GNEP is a welcome attempt to establish a long-term vision for the future of nuclear power.

To be successful, GNEP will require decades of research and development as well as major government investments.

Is there something which could be done now to put us on the road to implementing the vision?
TODAY
Process diagram for used fuel treatment

After discharge from the reactor, the used fuel is stored in a pool next to the reactor for 1 to 3 years.

Dry / wet unloading

Pool storage

Shearing Dissolution

Compaction

U/Pu/FP Separation

Vitrification

Storage

Storage

Uranium purification

Plutonium purification

Uranil nitrate

PuO2

Return to customer

Return to customer

The materials remain the property of the utility customers and are returned to them in their entirety.
More than 22,650 metric tons of used fuel treated at La Hague

<table>
<thead>
<tr>
<th>As of 1/1/2007</th>
<th>MT treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDF (France)</td>
<td>12,619</td>
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<tr>
<td>German utilities</td>
<td>5,381</td>
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<tr>
<td>Japanese utilities</td>
<td>2,944</td>
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<tr>
<td>Swiss utilities</td>
<td>709</td>
</tr>
<tr>
<td>Synatom (Belgium)</td>
<td>672</td>
</tr>
<tr>
<td>EPZ (Netherlands)</td>
<td>326</td>
</tr>
</tbody>
</table>
22,650 metric tons* of treated used fuel have conserved the equivalent of 4 years of Kuwait’s entire oil production

Used fuel treated at La Hague, 1976-2006 (in metric tons)

- Uranium oxide fuel
- MOX fuel for LWRs
- Fast reactor fuel

Completion of Service Agreement

* Excluding gas graphite fuel
** Annual consumption in France is close to 500 TWh
*** Electricity generated with the treated used fuel
**Why treat and recycle UNF?**

**Treatment and recycling** of used fuel meets the requirements of sustainable development:

- Be protective of public health, safety and environment
- Maximize the amount of material recovered from used fuel for use in producing additional energy and minimize the amount that needs disposal in a geological repository
- Make available the energy value of separated materials for future use
  - **The uranium** in used fuel has properties comparable to uranium mine concentrates. Recycling it therefore conserves the equivalent amount of natural uranium.
  - **The plutonium** has a high energy value: 1 gram of Pu = 100 grams of U = 1 metric ton of oil.
- Reduce proliferation risks
- Remain as economical as possible

*Recycling U + Pu = 25% natural resource conservation*
Reducing waste volumes

Final waste after treatment

Direct disposal of used fuel

% Pu in final waste

0.1%

100%

m³/MTU

Canistered used fuel

Compacted

Vitrified
AREVA La Hague: Waste Forms

- HLW for deep disposal: vitrified fission products including minor actinides and dissolution fines
  - 0.13 m³ /MTHM
- Long-lived intermediate waste for deep disposal: metal components, hulls and end-fittings, and dry active waste compacted at high pressure
  - 0.18 m³ /MTHM
- Short-lived Low and Intermediate level waste for surface disposal:
  - β/γ & α contaminated waste from operation and maintenance - immobilized by grouting
  - Spent solvent is mineralized - ashes immobilized by grouting
  - Spent resins - pre-treated and immobilized by grouting
  - Some metallic LLW are melted (final waste: ingots for disposal or reusable products) and combustible LLW are incinerated
  - 2,000 m³/year
**Used fuel radiotoxicity**

**Used fuel assembly**

- **Recyclable materials**
  - **94-96% U**

- **Waste**
  - **Other**
  - **1% Pu**
  - **3-5% FP**

**Used fuel radiotoxicity over time**

**Used fuel radiotoxicity by component**

- **U (Uranium)**
- **Pu (Plutonium)**
- **FP (Fission products)**
- **Am**, **Np**
- **Sv (Sievert)**

**Legend**

- U: Uranium
- Pu: Plutonium
- FP: Fission products
- Sv: Sievert

**Graphs**

- Time in years:
  - 1, 10, 100, 1,000, 10,000, 100,000, 1,000,000

- Radioactivity levels:
  - 0, 1, 2, 3, 4, 5, 6
  - $10^0$, $10^1$, $10^2$, $10^3$, $10^4$, $10^5$, $10^6$
Responsible used fuel management is a prerequisite to public acceptance of nuclear power

- Recycles 96% of the content of UNF
- Conserves 25% of our natural resources
- Consumes less than 6% of the cost of the kWh
- Divides waste volumes by 5
- Divides waste toxicity by 10

Our technologies produce waste packages that remain stable for tens of thousands of years

Treatment is an environmentally responsible choice
Worker exposure at the La Hague plants during operations and maintenance

Taking radiation protection into account at the design stage translates into continuous reductions in personnel exposure over the years.

Metric tons of used fuel treated per year
Dose impact from various sources of naturally occurring and manmade radiotoxicity

Approximate annual doses:

- Background radiation: 2.4 mSv per person on average
- Medical radiation: 1 mSv per person
- Adult consumption of one liter of mineral water per day: 0.03 mSv
- AREVA-La Hague releases in 2003*: < 0.02 mSv
- A Transatlantic flight from Paris: 0.02 mSv
- A 400-meter increase in altitude: 0.02 mSv
- Consumption of 200 grams of mussels: 0.02 mSv

* Reference group
MOX annual production in MELOX

Authorization received 4/2007
(195 t)

Authorization
(145 t)

Authorization
(100 t)
From a non-proliferation standpoint, MOX fuel is preferable to enriched uranium fuel.

* 88% load factor based on average burnup for a 900 MWe reactor
About 30% of the initial fissile Pu atoms have been destroyed

Pu isotopic composition of used MOX is not amenable for weapons use

- High content of even-numbered Pu isotopes (Pu-238, -240, -242)
- High spontaneous neutron emission
- High heat generation rate

Used MOX fuel is more self-protecting than used UOX fuel

Every atom of Pu fissioned reduces the number of atoms of U-235 which would otherwise need to be enriched
Recent Recycling Contract

- All Italian nuclear reactors shut down after Chernobyl
- Spent fuel remains on site today
- Contract signed this year for AREVA to take all 235 MT of used fuel to La Hague for reprocessing
- Recovered U and Pu will be sold to other customers
- Waste will be returned to Italy in accordance with French Law by 2025 for storage and disposal
- Removal of legacy spent fuel may help pave way for a nuclear “renaissance”.
- Could something similar be done for US fuel at decommissioned reactors?
TOMORROW
Treatment-Recycling plant characteristics

- U/Pu co-extraction
  - No separated plutonium
- Integrated plant
  - In line fabrication of recycled fuel
  - No accumulation
- Advanced safeguards

Just-in-time MOX recycle in reactors
Co-extraction (COEX™) Process

Used Nuclear Fuel → Shearing / Dissolution → Metallic Structures → Compaction → Compacted Waste

Co-extraction → Reprocessed Uranium (94%), to recycling

Fission Products (4%)

Co-conversion → Vitrification → Vitrified Waste

Depleted Uranium

Fuel pellet manufacturing

Fabrication of assemblies

Fresh U,Pu fuel

Oxide pellets

No separated Plutonium

(1) And minor actinides
COST OF RECYCLING AND ONCE-THROUGH STRATEGIES
COMPARABLE IN A GREENFIELD APPROACH
Especially Given Uncertainty on Yucca Mountain Costs and Future Uranium Price

Area of relative competitiveness of recycling and once-through strategy (in discounted costs)

Repository costs
($2005 / kgHM)

Comparable economics
Recycling more competitive
(10% cost difference)

Once through more competitive
(10% cost difference)

Recent trends

+/- 10% cost range

Uranium price

Repository costs
($2005 / kgHM)

Comparable economics
Recycling more competitive
(10% cost difference)

Once through more competitive
(10% cost difference)

Recent trends

+/- 10% cost range

Uranium price

($2005 / kgU)

($2005 / lb U₃O₈)

(19)

(39)

(58)
Summary

- Today dry fuel storage is being used on a large scale in order to deal with used fuel discharges and keep nuclear reactors operating.

- This is likely to remain the case for at least the foreseeable future: 10-15 years.

- A geologic repository will be needed for eventual disposal of nuclear waste products, and progress toward implementation is needed for public acceptance of nuclear power.

- Domestic treatment and recycling may be a valuable approach to the back end of the fuel cycle, but they will not make a contribution in the U.S. during the near term: 10-15 years.