The Global Nuclear Energy Partnership – The Technology Demonstration Program

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July 21, 2006
What is GNEP?

The Global Nuclear Energy partnership is a comprehensive strategy to:

- Increase U.S. and global energy security
- Encourage clean development around the world & improve the environment
- Reduce the risk of nuclear proliferation
Key Elements

- Expand Nuclear Energy
- Recycle Nuclear Fuel & Reduce Nuclear Waste
- Enhance Nonproliferation Arrangements
GNEP Strategy

- Build a new generation of nuclear power plants in the United States.
- Open the federal geologic repository.
- Develop and deploy new nuclear recycling technologies.
- Design Advance Burner Reactors that would produce energy from recycled nuclear fuel.
- Establish a fuel services program that would allow developing nations to acquire and use nuclear energy economically while minimizing the risk of nuclear proliferation.
- Develop and construct small scale reactors designed for the needs of developing countries.
- Improve nuclear safeguards to enhance the proliferation-resistance and safety of expanded nuclear power.
Why Recycle?

- **National Motivations:**
  - Optimal use of repository (ies)
  - Near-term management of spent nuclear fuel
  - Recovery of energy value in SNF (natural resource utilization)

- **International Motivations:**
  - Global nuclear-materials management options
  - Guidance for policy decisions on governance regimes
  - Leadership in defining advanced systems for proliferation resistance
Used Nuclear Fuel (less cladding)

- Uranium 95.6%
- Stable Fission Products 2.9%
- Other Long-Lived Fission Products 0.1%
- Cs and Sr 0.3%
- Long-lived I and Tc 0.1%
- Plutonium 0.9%
- Minor Actinides 0.1%

Isotopic basis
## Potential Repository Needs

<table>
<thead>
<tr>
<th>Nuclear Futures</th>
<th>Existing License Completion</th>
<th>Extended License Completion</th>
<th>Continuing Level Energy Generation</th>
<th>Continuing Market Share Generation</th>
<th>Growing Market Share Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative discharged fuel in the year 2100 (metric ton)</td>
<td>100,000</td>
<td>120,000</td>
<td>250,000</td>
<td>600,000</td>
<td>1,400,000</td>
</tr>
</tbody>
</table>

#### Fuel Management Approach

<table>
<thead>
<tr>
<th>Fuel Management Approach</th>
<th>Number of Repositories Needed at 70,000 Metric Ton Each</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Recycle</td>
<td></td>
</tr>
<tr>
<td>Once-Through</td>
<td>2</td>
</tr>
<tr>
<td>Once-Through, High Burnup Fuels</td>
<td>2</td>
</tr>
<tr>
<td>Limited Recycle, High Burnup Fuels</td>
<td>2</td>
</tr>
<tr>
<td>Transitional and Sustained Recycle</td>
<td>1</td>
</tr>
</tbody>
</table>

*Recycle not Recommended*
Repository Benefits
Radiotoxicity for Limited/Continuous Recycle
Plutonium Management
Impact of FR Deployment on Uranium Resource Needs

Unconventional resource estimates range from 180 (sandstone) to 4,299 (seawater) to 800,000 (phosphate) million metric tons.

Conventional resource estimates range from 3.1 to 16 million metric tons.

Estimate of unconventional resources

Estimate of conventional resources

Uranium ore consumed (millions of metric tons)

Year

2000  2020  2040  2060  2080  2100  2120

FR start 2020

FR start 2030

FR start 2070

04-GA50634-23
Transmutation System Approaches
GNEP Deployment Systems Requirements

- The system must result in a significant improvement in repository utilization, preferably avoiding the need for a second geologic repository this century

- The system must optimize waste management including minimizing waste that needs to be handled or stored, and producing only solid waste with robust waste forms

- The system must make available the energy value of separated materials for future use

- The system must reduce proliferation risk

- The system must be deployable in a timeframe so as to reassert U.S. leadership, and influence fuel cycle development worldwide (20 years)

- The system must remain as economical as possible

- The system must be environmentally sound
GNEP Deployment System
Global Nuclear Energy Partnership
Technology Demonstration (GNEP-TD)

- **GNEP Technology Demonstration Program**
  - Focus on domestic demonstration of key technologies
  - International partnerships in technology development
  - Embedded university program

- **5-year technology plan under development**
  - 10 labs involved

- **Provision of intellectual basis for GNEP-TD decisions**
  - Basis studies
Technology Demonstration Program Approach

- Systems Integration
- LWR Spent Nuclear Fuel Separation Technologies
- Transmutation Technologies
- Transmutation Fuels and Separations Technologies
- Modeling and Simulation
- International Safeguards and Proliferation Risk Reduction
GNEP Technology Demonstration Facilities
GNEP-TD Facilities

Engineering-Scale Demonstration (ESD)

- Demonstration of the UREX+1a process
- Source of supply of transuranic elements for Advanced Burner Test Reactor
- Suitable for process optimization
- Size is to be determined from performance requirements

Advanced Fuel Cycle Facility (AFCF)

- Demonstration of transmutation fuel fabrication and processing
- Modular research laboratory
  - Aqueous separations demonstration at up to 25 metric tons per year
  - Pyrochemical separations demonstration at >1 metric ton per year
  - Recycle fuel fabrication development and demonstration
  - Supporting R&D laboratories

Advanced Burner Test Reactor (ABTR)

- Demonstrate performance of transmutation fuel
- Size is to be determined from performance requirements
Suite of UREX+ Processes

<table>
<thead>
<tr>
<th>Process</th>
<th>Prod #1</th>
<th>Prod #2</th>
<th>Prod #3</th>
<th>Prod #4</th>
<th>Prod #5</th>
<th>Prod #6</th>
<th>Prod #7</th>
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</thead>
<tbody>
<tr>
<td>UREX+1</td>
<td>U</td>
<td>Tc</td>
<td>Cs/Sr</td>
<td>TRU+Ln</td>
<td>FP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UREX+1a</td>
<td>U</td>
<td>Tc</td>
<td>Cs/Sr</td>
<td>TRU</td>
<td>All FP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UREX+2</td>
<td>U</td>
<td>Tc</td>
<td>Cs/Sr</td>
<td>Pu+Np</td>
<td>Am+Cm+Ln</td>
<td>FP</td>
<td></td>
</tr>
<tr>
<td>UREX+3</td>
<td>U</td>
<td>Tc</td>
<td>Cs/Sr</td>
<td>Pu+Np</td>
<td>Am+Cm</td>
<td>All FP</td>
<td></td>
</tr>
<tr>
<td>UREX+4</td>
<td>U</td>
<td>Tc</td>
<td>Cs/Sr</td>
<td>Pu+Np</td>
<td>Am</td>
<td>Cm</td>
<td>All FP</td>
</tr>
</tbody>
</table>

Notes:
1. In all cases, iodine is removed as an off-gas from the dissolution process.
2. Processes are designed for the generation of no liquid high-level wastes.

U: uranium (removed in order to reduce the mass and volume of high-level waste)
Tc: technetium (long-lived fission product, prime contributor to long-term dose at Yucca Mountain)
Cs/Sr: cesium and strontium (primary short-term heat generators; repository impact)
TRU: transuranic elements (Pu: plutonium, Np: neptunium, Am: americium, Cm: curium)
Ln: lanthanide (rare earth) fission products
FP: fission products other than cesium, strontium, technetium, iodine, and the lanthanides
Advanced Fuel Cycle Facility (AFCF) main mission is to develop and demonstrate advanced fuel recycling technologies

- Cost effective alternatives for high level nuclear waste management in the form of advanced closed fuel cycles.
- Advanced proliferation-resistant fuel recycling technologies including chemical processing and fuel fabrication.
- Advanced safeguards including advanced instrumentation for materials protection, control and accountability (MC&A), and advanced control and monitoring systems.
Advanced Burner Test Reactor: A Key Component of GNEP-TD

- Thermal reactors only suited for limited transmutation
- The role of thermal reactors for transmutation in the US is strongly reduced by the policy that avoids separation of pure plutonium, and the lack of a specific US infrastructure
- Fast reactors can effectively destroy all transuranics
  - Proliferation issue
  - Waste issue
- GNEP-TD will focus on fast reactor recycling
- Major challenges
  - TRU fuels and reprocessing
  - Cost reduction
  - Demonstration of passive safety
GNEP-TD Key Milestones and Planning Dates

- **EIS Record of Decision (6/08)**
- **Secretarial Decision on proceeding with demonstration (6/08)**
- **ESD operational (2011-2015)**
- **ABTR operational (2014-2019)**
- **AFCF operational (2016-2019)**

DATES PROVISIONAL—To be determined through Technology Development plan
The Global Partnership is Under Development

Countries Approached by U.S. to be possible Fuel Cycle States

- Japan – active follow-up
- France – active follow-up
- Russia – active follow-up
- United Kingdom (In midst of Government Energy Study)
- China (Follow-up being arranged)

~ 40 Countries briefed at International Atomic Energy Agency
- Science Attaches briefed in DC
- Detailed Discussion with Canada, South Korea

International Response Positive
Summary

- The GNEP Technology Demonstration Program
  - LWR spent fuel separations
  - Transmutation
  - Transmutation fuel separations and fabrication

- Key challenges exist for each technology demonstration
  - Separations efficiencies
  - Acceptable costs for fast reactors
  - Transmutation fuels

- A successful GNEP Technology Demonstration Program will require the expertise at national laboratories, universities, and industry

- GNEP will develop and demonstrate technologies that enable the transition to a stable, long-term, environmentally, economically, and politically acceptable advanced fuel cycle