Optimization of waste and materials disposition in France
Policy, strategies, and techniques

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Recycling of metals arising from operation and decommissioning of nuclear facilities: the challenges in France

1. The landscape and involved actors in waste management in France

2. Present status of waste disposal in France: the issues

3. Policy, strategies: the national governance
   - The National radioactive wastes and materials management plan

4. Metals recycling
   - Present experiences in France
   - Very low level metallic waste recycling: some issues

5. Conclusion
The landscape and involved actors in waste management
A significant nuclear industry

Main waste generators

- Nuclear power plants
- Nuclear fuel cycle
- Research
- Military applications

58 PWR in operation
- 1 PWR under construction
Fuel cycle facilities
Nuclear research centres
Military activities

Many different operating facilities, a significant decommissioning program,

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The landscape and involved actors in waste management
EDF decommissioning programme

1 heavy water reactor

1 pressurized light water reactor

6 natural uranium graphite gaz cooled

1 fast breeder reactor
The landscape and involved actors in waste management
AREVA decommissioning programme

Some operations already completed

Reprocessing plant

Fuel fabrication plants

Enrichment plant

MOX Fuel fabrication plant
The landscape and involved actors in waste management CEA decommissioning programme

Nuclear submarines

Fontenay aux Roses Pilot facilities for reprocessing

Marcoule Reprocessing plant

Grenoble Various facilities

Some operations already completed
The landscape and involved actors in waste management

The involved actors

- **Independent authority**
  - Advises on regulation
  - Controls
  - Takes technical decisions
  - Informs

- **Services providers**
  - Including
    - EDF
    - AREVA
    - CEA
    - Socodei

- **Industrial operators**
  - Involvement in decommissioning waste management:
    - Industry
    - R&D
    - Services (studies)
    - Support to authorities

- **A State owned agency in charge of implementing solutions for long term radioactive waste management**

- **700 small producers**
The landscape and involved actors in waste management
A specific regulation for nuclear facilities

**WASTE ZONING**

**Conventional waste**

- **REFERENCE**
  - **ZONAGE DECHET**
  - **ZC**
    - **ZONE CONVENTIONNELLE**
    - Cette zone produit des déchets conventionnels
    -Pour tous travaux ou entreposages,
    -Respecter les consignes relatives à cette zone.

- **Date:**
- **Tél:**

- **Nuclear waste**

- **REFERENCE**
  - **ZONAGE DECHET**
  - **ZN**
    - **ZONE NUCLEAIRE**
    - Cette zone produit des déchets nucléaires
    -Pour tous travaux ou entreposages,
    -Respecter les consignes relatives à cette zone.

- **Date:**
- **Tél:**

**No free release for nuclear wastes**

areas where there is no possibility of contamination or activation

areas in which waste is or may be contaminated or activated

No free release for nuclear wastes
Present status of waste disposal in France: the issues
Disposal operated and planned routes

More than 90% of the volume of waste have a disposal solution

**RADIOACTIVE WASTE CLASSIFICATION**

| Very low level | Operating Centre de Morvilliers |
| Low level      | Mining Residue |
| Intermediate level | Deep geological disposal |
| High level     | Storage for tritiated wastes |

**Short lived waste** (period of main nuclides < 30 years)

- Operating Centre de l’Aube
- Deep geological disposal (application planned in 2015, start up in 2025 – Waste Act 28th June 2006)

**Long lived waste**

- To be implemented (Waste Act 28th June 2006, graphite, radium bearing)
- Near surface

**Centre de la Manche**
Institutional control period since 2003

First deliveries: October 2003

Centre de la Manche
Institutional control period since 2003

Storage for tritiated wastes

**Bures URL**
Present status of waste disposal in France: the issues
Situation of the operational routes

Centre de l’Aube

Operated since 1992

Licensed capacity : 1 000 000 m³

Volume disposed of : 280 000 m³
(end 2013)
(Centre de la Manche: 527,000 m³ disposed)

Present deliveries: 14 000 m³

Initial design for operational waste (30 000 m³/year) . Initially forecast for 30 years of operation

VLLW disposal at CIRES (centre de Morvilliers)

Surface : 45 ha

Licensed capacity : 650 000 m³

Operated since 2003

Volume disposed of (end 2013) : 252 000 m³

Initial design for 30 years of operation
Present status of waste disposal in France: the issues
Disposal of large components

Overall optimization

Read this book!
Present status of waste disposal in France: the issues
The issues for the operated disposal routes

Low level wastes

Waste generation forecast (2012)
1 200 000 m$^3$ in 2030
(including 527,000 m$^3$ at Centre de la Manche)

1 500 000 m$^3$ after decommissioning of present or decided facilities

No volume problem to be anticipated

Very low level wastes

Waste generation forecast (2012)
1 300 000 m$^3$ in 2030

2 000 000 m$^3$ after decommissioning of present or decided facilities

New disposal capacities needed
Policy, strategies: the National governance
The National radioactive wastes and materials management plan

Legal framework: June 28th, 2006, waste act

Code of Environment: laws and regulation

Implementation of a National radioactive wastes and materials management plan (PNGMDR)

- Co-chaired by Ministry and ASN
- Involves
  - Ministries
  - ASN
  - IRSN
  - Operators
  - NGO
- Input: national inventory by Andra
- Develops the strategy for waste management
- Update every 3 years
Disposal should be considered as a rare resource

- For VLL waste
  - Densification of waste
  - Densification of the disposal facility
  - Re-use of concrete scrap to backfill disposal cells
  - Recycling of metallic wastes

Program for 2010-2012:

- A shared study by the main French nuclear operators, AREVA, CEA and EDF, and Andra
- To assess the opportunity and economical/technical feasibility of the implementation of recycling routes.

In accordance with the French doctrine:

- Recycling should be performed within the nuclear industry.
- Therefore stringent constraints on the traceability of materials.
- Potential constraints in the facilities that could process these materials
  - Radiation protection
  - Management of secondary wastes generated by the processes.
Implementation by Areva in 2003 and operated by the CEA since 2005.
Collection of lead inside Marcoule nuclear facilities,
First melting inside Marcoule facility to make ingots (activity < 1 bq/g)
Second melting in a conventional facility to manufacture shieldings,
Recycling in nuclear facilities.
100 tons of lead per year currently recycled.
However
- a fourth of the capacity of the melting furnace
- costly in comparison with a direct disposal in a VLL disposal facility.

Therefore it is planned to stop this route.
Electric induction furnace with a capacity of 4 tons

Treatment of an average of nearly 1,700 t / year.

waste outputs:
- volume reduction: non-recyclable waste shipped as ingots to disposal facilities
  - LL ➔ VLL
- Recycling: internal cylindrical shieldings for packages used for intermediate level waste (spent resins).

Mean activity of metal that was process to make shielding: 6 Bq/g, with a maximum value of more than 160 bq/g.

Between 1999 and 2011 21,700 tons processed
  - 600 tons recycled in shieldings.
LOW LEVEL RAD-WASTE VOLUME REDUCTION: THE CENTRACO FACILITY
Waste acceptance criteria (melting)

Radiological criteria

- $\beta\gamma$-emitters: 20,000 Bq/g max + 20,000 Bq/g $^3$H
- $\alpha$-emitters: 370 Bq/g max

Physical and chemical criteria: limits on:

- Non ferrous

Conditioning accepted

- Melting: Reusable ISO CTRS & boxes, single use drums
Tubular radiological shields (MERCURE ctrs):

Material: carbon steel
Size: 100 x 100 cm,
Thickness: 40 mm or 70 mm,
Top, bottom & stirring bar: non radioactive carbon steel,

These shields are incorporated in concrete shells to form shielded containers (300 years certification). They are used for waste conditioning in the embedding processes.
SEALED CONTAINER SECTION
Decontamination by melting
Centrifugation
Control of finished products
A review of the forecast inventory of metallic VLL waste to be generated

- 400,000 tons for the next 30 years
  - 250 to 375,000 tons with a very very low level activity
  - 90% of ferrous waste

5 to 10,000 tons easy to be recycled
- But 0.1% of conventional recycled steels in France

Homogeneous components: 140,000 tons from the dismantling of a gaseous diffusion enrichment plant

Other more heterogeneous
Metals recycling
Metals potential re-use

Recycling within the nuclear industry

Different types of products considered with a potential re-use of 300,000 tons for the next 30 years:

- Construction products in nuclear facilities with a focus on steel frames to reinforce concrete,
  - But
    - Mainly steel materials
      - Not relevant to be processed in a dedicated steel facility (low quantities)
      - Generally manufactured prior use
      - Traceability constraints for re-use
      - During implementation
      - When decommissioning the facilities (if planned)
  - Industrially and economically not relevant

- Packages to condition wastes with a focus on the replacement of LL concrete containers
  - Cast iron containers
    - Relevant with a dedicated cast iron facility (foundry)
    - Could enable volume reduction for LL and VLL waste packages
  - But
    - Re-assessment of disposal safety case needed
    - Modification of conditioning and handling tools in facilities where wastes are processed
  - Significant industrial impact on operated facilities
  - Significant costs forecast on waste conditioning facilities
Conclusion

No obvious short term outlet for VLL recycled metals in presently operated facilities

⇒ Should rather be considered for new built facilities or opportunities
  ▪ New nuclear facilities
  ▪ New disposal facilities: components or packages
  ▪ ...

Economical and industrial relevance as a major challenge

◆ Competition with direct VLL disposal route
◆ Sensitivity to constraints derived by the interpretation of the French regulation

New options to be explored and assessed

Still a sustainable development challenge!