additional physics analysis and testing have been initiated. Critical technology R&D needs have been identified for future test programs, and for the Generation IV Technology Roadmap R&D effort. (Project No. 99-199)
- ORNL worked on developing an advanced reactor concept that uses an ORNL-developed graphite foam material with superior heat transfer characteristics. Irradiation tests at ORNL's High Flux Reactor have demonstrated that this graphite foam can withstand extreme neutron damage and still provide superior heat transfer capability. A simple nuclear "battery" reactor with nuclear fuel dispersed within the light graphite foam would allow for new and remote applications. (Project No. 99-064)

Reactor Physics Experiments for Advanced Nuclear Power Systems

- Experimental measurements of reactor physics data for lead-cooled fast reactors and nuclear waste transmutation systems have being conducted by ANL in collaboration with the French Atomic Energy Commission (CEA) at the Caderache facilities. The Argonne team has completed the development, planning, and implementation of no-cost experiments in France that will lead to valuable physics information

needed for advanced Generation IV reactor designs. The experiments are being used for formal reactor physics calculation benchmarks to validate U.S. and international reactor engineering computer codes and cross section data bases. (Project No. 99-039)

- Two experimental projects at SNL will provide important information on criticality safety and spent fuel shipment safety, needed for advanced reactor fuel designs that use higher initial fuel enrichments and have larger end-of-life fuel burn-up exposures than currently-operating plants. The data generated from these experiments will serve to verify computational methods used for reactor safety calculations, reduce the licensing burden on future reactor designs, and remove overly conservative assumptions made in the absence of such data. (Project No. 99-200)

U.S. University Involvement

Twenty-eight U.S. universities participate either as lead investigators or collaborators in about 75 percent of the 93 NERI projects that have been funded. Figure 3 indicates the location and names of the participating institutions. A significant increased enrollment of students across the Nation in nuclear-related fields is attributed to the research opportunities provided by NERI at these universities.

University student participation has been at all levels-in undergraduate, master's, and doctoral degree programs. Figure 4 is a summary of student participation by degree

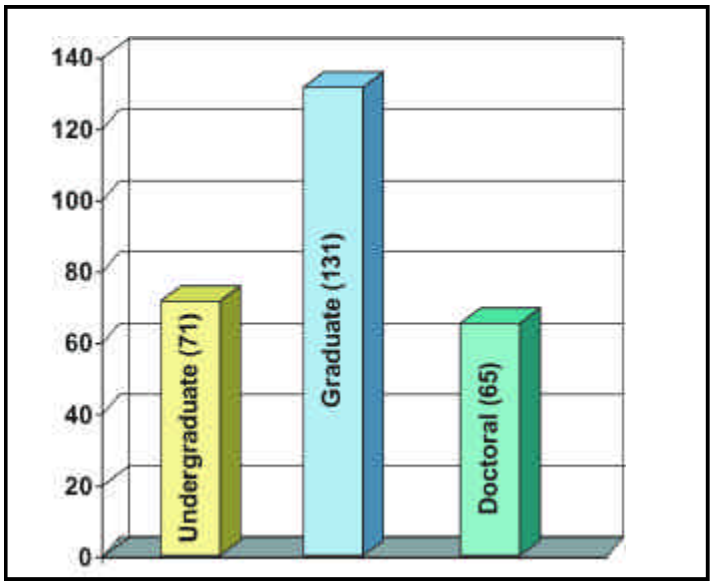

Figure 4. The graph indicates the number of university students participating in NERI projects in each type of academic degree program.

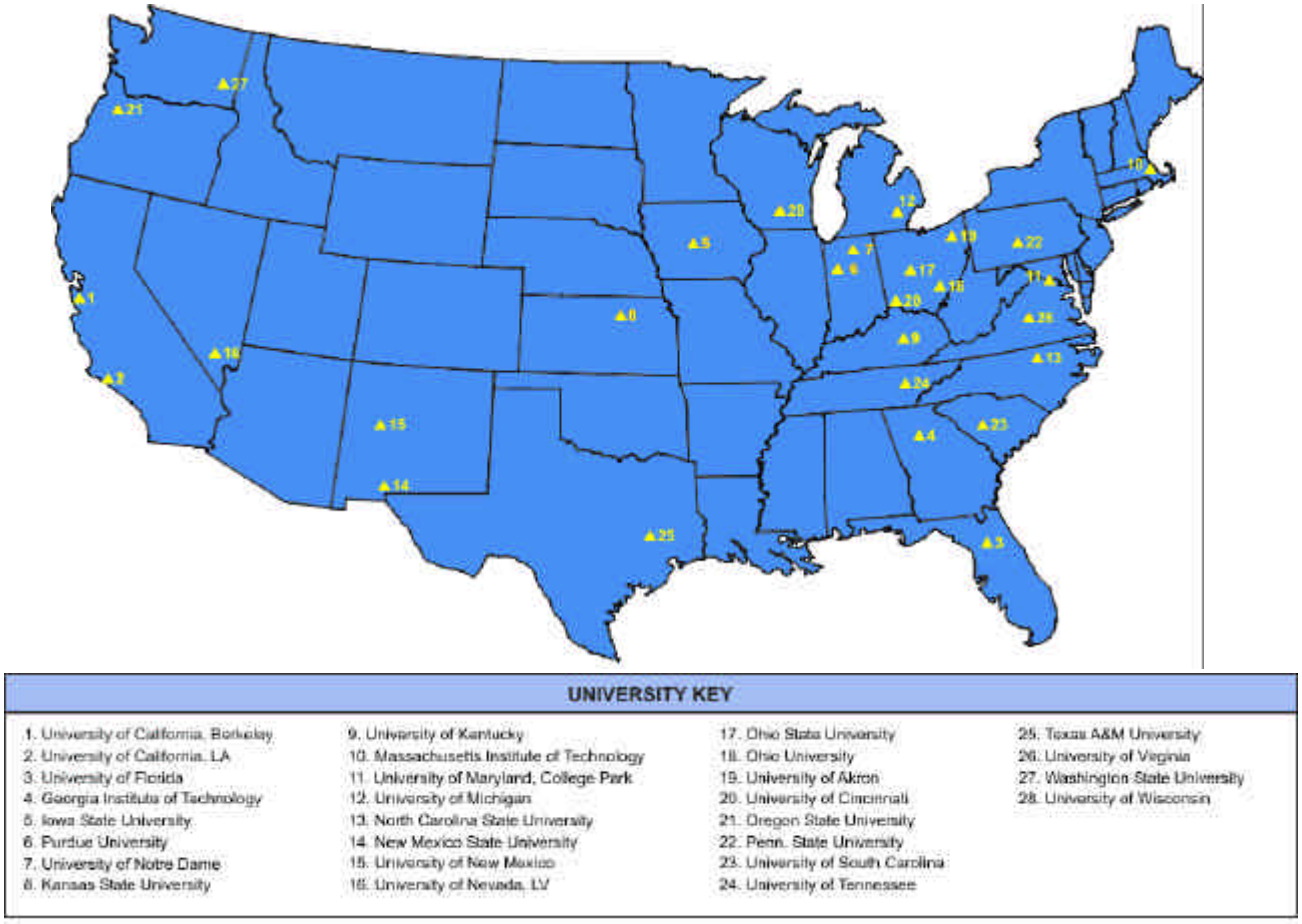

Figure 3. The map shows the state locations for universities participating in NERI projects; the key names the universities.

program at individual universities associated with the FY 1999, 2000, and 2001 NERI projects. A total of 267 students have participated in 49 of the 69 projects funded during these three years. In addition, numerous post-doctoral participants have been involved at these universities in NERI research projects. The number of students participating in the newly awarded FY 2002 projects is yet to be determined.

Other NERI Participants

In addition to the 28 U.S. universities noted in the previous section, since FY 1999 NERI research participants have included 11 national laboratories, 2 government agencies, 27 private businesses, and 28 foreign organizations. The names of these participating organizations are provided in the following tables.

U. S. Department of Energy Laboratories
Ames Laboratory
Argonne National Laboratory
Brookhaven National Laboratory
Idaho National Engineering and Environmental National Laboratory
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
Oak Ridge National Laboratory
Pacific Northwest National Laboratory
Sandia National Laboratory
Savannah River Technology Center

Government Agencies
National Institute of Standards and Technology
U.S. Nuclear Regulatory Commission

Industrial Organizations
Bechtel
CEGA Corporation
Dominion Generation
Duke Engineering
Egan Associates
Electric Power Research Institute
Entergy Nuclear, Inc.
Florida Power and Light
Framatome ANP, Inc.

continued

Industrial Organizations (continued)
Gamma Engineering
General Electric
General Electric Global Research Center
General Atomics
Global Nuclear Fuel
McDermott Technologies
Newport News Ship Building and Drydock Co.
Northern Engineering and Research
Pacific Sierra
Pacific Southern Electric and Gas
Panlyon Technologies
Rockwell Science Center
Siemens Power Corporation
SRI International
Swales Aerospace
Tennessee Valley Authority
Westinghouse Electric Company
(n,p) Energy, Inc.

International Collaborators
Atomic Energy of Canada (Canada)
Ben Gurion University (Israel)
British Nuclear Fuel (UK)
Chosun University (Korea)
Commissariat a l'Energie Atomique (France)
Framatome (France)
Forschungszentrum (Germany)
Hitachi (Japan)
Imperial College of London (United Kingdom)
Institute of Physics and Power Engineering (Russia)
Italian National Agency for New Technologies, Energy and Environment (ENEA)
Japan Nuclear Cycle Development Institute (Japan)
Japan Atomic Power Company (Japan)
Kurchatov Institute (Russia)
Mitsubishi Heavy Industries (Japan)
National Atomic Energy Commission and University of Cuyo (Argentina)
OECD Nuclear Energy Agency (France)
PBMR, Ltd. (South Africa)
Polytechnical Institute of Milan (Italy)
Studsvik Scanpower Inc. (Sweden)
Tokai University (Japan)
Tokyo Institute of Technology (Japan)
Toshiba (Japan)
Toyama University (Japan)
University of Manchester (UK)
University of Rome (Italy)
University of Tokyo (Japan)
VTT Manufacturing Technology (Finland)