Fuel Cycle Research and Development

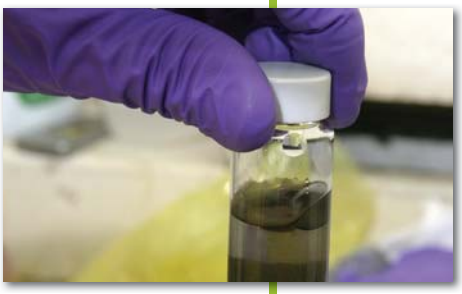
The U.S. Department of Energy's Office of Nuclear Energy

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 program is to perform results-oriented, science-based R&D to provide options for decision-makers for future commercial fuel cycle management strategies. This will enable the safe, secure, economic, and sustainable expansion of nuclear energy while minimizing proliferation risks.

FUEL CYCLE STRATEGIES

The program will examine three fuel cycle strategies: **once-through fuel cycle**, **modified open fuel cycle**, and **full recycle fuel cycle**. 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. For each fuel cycle strategy, the Fuel Cycle R&D program has objectives to pursue in fulfilling its mission.



Once-Through Fuel Cycle Strategy —

Nuclear fuel makes a single pass through a reactor, after which the used fuel is removed, stored for some period of time, and then directly disposed in a geologic repository for long-term isolation from the environment. The objectives in this strategy are to develop fuels for use in reactors that would increase the efficient use of uranium resources and reduce the amount of used fuel for direct disposal for each megawatt-hour of electricity produced.

Modified Open Fuel Cycle Strategy —

Limited separations and fuel processing technologies are applied to the used light water reactor fuel to create fuels that enable the extraction of much more energy from the same mass of material and accomplish waste management goals. The objectives in this strategy are to investigate fuel forms, reactors, and fuel/waste management approaches that would dramatically increase utilization of fuel resources and reduce the quantity of long-lived radiotoxic elements in the used fuel to be disposed. Technologies will be considered that require at most limited separation steps and minimize proliferation risks.

Full Recycle Fuel Cycle Strategy —

All of the long-lived, radiotoxic chemical elements important for waste management are recycled in thermal- or fast-spectrum systems to reduce the radiotoxicity of the waste placed in a geologic repository while more fully utilizing uranium resources. In a full recycle system, only those elements that are considered to be waste (primarily the fission

Program Budget

Fuel Cycle R&D Program
($ in Millions)

FY 2010 Actual	FY 2011 Request
$136.0	$201.0

products) would be disposed, not used fuel. The objectives in this strategy are to develop techniques that will enable long-lived, radiotoxic chemical elements to be repeatedly recycled. The ultimate goal is to develop a cost-effective and low-proliferation-risk approach that would dramatically decrease the long-term challenges posed by the waste and reduce uncertainties associated with its disposal.

NEW AREAS OF FOCUS

The modified open fuel cycle constitutes a range of technology options in between once-through fuel cycle and full recycle fuel cycle and could be an important part of achieving a sustainable fuel cycle. The full recycle fuel cycle has been the focus of the Fuel Cycle R&D program to date and the once-through fuel cycle is the current practice in the United States. The modified open fuel cycle has not been studied in any depth and that is why it is being introduced as a new focus area for FY 2011.

The Used Nuclear Fuel Disposition technical area is being expanded in order to conduct more R&D for storage, transportation, and disposal options for used nuclear fuel and high-level waste. These activities are consistent with NE responsibilities under the Nuclear Waste Policy Act associated with nuclear waste management.

CONTRIBUTING TO THE SECRETARY'S ENERGY GOAL

The Fuel Cycle R&D program contributes to the Secretary of Energy's goal of *Energy: Build a Competitive, Low-Carbon Economy and Secure America's Energy Future*. The program is designed to develop advanced fuel cycle technologies that will help enable the deployment of nuclear power. The program will help create a safe and sustainable path forward for the expansion of nuclear power and help to optimize the nuclear fuel cycle. Developing these advanced technologies decreases the fuel cycle risks associated with constructing and operating nuclear power plants, increasing the likelihood that new nuclear power plants will be deployed, thus contributing to greenhouse gas abatement efforts.

A SCIENCE-BASED R&D PROGRAM

The Fuel Cycle R&D program is an integrated program to research, develop, and improve fuel cycle waste management options and transformational technologies. It involves small-scale experiments coupled with theory development and advanced modeling and simulation with validation experiments. This science-based R&D program will provide a more complete understanding of the underlying science supporting the development of advanced fuel cycle technologies and waste management options and, therefore, help provide a sound basis for future decision-making. The program will also identify alternatives and conduct scientific research and technology development to enable storage, transportation, and disposal of used nuclear fuel and all radioactive wastes generated by existing and future nuclear fuel cycles.

A WELL-MANAGED, SCIENTIFIC COLLABORATION

DOE's NE programs allocate R&D funding to those entities (*e.g.*, national laboratories, universities, and industry) that are best qualified to carry out 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; therefore, a majority of NE activities are carried out here.

Consistent with NE's commitment to supporting R&D activities at university and educational research institutions, NE designates up to 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 towards advanced fuel cycles that are economic, minimize waste, and reduce proliferation risk.

At Argonne National Laboratory, research in electrorefining of nuclear fuel is being tested to reduce the amount of high-level waste requiring long-term storage.

PLANNED PROGRAM ACCOMPLISHMENTS

FY 2010

- Initiate a series of fundamental measurements to serve as a basis for expanding the understanding of actinide separations science.
- Begin to develop advanced safeguards instrumentation for materials accountability measurements with increased accuracy and reliability for future separations facilities.
- Initiate the use of advanced experimental techniques and modeling tools to design novel fuel forms with significantly improved performance.
- Continue R&D on advanced alloy and composite cladding materials to support the improved performance goals of advanced fuels.
- Continue R&D activities on high precision measurements of nuclear data, sensitivity analyses to reduce uncertainty, and development of advanced measurement techniques.
- Initiate development of a system capable of capturing and managing all types of fuel cycle R&D knowledge.
- Conduct system studies for a range of possible fuel cycles and geologic repository environments in order to specify technical requirements for each key step of the fuel cycle to achieve a "near-zero" loss cycle.

FY 2011

- Continue to develop advanced concepts for electrochemical processing to recycle salt for waste minimization, advanced methods for transuranic recovery, and novel product consolidation methods.
- Continue to 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, options to declad and reclad used fuel to allow volatile and gaseous fission products to be removed and captured before recycling.