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A rationale for the disposal of Low Level Long-Lived radioactive waste
Radioactive Waste in France

- Waste from Nuclear industry current operation (40 years prospect)
  - Low Level Short Lived Waste: 1,000,000 m$^3$
  - High Level Waste: 8,000 m$^3$ of vitrified fission products
  - Intermediate level Waste: 80,000 m$^3$ (Compacted ends and hulls, bituminised sludges, technological waste)
  - Spent fuel (if not reprocessed): 4,600 t Uox, 3,250 t Mox

- and also:
  - Very Low Level Waste
  - 5,000,000 m$^3$ of LLSSLW disposed of from 1969 to 1990
  - Uranium mine and mill tailings (about 50 million tons)
  - Graphite waste from decommissioning of Gas-Graphite reactors (some 10$^4$ tons-10$^5$ Bq/g - 3,000 TBq)
  - TE-Norm: waste from ore processing enhanced in Radium content (Some hundred thousand tons-Some 100 Bq/g in Ra226)
  - Disused Sources (some hundred thousands)
LEGAL ROAD MAP

● Law on RWM (Law 206-739 of 28 July 2007)
  - Reversible deep disposal-construction to be licensed in 2015
  - New law on reversibility to be submitted to vote prior to licensing
  - Continuation of separation-transmutation studies (in connection with « generation IV » new reactors projects)
  - Enlargement of ANDRA’s responsibilities
  - Long term storage to be implemented (in new or existing facilities)
  - Disposal of graphite-radium enhanced waste to be effective within 7 years
  - PNGMDR to establish policy and strategies for every radioactive waste and to report every 3 years
  - ...

● Law on transparency
  - Sets up an independant safety authority
  - Recognises role and allocate resources to local stakeholders
Strategy for disposal

- **Contain and Isolate**
  - Limit transfer and/or amount of long lived activity

- **300 years for surface disposal**
- **Some $10^5$ years for geological disposal**
- **Some $10^4$ years for "intermediate" disposal**
Strategy for disposal

A (Bq/g)

Performance +

Robustness +

Time (years)

Volume-Related Long-Lived Wastes (VLLW)

High-Level Wastes (HLW)

Low-Level Wastes - Long (LLW-LL)

Low-Level Wastes - Short (LILW-SL)

VLLW
VLLW Disposal Facility

- Surface disposal
- “Light” technical measures sufficient to ensure safety

**Cross section of a disposal cell**

- Clay
- Sand
- Membrane
- Inspection hole
- Waste

**An institutional control period of 30 years**

- Need for accurate sorting prior to shipment
LILW-SL Disposal Facility

- Surface disposal
- Containment and isolation required for 300 years
- Safety based on multiple barriers and institutional control
- Limitation of long-lived activity
LILW-SL Disposal Facility

- Passive ...
  - Favorable and simple hydrogeology
  - Waste packages and vaults bear key containment functions
  - Cover against external aggression

- ... & “active” provisions
  - Control of waste properties and distribution in facility
  - Control of containment effectiveness (drainage system)
  - Corrective actions if dysfunctions occur
- Deep disposal
- Containment and isolation required for several $10^5$ years
- Long term safety based on high performance multiple barriers
HLW-LL Disposal Facility

- **Stringent siting conditions**
  - Depth > 200m
  - Highly impermeable medium
  - High stability
  - Favorable mechanical and geochemical properties
  - No natural resources

- **High performance barriers**
  - Waste package and canister
  - Engineered barriers and seals

- **Strong requirement for accurate appraisal of perturbations and consequent design**
  - Knowledge of site features and possible evolution
  - Knowledge of thermal, mechanical, chemical and transport processes
LLW-LL Disposal Facility

- Time required for containment requires safety options comparable to deep disposal
- Requirement for performance not as stringent as for deep disposal
Guidelines for safety (ASN-05/05/08)

- Contain and isolate during period of substantial decay (some 10,000 years)
  - Passive safety, relying on the confinement properties of geological formation, waste packages and excavation filling/sealing systems (Multi-barrier/function system)
  - Siting and design must allow prevention against human intrusion and resilience to climate perturbation during containment period

- Limit long term consequences after decay
  - Central role of geological settings
    - Host rock and site features should allow for low dissemination of radioactive substances
    - Low permeability rock
    - Favorable hydrological context
  - Limitation of very long lived radioactive content
Conclusions

- Basic safety principles for siting and designing a LLW-LL disposal facility are comparable to those applicable to the deep geological disposal of high level waste but the comparatively low activity contained allows for less stringent performance requirements, concerning in particular:
  - The depth of the repository and the performance in time of the geological barrier
  - The waste package performance
  - The conditions to ensure operational safety
THANK YOU!
Strategy for disposal

A (Bq/g)

Time (years)

Performance +

Robustness +

HLW

LILW-SL

VLLW