Advanced Nuclear Fuel Cycle

Challenge

Nuclear energy is a key technology of choice to meet expanding world energy needs. Future nuclear energy systems should meet five key criteria:

- Reduce the volume and toxicity of nuclear waste,
- Ensure that nuclear materials are unsuitable for direct use in weapons,
- Be passively safe by virtue of characteristics inherent in systems design and materials,
- Provide a long-term energy source not limited by resources, and
- Be economically competitive with other energy sources.

The first two criteria can be addressed promptly by

- Developing a technology-based solution to dispose of spent fuel and other high-level waste and
- Improving international control of weapons-capable materials.

Argonne's Answer

The most promising large-scale electricity-production system capable of meeting all five criteria is a fast-reactor system with a closed-fuel cycle based on pyroprocessing. The pyroprocessing technology developed and demonstrated at Argonne is a key innovation in this area.

Pyroprocessing (Figure 1) is significantly different from conventional aqueous reprocessing technologies deployed overseas and offers revolutionary improvements in waste management, proliferation resistance, and economic potential. With the addition of an oxide-to-metal conversion step, the process can be adapted to treat commercial spent fuel. With this technology, actinides can be recovered from spent fuel and recycled into a fast reactor for *in-situ* destruction, all the while generating energy. Waste is predominantly short-lived fission products, thus simplifying geologic storage. Pyroprocessing, though it does not obviate the need for

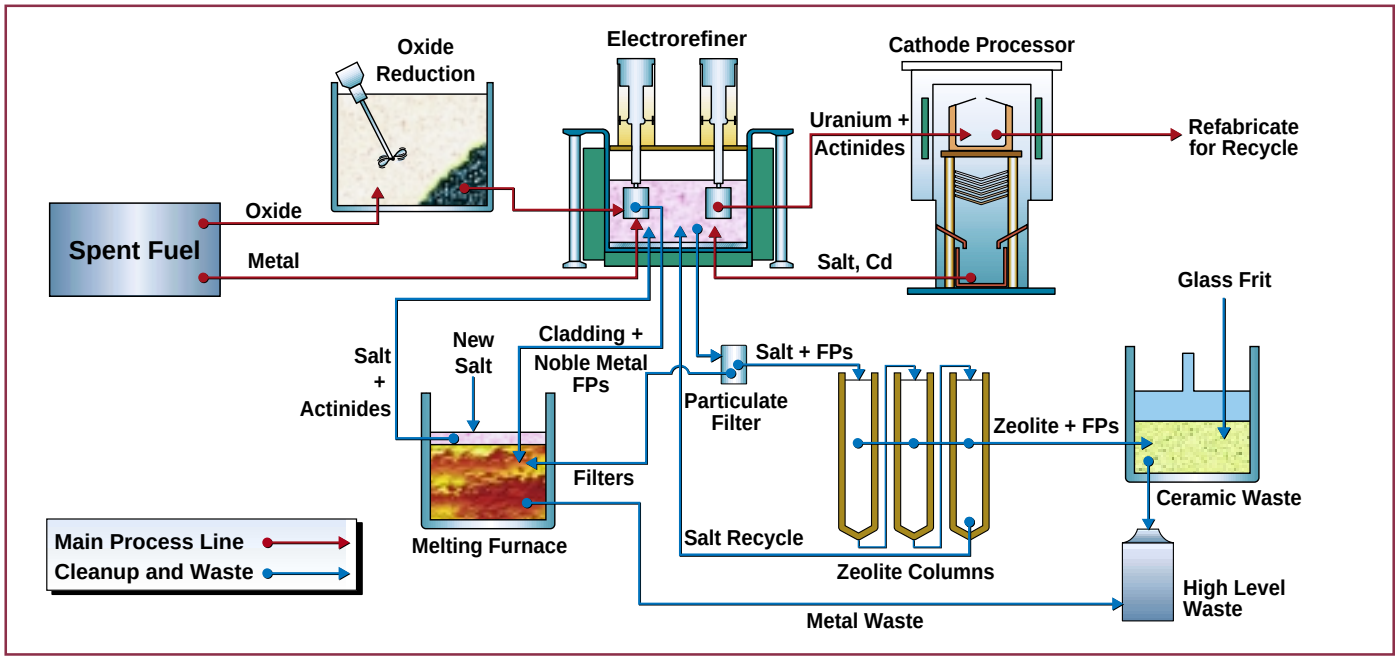

Figure 1. The pyroprocess is the basis for a proliferation-resistant, safeguards-transparent, closed-fuel cycle that can significantly reduce the need for a second Yucca Mountain.

the Yucca Mountain repository, will allow the technical performance requirements to be met more easily and reduce the burden of long-term stewardship.

The pyroprocess cannot be used to separate pure plutonium for use in nuclear weapons. Its product is a mixture of uranium, plutonium, other actinides, and fission products that is highly radioactive and therefore self-protecting. Pyroprocessing can be employed on-site, thus largely eliminating the need to transport spent fuel.

A properly designed fast reactor has inherent passive safety. Two landmark tests conducted by Argonne at Experimental Breeder Reactor II (EBR-II) demonstrated that even the most severe accidents do not damage the reactor or release radioactive material.

The fast reactor with a pyroprocessing-based fuel cycle can provide a vast improvement in energy efficiency. By recycling spent fuel, such a fast reactor system can deliver 100 times more energy from available uranium resources than today's reactors — without harmful greenhouse gas emissions — thereby assuring a sustainable long-term energy source.

Development Program

Argonne's Advanced Nuclear Fuel Cycle Development Initiative has four components:

1. Development and demonstration of processes for oxide fuel reduction and for recovering plutonium and minor actinides for recycling into fast reactor fuel.
2. Demonstration of transmutation of actinides in a fast reactor, including fabrication of fuel-containing actinides and irradiation of the fuel in a fast reactor.
3. Design, construction, licensing, and operation of a prototype spent-fuel pyroprocessing facility.
4. Design of a prototype fast reactor.

Development and demonstration of oxide fuel reduction, actinide recovery, and fuel fabrication can be accomplished using existing facilities at Argonne-West (Figure 2). Because there is no operating fast reactor in the United States, irradiation of the fuel will require international cooperation.

Figure 2. A full pyroprocessing demonstration can be accomplished using Argonne-West facilities.

The Next Step

The Advanced Nuclear Fuel Cycle Development Initiative will focus on the pyroprocessing and fuel fabrication demonstration at Argonne-West. The Argonne-West demonstration could be followed by a commercial-scale demonstration project. This facility would provide an integrated demonstration of the waste management, proliferation resistance, and economics of the pyroprocess on a commercial scale.

Sponsor

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

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