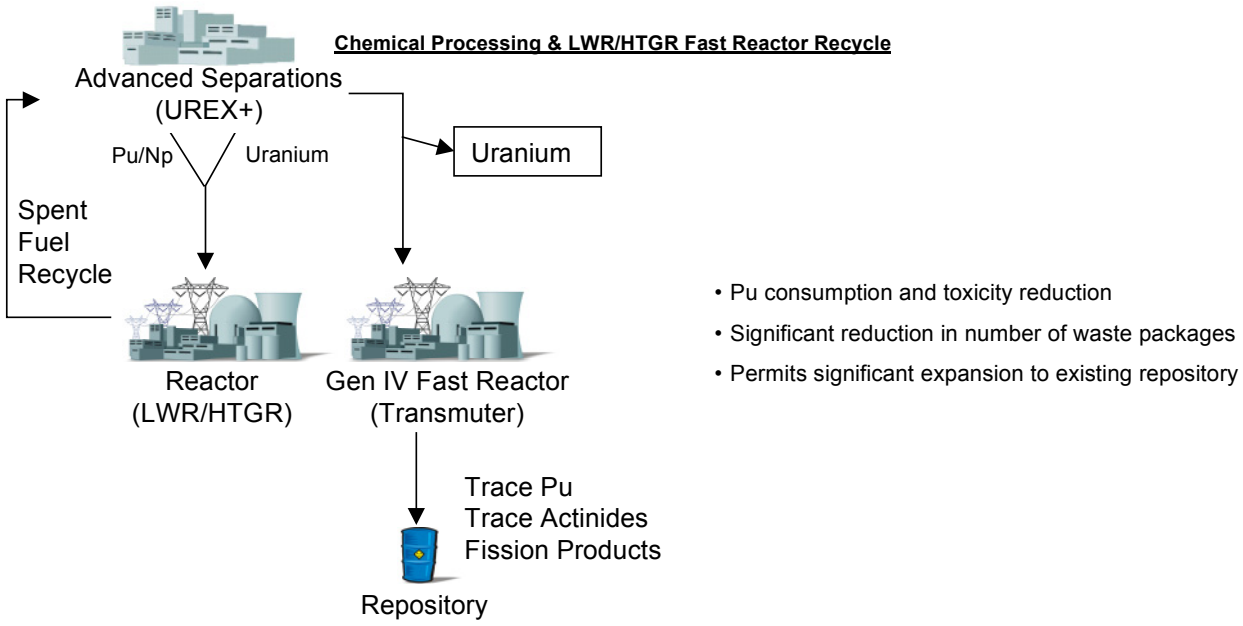
2.4.4 ADVANCED NUCLEAR FUEL CYCLE PROCESSES

Technology Description



Electricity from nuclear power generates no greenhouse gas emissions. To the extent that deployment of advanced nuclear fuel cycle processes can contribute to the success of next-generation fission systems, nuclear power can continue to be an important part of a greenhouse gas emissions-free energy portfolio. Current nuclear fission reactors operate in the United States with once-through fuel cycles and produce significant quantities of used or "spent" nuclear fuel. Several current designs for future fission reactors also rely on once-through fuel cycles. The planned disposal of spent nuclear fuel is in geologic repositories, and the accumulation of spent nuclear fuel raises public concerns about radiotoxicity, dose, and proliferation risk. Once-through fuel cycle technology also does not make optimal use of natural uranium resources. DOE activities under the Advanced Fuel Cycle Initiative aim at developing the technologies needed to dramatically reduce the waste stream from nuclear fission, thus lowering the potential environmental consequences, reducing the cost of geologic disposal, reducing the technical need for a second repository, and making better use of natural resources. These activities include transmutation research, in which the actinides and selected fission products in spent nuclear fuel are separated, stored, and potentially formed into fuels that can be bombarded by neutrons in reactors or accelerator driven systems, causing them to fission or transmute into shorter-lived or stable elements/isotopes. In the long term, these technologies may be assembled into advanced Generation IV nuclear systems that could result in decreased amounts of waste, while generating substantial amounts of energy.

System Concepts

- Advanced nuclear systems (fission reactors and accelerator-driven systems) that aim to reduce the lifetime of the waste from current-generation fission reactors to short times.
- Advanced nuclear systems that aim to extract the full energy potential of the spent nuclear fuel from current fission reactors, while reducing or eliminating the potential for proliferation of nuclear materials and technologies, and reducing the amount of waste produced.

Representative Technologies

- Spent-fuel treatment technologies that are proliferation resistant.
- Advanced fuel types for waste transmutation.
- Advanced fuel types for sustained nuclear energy.
- Accelerator-driven systems for rapid waste transmutation.
- Advanced reactors for sustained nuclear energy.

Technology Status/Applications

- Advanced fuel-cycle development has reached the laboratory scale-demonstration stage in some cases.
- Transmutation fuels are in early R&D stages.
- Development of accelerator-driven systems is at the preliminary R&D stage.

Current Research, Development, and Demonstration

RD&D Goals

- Prove design principles of spent-fuel treatment and transmutation technologies.
- Demonstrate the fuel and separation technologies for waste transmutation.
- Deploy Generation IV advanced fast spectrum reactors that can transmute nuclear waste.

RD&D Challenges

- Demonstrate performance of advanced fuel cycles.
- Demonstrate performance of advanced transmutation fuels.
- Demonstrate technology for advanced fission reactor concepts.
- Demonstrate feasibility and technology for accelerator-driven systems.

RD&D Activities

- Continued development and demonstration of aqueous and electrometallurgical spent-fuel treatment technologies.
- Development of transmutation fuels for Generation IV reactor systems.
- Development of technologies for accelerator-driven systems.

Recent Progress

- Hot demonstration of the UREX (Uranium Extraction) aqueous spent fuel treatment process.

Commercialization and Deployment Activities

- Disposal of spent nuclear fuel is a government activity in the United States. Similar spent-fuel treatment and transmutation technology development programs exist in France, Japan, and the United States. Development of treatment and transmutation technologies for use with advanced Generation IV fuel cycles will increase the acceptability of nuclear energy.
- Advanced Fuel Cycle Initiative has the potential to decrease the quantity and toxicity of nuclear waste, possibly eliminating the need for a second geologic repository.

Market Context

- Technologies to improve spent-fuel disposition increase the value of keeping existing nuclear power plants online as well as increase the likelihood for expanded new nuclear power capacity.