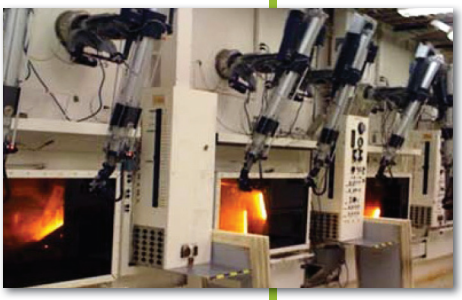
Fuel Cycle Research and Development

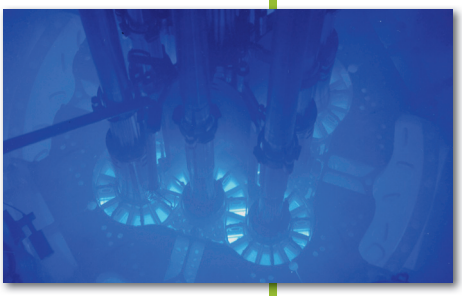
The U.S. Department of Energy's Office of Nuclear Energy

The U.S. Department of Energy (DOE) supports long-term, results-oriented, science-based research and development (R&D) through its Fuel Cycle R&D Program.

The mission of the Fuel Cycle Research and Development (FCRD) program is to conduct research and development to help develop sustainable fuel cycles, as described in the *Nuclear Energy Research and Development Roadmap*. Sustainable fuel cycle options are those that improve uranium resource utilization, maximize energy generation, minimize waste generation, improve safety, and limit proliferation risk.

The FCRD program will develop a suite of options to enable future policymakers to make informed decisions about how best to manage used fuel from nuclear reactors. The overall goal is to demonstrate the technologies necessary to allow commercial deployment of solutions for the sustainable management of used nuclear fuel that is safe, economic, secure, and widely acceptable to American society by 2050.





FUEL CYCLE STRATEGIES

The program will examine three fuel cycle strategies: once-through, modified open, and full recycling. Examination of this full range of strategies is critical to provide future decision-makers with adequate information to make decisions on how best to manage used fuel.

Once-Through Fuel Cycle Strategy —

The FCRD program will develop fuels for use in reactors that increase the efficient use of uranium resources and reduce the amount of used fuel requiring direct disposal for each megawatt-hour of electricity produced. Under the once-through fuel cycle strategy, developing ways to increase the availability of fuel resources is critical, although resource extension is important for all fuel cycle options.

Modified Open Fuel Cycle Strategy —

The FCRD program will 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, with limited or no separations steps, using technologies that substantially lower proliferation risk. Additionally, the FCRD program will evaluate the inclusion of non-uranium materials as reactor fuel options that may reduce the long-lived radiotoxic elements in the used fuel for repository disposal.

Program Budget	
Fuel Cycle R&D Program ($ in Millions)	
	FY 2012 Request
	$155.0

Full Recycle Fuel Cycle Strategy —

The FCRD program will develop techniques to 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 will dramatically decrease the long-term risk posed by the waste, reducing uncertainties associated with its disposal.

A NEW APPROACH TO R&D

The FCRD program seeks to develop innovative and transformational options within each of the fuel cycle strategies, leading to the research, development, and demonstration (RD&D) of the best options. A new approach to R&D, along with new partnerships, methods, and technologies, will contribute to the achievement of this goal. The FCRD program will focus on science-based R&D that integrates theory, experiment, and high-performance modeling and simulation.

SCIENTIFIC COLLABORATION

DOE's Office of Nuclear Energy (NE) has a diversified portfolio of research and development programs. NE allocates R&D funding to the best qualified entities (e.g., national laboratories, universities, and industry) to conduct the work in support of NE's mission. NE R&D activities typically require highly specialized R&D facilities and capabilities that are primarily available only at DOE national laboratories.

Consistent with NE's commitment to supporting R&D activities at university and educational research institutions, NE designates at least 20 percent of funds appropriated to its R&D programs for work to be performed at university and research institutions through open, competitive solicitations for investigator-led projects. Universities often collaborate with the DOE national laboratories, thereby expanding the base of highly qualified engineers and scientists in the future.

The Fuel Cycle R&D program also collaborates with nuclear industry and international partners with advanced fuel cycles to leverage U.S. research investments and pursue common goals toward advanced fuel cycles that are economic, minimize waste, and reduce proliferation risk.

CHANGES FOR FY 2012 THAT WILL LEAD TO FUNDING REDUCTIONS

In FY 2012, modeling and simulation activities that support Fuel Cycle R&D are consolidated within Nuclear Energy Enabling Technologies, another R&D program within the Office of Nuclear Energy. This accounted for more than $15M in the FY 2011 Request. In the Used Nuclear Fuel Disposition technical area, activities associated with the transition of Office of Civilian Radioactive Waste Management responsibilities to the Office of Nuclear Energy were completed in FY 2011. In FY 2011, Fuel Cycle R&D began to implement a systems engineering approach to define and analyze a wide range of fuel cycle options, many of them associated with the modified open fuel cycle strategy that was introduced in FY 2011. In FY 2012, the program will begin to use the results of these analyses to prioritize its activities, focusing on the most promising options. In addition, many of the technologies associated with the modified open fuel cycle strategy are similar to the technologies the FCRD program is already studying under the full recycling strategy, resulting in a reduction in the scope of technologies that need to be studied.

BLUE RIBBON COMMISSION

The Blue Ribbon Commission on America's Nuclear Future is conducting a comprehensive review of policies for managing the back end of the nuclear fuel cycle. The Commission is scheduled to submit a draft report to the Secretary of Energy in July 2011 and a final report in January 2012. NE's R&D plans will be revisited and revised as needed to reflect the Commission's findings and associated Administration decisions.

PLANNED PROGRAM ACCOMPLISHMENTS

FY 2011

- Develop advanced concepts for electrochemical processing to recycle salt for waste minimization, advanced methods for transuranic recovery, and novel product consolidation methods.
- Develop alternative waste forms that are tailored to specific radionuclides and potential geologic media.
- Initiate development of innovative fuel systems that possibly support alternative fuel cycles to the current once-through fuel cycle with the potential for dramatic performance and waste minimization potential.
- Develop an initial modeling and simulation integration framework that facilitates capability transfer by allowing interoperability of existing codes and newly developed capabilities.
- Using a systems engineering approach, conduct systems analyses to define and analyze a broad variety of innovative fuel cycle options including analyzing the effects of a variety of alternative disposal geologies to inform R&D prioritization and program planning.
- Based on a roadmap created in FY 2010, continue development of improved proliferation risk assessment tools to evaluate fuel cycle options.
- Provide technical expertise to inform policy decision-making regarding the storage, transportation, and disposal of used nuclear fuel and radioactive waste that would be generated under existing and potential future nuclear fuel cycles, including the long-term durability of the materials.
- Identify novel approaches to improve resource utilization, including new fuel forms; ultra-high burnup fuels; thorium-based fuels; deep burn of transuranic-bearing tristructural-isotropic (TRISO) fuels; new advanced reactors designed for transuranic burn-up, such as molten salt reactors and travelling wave reactors; and options to declad and reclad used fuel to allow volatile and gaseous fission products to be removed and captured before recycling.

The Tecnical Working Group of the U.S.–China Bilateral Civil Nuclear Energy Cooperative Action Plan met in Beijing on May 20–21, 2009. The U.S. and Chinese delegations laid out the scope of R&D for three working groups: advanced fuel cycle technology, fast reactor technology and safeguards and physical protection technology.

Fuel Cycle Research and Development focuses on long-term, science-based R&D of technologies with the potential to change the way nuclear waste is managed.

FY 2012

- Address the grand challenges facing the Separations and Waste Forms technical area by investigating minor actinide separation and off-gas capture and immobilization using sigma teams. Sigma teams are multidisciplinary teams of technical experts from across many national laboratories focused on solving difficult technical problems.
- Develop fundamental science and methods related to separation processes, which are associated with chemistry, thermodynamics, and kinetics.
- Support the fundamental understanding of the fuel behavior by developing novel characterization and in-pile measurement instrumentation.
- Improve transmutation fuels development by increased coordination with separations and waste forms R&D and systems analysis technical teams.
- Develop systems analyses, optimization, and trade-off studies regarding fuel cycle strategies and technologies.
- Conduct "safeguards and security by design" activities that consider proliferation of terrorism risks from the very earliest stages of development.
- Continue R&D associated with the disposal of all classifications of radioactive waste.
- Continue R&D associated with the storage and transportation of waste and by-product materials that are generated from current and future fuel cycles in the United States.