Sino-French cooperation for developing responsible used fuel and waste management

Erwan HINAULT
Senior Vice President, Strategy & Marketing
AREVA China

Asia Nuclear Business Platform 2016
May 19th 2016
Sustainable and responsible management of used fuel is crucial for nuclear development.

Deep geological repositories will remain very long-term plans and a scarce resource.

LWR used fuel inventories:
- 2013: +70%
- 2030: 400 tHM/Y

LWR used fuel annual unloading:
- 2013: +90%
- 2030: 12 tHM/Y

Deep geological repositories:
- 2025 - 2040
- >2050

Rest of the world | Asia | Russia & CIS | Europe | North America
----|----|---------|------|---------
Used fuel management is sustainable and responsible 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
Manage used fuel long-term storage and avoid saturation: A short-term priority

Used fuel management challenges

- Significant inventories
- No final disposal site (or major delay in project development)
- Industrial interim systems not capable of bridging the gap
- Uncertainty over used fuels long term behavior

- Constraints on NPP operation because of saturation of reactors pool
  - Safety demonstration
  - Pool unloading for phase out
  - Damaged fuels

- Reactors’ life extension
- Reactors’ shutdown
Used fuel management policies
Once-through (open cycle) / Recycling (closed cycle)

Once-through
Used Fuel = Waste

Recycling
Used Fuel = Valuable Material + 4% waste

~10 y

MOX
LWR and FR
ERU

Reprocessing - Recycling

Universal canister

Interim storage

Encapsulation

Final disposal

Interim storage

ANBP 2016 - Sino-French Cooperation for developing responsible used fuel and waste management – May 19th 2016
Open fuel cycle
Characterized by technical and economical uncertainties

Once-through
Used Fuel = Waste

Interim storage
- Issues with fuel integrity for extended dry storage period
- Fuel not self protecting
- Reconditioning for transportation?

Encapsulation
- Under development

Final disposal

ANBP 2016 - Sino-French Cooperation for developing responsible used fuel and waste management – May 19th 2016
Extension of interim storage well beyond original license due to final disposal delay induces risks and uncertainties

- **Safety**
  - Fuel integrity over time
  - Aging of materials / storage components

- **Security**
  - Self-protection of used fuels

- **Capability**
  - Lost of records especially on stranded sites (fuel, systems,..)

“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)

“Experience to date indicate that spent nuclear fuel can be safely stored in the short term and then transported without significant concern. Additional information is required to demonstrate with similar high-confidence that spent nuclear fuel can be stored in dry-storage facilities for extended periods without affecting the performance of the fuel during very long-term storage and subsequent transportation."
Closed fuel cycle
Industrial and safe path optimizing final disposal

- Industrial operations
- Demonstrated safe long-term storage
- No time, no space, no safeguards constraints
- Optimized vs. open cycle
  - Footprint: by 4
  - Volume: by 5
  - Toxicity: by 10
- No safeguards / no proliferation risk

Recycling
Used Fuel = Valuable Material + 4% waste

~10 y

Reprocessing-
Recycling

Interim storage

Final disposal

MOX
LWR and FR

ERU

Universal canister

ANBP 2016 - Sino-French Cooperation for developing responsible used fuel and waste management – May 19th 2016
Vitrified / compacted waste forms drastically reduce storage and disposal risks

Numerous Merits

- Stable and robust
- Unique and standardized
- Easy on-site handling
- Easy to transport
- Not subject to IAEA safeguards
- Suitable for long-term storage and final disposal … rationalization of ultimate waste policy
- Reduce final waste volume by a factor 4

Universal Canister (UC)
(of compacted waste or vitrified waste)
AREVA made the industrial demonstration of reprocessing-recycling

**Reprocessing**
- La Hague
- 1,700 tHM/year capacity
- > 30,000 tHM spent fuel reprocessed

**Recycling**
- Melox
- 195 tHM/year capacity (MOX)
- > 7,300 Mixed Oxide (MOX) fuel assemblies manufactured
- > 7,200 Enriched Reprocessed Uranium (ERU) fuel assemblies manufactured
If direct costs are comparable (*1), overall value of recycling is superior

- Long term storage
- Minimize waste generated
- Nuclear safety
- Environmental impact & footprint
- Relieve constraints on reactors’ operation
- Optimize cost of nuclear electricity in the short and long term
- Preserve natural resources
- Optimize cost of nuclear electricity in the short term
- Relieve constraints on reactors’ operation

(*1) OECD-NEA 2013: The Economics of the back end of the nuclear fuel
Large-scale commercial reprocessing-recycling plant
A clear path forward towards reprocessing-recycling

- China has formulated an energy policy to actively, safely and efficiently develop nuclear power together with a closed nuclear fuel cycle.

- In 2007 China (CNNC) and France (AREVA) decided to cooperate on the design, construction and operation of a large-scale commercial reprocessing-recycling plant in China, based on the reference of AREVA’s La Hague and Melox plants.

- China established a back-end fund in 2010 to finance this large scale plant. (0.026 RMB per kWh taxed on-grid electricity of LWRs after 5 years of commercial operation)

- CNNC Nuclear Fuel Reprocessing (CNFR) established as the dedicated project management company.

- Outline of China’s 13th Five-Year Plan (Mar. 2016) put forward the acceleration of the construction of the large-scale plant.

- Siting work progresses smoothly.
Large-scale commercial reprocessing-recycling plant
Sino-French cooperation is progressing smoothly

2007: Sino-French cooperation agreement on the Back-end of the fuel cycle

2007: AREVA-CNNC Cooperation Agreement for the design, construction and operation of a reprocessing-recycling plant in China

2008: Completion of CNNC-AREVA « Preparatory Work »

2008: Completion of CNNC-AREVA « Preparatory Work »

2009: Sino-French joint declaration on the construction of the reprocessing-recycling plant

2009: Sino-French joint declaration on the construction of the reprocessing-recycling plant

2010: MOU defining the mutual cooperation model (scope and responsibilities of AREVA and CNNC)

2010: MOU defining the mutual cooperation model (scope and responsibilities of AREVA and CNNC)

2011: AREVA-CNNC Letter of Intent on the construction of a 800t recycling-reprocessing plant in China

2011: AREVA-CNNC Letter of Intent on the construction of a 800t recycling-reprocessing plant in China

2012: MOU on long-term cooperation in back-end of the fuel cycle

2012: MOU on long-term cooperation in back-end of the fuel cycle

2013: MOU on long-term cooperation in back-end of the fuel cycle

2013: MOU on long-term cooperation in back-end of the fuel cycle

2014: MOU on long-term cooperation in back-end of the fuel cycle

2014: MOU on long-term cooperation in back-end of the fuel cycle

2015: Completion of technical discussions; MOU on commercial negotiation roadmap; Start of negotiations

2015: Completion of technical discussions; MOU on commercial negotiation roadmap; Start of negotiations

2015: Sino-French joint declaration on reinforcing nuclear cooperation

2015: Sino-French joint declaration on reinforcing nuclear cooperation
Large-scale commercial reprocessing-recycling plant
Insights on the project

▶ Few characteristics

◆ PWR used fuel
◆ Capacity : 800t/year
◆ Design life time : 40 years
◆ Products : Uranium oxide (UO3) and MOX fuel for fast reactors

▶ Planning

◆ Construction start : Around 2020
◆ Commissioning : 2030

▶ AREVA will provide the core technology and technical services all along the project
In 2030, in China too ...