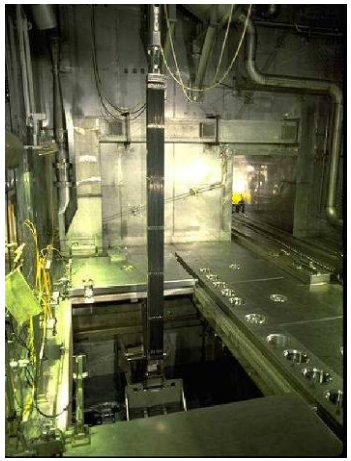
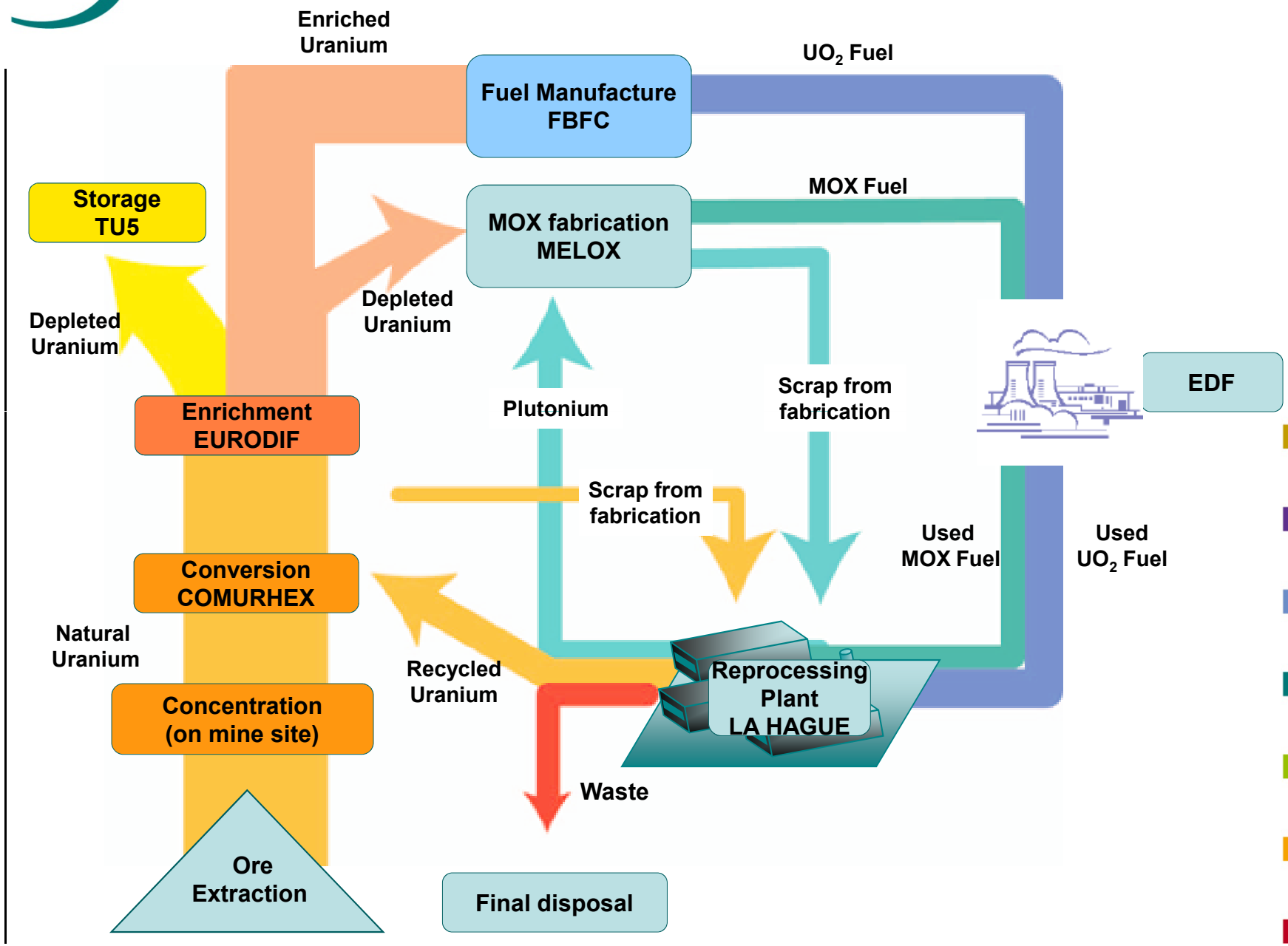
French oversight of fuel cycle facilities

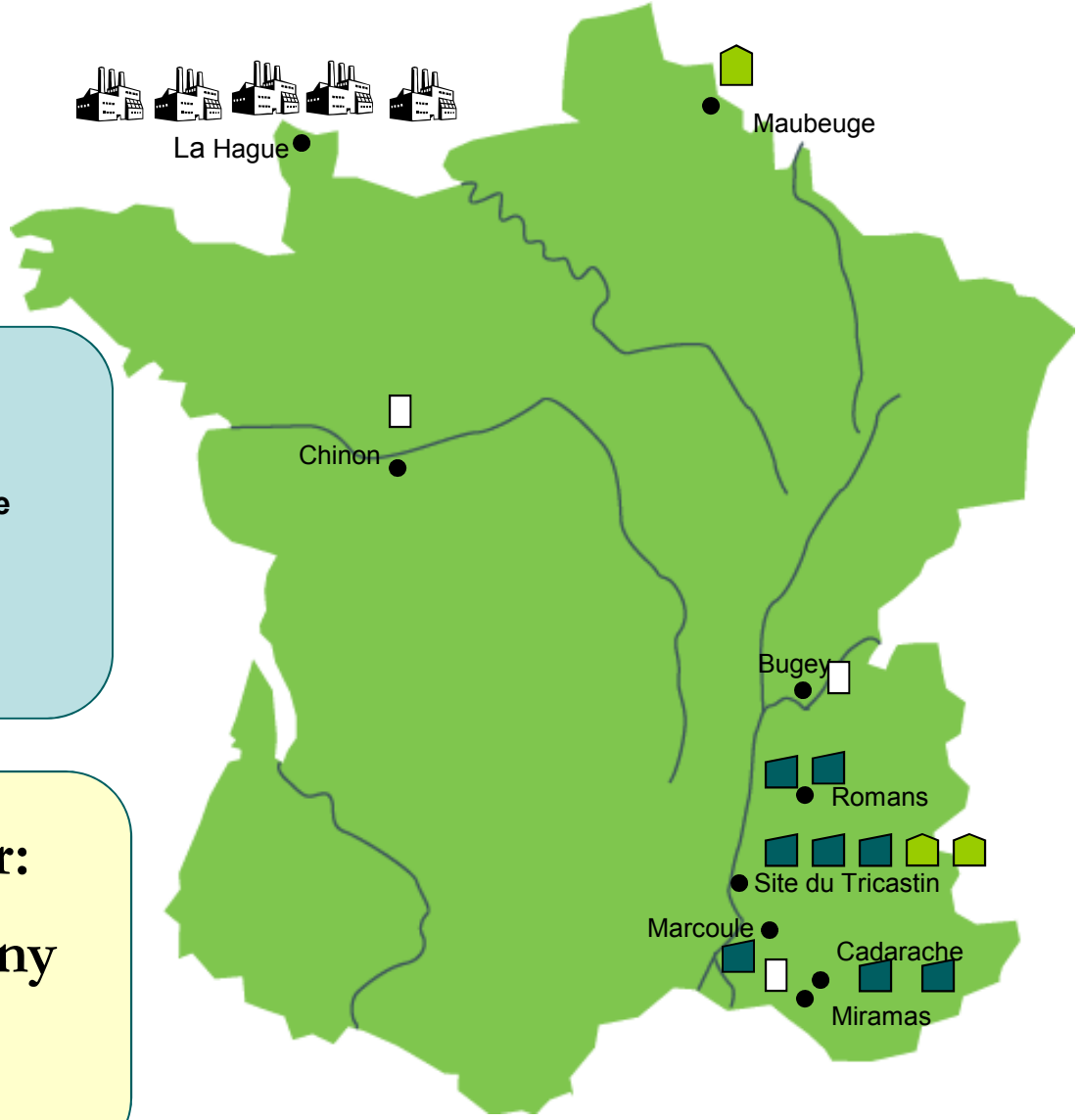


Jean-Luc LACHAUME, ASN DDG

The French fuel cycle



The French fuel cycle: main nuclear facilities



Upstream fuel cycle
(enrichment, fabrication)

Downstream fuel cycle
(reprocessing)

Storage facilities

Fuel workshops

A single operator:

AREVA's company

AREVA

Upstream fuel cycle: extraction - concentration

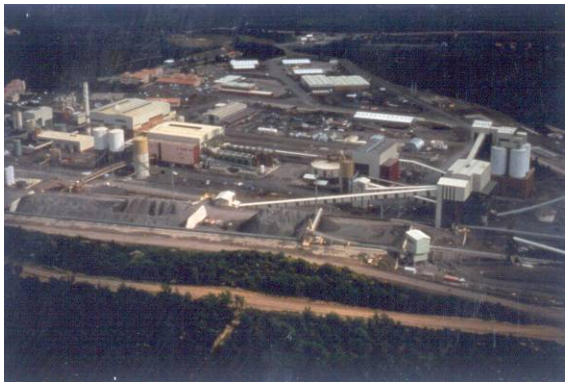
- Transformation of the uranium ore into a purified concentrate (yellow cake)
- Metallurgic and chemical processes

  - *Mechanical preparation*
  - *Chemical treatment*
  - *Liquid-solid separation*
  - *Purification*
  - *Concentration*

  ❶ **Stages of the uranium's purification**

  - *Release treatments*
  - *On-site water treatment*

  ❷ **Stages of waste treatment**



- Closure of the last French uranium mine (Jouac) in 2001

Upstream fuel cycle: conversion – enrichment (1)

- **Enrichment: a necessity**
  - **Natural U : 0,7 % on U_{235} → Reactor U : 3 à 5 % in U_{235}**
- **Conversion: uranium's fluoration**
  - **Preliminary step to enrichment:**
    - Utilization of a handleable gas at 80°C
    - Choice of Fluor: one isotope → permits the use of the weight's difference between U_{235} et U_{238} in the enrichment process
  - **COMURHEX company:**
    - Transformation of the yellow cake to UF4 at Malvési plant (Aude)
    - Transformation of the UF4 to UF6 at Pierrelatte plant (Drôme)
  - **Standard capacity: 14 000 t/year**

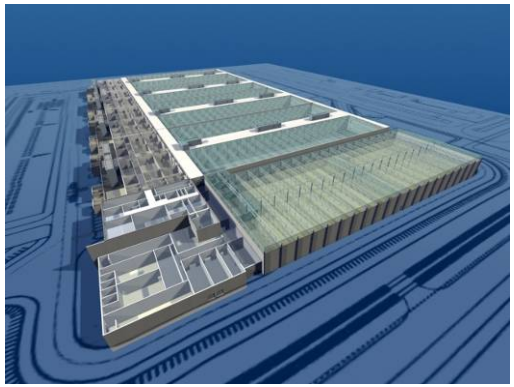
Upstream of the fuel cycle: conversion – enrichment (2)

EURODIF (Pierrelatte)

- Process: gaseous diffusion (cascades)
- Standard capacity: 11,8 MUTS (équivalent of 100 recharges 900MWe PWR)
- 1/3 of the world's civil enrichment market

GBII (Pierrelatte)

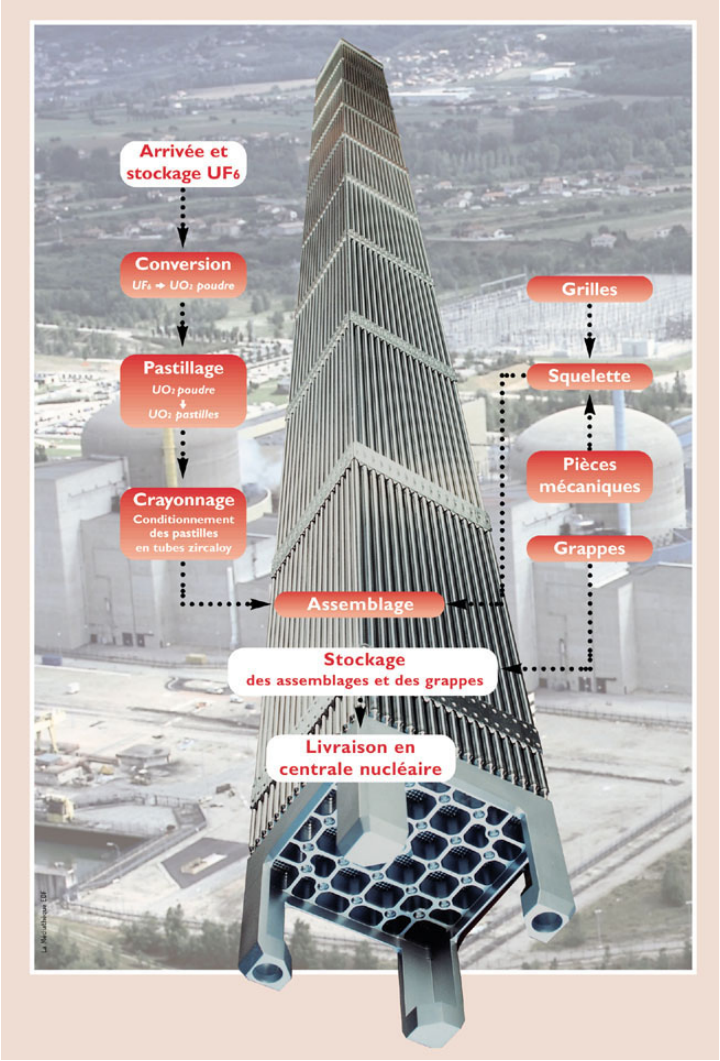
- Process: ultracentrifugation (URENCO's technology)
- Progressive replacement of the EURODIF plant (start: 2011)
- Benefits: lower source term of uranium (divided by 1000), lower use of electricity (from 3x900 MWe PWR to less than 1)



Fuel fabrication (1)

➢ Uranium fuel: FBFC plant (Romans)

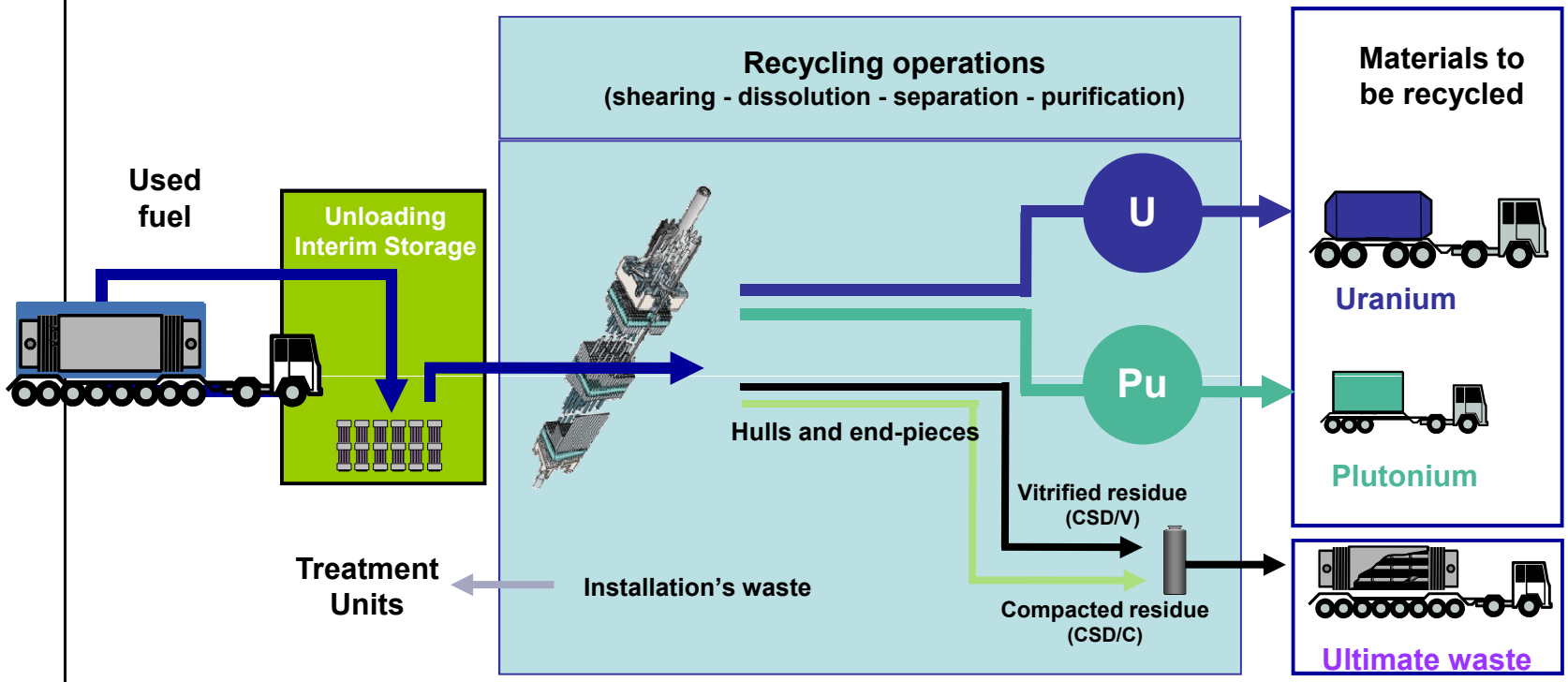
- **Standard capacity:**
  - Conversion : 1800 t/year
  - Pastillage : 1400 t/an
- **Taking up the activities of Pierrelatte plant (stopped in 1998) and Dessel plant (Belgium)**



Fuel fabrication (2)

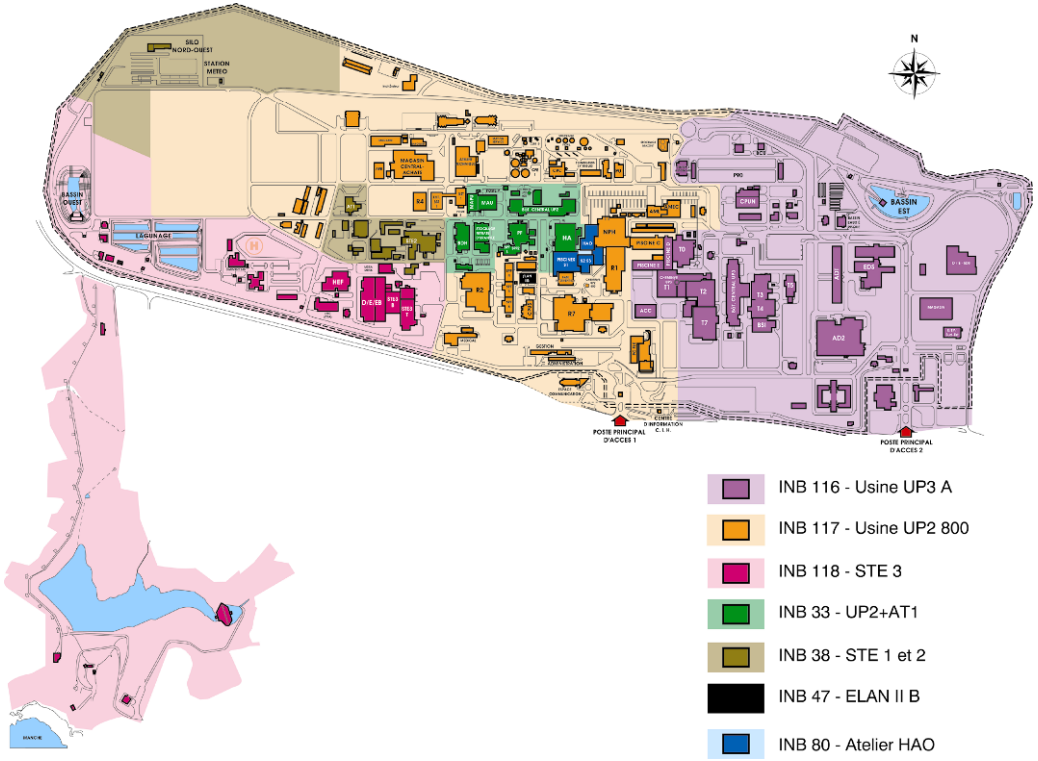
- **MOX (uranium-plutonium) fuel: Mélox plant (Marcoule)**
  - Standard capacity: 195 t/year
  - Taking up the activities of the ATPu plant in Cadarache (stopped in 2003)

Spent fuel reprocessing (1)



Spent fuel reprocessing (2)

- 540 acre
- 7 nuclear installations
- More than 3 000 AREVA employees
- More than 3 000 other workers each year
- Reprocessing capacity: 1 700 t/year
- Environmental impact < 0,02 mSv



Main safety stakes of the fuel cycle

Main risks:

CRITICITY
geometry - mass - moderation

CHEMISTRY
ex: UF6 - acids

CONTAINMENT
Static and dynamic

HUMAN FACTORS
Organization - ergonomy

ON SITE HAZARDS
Fire - explosion

OFF SITE HAZARDS
earthquake - fire –
airplane crash – weather conditions

The French classification of radioactive waste

Activity \ Period	Very short-lived (<100 days)	Short-lived (<30 years)	Long-lived (>30 years)
Very low level	Management by radioactive decay	**VLL surface disposal** (or recycling) Activity < 100Bq/g	
Low level		Surface disposal (Aube repository)	Sub-surface disposal (under investigation)
Intermediate level			under investigation within the framework of article L. 542 of the Environment Code
High level			

Anticipated volumes in 2020 (ANDRA inventory – March 2006)

- **580,000 m³**
- **105,000 m³**
- **1,193,000 m³**
- **3,600 m³ of HLW**

And 55,000 m³ Of LL ILW

The final deep geological disposal

R&D program in progress in the underground laboratory of Bure

2005 | 2009 | 2012 | 2014 | 2025

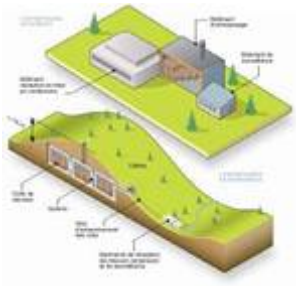
Feasibility of GD in clay formation

Report for public debate
Sitting of underground and surface facilities

Commissioning

License application for creation
- **Safety assessment**
- **Waste acceptance criteria**
- **Assessment of environmental and radiological impact**

- **Suitable interest zone within the transposition zone**
- **Options for design, LT safety, reversibility**
- **Updated waste inventory model**
- **Options for LT storage**



Thank you for your attention!

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