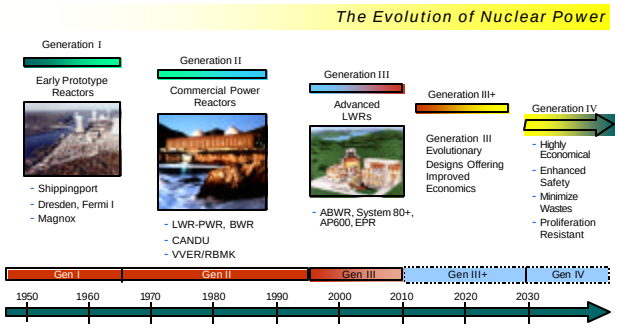
Generation IV Nuclear Energy Systems Initiative

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

February 2005

What is Generation IV?

Today there are 441 nuclear power reactors in operation in 31 countries around the world. Generating electricity for nearly 1 billion people, they account for approximately 17 percent of worldwide electricity generation and provide half or more of the electricity in a number of industrialized countries. Another 32 are presently under construction overseas. Nuclear power has an excellent operating record and generates electricity in a reliable, environmentally safe, and affordable manner without emitting noxious gases into the atmosphere.



Concerns over energy resource availability, climate change, air quality, and energy security suggest an important role for nuclear power in future energy supplies. While the current Generation II and III nuclear power plant designs provide an economically and publicly acceptable electricity supply in many markets, further advances in nuclear energy system design can broaden the opportunities for the use of nuclear energy. To explore these opportunities, the U.S. Department of Energy's Office of Nuclear Energy, Science and Technology has engaged governments, industry, and the research community worldwide in a wide-ranging discussion on the development of next-generation nuclear energy systems known as **"**Generation IV**"**.

Generation IV International Forum (GIF)

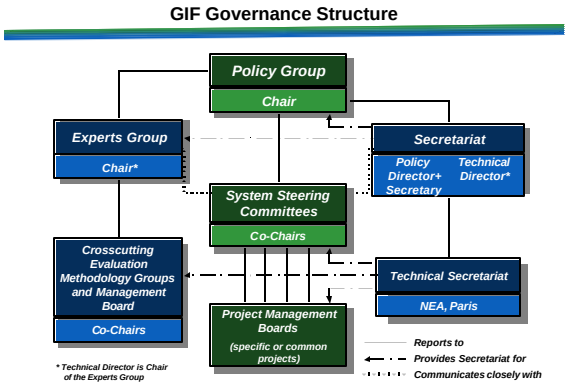
The objective of the U.S. Generation IV Nuclear Energy Systems Initiative is to develop and demonstrate advanced nuclear energy systems that meet future needs for safe, sustainable, environmentally responsible, economical, proliferation-resistant and physically secure energy. Under U.S. DOE leadership, this initiative has led a group of ten countries (Argentina, Brazil, Canada, France, Japan, the Republic of Korea, the Republic of South Africa, Switzerland, the United Kingdom, and the United States) and Euratom to jointly plan the fulfillment of this objective. In 2002, the Generation IV International Forum (GIF) was chartered, establishing a Policy Group as the highest policy-making organ, an Experts Group as the technical advisory organ, and a Secretariat to administer and coordinate GIF activities. In

Technology Goals

Generation IV nuclear energy systems will:

- Provide sustainable energy generation that meets clean air objectives and promotes long-term availability of systems and effective fuel utilization for worldwide energy production.
- Minimize and manage their nuclear waste and notably reduce the long term stewardship burden in the future, thereby improving protection for the public health and the environment.
- Increase the assurance that they are a very unattractive and least desirable route for diversion or theft of weapons-usable materials.
- Excel in safety and reliability.
- Have a very low likelihood and degree of reactor core damage.
- Eliminate the need for offsite emergency response.
- Have a clear life-cycle cost advantage over other energy sources.
- Have a level of financial risk comparable to other energy projects.

2003, the GIF, together with the Department's Nuclear Energy Research Advisory Committee, issued *A Technology Roadmap for Generation IV Nuclear Energy Systems*. Based on the *Roadmap*, GIF countries are jointly preparing



collaborative R&D programs to develop and demonstrate candidate concepts.

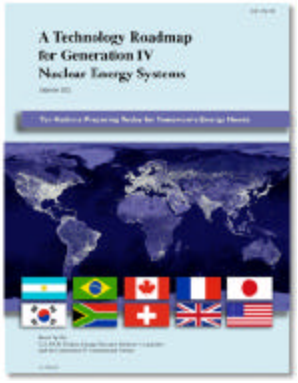
Generation IV Technology Roadmap

A Technology Roadmap for Generation IV Nuclear Energy Systems documents a comprehensive evaluation of nuclear energy concepts and selects the most promising ones as candidates for next-generation nuclear energy system concepts. For these concepts, detailed R&D plans were developed for establishing technical and commercial viability, demonstration and, potentially, commercialization. More than 100 experts from twelve countries and international organizations collaborated to complete the *Roadmap* over a period of two years. The *Roadmap* was submitted to Congress, followed by the *U.S. Generation IV*

Implementation Strategy, which provides the strategy for implementing the Generation IV program in the United States.

International Collaboration on Generation IV Systems

The Department seeks to leverage its research investments in Generation IV concepts with research funding from interested members of the GIF. In FY 2004, the GIF countries, including the United States, began formulating joint R&D plans based on the *Roadmap*. The GIF countries began the formulation of multilateral agreements to enable the planned R&D collaboration and established a governance structure involving System Steering Committees and Project Management Boards. The United States is currently working closely with France, Japan, Korea, South Africa, and the United Kingdom through the GIF to establish a multinational research program to develop the technologies needed to support the design and construction of next-generation, very-high-temperature, gas-cooled reactors. In the meantime, R&D was initiated on several Generation IV reactor concepts under existing bilateral I-NERI agreements. These concepts include the Gas-Cooled and Lead-Cooled Fast Reactor Systems, the Supercritical-Water-Cooled Reactor, and the Very-High-Temperature Reactor (VHTR).



http://gen-iv.ne.doe.gov

U.S. Generation IV Priorities

While the Department is supporting research on several reactor concepts, priority is being given to the VHTR, a system compatible with advanced hydrogen and electricity generation capabilities. The emphasis on VHTR reflects its potential for economically and safely producing electricity and hydrogen without emitting greenhouse gasses. FY 2005 VHTR activities will be focused primarily on research and development associated with fuels and structural materials for high-temperature, high-radiation service conditions and continuing concept design activities initiated in FY 2004.

Research and development for the other Generation IV systems will focus on establishing technical and economic viability, and the resulting core and fuel designs and materials requirements.

FY 2004 Accomplishments:

- Completed the independent technical review of VHTR technologies.
- Held public meetings on a proposed strategy for developing a nuclear hydrogen production capability.
- Developed high-temperature fuel particles and compacts including quality control approaches.
- Received approval of the mission need for demonstrating commercial nuclear hydrogen production technology.
- Completed plans for high-temperature materials irradiation testing.
- Completed the point design of a 20 Megawatt Lead-Cooled Fast Reactor with a 20-year core life.

FY 2005 Planned Accomplishments:

- Initiate university R&D activities directed toward Generation IV reactor development.
- Conduct comprehensive evaluation of VHTR technologies.
- Initiate VHTR materials testing.
- Demonstrate the fabrication of advanced Gas-Cooled Fast Reactor uranium nitride fuel.

FY 2006 Planned Accomplishments:

- Develop and issue a detailed VHTR research and development plan that identifies all outstanding technology data needs and associated schedules for meeting them.
- Initiate the irradiation of TRISO fuel in the new ATR multi-cell capsule and test train to provide shakedown test information.
- Complete the consolidation of existing phenomenological models into an integrated fuel performance model.
- Complete preliminary high-flux irradiations and initiate post-irradiation examination of potential metallic alloys for VHTR reactor internals
- Support the American Society for the Testing of Materials standard materials specification development of VHTR graphite.
- Develop models to predict the behavior of candidate VHTR pressure boundary materials and very-high-temperature component materials under expected operating conditions.
- Complete irradiation and post-irradiation examination of advanced inert matrix Gas-Cooled Fast Reactor fuel.

Program Budget
Generation IV
($ in Millions)

FY 2004 Adj. Approp.	FY 2005 Adj. Approp.	FY 2006 Request
$22.9	$34.8	$39.8