Advanced Fuel Cycle Initiative

Office of Nuclear Energy, Science and Technology
U. S. Department of Energy

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Background

The May 2001 *National Energy Policy* (NEP) recommended that the United States "develop reprocessing and fuel treatment technologies that are cleaner, more efficient, less waste-intensive, and more proliferation-resistant." These technologies are key components of advanced nuclear fuel cycles that will be needed for next-generation nuclear energy systems. DOE's *Generation IV Technology Roadmap* has identified six advanced reactor designs that offer the promise of commercial deployment after 2010 and before 2030. Several of these designs are among those that will use fuel cycles significantly different from those used by existing U.S. reactors.

These same advanced fuel cycle technologies also have potential application for supporting the Nation's current generation of operating nuclear plants. In 2002, Congress voted to proceed with development of a geologic repository at Yucca Mountain, Nevada. Yucca Mountain has a statutory limit of 63,000 metric tonnes of commercial spent nuclear fuel. Since the amount of accumulated spent nuclear fuel from current reactors is expected to reach that limit by 2015, disposing of spent fuel beyond that limit will require additional repository capacity. Recycling, fuel treatment, and conditioning technologies, including transmutation, have the potential to dramatically reduce the quantity and toxicity of waste requiring geologic disposal. These technologies are not alternatives to a geologic repository but could help reduce the cost and optimize the use of a geologic repository as envisioned in the NEP.

Mission

The mission of the Advanced Fuel Cycle Initiative (AFCI) is to develop proliferation-resistant spent nuclear fuel treatment and transmutation technologies in order to enable a transition from the current once-through nuclear fuel cycle to a future sustainable, closed nuclear fuel cycle. The primary goals of the AFCI program are to:

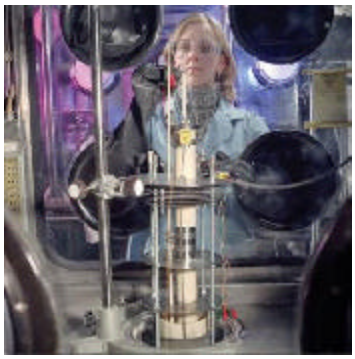
- Develop technologies that will reduce the cost of geologic disposal of high-level waste from spent nuclear fuel, enhancing the repository performance.
- Develop reactor fuel and fuel cycle technologies to support Generation IV nuclear energy systems.

By achieving these goals, the potential is created to significantly delay the need for a second geologic repository and dramatically reduce the inventories of civilian plutonium in the United States while at the same time using the energy value in spent nuclear fuel. The AFCI program seeks in the near-term to develop technical information to inform a Secretarial recommendation in the 2007-2010 timeframe on the need for a second repository.

Research and Development

The AFCI research and development (R&D) program is an integrated research effort aimed at addressing both intermediate-term and long-term issues.

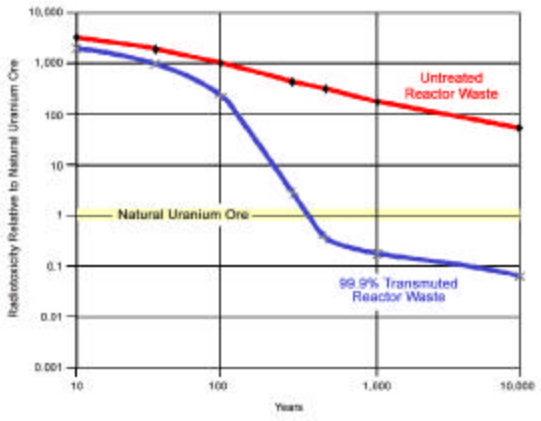
The **intermediate-term** issues associated with spent nuclear fuel, primarily the reduction of the volume and heat generation of material requiring geologic disposal, will be addressed using advanced separations technologies and proliferation-resistant recycle fuels in existing and advanced light water reactors, and possibly gas-cooled reactors if deployed in the near future.



Glovebox operations demonstrating electro-chemical process selected for reducing spent fuel oxides to metals

Nitride fuel pellets for AFCI actinide-bearing fuel tests at ATR

A **longer-term** effort will develop fuel cycle technologies to destroy minor actinides in fast neutron spectrum systems, greatly reducing the long-term radiotoxicity and heat load of high-level waste sent to a geologic repository. This will be accomplished through the development of a transmutation fuel cycle using Generation IV fast reactors.



With transmutation, used fuel reaches the toxicity of the source uranium ore within a few centuries

Implementation of AFCI technologies is expected to significantly delay or eliminate the need for additional repositories and provide an effective transition from the current once-through nuclear fuel cycle to a sustainable advanced fuel cycle.

AFCI is closely coupled with the Generation IV Nuclear Energy Systems Initiative, which seeks to deploy a new generation of nuclear power plants by 2030. Together, these two programs enable an expanded role for nuclear power as a carbon-free, sustainable energy resource that will address long-term U.S. energy security, environmental, and economic concerns.

FY 2003 Accomplishments

- Initiated high burnup testing of metallic transmutation fuels.
- Fabricated nitride transmutation fuel.
- Initiated 1,000-hour test of Lead-Bismuth Loop which includes the use of a university developed oxygen sensor.
- Completed development of advanced fuel separations baseline flow sheet.
- Completed preliminary quantification of repository benefits derived from separation and transmutation of spent fuel.

FY 2004 Planned Accomplishments

- Complete high-burnup irradiation testing of oxide and nitride transmutation fuels.
- Complete laboratory-scale separation of americium/curium from spent nuclear fuel.
- Complete measurement and analysis of cross-sections for the production of helium and hydrogen.
- Complete 1,000-hour test of Lead-Bismuth Loop.

FY 2005 Planned Accomplishments

- Complete laboratory-scale testing of the UREX+ advanced separations process, successfully separating plutonium/neptunium at a purity of 99.9 percent or higher.
- Complete the first irradiation experiment to test the integrity of oxide fuel containing 5 percent plutonium.
- Submit a Report to Congress identifying advanced recycle technologies and associated capacities and time scales.

Program Budget
AFCI
($ in Millions)

FY 2003 Adjusted Approp.	FY 2004 Adjusted Approp.	FY 2005 Request
$ 57.3	$ 66.7	$ 46.3