



Office of Nuclear Energy

Long-Term Sustainability of Nuclear Fission Energy – DOE's Programs

American Nuclear Society Annual Meeting

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Buzz Savage

Office of Nuclear Energy

U.S. Department of Energy





DOE's Nuclear Energy R&D Programs

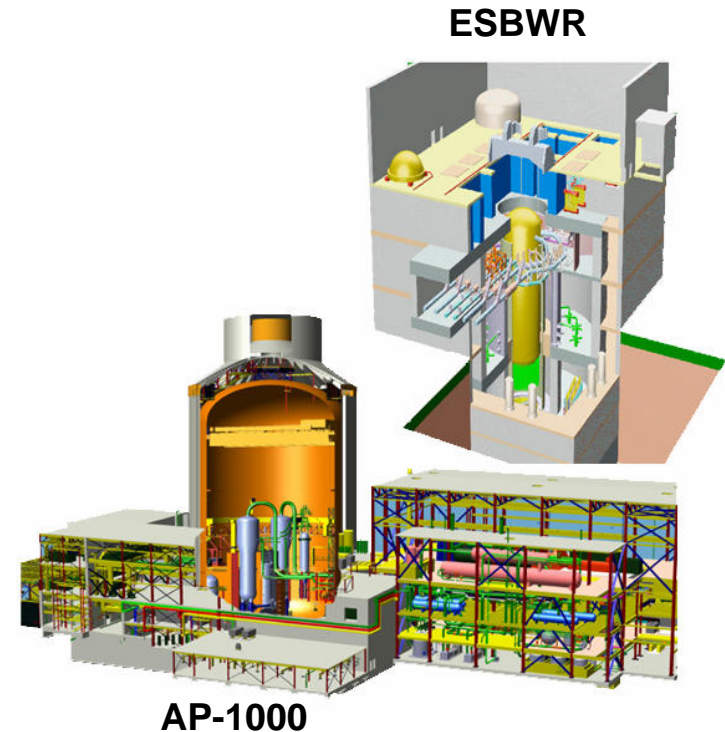
- ◆ **Nuclear Power 2010**
- ◆ **Generation IV Nuclear Energy Systems**
 - **Next Generation Nuclear Plant**
- ◆ **Nuclear Hydrogen Initiative**
- ◆ **University Programs**
- ◆ **Global Nuclear Energy Partnership**



Nuclear Power 2010

Working with Industry to Build New Nuclear Plants

- ◆ **Focused on addressing technical, regulatory and institutional challenges**
- ◆ **Government/industry cooperative effort**
 - 50-50 Cost-shared industry projects
 - Market-driven
 - Exploring sites for new nuclear plants
- ◆ **Demonstrating key untested regulatory processes**
 - Early Site Permit (ESP) – North Anna, Grand Gulf, Clinton
 - Combined Construction and Operating License (COL)
- ◆ **Developing new light water reactor designs**
 - Design Certification for new technologies
 - First-of-a-kind engineering for new standardized nuclear plant designs
- ◆ **Developing concepts to mitigate financing risks**



Program Goal

Pave the way for an industry decision to build at least one new advanced light water reactor nuclear plant in the United States that would begin operation within the next decade.



Nuclear Power 2010 - New Plant Licensing Demonstration Projects

- ◆ **Dominion Energy - COL for ESBWR at North Anna Site**
 - COL Application preparation and NRC review
 - ESBWR design certification and first-of-a-kind engineering for standard plant design
 - Site deployment planning: financial, legal, and risk assessment

- ◆ **NuStart Energy LLC (Nine power companies teamed with GE & Westinghouse) - COL for single site/technology yet to be selected**
 - Design certification and COL Application development for two reactor technologies: AP1000 – Certified: December 2005 (Bellefonte site) or ESBWR – Design Certification application to NRC: September 2005, expected to be issued January 2010 (Grand Gulf site)
 - Funding for one COL and completion of standard plant design for selected reactor technology





Latest Industry Outlook ... *New Plant Licensing*

- ◆ **Three industry teams currently are pursuing new nuclear plant deployment**
 - **Dominion – North Anna**
 - **NuStart – Bellefonte and Grand Gulf**
 - **UniStar (Constellation, AREVA, Bechtel Power) – Calvert Cliffs or Nine Mile Point**
- ◆ **Eight U.S. power companies have announced intentions to apply for COLs (Dominion, Entergy, Southern Company, Progress Energy, South Carolina Electric & Gas, Duke Power, Constellation and FP&L)**
- ◆ **Minimum of 13 new nuclear plants are identified for potential COL application**
- ◆ **The earliest construction date after COLs are granted is 2010.**
- ◆ **The earliest completion date of the first plant would be around 2014.**
- ◆ **Energy Policy Act of 2005 impact**



Generation IV Nuclear Energy Systems Initiative

Developing Next-Generation Technologies

Generation IV Technology Goals:

◆ Sustainability

- Provide sustainable energy generation and effective fuel utilization
- Minimize and manage nuclear waste and reduce long-term stewardship burden

◆ Economics

- Provide a clear life-cycle cost advantage over other energy sources
- Provide a level of financial risk comparable to other energy products

◆ Safety and Reliability

- Excel in safety and reliability
- Have a very low likelihood and degree of core damage
- Eliminate the need for offsite emergency response

◆ Proliferation Resistance and Physical Protection

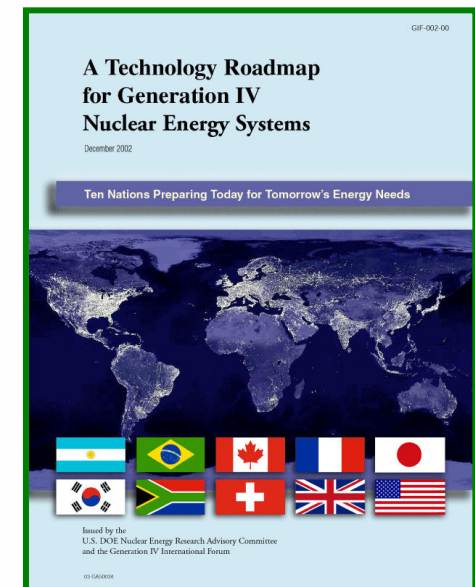
- Increase assurance of being very unattractive and least-desirable route for diversion or theft of materials and increase physical protection against terrorism



Generation IV Nuclear Energy Systems Initiative

Developing Next-Generation Technologies

- ◆ **Six candidate Generation IV systems selected by the U.S. led Generation IV International Forum and the U.S. Department of Energy's Nuclear Energy Research Advisory Committee for further development:**
 - Gas-cooled Fast Reactor (GFR)
 - Lead-cooled Fast Reactor (LFR)
 - Sodium-cooled Fast Reactor (SFR)
 - Molten Salt Reactor (MSR)
 - Supercritical Water-cooled Reactor (SCWR)
 - Very High Temperature Reactor (VHTR)
- ◆ **Roadmap identifies R&D needs for all six systems**
- ◆ **Crosscutting R&D needs**
 - Fuels, materials, energy conversion, design and evaluation methods



<http://nuclear.gov/nerac/FinalRoadmapforNERACReview.pdf>



Generation IV International Forum

U.S. Participation



- ◆ **U.S. Gen IV program deeply engaged in international collaboration activities:**
 - Bilateral projects with Brazil, Canada, Euratom, France, Japan, Korea (I-NERI)
 - GIF R&D planning activities:
 - System Research Plans
 - Project Plans
 - GIF governance activities:
 - GIF Policy and Expert Groups
 - GIF Secretariat
 - GIF Evaluation Working Groups (PR&PP, Economics, Safety)
- ◆ **U.S. became member of INPRO (IAEA) in December 2005**

Jul '01	GIF Charter
Feb '05	<u>GIF Framework Agreement</u>
	<u>GIF System Arrangement</u> System Steering Committee System Research Plan
Feb '06 Next:	SFR System Arrangement VHTR System Arrangement
	<u>GIF Project Arrangement</u> Project Management Board Project Plan
Ongoing:	SFR Advanced Fuels VHTR Materials and Components VHTR Hydrogen Production



Energy Policy Act of 2005 – Impact on U.S. Generation IV Program

- ◆ **Authorizes Next Generation Nuclear Plant (NGNP) project and associated funding**
- ◆ **Establishes 2 project phases**
 - Phase I (present -2011): R&D
 - Phase II (2011-2021): Design and construction
- ◆ **Names Idaho National Laboratory (INL) as the site of construction**
- ◆ **Charges INL with responsibility for integrating the project R&D and procurements**
- ◆ **Directs DOE to undergo periodic review**
- ◆ **Requires a licensing strategy be developed with NRC**



Nuclear Hydrogen Initiative

Nuclear Power for Transportation

- ◆ Important piece of the President's *National Hydrogen Fuel Initiative* production portfolio, and included in the Energy Policy Act of 2005
- ◆ Developing hydrogen production processes for use with advanced nuclear energy technologies that can provide large amounts of hydrogen for a "hydrogen economy"
- ◆ Program Goal: By 2019, operate nuclear hydrogen production plant to produce hydrogen at a cost competitive with other alternative transportation fuels



The energy from one pound of nuclear fuel could provide the hydrogen equivalent of 250,000 gallons of gasoline without any carbon emissions.



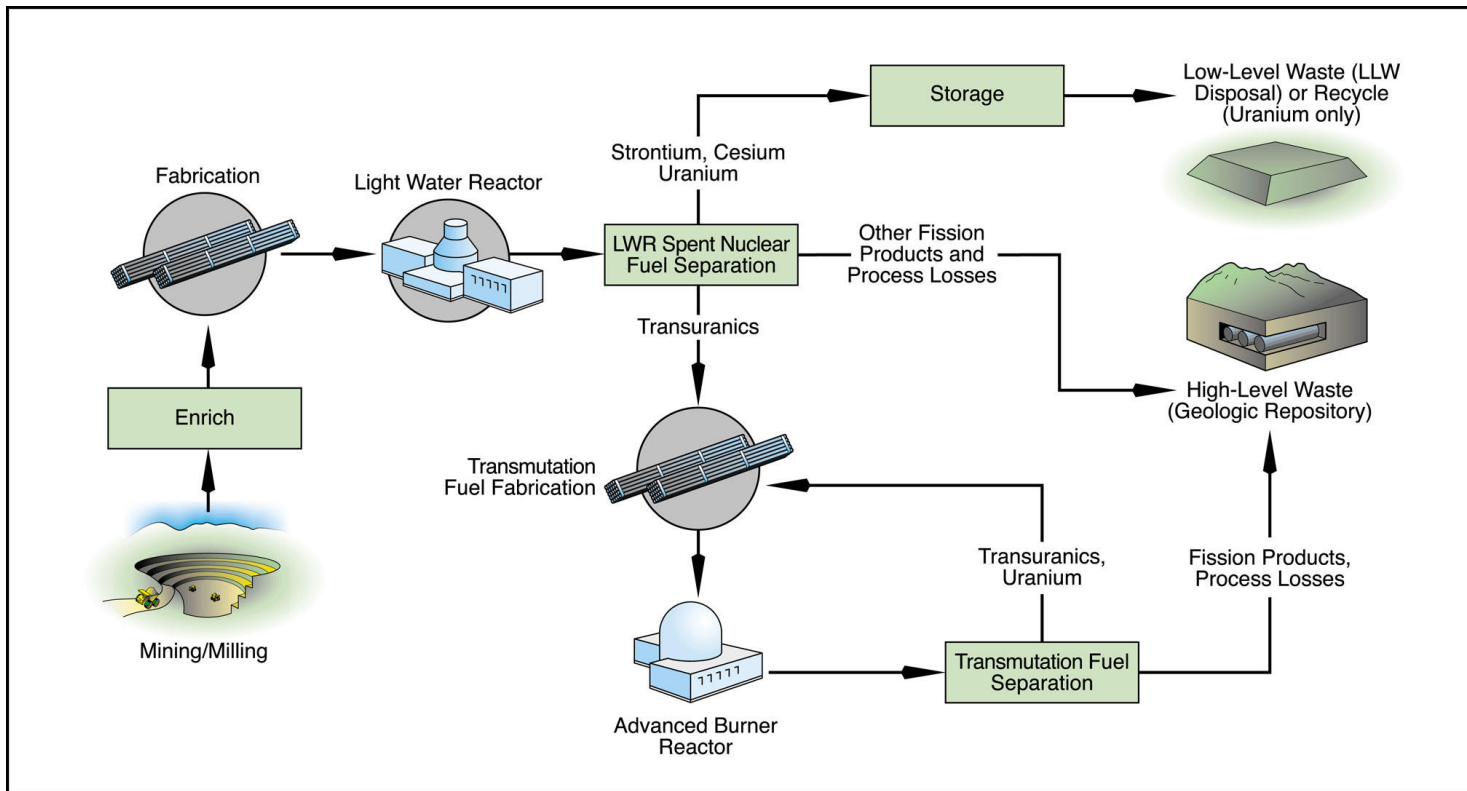
Global Nuclear Energy Partnership (GNEP)

- ◆ **The Global Nuclear Energy Partnership (GNEP) is a key element of the Advanced Energy Initiative announced by President Bush in his January 31, 2006 State of the Union Address**
- ◆ **GNEP is linked to the Advanced Energy Initiative and spent fuel recycling objectives of the Energy Policy Act of 2005:**
 - **Expand the use of safe, clean nuclear power to meet increasing global energy demand**
 - Nuclear Power 2010 Program
 - Demonstrate small, exportable reactors
 - Establish reliable fuel services
 - **Address the nuclear waste management concerns**
 - Volume, heat load, and radiotoxicity
 - **Promote non-proliferation**
 - Proliferation resistant fuel cycle technologies
 - Concept of fuel cycle nations and reactor nations





Initial GNEP U.S. Deployment System Architecture





GNEP Major System Projects

- ◆ **GNEP implementation requires three Major System technology demonstration projects (capabilities):**
 - LWR Spent fuel separations that provide a proliferation-resistant fuel feed material (Engineering Scale Demonstration, ESD)
 - Transmutation of the transuranic-bearing fuel in an advanced test reactor that will reduce the long-term heat load and radiotoxicity of the resultant spent fuel while generating power (Advanced Burner Test Reactor, ABTR)
 - Fabrication of the separated spent fuel material into proliferation-resistant fuels for use in fast burner reactors, recycling of that fuel (Advanced Fuel Cycle Facility, AFCF)

- ◆ **Other capabilities:**
 - Demonstration of advanced instrumentation and monitoring systems to enhance proliferation-resistance
 - Continued long-term research and development to provide alternatives to improve the fuel cycle
 - Industry and International engagement necessary

- ◆ **The Department is planning to design, construct and operate these demonstration facilities in the next 10-15 years**



Global Nuclear Energy Partnership Activities

- ◆ **Since GNEP was announced on February 6, 2006 by Secretary Bodman with the FY 2007 budget request rollout, the following activities have been initiated:**
 - **On March 17, 2006 DOE issued a request for Expressions of Interest with regards to siting integrated spent fuel recycling facilities for GNEP technology demonstrations. 43 responses were received which are currently under review**
 - **On March 22 an Advanced Notice of Intent was issued for the GNEP Technology Demonstration Program covering the three planned demonstration projects –**
 - **On March 28 Deputy Secretary Clay Sell approved initiation of conceptual design activities for the three demonstration projects**
- ◆ **June 2006: DOE intends to issue a solicitation for detailed site proposals for integrated spent fuel recycling facilities. Up to \$20 million in awards, each no more than \$5 million, will be made**
- ◆ **May 2008: Complete conceptual design of demonstration projects; Issue the Final EIS for the GNEP Technology Demonstration Program**
- ◆ **June 2008: Issue the Record of Decision in which the Secretary will determine the path forward for implementation of the GNEP Technology Demonstration Program**



GNEP Project Cost and Schedule Ranges

Project	Total Project Cost (Range)	Conceptual Design Cost Range	Operational Target Date
ESD	\$700M-\$1, 700M	\$55M-\$77M	2011-2015
ABTR	\$2,000M-\$5,000M	\$60M-\$200M	2014-2019
AFCF	\$1,500M-\$3,000M	\$60M-\$150M	2016-2019*
Total:	\$4.2B-\$9.7B	\$175M-\$427M	

* Applies only to initial remote fuel fabrication capability



Generation IV International Forum *Relationship to GNEP*

- ◆ **GNEP has commonality with the Gen IV mission**
 - GNEP focus is on waste management and nonproliferation but not long-term sustainability and economics
 - GNEP schedule compressed – uses available technology where possible
 - Largest technology gap: development of recycle-fuel for ABR
 - Small modular reactor with long-life core
- ◆ **GIF can support GNEP goals:**
 - Collaboration infrastructure for non-sensitive technology RD&D
 - Program and task leaders with a history of collaboration
 - Multilateral agreements and implementing arrangements
 - SFR technology improvements applicable to next-generation ABR
 - Fuel, cladding, structural materials, SCO_2 turbo-machinery, for better economics
 - Small modular reactor with long-life core (many concepts exist)





Conclusion

- ◆ **The U.S. and the world are faced with a set of challenges related to secure energy supplies, nuclear proliferation, and global climate change**
- ◆ **The Global Nuclear Energy Partnership uniquely addresses these challenges to:**
 - Meet rapidly growing energy demand
 - Reduce carbon emissions
 - Enable clean development
 - Avoid proliferation
- ◆ **Generation IV addresses long-term, sustainable closed fuel cycles**

“So tonight I announce the Advanced Energy Initiative... We will invest more in... clean, safe nuclear energy.”
President Bush, 31 Jan. 2006

