IAEA – Spent Fuel Management Sustainable Cycle Solutions

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An option for the management of used nuclear fuel is sustainable if it:

- Covers all the steps of used fuel management until final disposal, in accordance with an acceptable, practical plan
- Proves to be feasible with an acceptable impact level
- Includes a realistic and balanced financing plan
- Does not impose undue burdens on future generations

Deep disposal with a safe and acceptable route
Ensuring stability and containment for thousands of years

Glass has proven scientifically as a very robust matrix against alteration by water

Challenge #1:
Implement deep geological repository

<table>
<thead>
<tr>
<th>Licence to build</th>
<th>Start of operations</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed cycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>2026-2076</td>
<td>Siting in progress</td>
</tr>
<tr>
<td>2025</td>
<td>2035</td>
<td>Two sites under discussion</td>
</tr>
<tr>
<td>2030-2040</td>
<td>2050-2080</td>
<td>Under discussion</td>
</tr>
<tr>
<td>Open &amp; Closed cycle</td>
<td></td>
<td></td>
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<tr>
<td>2026</td>
<td>2045-2060</td>
<td>Siting under discussion</td>
</tr>
<tr>
<td>Open cycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>2048</td>
<td>Project stopped by the Obama administration in 2010 – New project expected for 2048</td>
</tr>
<tr>
<td>2010</td>
<td>2025</td>
<td>Application submitted – Main criticality safety issues to be solved – Licence expected for 2017</td>
</tr>
<tr>
<td>2012</td>
<td>2021</td>
<td></td>
</tr>
</tbody>
</table>

Anticipation, international cooperation and continuity of efforts
Global nuclear capacity is expected to increase significantly by 2030.

- Deep geological repository will remain a scarce resource.
  - 2025 - 2040
  - >2050

Optimizing the use of scarce resources is critical for the durability of the nuclear power.
Challenge #2:
Manage long term storage and avoid saturation

**Used Fuel Management**
- Significant inventories
- Lack of (or major delay in developing) final disposal path
- Industrial interim systems not capable of bridging the gap
- Uncertainty over used fuels LT behavior

**Main issues**
- Saturation of reactors pools and constraints on operations
- Safety demonstration
- Pool unloading for phase out
- Damaged fuels
- Difficulty to get new license

**Risks reduction: a short-term priority**
AREVA: Sustainable Solutions for an optimized, long-term and responsible management of used fuel

Recycling and HLW storage

Interim options for used fuel

Dry storage

Wet storage

Transport systems

Sustainable Cycle Solutions

A smart mix of proven and evolving technologies tailored to stakeholders’ priorities and constraints
The Netherlands or how to use recycling to reduce risks?

**Situation**
- 17 M inhabitants
- 110TWh
- 1 reactor, shut-down 2034
- 1 storage facility: HABOG

**Ambitions / Challenges**
- **Strategy:**
  - Surface storage 100 years
  - Responsible management
  - Public acceptance
  - Choice of the recycling

**AREVA solution**
- Precycling

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No safeguards, no corrosion, no leakage, no safety issue, high public acceptance

Safe long term storage of glass canisters (>100 years) has a major value
AREVA solutions for managing defective fuels

Transport
TN®117 cask

Interim Dry Storage
Capsule Canister to be loaded in a TN®24E

Treatment - Recycling
DAMAGED USED FUEL
Customer reactors
REUSABLE material Used by initial owner or by another party
TREATMENT at La Hague plant
Final WASTE package returned to customer
Storage or disposal center

Challenge #3:
Manage long term interim storage risks

Can you imagine this in 100 years?

With Extension of dry storage well beyond original license, risks to be mitigated

Safety:
- Fuel integrity overtime
- Aging of materials/storage components

Security:
- With less radiation overtime, easier access to fuel

Others:
- Loss of records especially on stranded sites (fuel, systems,..)
- Higher risks on stranded sites with no pool and “aging “expertise

“Research on long-term spent fuel integrity, currently underway in the U.S. and elsewhere, will be critical to protecting public health and safety.”
NRC Chairman Macfarlane, 17 November 2014

Used fuel storage: from “commodity” to “critical system” requiring much focus and means
AREVA:
New solutions and business models under development

**Ageing management early detection, monitoring and repair equipments**

**Early Detection and Monitoring**

*Installed base: Detection and Monitoring*

- Inspection models
- Tool development for welding integrity monitoring
- Corrosion monitoring and heat sensors

**New systems:**

- New materials with better resistance to corrosion, fabrication process, ...
- Sensors for internal and external monitoring

**Mitigation/Repair**

*Repackaging capabilities on-site*

**And: Consolidated Interim Storage Facilities (CIS)**

Consolidation of expertise and equipment (too complex and expensive on stranded sites) with capability of:

- Monitoring
- Fuel retrievability and examination
- Fuel repackaging
Challenge #4: Increase worldwide recycling capability and develop advanced solutions

**United Kingdom**
- Different recycling solutions to dispose of the Pu stockpile
- LWR, PHWRs and SFR being considered

**France**
- La Hague (up to 1700t/y) and Melox (up to 195t/y) in operation
- Astrid fast reactor program development
- Design for fast reactor fuel fabrication & R&D for treatment

**Russia**
- BN-800
- Mayak (400t/y) in operation
- Plans to develop Krasnoyarsk (1700t/y) and MOX facilities

**Japan**
- Rokkasho-Mura (800t/an)
- J-Mox under construction
- Tokai plant & Monju fast reactor (stand-by)

**South Korea**
- R&D on Pyroprocessing
- R&D program on Fast Reactors

**China**
- Recycling pilot unit Lanzhou (up to 50t/y) being developed
- LOI for a 800t/y recycling plant
- Ambitious plan for recycling installations
- Ambitious fast reactor program

**India**
- Kalpakkam (up to 400t/y) in operation and plans to develop capacity
- 500MW fast reactor
- Ambitious fast reactor/AHWR program

**USA**
- MFFF facility for military Pu in excess
- R&D program on Fast Reactors
- PRISM reactor suggested by GE
- No solution for used fuel

**Support key nuclear developers in implementing real “industrial strategies”**
AREVA Solutions
Technology, industrial experience and system design for a sustainable nuclear deployment

Support to RRP and JMOX
MFFF design and construction
Pu management solution
Recycling platform

Reducing risks and leveraging nuclear systems

On going contracts
Studies/offers in progress

Our mission:

Provide Sustainable Cycle Solutions for optimized, long-term and responsible management of used fuel

Reduce risks
- Safety & security
- Environment impact
- Non proliferation

Increase value
- Economic value
- Fleet performance

Favor acceptability, public acceptance

Responsible towards coming generations