Advances in Treatment of Wastes from Reprocessing of Spent Fuel

P. Bernard

Director of Nuclear Development and Innovation

Reprocessing & Recycling, a cornerstone for future energy needs

➢ **Extract the maximum energy from the fuel**

Valuable materials (96%)

Uranium (94 to 96 %)

Plutonium (1 %)

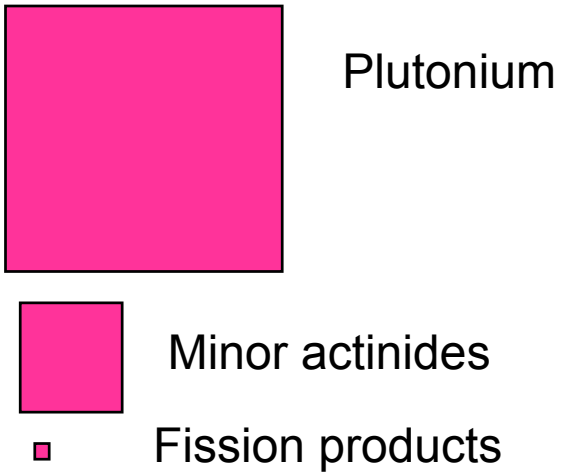
Wastes (4%)

FissionProducts (3 to 5 %)

Minor Actinides (0,1 %)

Reprocessing & Recycling

➢ **Drastically minimize radiotoxicity of the waste**



Radiotoxicity after 1 000 years

➢ **Pu stockpile stabilisation : the Pu produced is consumed in LWR**

R&D for long term management of HLLW in France

3 areas of R&D set out by law of December 30, 1991 :

- **minimization** of the **quantity** and **toxicity** of **waste**, by **partitioning and transmutation,**

- packaging and **conditioning**, for safe long lasting containment, and also studying **long term surface storage,**

- feasibility of **deep geological disposal**, whether reversible or irreversible.

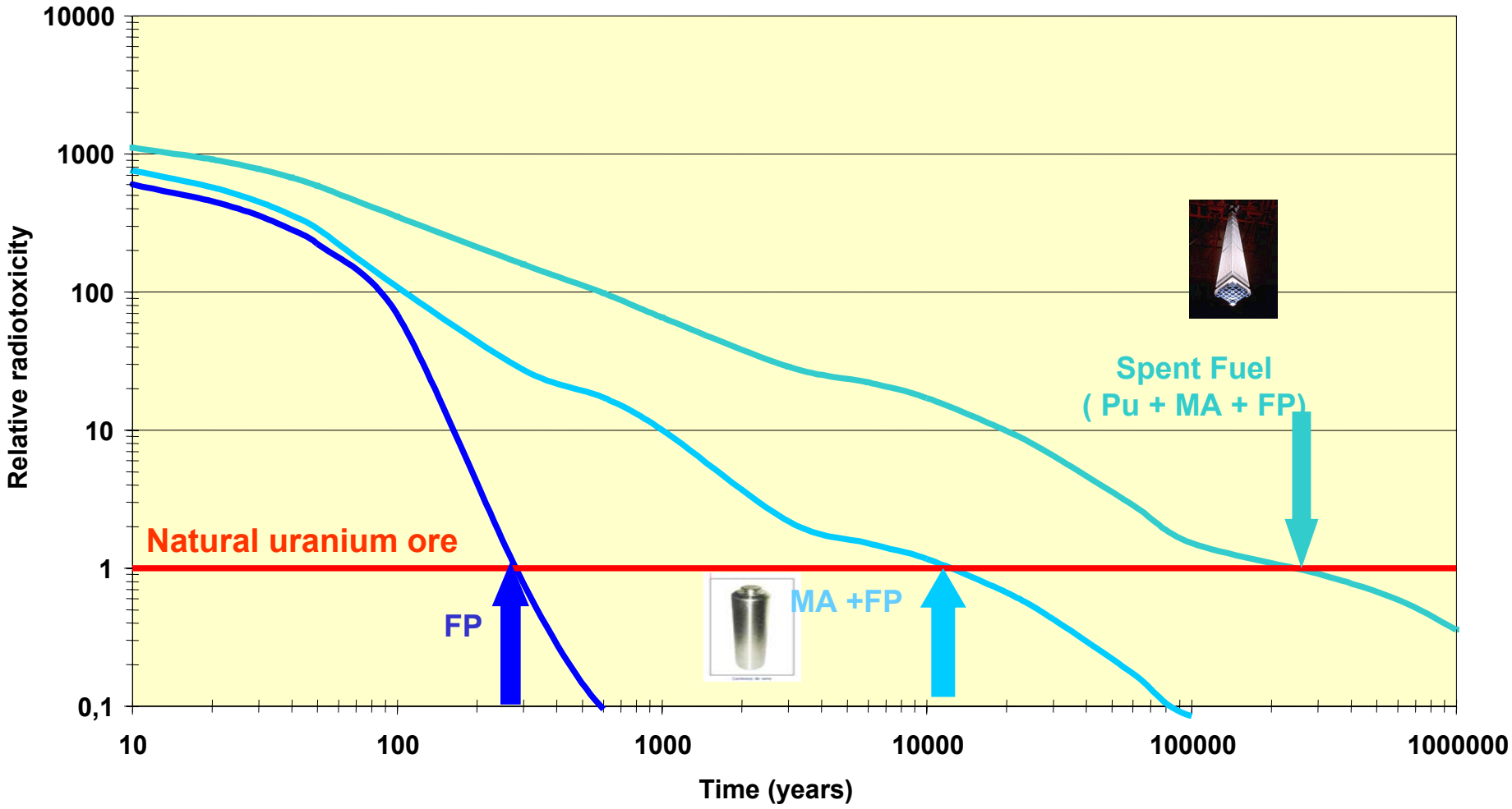
≤ 15 years of R&D ⇨ ≤ 2006 ; evaluation by National Evaluation Commission

At present time :

1) Significant results have been produced by R&D since 1991,

2) Technical solutions do exist, that can be implemented in a progressive manner.

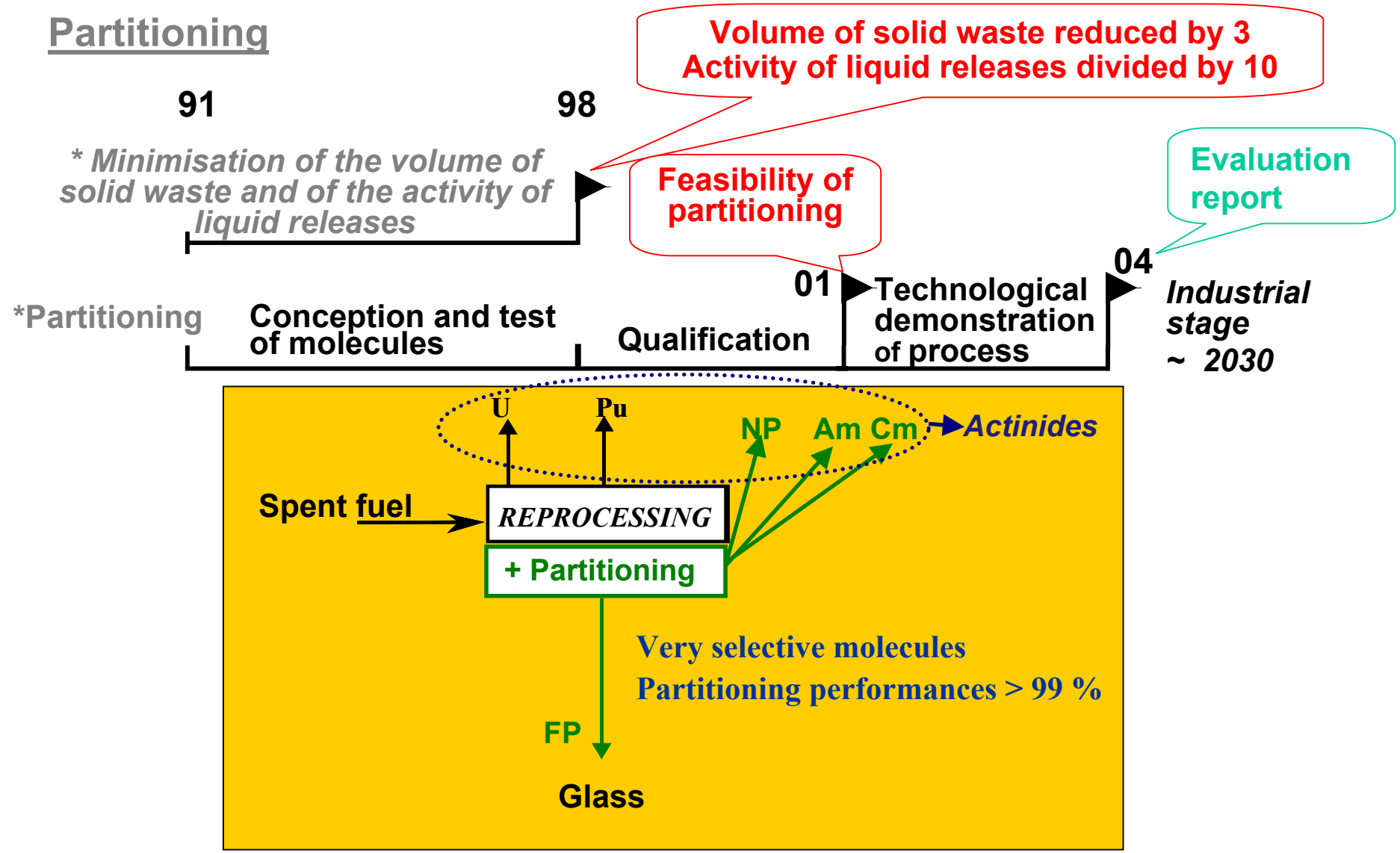
Evolution of the radiotoxicity



- **SUSTAINABLE NUCLEAR ENERGY WITH REPROCESSING AND RECYCLING**
  - ✓ Recover and recycle valuable materials
  - ✓ Minimise waste : volume/5, radiotoxicity/10
  - ✓ No plutonium in ultimate waste
  - ✓ Vitrification of ultimate waste : very safe conditioning providing long lasting confinement of radioactive waste
  - ✓ Open strategy to the future

- **MATURE INDUSTRIAL IMPLEMENTATION AND COMPETITIVE**
  - ✓ > 18 000T reprocessed at La Hague
  - ✓ 20 reactors in France recycling plutonium

Minimisation of the quantity and the toxicity of waste



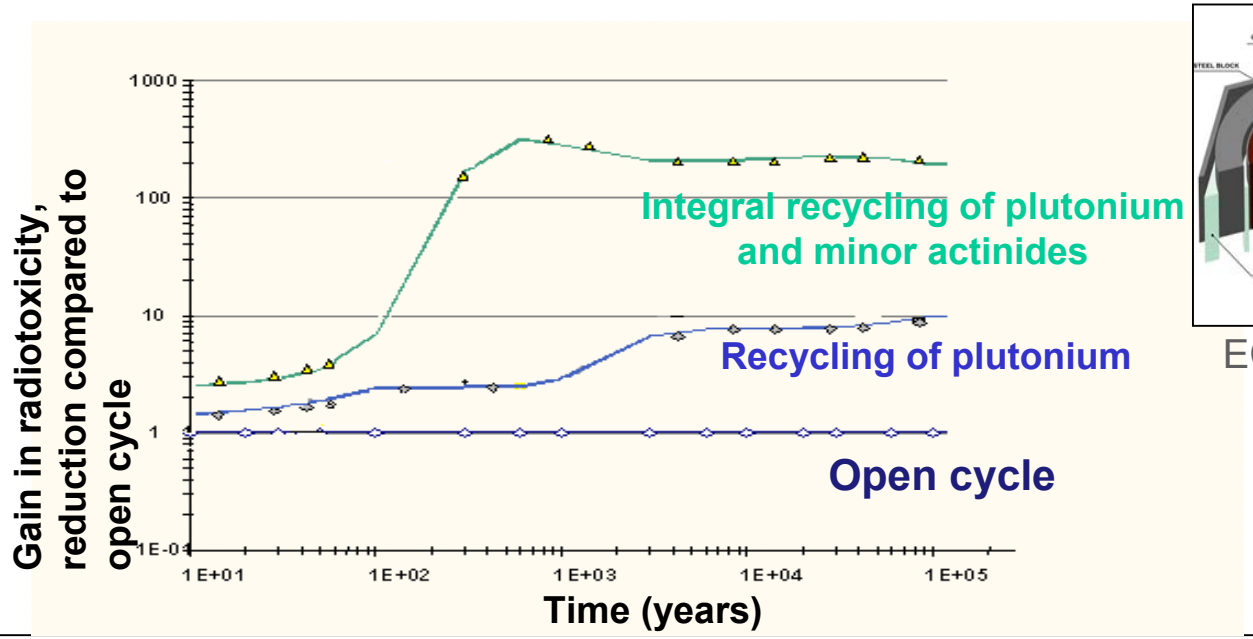
Transmutation

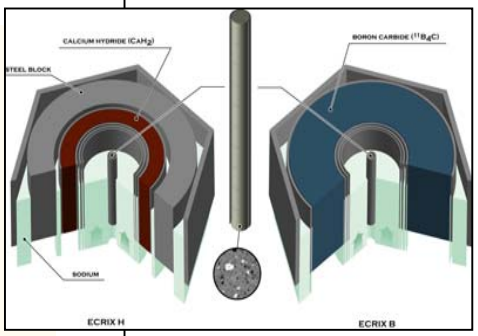
* *Physics and scenarios studies*

Feasibility of transmutation

Evaluation report

91 **Physics** **98** **01** **scenarios** **and systems** **04** **Industrial stage** **~ 2040**





ECRIX (2,75 g of Am)

CENTRALE PHENIX CEA-EDF

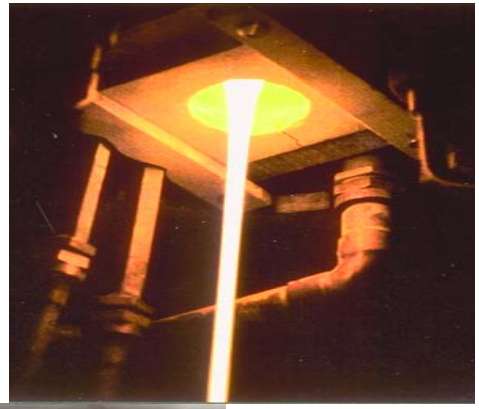
Conditioning and long term interim storage

Conditioning

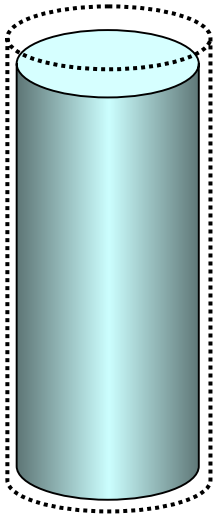
** processes*

Processes available for various categories of waste

91 Development and qualification of processes → 02 Technological qualification → 04 Evaluation Report



Alteration of glass by water



** Long term behaviour of waste packages*

Operational models

01 Phenomenology - modelisation → 05 qualification → Evaluation report

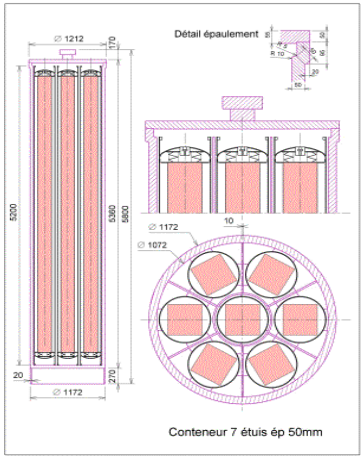
* Containers

Fonctional demonstrators

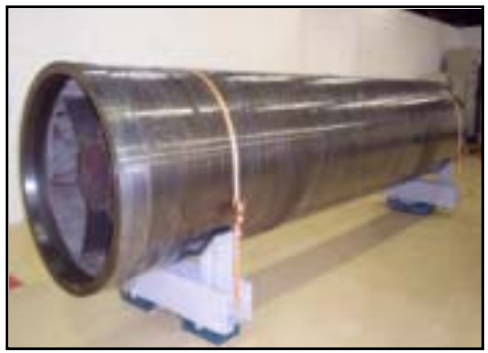
Technological demonstrators

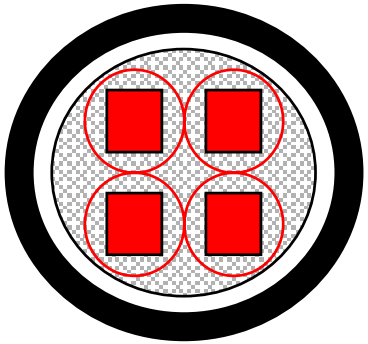
02 Specification, fabrication of demonstrators → qualification **04** → **Evaluation report**

CECER
(Centre d'Expertise sur le Conditionnement et l'Entreposage des matières Radioactives) at Marcoule



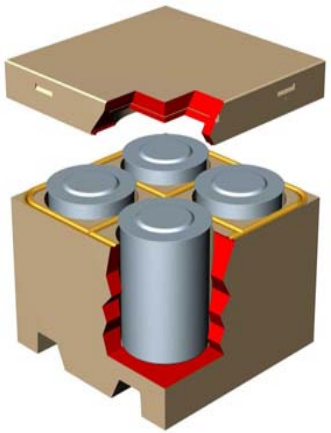
Containers for spent fuel





Storage

Storage - Disposal

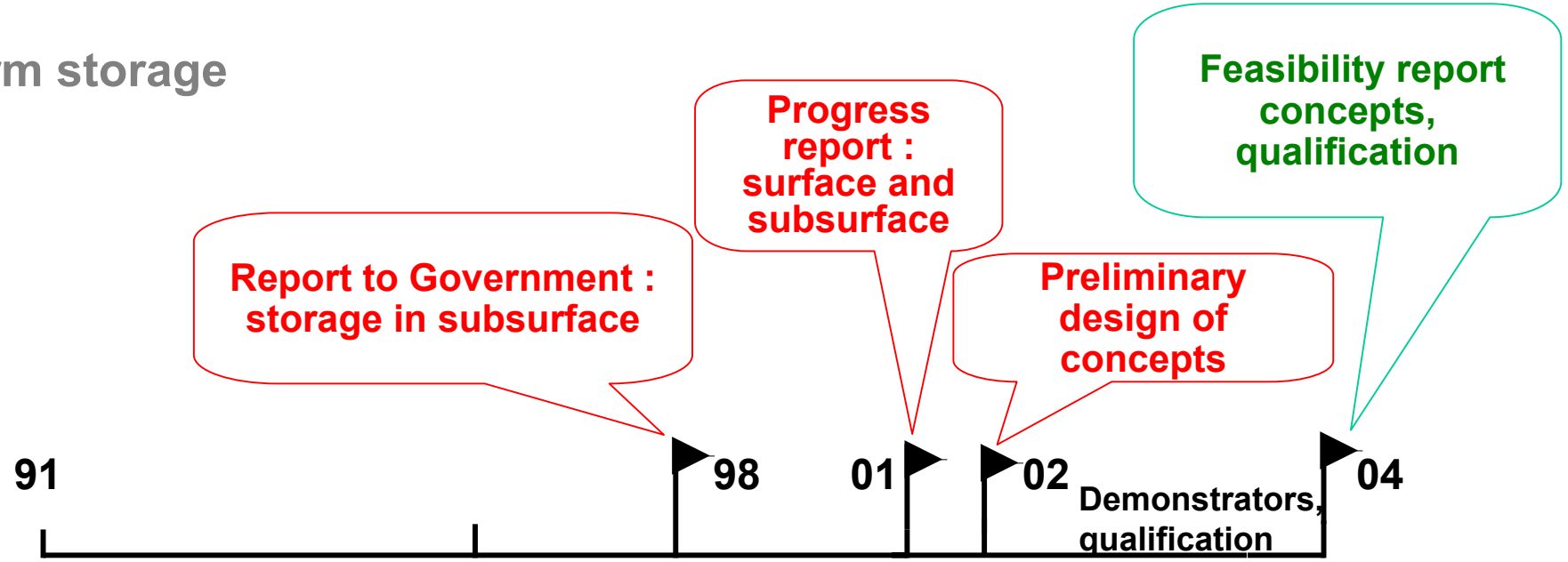


Containers for ILLW

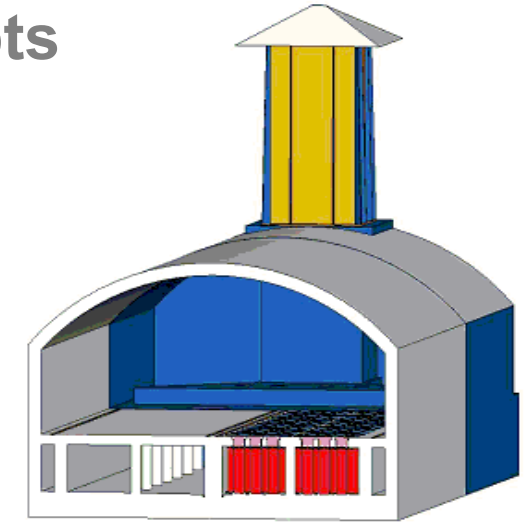
Internal barrel in ceramics

Internal barrel in enameled steel

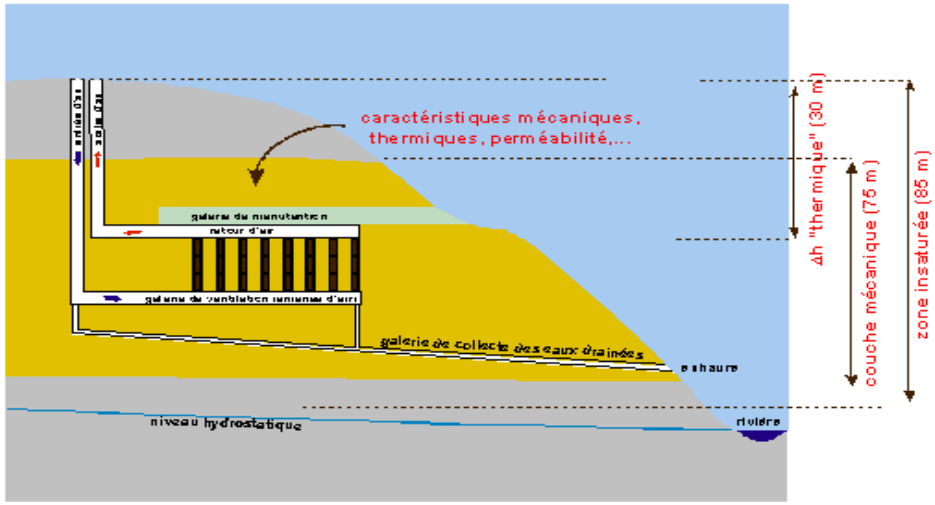
Long term storage



Concepts



Storage in surface

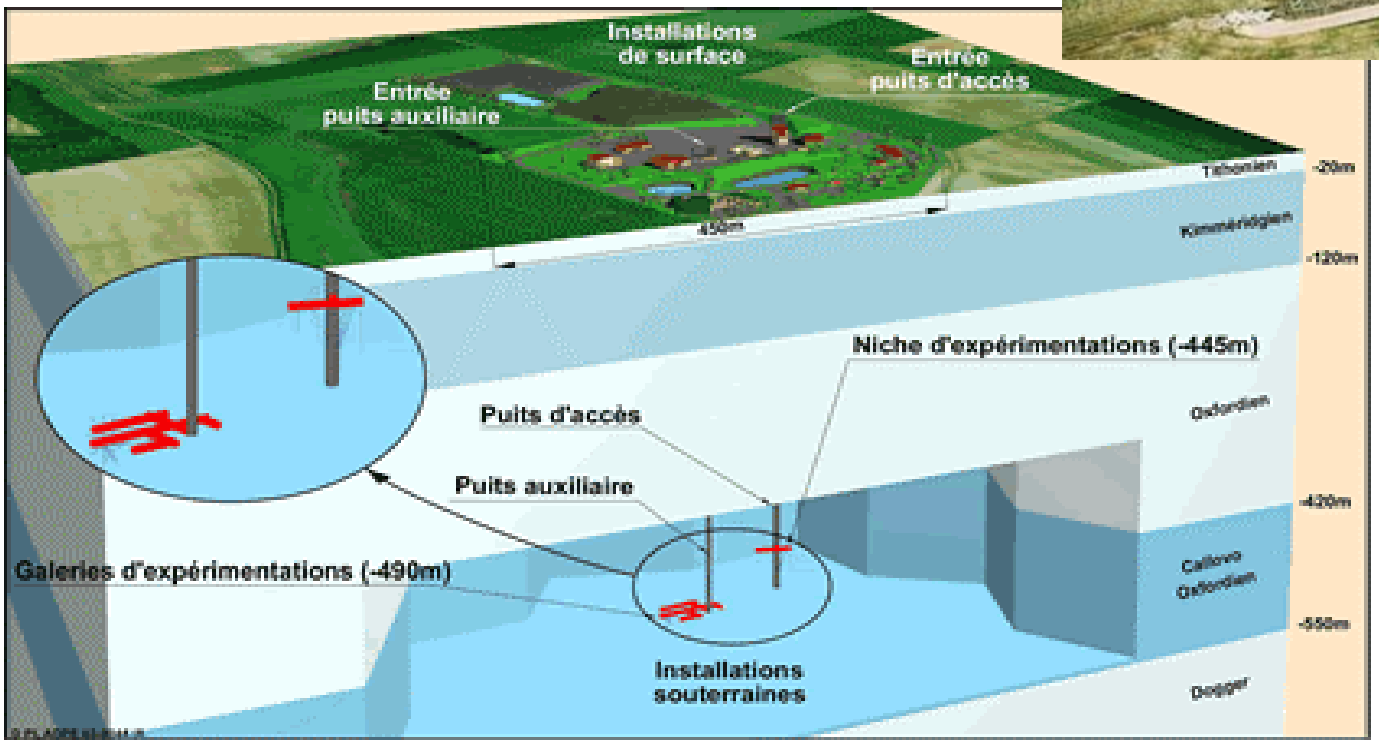


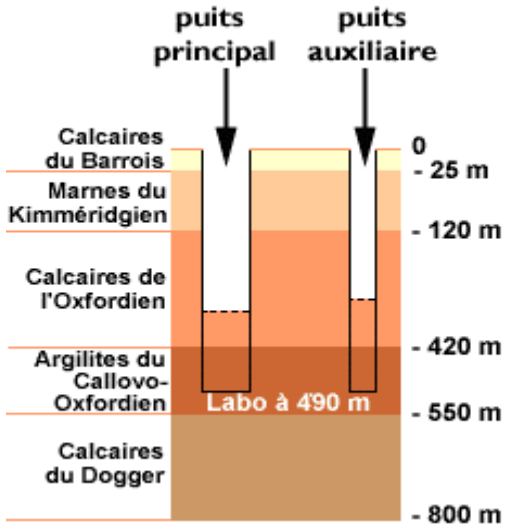
Storage in subsurface

Deep geological disposal

Meuse-Haute-Marne Underground Laboratory

General architecture of the laboratory





PERSPECTIVES

Closing the fuel cycle has a major impact on :

- Minimization of waste
- Resources Extension

Technical solutions do exist, progressive implementation

-Reprocessing and recycling for sustainable nuclear energy

-Quite advanced processes (minimisation of volume and radiotoxicity, safe conditioning) at competitive industrial maturity

-Recycling of plutonium in present LWR is demonstrated at large scale; further possible improvements with 3rd generation LWR type reactors

Next steps for the future

-4th generation systems with closed fuel cycle for integral recycling of actinides

➡ ***HLLW decay within some hundred years***

Safe long term management of waste

-Geological disposal of ultimate waste = long term burden free solution , taking benefit from the most important reduction of the quantity and toxicity of waste brought by closed fuel cycle

-Storage of radioactive material ➡ flexibility

Fuel cycle : Perspective for actinides management