ONDRAF/NIRAS

September 22nd 2023

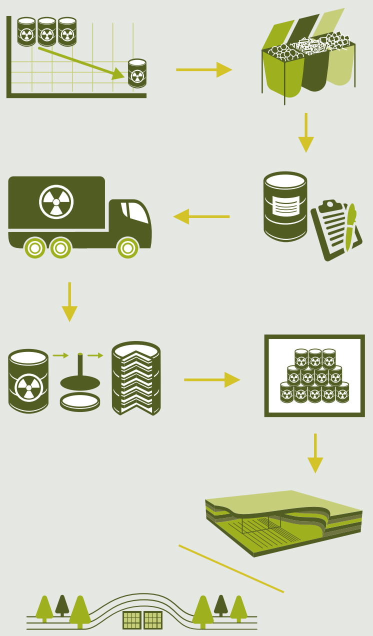
Radioactive waste management in Belgium

Potential Impact of SMR

Didier LEONARD

What does ONDRAF/NIRAS do?

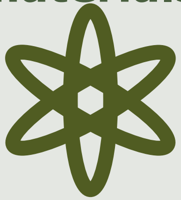
Radioactive waste management



Dismantling and remediation

Inventory

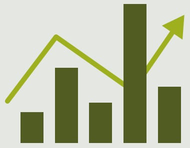
Enriched fissile materials



Scientific research

Preparation of policy

Socio-economic investments

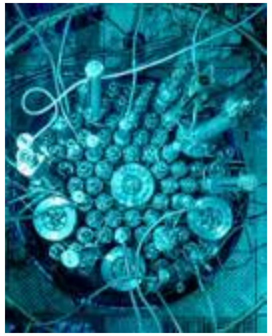


Participation and involvement

Long-term financing

Origin

of radioactive waste



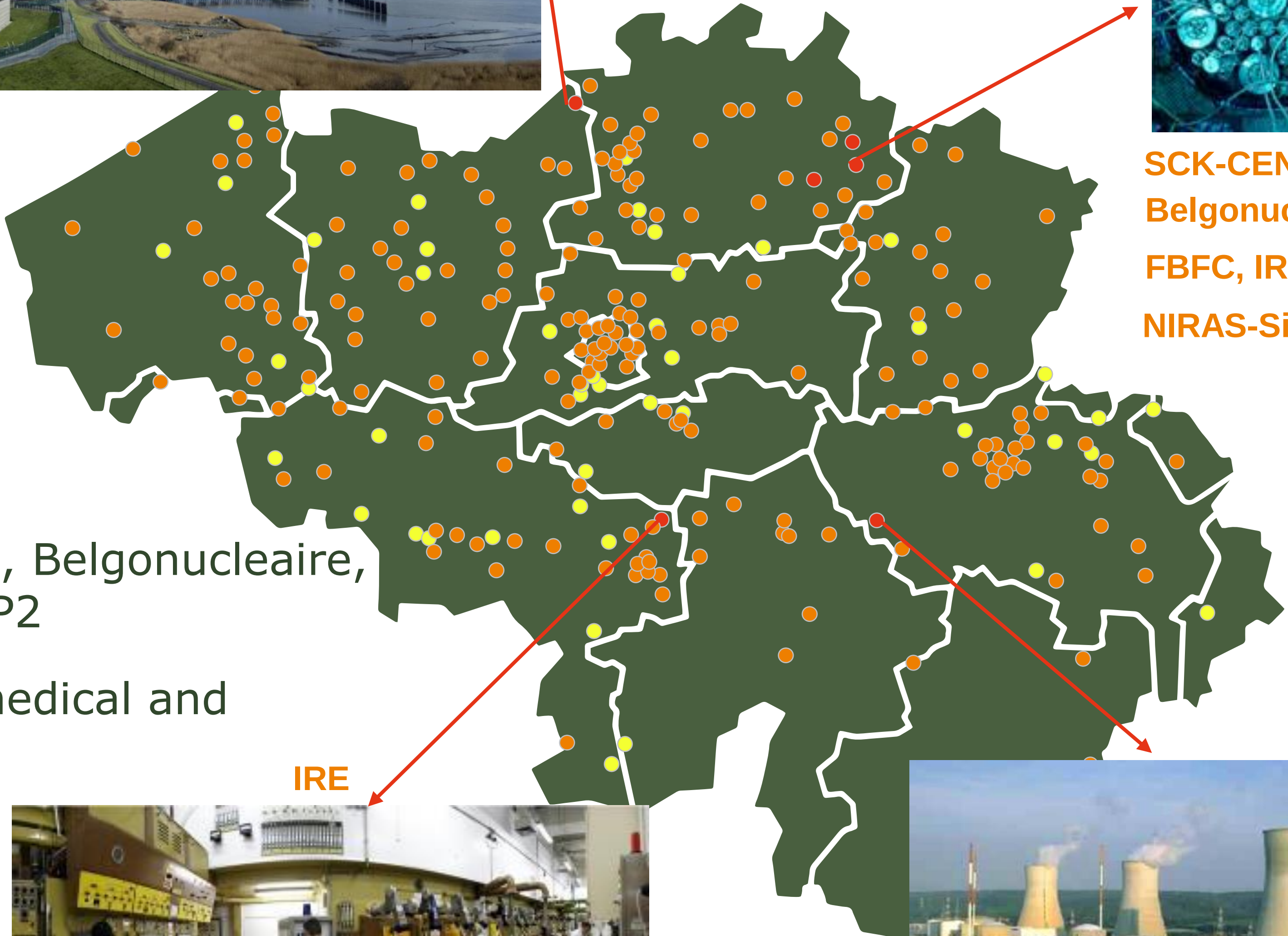
SCK-CEN

Belgonucleaire

FBFC, IRMM

NIRAS-Site Dessel

Universities, Hospitals,
X-Ray users,…

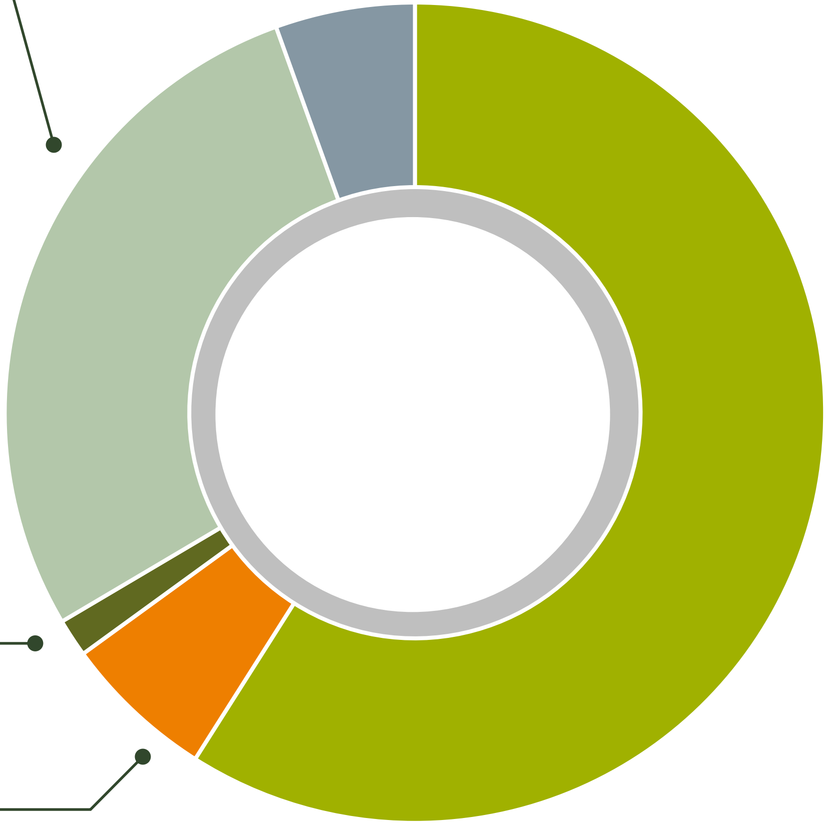


- **Class I:** Doel and Tihange, FBFC, Belgonucleaire, SCK CEN, IRE, IRMM, BP1 and BP2
- **Class II:** mainly research and medical and industrial applications
- **Class III:** mainly non-nuclear industry actors and laboratories

IRE

Current production of waste

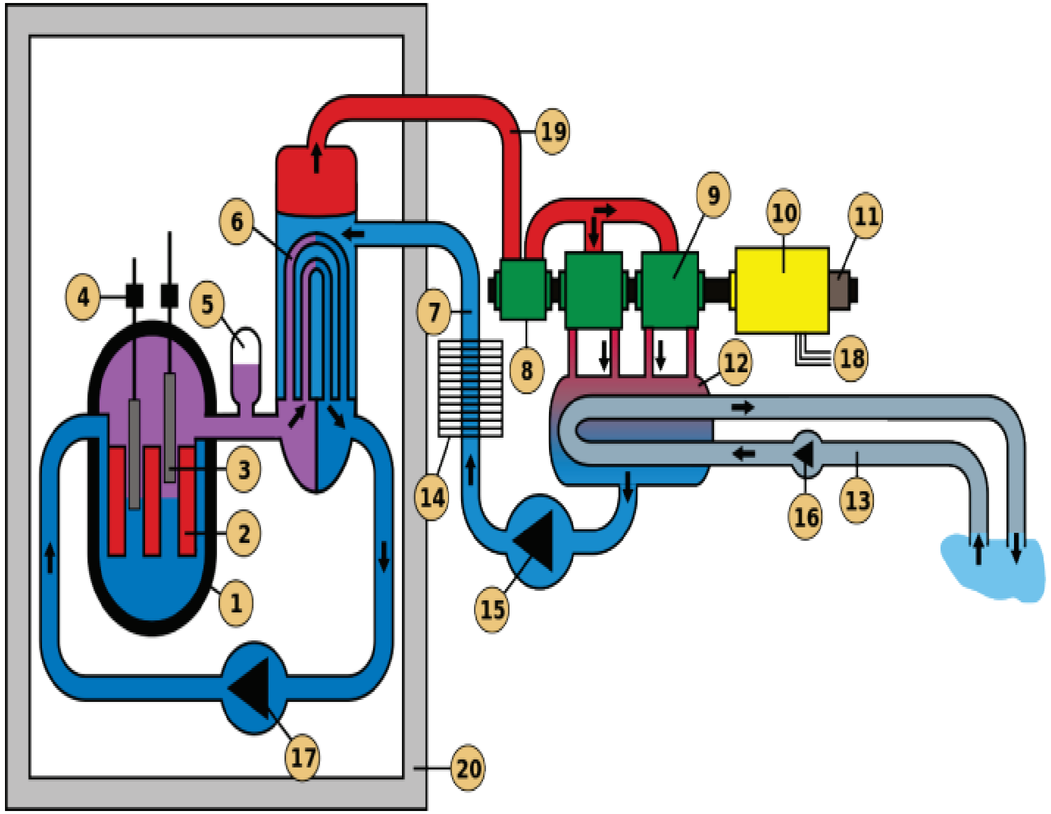
in Belgium [2017]



Radioactive waste in Belgium

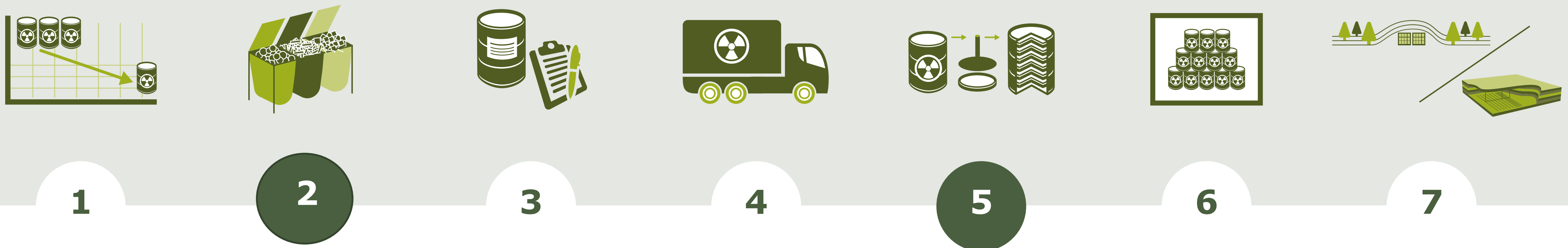
Origin of the radioactivity in a PWR

- **Fission products (FP)** (Cs-137, I-129, Sr-90, Xe-133, …)
  - Built-up in nuclear fuel (fission U-235 & Pu-239)
  - Diffusion to the primary circuit through cladding defects
- Production of heavy nuclides : isotopes of U and Pu + **minor actinides (Np, Am, Cm,…)**
- **Activation products** (Co-60, Ni-59, Ni-63, …)
  - Built-up by neutron activation of
    - Fuel rods and assemblies (^{14}C)
    - Corrosion products from components of the primary circuit
  - Circulation and deposition on the internal side of piping and equipment in contact with the water of the primary circuit
- **Gaseous waste** from primary circuit (fission product gases + injection of hydrogen and nitrogen gas in CVCS)



Source: SPF Economie

Sustainable radioactive waste management



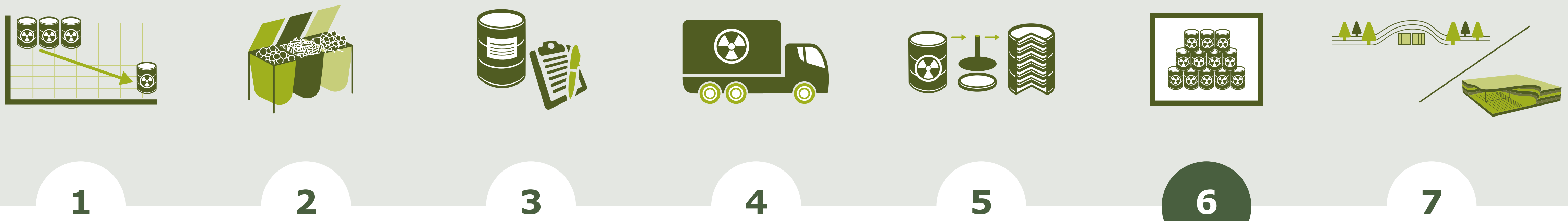
Short Term Management

SORTING/PROCESSING

SORTING

COMPACTION

PROCESSING AND ENCAPSULATION



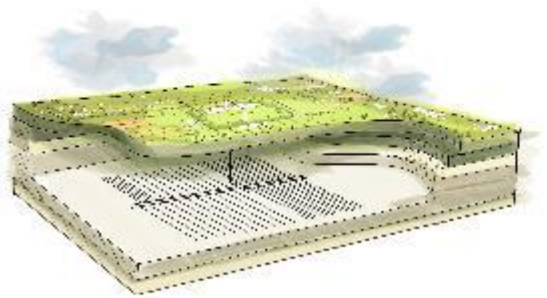
Medium Term Management

TEMPORARY STORAGE

LLW

Vitrified HLW

Long term management



Three waste categories

	Low activity	Medium Activity	High activity
Short lived	Category A Hundreds of years		Category C
Long lived	Category B Hundreds of thousands of years		

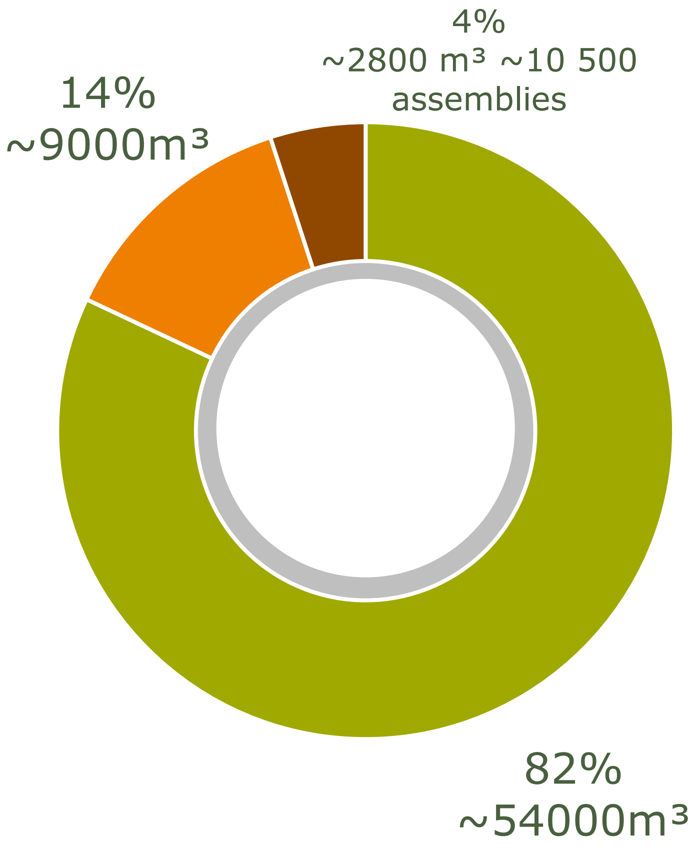
- End 2022 → Royal Decree : First step to a National Policy to manage B&C waste
- Geological disposal on the Belgian Territory
- Decision-making process – Societal debate organised by King Baudouin Foundation
  - Start : April 2023
  - Site web : https://www.presentspourlefutur.be/

NU VOOR MORGEN

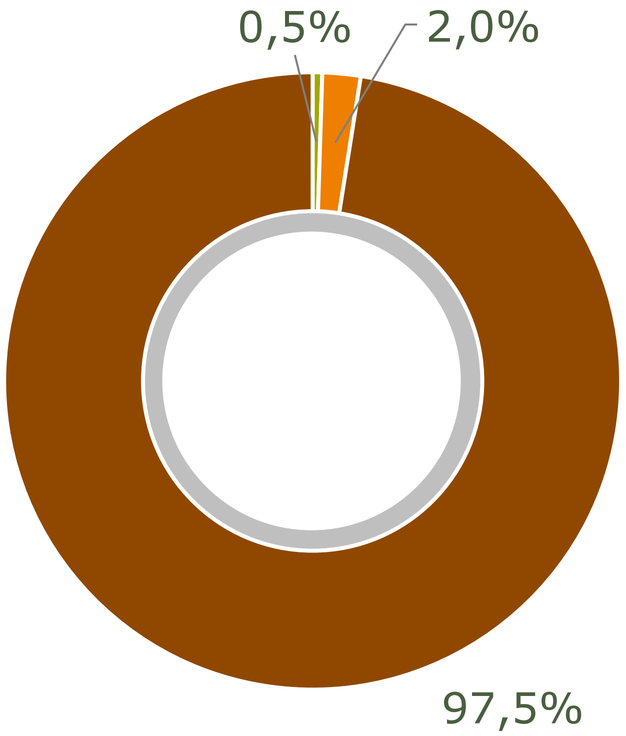
PRÉSENT·E·S POUR LE FUTUR

Volume and activity

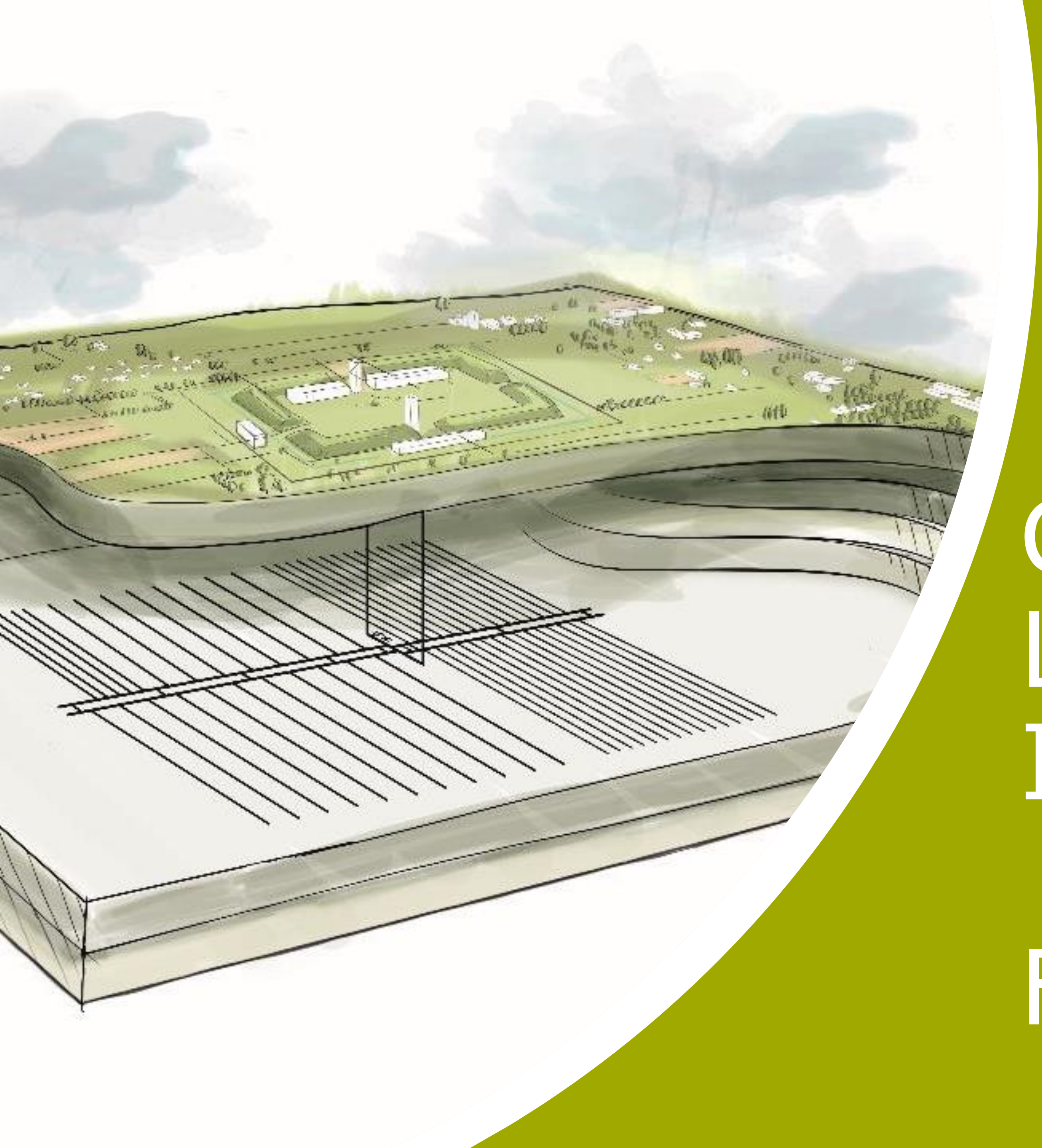
► **Volume**



► **Activity**



- Low activity
- Medium activity
- High activity

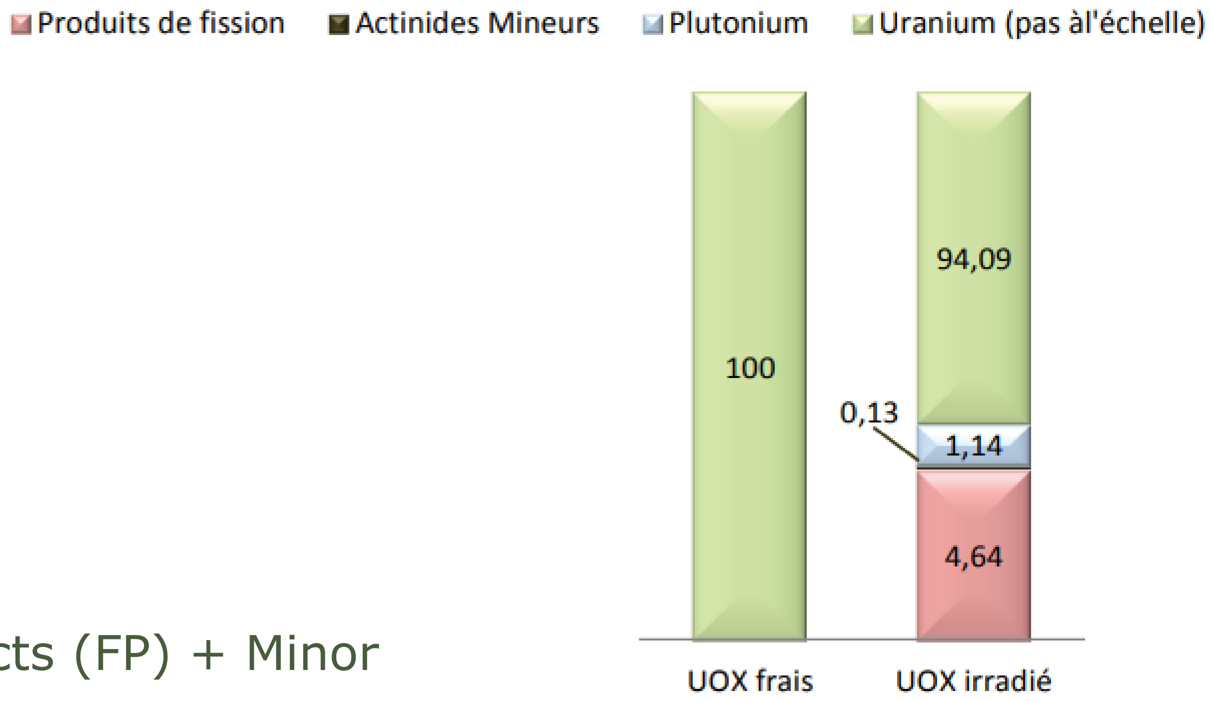


Geological disposal
Long-lived waste
ILW and HLW

Focus spent fuel

Mass composition

Open cycle vs Closed Cycle



Spent fuel (450 kg)

- 95% fuel
  - 94% U-238/U-235 (427 kg)
  - 1% Plutonium (5 kg)
- 5% waste (18 kg): Fission Products (FP) + Minor Actinides (MA)

- Two options for the spent fuel management
  - Open Cycle → No reprocessing
  - Closed Cycle (mono) → Reprocessing

- Future perspective (SMR) : Multi-recycling+burner MA

Source des illustrations : AREVA/CEA/EDF/ SPF Economie

DOEL
Deactivation Pool

Dry storage SCG

Dry storage SF²

Dry storage (Doel)
- Dual-purpose metal cask, aircraft crash resistant
- Capacity : 165 casks (24 to 37 assemblies per cask)
- Concrete building

Electrabel

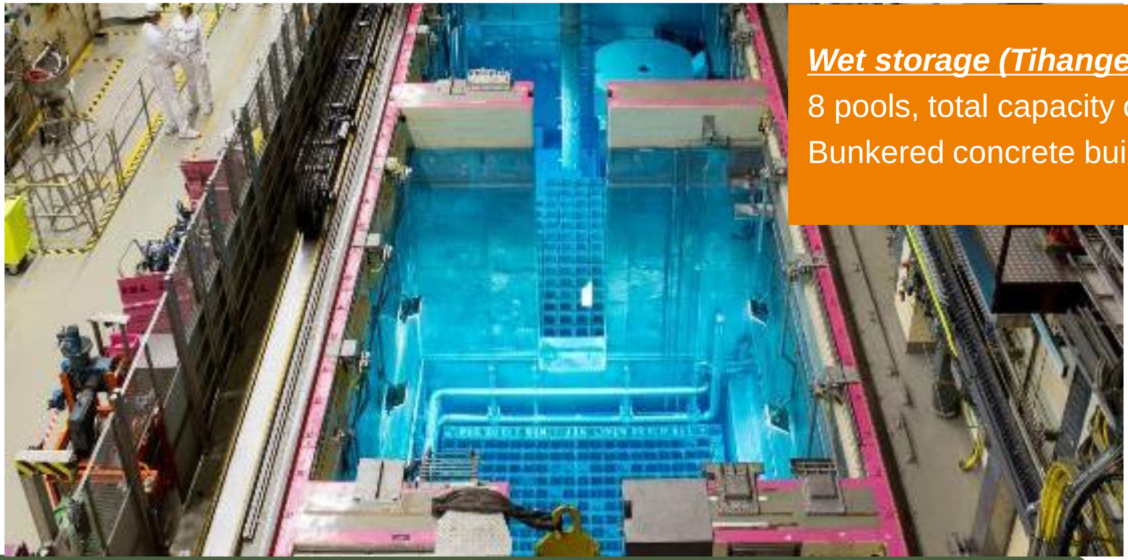
ONDRAF

Orano

TIHANGE
Deactivation Pool

Wet storage Pool DE

Dry storage SF²

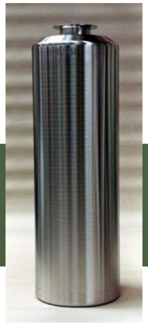


Wet storage (Tihange)

8 pools, total capacity of 3700 assemblies

Bunkered concrete building

ORANO
Reprocessing



ONDRAF
Storage BELGOPROCESS CSD-C/CSD-V

→ ~2130

Electrabel

ONDRAF

Orano

DOEL
Deactivation Pool

→

Dry storage SCG

Dry storage SF²

TIHANGE
Deactiation Pool

→

Wet storage Pool DE

Dry storage SF²

Conditioning Spent Fuel

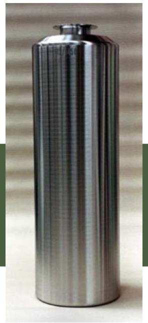
2065-~2080

2065-~2130

ONDRAF
Storage of conditioned fuel

ORANO
Reprocessing

→

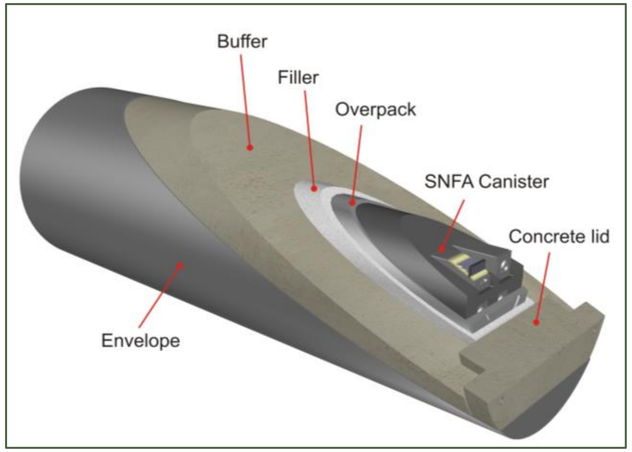


ONDRAF
Storage BELGOPROCESS CSD-C/CSD-V

→ ~2130

Post-conditioning

2117-~2130



DOEL
Deactivation
Pool

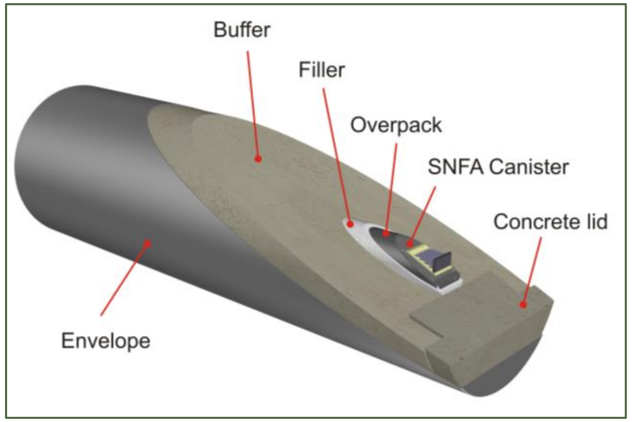
→

Dry Storage
SCG

Dry Storage
SF²

Conditioning
spent fuel

2065-~2080



TIHANGE
Deactivation
Pool

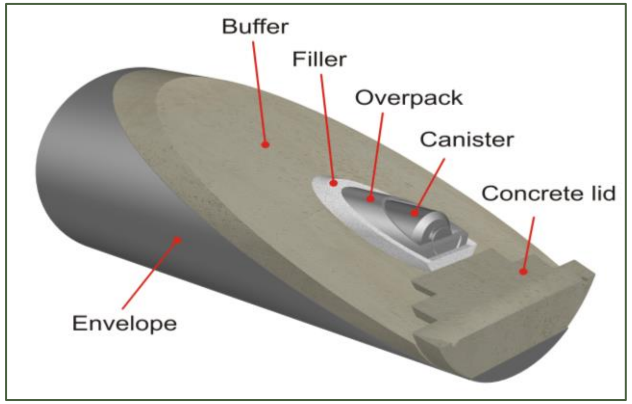
→

Wet Storage
Pool DE

Dry Storage
SF²

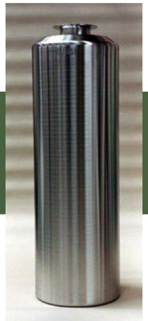
2065-~2130

Storage of conditioned spent fuel



ORANO
Reprocessing

→



Storage BELGOPROCESS CSD-C/CSD-V

→ ~2130

Post-conditioning

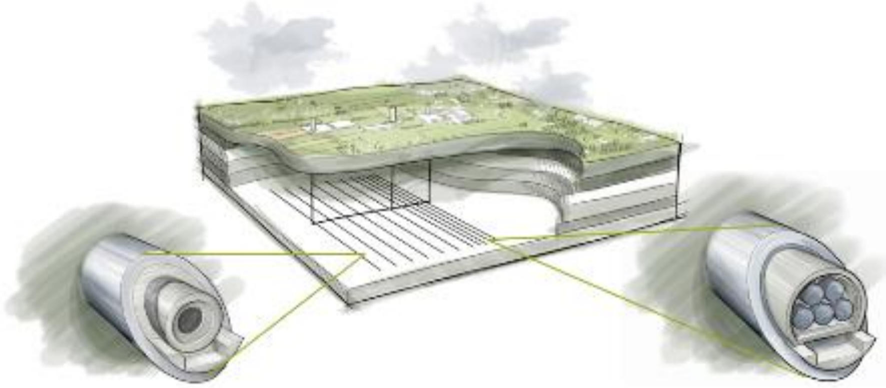
2117- ~2130

DOEL
Deactivation Pool

Dry Storage SCG

Dry Storage SF²

Geological disposal



Conditioning spent fuel

2065-~2080

TIHANGE
Deactivation pool

Wet Storage Pool DE

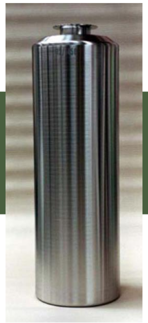
Dry Storage SF²

2065-~2130

Storage conditioned spent fuel

- Poorly indurated clay
- Depth 400 m
- Unique site for B and C
- License in 2050
- 12 Billions EUR

ORANO
Reprocessing



Storage BELGOPROCESS CSD-C/CSD-V

→ ~2130

SMR

Impact on waste management

- Lot of effort to develop SMR technology BUT (very) reduced R&D on waste/watt

- Two main impacts on waste management
  - Dismantling
  - Waste streams related to SMR technology

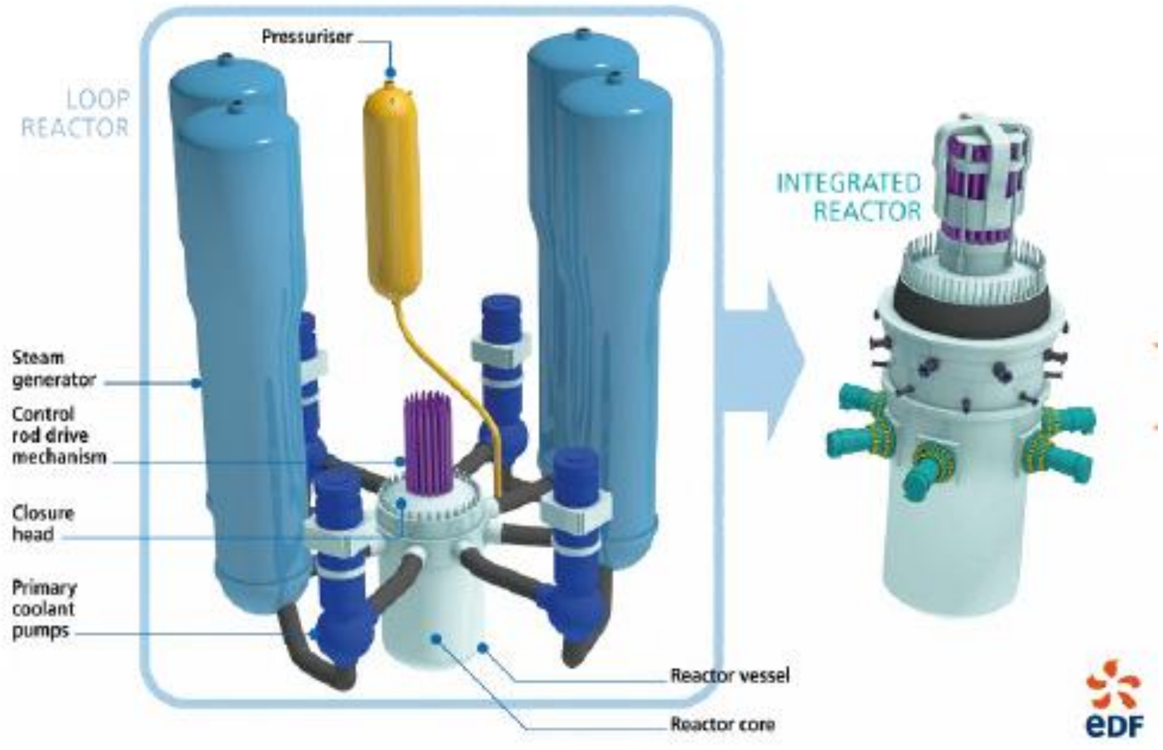
- Dismantling (D&D)
  - SMR = Modular → Improves D&D
  - Design for D&D → To be integrated in early phase of design
  - Potential increased neutron leakages → Increased activation → D&D

SMR

Impact on waste management

Waste stream

- Technology driven
  - LWR : No specific R&D for waste
  - FR → Reduces MA but still FP
  - Molten salt reactors - Liquid uraniun salt (uranium chloride)
    - Activation of chlorine salts → Cl-36
      → limited retention in the host rock
      → Extensive R&D required
  - Lower burnup
    - (+) Less heat
    - (-) Increased risk of criticality
  - Fuel backend : Open cycle vs closed cycle (multi-recycling)



FP Fission Products
MA Minor Actinides

Takeaways

In summary

- Radioactive waste are safely managed from cradle-to-grave
- SMR – Radioactive waste management
  - LWR → No specific issue
  - SMR is Modular → Ease the D&D activities (if integrated at early stage)
  - Management of the specific SMR waste (technology driven)
- Waste management for SMR is a critical topic for SMR deployment

→ **Need to anticipate future R&D needs for SMR specific radioactive waste**