2.4.2 NEXT-GENERATION FISSION ENERGY SYSTEMS

Technology Description

Electricity from nuclear power generates no greenhouse gas emissions. To the extent that next-generation nuclear fission energy systems can address prevailing concerns, nuclear power can continue to be an important part of a greenhouse gas emissions-free energy portfolio. Although evolutionary light water reactors of standardized design are now available – and have received Nuclear Regulatory Commission design certification and been constructed on schedule in Japan and South Korea – newer nuclear energy systems in the long term need to offer significant advances in the areas of sustainability, proliferation resistance and physical protection, safety, and economics. These newer nuclear energy systems are required to replace or add to existing light water reactor capacity and can be available starting in 2015.

To develop these next-generation systems, DOE has initiated the Generation IV Nuclear Energy Systems Initiative. Generation IV is an international effort, with participation by Argentina, Brazil, Canada, France, Japan, Republic of Korea, Republic of South Africa, Switzerland, the United Kingdom, and the United States. The *Generation IV Nuclear Energy Systems Technology Roadmap* was completed in December 2002. The completed roadmap has identified the six most promising fission energy systems for potential further development. In FY 2003, DOE and its international partners initiated preconceptual design studies, fuel and materials development, and energy conversion development on promising systems of interest, which will lead to demonstration and eventual deployment (with industry and international participation) of one or more systems.

System Concepts

- Advanced fission reactors and fuel cycles that will reduce the potential for proliferation of nuclear materials, provide economical electricity generation, and contribute to hydrogen generation, with minimal waste products.

Representative Technologies

- Gas-Cooled Fast Reactor (GFR).
- Lead-Cooled Fast Reactor (LFR).
- Molten Salt Reactor (MSR).
- Sodium-Cooled Fast Reactor (SFR).
- Supercritical-Water-Cooled Reactor (SCWR).
- Very-High-Temperature Reactor (VHTR).

Technology Status/Applications

- Advanced fission reactors and fuel cycles: development is at advanced stage; demonstration is incomplete.
- High-temperature gas-cooled reactor development is focused on high-conversion efficiency through direct use of the high-temperature gaseous reactor coolant to power a gas turbine driving a generator (i.e., direct conversion), also capable of high-efficiency hydrogen production through electrolysis or chemical processes.
- Liquid metal-cooled reactors (both sodium and lead) have been successfully operated worldwide. Safety performance has been demonstrated, but economic performance needs improvement.
- Technologies for advanced fuel recycle and remote fuel refabrication have been developed in the laboratory, and some elements have advanced to pilot scale.
- Nuclear-assisted hydrogen production by means of thermochemical cracking of water is at the preconceptual design stage, requiring extensive development.
- Other advanced fission systems are at a preconceptual stage, requiring extensive development and irradiation testing of new fuel forms and high-temperature materials.
- Direct-cycle turbine technology requires development and demonstration.

Current Research, Development, and Demonstration
RD&D Goals
• Generation IV research is focusing on reactors and fuel cycles that are safer, more economically competitive, more resistant to proliferation, produce less waste, and make better use of the energy content in uranium.
RD&D Challenges
• Demonstrate technology for advanced concepts. • Develop proliferation-resistant fuel-cycle concepts. • Develop safety, waste, and proliferation aspects of advanced fission reactors. • Conduct comprehensive R&D on advanced fission reactor concepts, relying heavily on international collaboration.
RD&D Activities
• Federally funded development of advanced reactors and fuel cycles has been resumed in the United States, through the Nuclear Energy Research Initiative, the Generation IV Nuclear Energy Systems Initiative, and the Advanced Fuel Cycle Initiative. • Advanced used fuel treatment technologies are under development through the Advanced Fuel Cycle Initiative.
Recent Progress
• Advanced light water reactors have received design certification from the Nuclear Regulatory Commission. • An advanced boiling water reactor, which was built in less than five years, is operating in Japan.
Commercialization and Deployment Activities
• Generation IV Nuclear Energy Systems are projected to be ready for commercial deployment in the timeframe of 2015 to 2030.
Market Context
• Indeterminate at this time. Potentially large international and domestic markets.