Light Water Reactor Sustainability

The U.S. Department of Energy's Office of Nuclear Energy

The current fleet of nuclear power plants provides almost 20 percent of the total U.S. electricity production and more than 70 percent of the U.S. non-greenhouse-gas-emitting electric power generation.

The Light Water Reactor Sustainability (LWRS) Program is developing the scientific basis to extend existing nuclear power plant operating life beyond the current 60-year licensing period and ensure long-term reliability, productivity, safety, and security. The program is conducted in collaboration with national laboratories, universities, industry, and international partners. Idaho National Laboratory serves as the Technical Integration Office and coordinates the Research and Development (R&D) projects in the following pathways: Nuclear Materials Aging and Degradation; Advanced Light Water Reactor Fuel Development; Advanced Instrumentation, Controls, and Information Systems Technology; Risk-Informed Safety Margin Characterization, and Efficiency Improvements.

BENEFITS OF THE INITIATIVE

Nuclear power has reliably and economically contributed almost 20 percent of electrical generation in the United States over the past 2 decades. It remains the single largest contributor (more than 70 percent) of non-greenhouse-gas-emitting electric power generation in the United States. By the year 2030, domestic demand for electrical energy is expected to grow to levels of 16 to 36 percent higher than 2007 levels. At the same time, most currently operating nuclear power plants will begin reaching the end of their 60-year operating licenses.

If current operating nuclear power plants do not operate beyond 60 years, the total fraction of generated electrical energy from nuclear power will begin to decline — even with the expected addition of new nuclear generating capacity. The oldest commercial plants in the United States reached their 40th anniversary this year.

Continued safe and economical operation of current reactors for an even longer period of commercial operation, beyond the current license renewal lifetime of 60 years, is a low-risk option to fill the gap and to add new power generation at a fraction of the cost of building new plants. The cost to replace the current fleet would require hundreds of billions of dollars. Replacement of this 100 GWe generating capacity with traditional fossil plants would lead to significant increases in greenhouse gas emissions. Extending operating licenses beyond 60 to perhaps 80 years would enable existing plants to continue providing safe, clean, and economic electricity.

Light Water Reactor Sustainability

Program Budget

Light Water Reactor Sustainability
($ in Millions)

	FY 2010 Actual	FY 2011 Request
	$9.7*	$25.8

**appropriated under GEN IV programs*

To provide the technical basis for this life extension, the following five R&D pathways have been identified:

- **The Nuclear Materials Aging and Degradation** pathway will conduct research to develop the scientific basis for understanding and predicting long-term environmental degradation behavior of materials in nuclear power plants. Data and methods to assess performance of systems, structures, and components essential to safe and sustained nuclear power plant operation will be developed.
- **The Advanced LWR Nuclear Fuel Development** pathway will improve the scientific knowledge basis for understanding and predicting fundamental nuclear fuel and cladding performance in nuclear power plants. This information will be applied to the development of high-performance, high burn-up fuels with improved safety, cladding integrity, and improved nuclear fuel cycle economics.
- **The Advanced Instrumentation, Information, and Control Systems Technologies** pathway addresses long-term aging and obsolescence of instrumentation and control technologies and the development and testing of new information and control technologies. Advanced condition monitoring for more automated and reliable plant operation will be developed.
- **The Risk-Informed Safety Margin Characterization** pathway will bring together risk-informed, performance-based methodologies with scientific understanding of critical conditions and predictions of nuclear power plant performance, leading to an integrated characterization of public safety margins in an optimization of nuclear safety, plant performance, and long-term asset management.
- **The Economics and Efficiency Improvement** pathway will improve the economics and efficiency of the current fleet of reactors while maintaining excellent safety performance. Methodologies and the scientific basis to enable more extended power uprates or ultra-high power uprates will be developed. In addition, improving thermal efficiency by developing advanced cooling technologies to minimize water usage will be explored.

With the 60-year licenses beginning to expire between the years 2029 and 2039, utilities are likely to initiate planning baseload replacement power by 2014 or earlier. Research for addressing nuclear power plant aging questions must start now. The LWRS Program represents the timely collaborative research needed to retain the existing nuclear power plant infrastructure in the United States.

PLANNED PROGRAM ACCOMPLISHMENTS

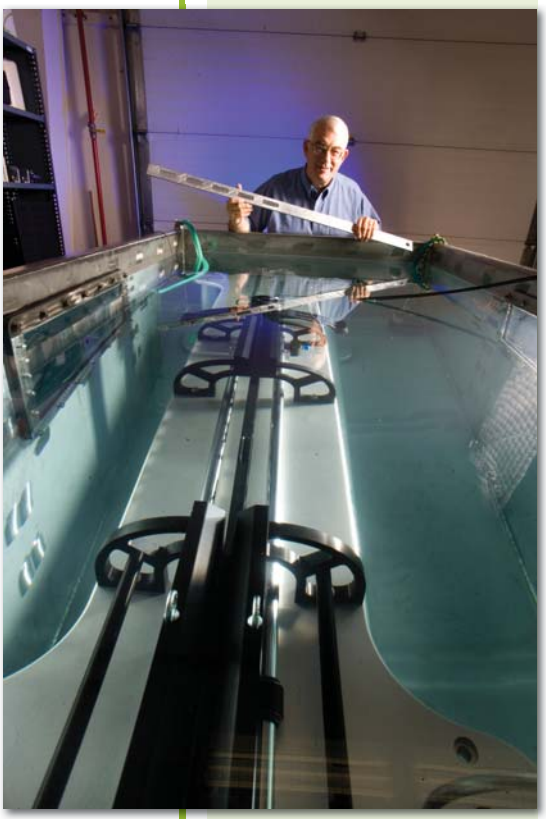
FY 2010

- Complete a review of current information and technology related to concrete durability and aging relevant to nuclear power plant environments.
- Complete a technology development plan for Silicone Carbide clad fuel development.
- Complete a workshop and research and development plan for online monitoring and non-destructive examination technologies.
- Complete a report on the architectural and algorithmic requirements for a next-generation system analysis code.
- Complete the development of the initial test code version of the R7 system analysis computer code.

FY 2011

- Address high-fluence neutron irradiation effects on reactor metals including the reactor pressure vessels and core internals (stainless steels and high strength alloys), radiation-induced swelling effects, and phase transformation of core internals.
- Evaluate long-term aging of concrete structures.
- Investigate crack initiation in nickel-based alloys (steam generator tubing).
- Examine advanced mitigation techniques such as welding and weld repair techniques, post-irradiation annealing and modern replacement alloys.
- Develop a risk-informed simulation-driven methodology to guide safety system analysis and uncertainty quantification.
- Enhance the deterministic safety analysis capability to simulate plant dynamics and compute safety margin.
- Incorporate passive structures, systems, and components into a probabilistic safety analysis at one plant type.
- Develop alternative and new cooling technologies that can be applied in the near term to reactors impacted by insufficient cooling water supplies and innovative technologies that lessen the environmental impacts of removing large volumes of cooling water from naturally occurring sources.
- Develop plant control and monitoring systems to improve plant efficiency, facilitate power up-rates, and enable remote monitoring and support.
- Develop a model for fuel cracking at the mesoscale level with sufficient understanding to develop a predictive model for fission gas release.
- Begin the development of new long-life fuel designs with advanced fuel and cladding materials.

Fuel testing increases our understanding of material performance and is essential to safe and sustained nuclear power plant operation.



Light Water Reactor Sustainability

The U.S. Department of Energy's Office of Nuclear Energy

www.nuclear.energy.gov
February 2010