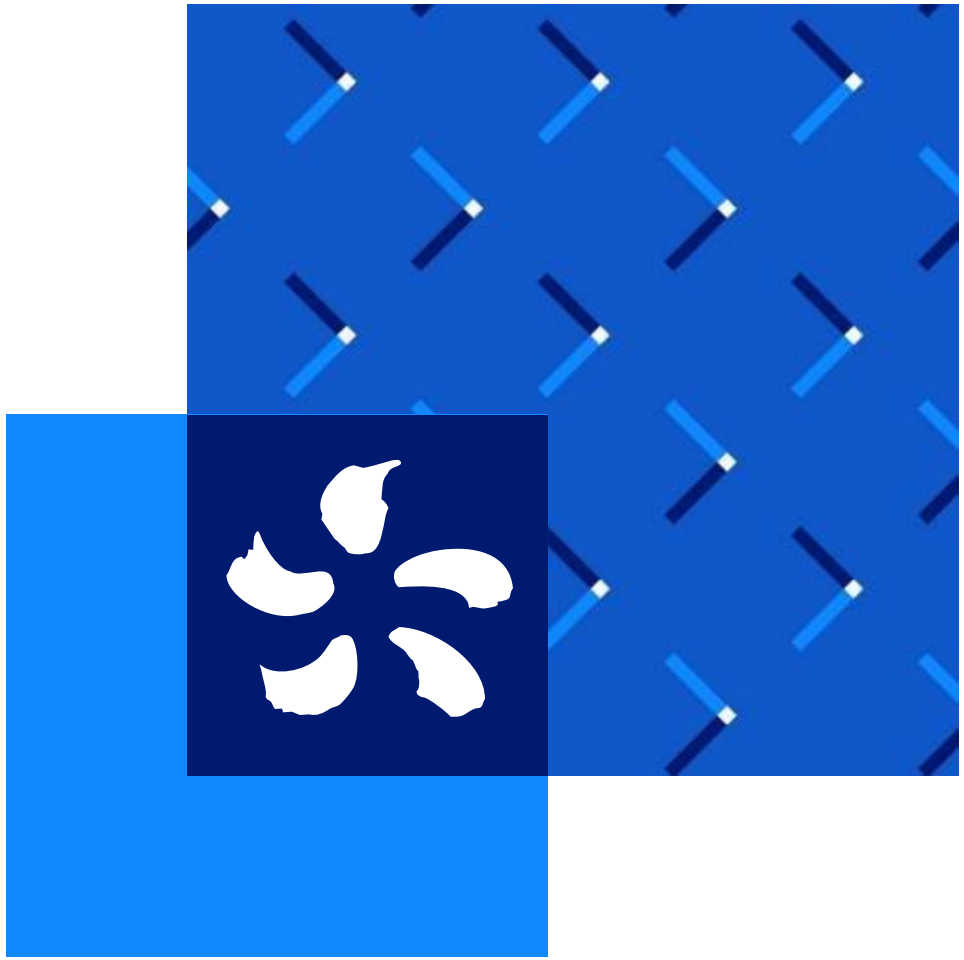


Decommissioning, Waste Management and Clearance System in France

Tsuruga International Symposium 2025
Overseas Advanced Practices

November 14th 2025

Patrick Dupeyrat
EDF Group Representative for Nuclear Decommissioning and Waste Management in Japan & Managing Director, Cyclife Japan

AGENDA

1. France’s D&D Landscape
2. EDF Group D&D Strategy
3. Decommissioning projects in France
4. Waste Solutions and Clearance
5. Optimizing Metallic Waste Streams
6. Conclusion and key messages

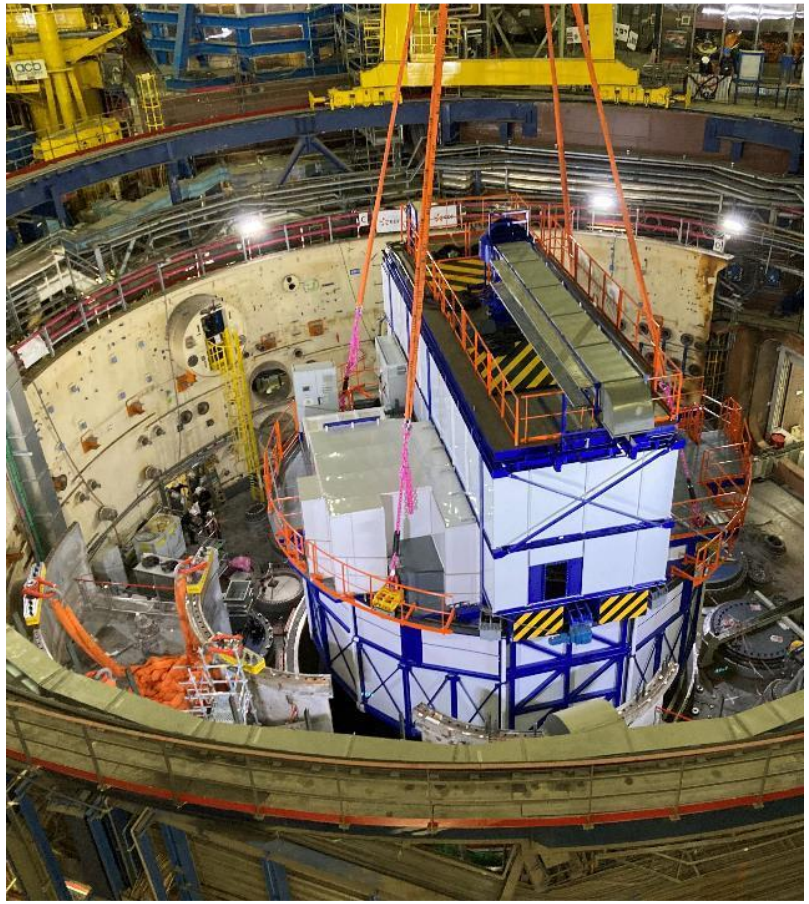
1. France’s Landscape

Governance, Strategy, and National Commitment to Decommissioning

From Operation to Decommissioning: France's Nuclear Commitment

Nuclear Context

- France operates one of the largest nuclear fleets globally, managed by a single operator—EDF
- Most reactors were built in the 1980s and are now reaching or exceeding their original 40-year design life.
- The government is investing in new EPRs and SMRs, signaling a long-term commitment to nuclear energy.



Dismantling & Decommissioning Strategy

- In France, D&D is a strategic national priority, essential for the credibility and sustainability of the nuclear sector.
- Immediate dismantling is mandated by French legislation and supported by operational readiness.
- Dismantling is carried out under the responsibility of the historical operator—EDF, ORANO, or CEA—depending on the facility.

France’s D&D Governance: Roles & Responsibilities

REGULATOR

Autorité de Sûreté Nucléaire et de Radioprotection

- Independent regulator for nuclear safety and radiation protection.
- Approves decommissioning plans, sets clearance levels, ensures public transparency.

STATE AUTHORITIES

French Government – Ministries for Ecological Transition and Economy

- Defines national nuclear policy and supports investment in dismantling and waste management.
- Oversees public assets and facilitates public dialogue

OPERATORS

EDF, Orano, CEA

- Directly responsible for dismantling and waste management of their respective facilities.
- Supported by a specialized supply chain, including companies providing D&D services, waste treatment, and related technologies.

WASTE REPOSITORY

Agence Nationale pour la Gestion des Déchets Radioactifs

- Public agency managing radioactive waste.
- Designs and operates disposal facilities
- Maintains national inventories and supports long-term waste planning

2. EDF Group D&D Strategy

Leading France’s Nuclear Operations and Dismantling Activities

EDF: France Nuclear Operator

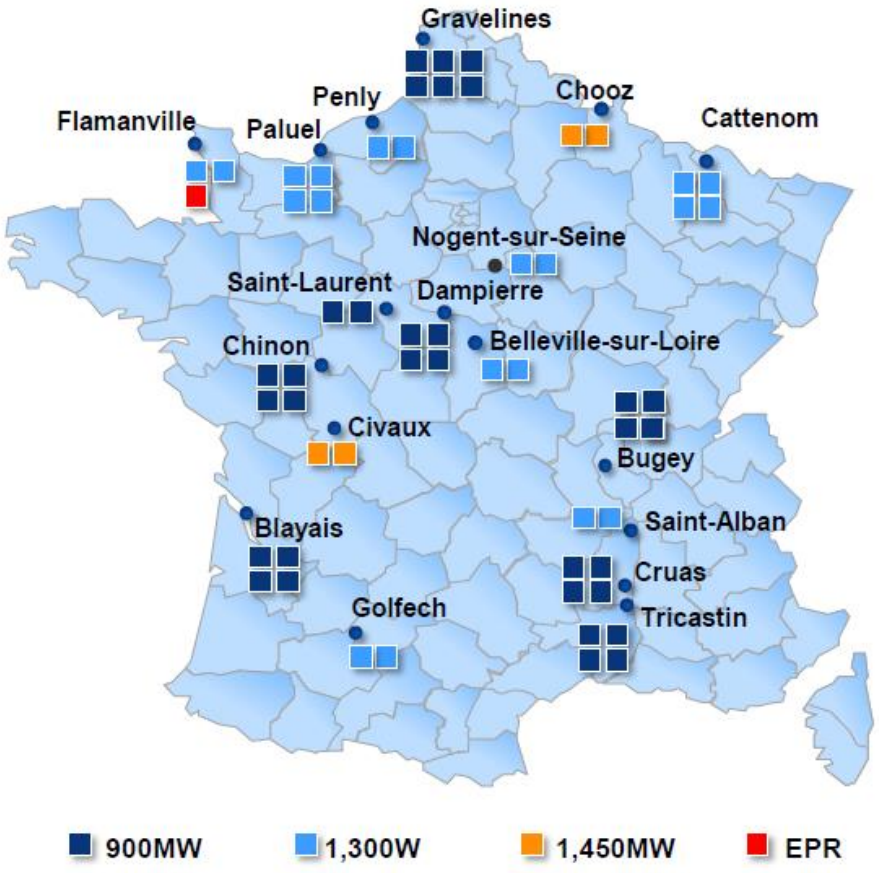
About the EDF Group

- EDF is a global leader in low-carbon energy, committed to building a net zero energy future. The Group serves 41.5 million customers worldwide, employs over 119,000 people, and generates 94% of its electricity without CO_2 emissions.
- EDF's activities span generation (nuclear, thermal, hydro, renewables) transmission, distribution, and energy services, making it a key player in sustainable energy solutions.

EDF's Nuclear Fleet in France

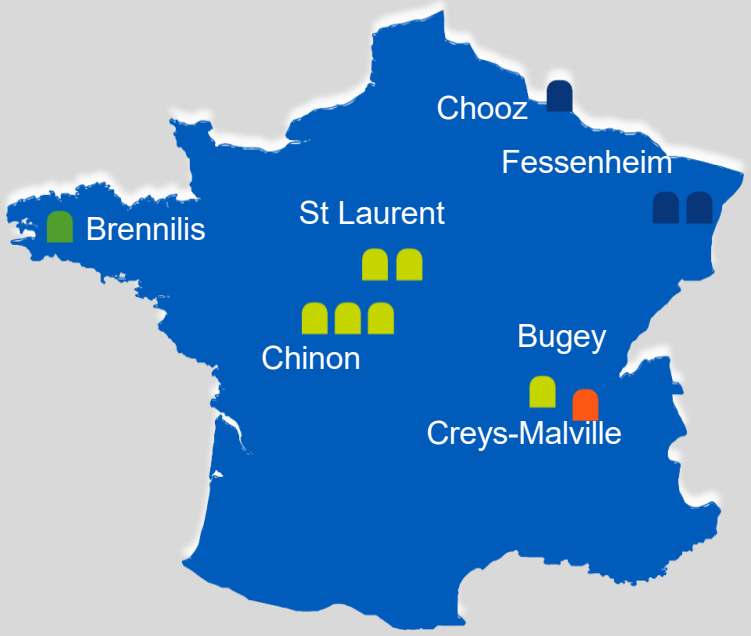
- EDF operates 57 reactors across 18 sites, all Pressurized Water Reactors (PWRs), and has one EPR in start up, Flamanville 3.
- EDF's 56 reactors generates 350 to 370 TWh/year, covering 70% of France's electricity needs, and are divided as follows:

- 900 MW : 32 reactors
- 1,300 MW : 20 reactors
- 1,450 MW : 4 reactors
- 1,600 MW : 1 reactor



Decommissioning and radioactive waste management within EDF

EDF decommissioning projects in France



Pressurized Water Reactor
Heavy Water Reactor
Graphite Reactor
Fast Breeder Reactor

EDF's Legal Responsibility

- EDF is legally responsible for dismantling its own nuclear reactors in France and is committed to: *"Assuming full responsibility as a nuclear producer by developing and promoting, with an international outlook, a high-performing industrial sector for deconstruction and radioactive waste management."*

Current Dismantling Scope

- 11 reactors under dismantling.4 reactor technologies: PWR (Pressurized Water Reactor), HWR (Heavy Water Reactor), Graphite Reactors, FBR (Fast Breeder Reactor).
- Additional facilities: graphite silos, research laboratories.

Organization & Resources

- Creation of DP2D in 2015 – EDF's dedicated entity for Decommissioning and Waste Management. Acts as Project Owner for EDF dismantling projects and manages all radioactive waste across the Group (operational and dismantling).
- Key Figures: ~1,200 employees dedicated to dismantling and waste management.

Cyclife – EDF's International Subsidiary for Decommissioning and Waste Management

In complement to DP2D, **EDF created Cyclife**, a wholly-owned subsidiary dedicated to nuclear decommissioning and radioactive waste management, with two key missions:

- Support EDF projects in France
- Deliver proven solutions to international markets

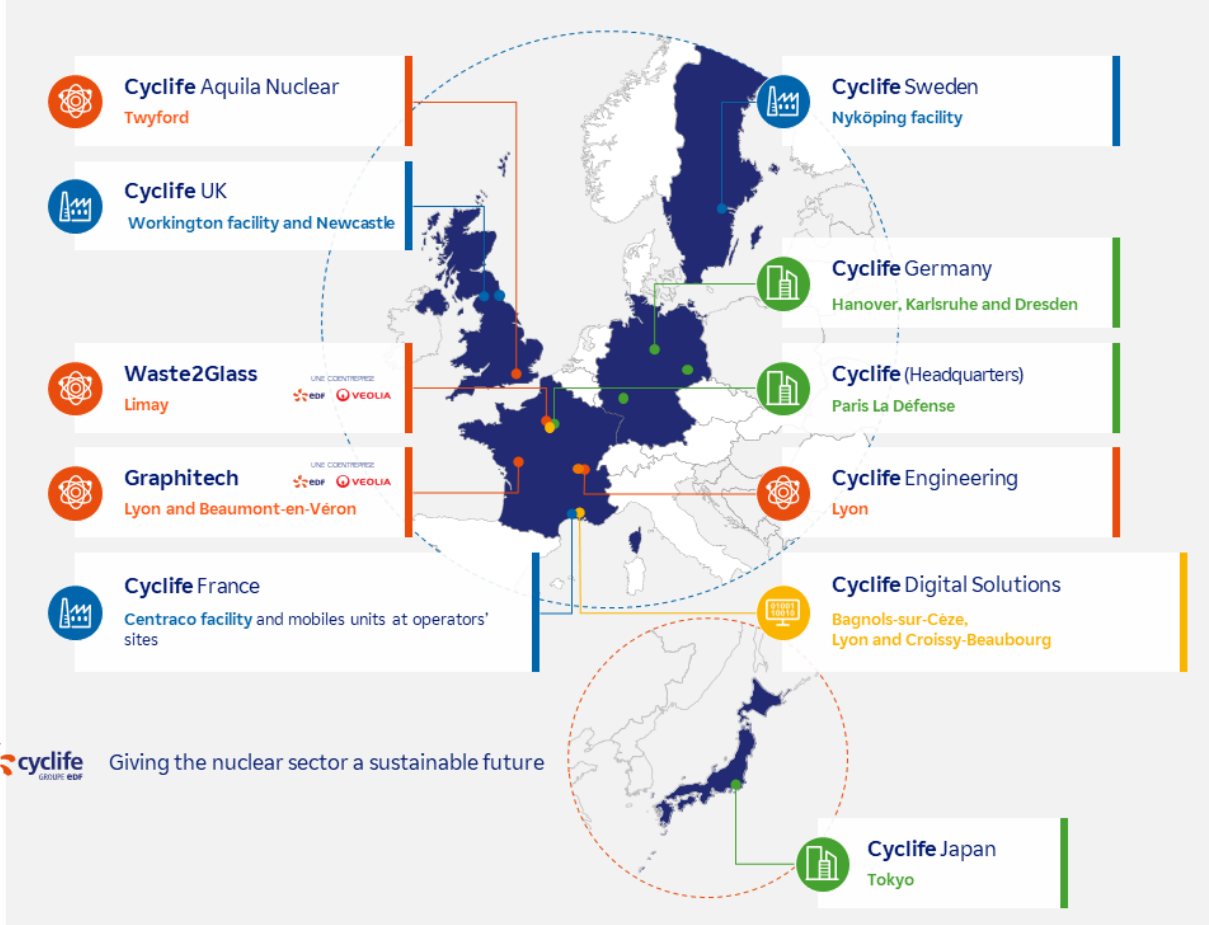
Activities

3 industrial facilities processing ~90,000 tons/year of radioactive waste

End-to-end dismantling expertise, from design to execution, using advanced remote-controlled tools and robotics

Specialized regional entities providing complementary expertise to strengthen Cyclife's integrated solutions.

Digital platforms for simulation, planning, and optimization to maximize efficiency in dismantling operations.



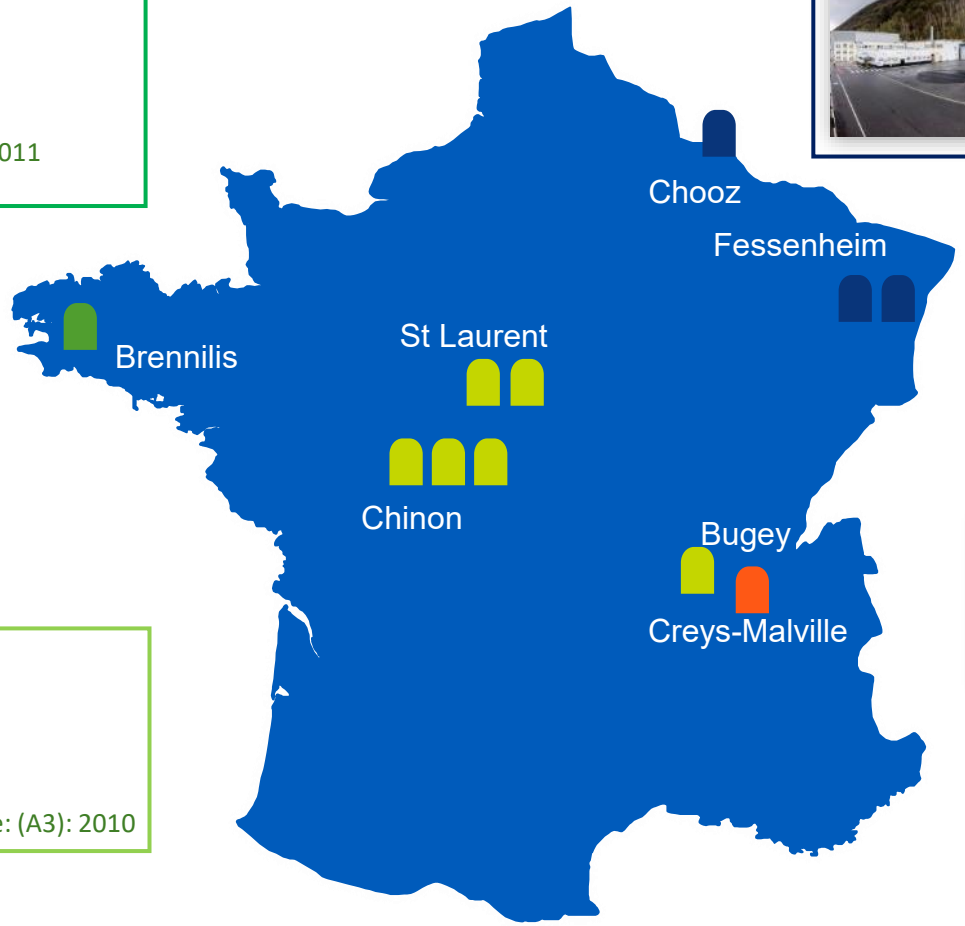
Resources:~1,400 employees operating across France, UK, Germany, Sweden, and Japan.

3. Decommissioning projects in France

EDF Decommissioning projects in France

Brennilis
HWR
1967-1985
Decommissioning decree: 2011

Chooz A
PWR
1967-1991
Decommissioning decree: 2007



Fessenheim
2 units PWR
1978-2020
Decommissioning decree: expected 2026

Saint Laurent
2 units UNGG
1969-1990 et 1971-1992
Decommissioning decree: 2010

Bugey
UNGG
1972-1994
Decommissioning decree: 2008

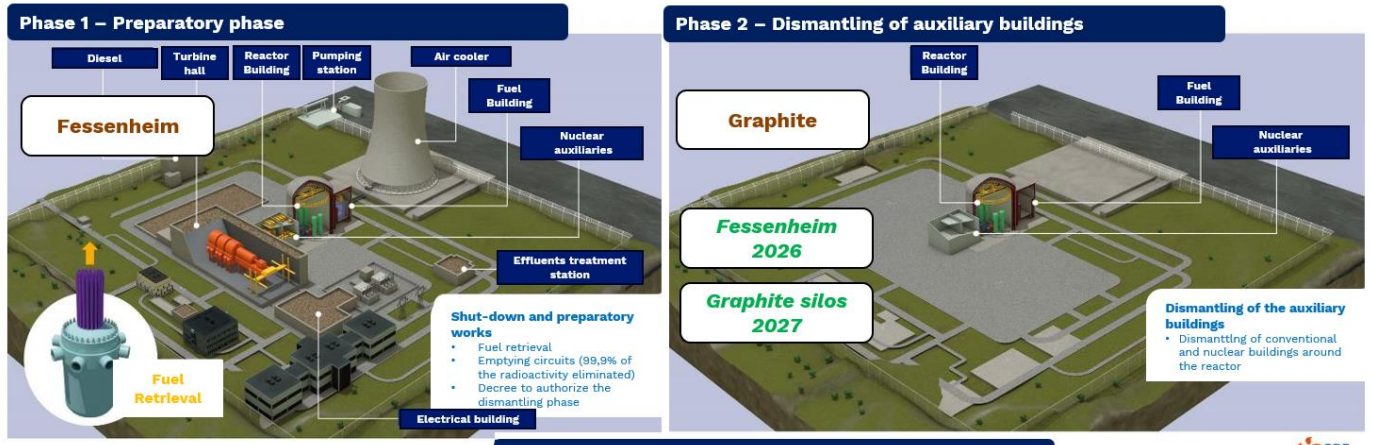
Chinon
3 units UNGG
1963-1973, 1965-1985
1966-1990
Decommissioning decree: (A3): 2010

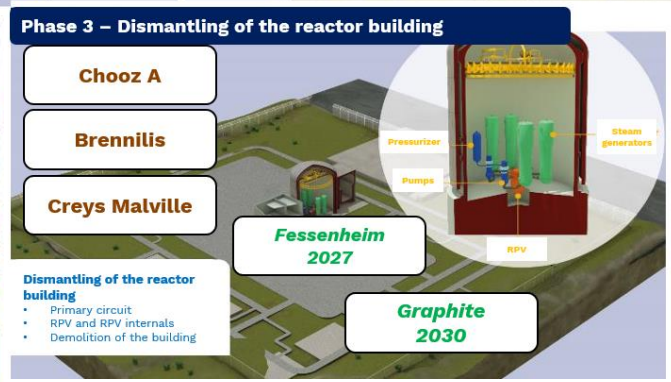
Creys-Malville
FBR
1986-1998
Decommissioning decree: 2006

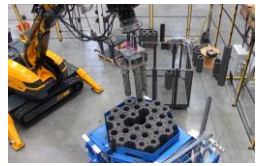
Pressurized Water Reactor
Heavy Water Reactor
Graphite Reactor
Fast Breeder Reactor

4 use case to illustrate the solutions provided to the different stages and issues of dismantling program

Case Study 1: FESSENHEIM - PWR DISMANTLING
- Key preparatory works
- Tools design and procurement – mutualization effects
- Waste routes



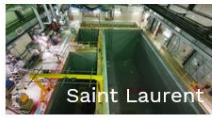




Case Study 2: CHINON- GRAPHITE REACTOR DISMANTLING
- Deal with very complex reactors / with a FOAK
- Design of specific remoted tools and robots
- Derisking campaigns

Case Study 3: BRENNILIS – HWR REACTOR
- Use robots to deal with a very constraint environment
- Optimize dismantling / on site waste management

Case Study 4: SAINT LAURENT – GRAPHITE SLEEVES SILOS DISMANTLING
- Legacy waste retrieval in unknown environment
- Optimize waste routes



Case Study 1

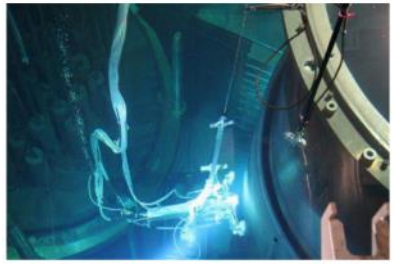
FESSENHEIM PWR DISMANTLING

2 PWR reactors shut-down in 2020
Dismantling decree expected end of 2025

Key issues:
1. Use the **preliminary works** phase to facilitate future dismantling operations
2. Optimize **scenarios, tools design and supply** for the large components dismantling
3. Choose / Secure the **waste routes**

Addressing the question of scale effect / solutions mutualization for the global reactor fleet

1 In addition to spent fuel evacuation / circuits decontamination, characterization campaigns and legacy waste evacuation are essential for a waste-led decommissioning approach



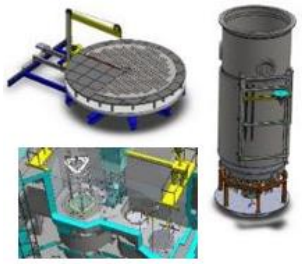
Development of a sampling machine for LWR reactors

Evacuation of Used Steam Generators stored on sites – Treatment in Cyclife Sweden facility

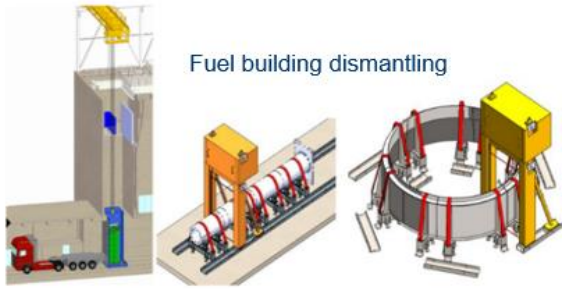
Deployment of mobile machines to condition legacy waste / substances: sludge, boron, resins…

2 The feasibility of LWR dismantling has been demonstrated, the main studies are now focused on scenario, operations kinematics and tools design optimization
Another key issue is the reuse of tools on several operations on the same reactor, on both reactors and at the level of a fleet of reactors - scale effect

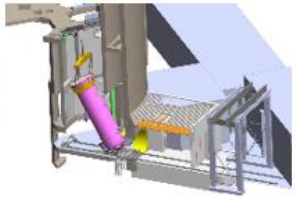
Example of design studies and first supplies



RPVi dismantling tools



Extraction of steam generators scenario and tooling design



Supply and set up of the main auxiliary handling system for SG extraction Also use for

Case Study 1

FESSENHEIM PWR DISMANTLING

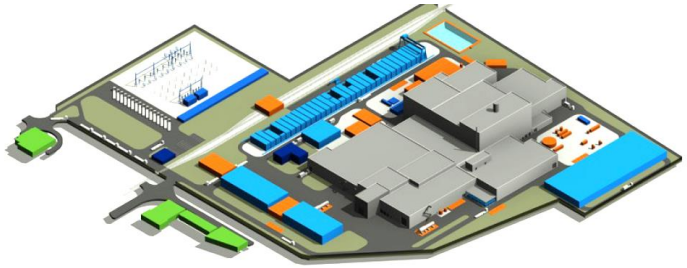
2 PWR reactors shut-down in 2020
Dismantling decree expected end of 2025

Key issues:
1. Use the **preliminary works** phase to facilitate future dismantling operations
2. Optimize **scenarios, tools design and supply** for the large components dismantling
3. Choose / secure the **waste routes**

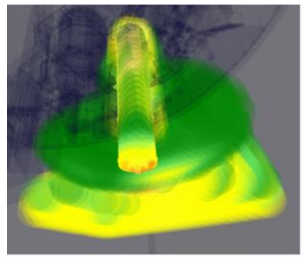
Addressing the question of scale effect / solutions mutualization for the global reactor fleet

3 Optimization of waste routes with the following main questions:
→ Avoid final disposal of VLL metallic waste -
→ For metallic LLW, optimization of on-site/off-site

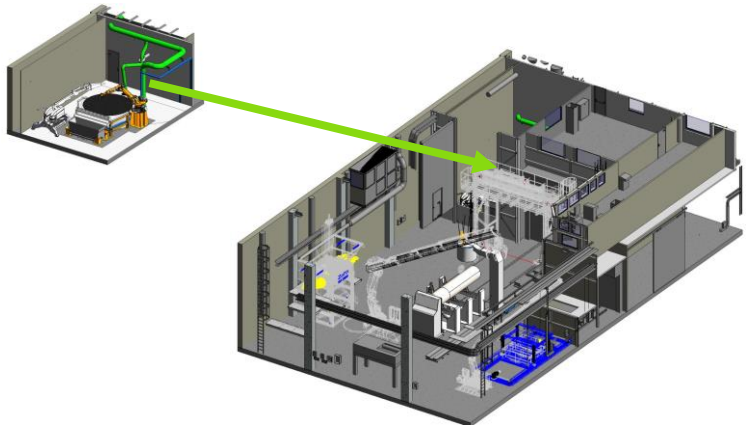
Feasibility demonstration of Fessenheim's used SGs upper parts treatment and recycling



Conceptual design of the "Technocentre" facility – To be commissioned in 2031 – 15 000 t/y of metallic waste



DEMplus® simulation of different scenarios for large components treatment (pressurizers), in-situ cutting/conditioning or off site treatment → comparison in terms of dosimetry, waste volumes, schedule, costs…



Detailed design study for the revamping of a centralized large components cutting workshop of Cyclife France existing facility

Case Study 2

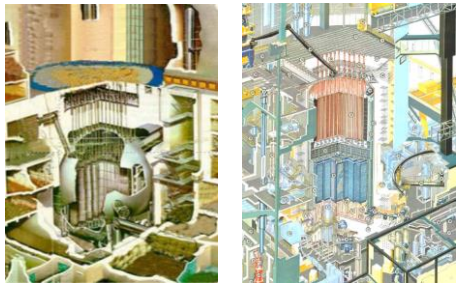
CHINON A2 GRAPHITE REACTOR DISMANTLING

6 graphite reactors shutdown in the 80 - 90's – Very large/complex reactors
A progressive approach –First French core reactor dismantling starting in 2030's

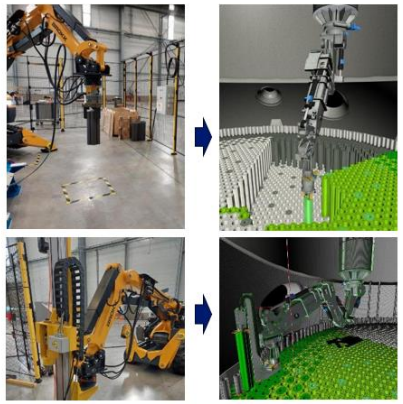
Key issues:
1. Set up the conditions to **deal with very complex reactors / with a FOAK**
2. Design of specific **remoted tools and robots**
3. **Derisking campaigns** to address questions of deployment on large heights, repetitive teleoperated tasks, incidental situations

1 Graphite reactor design is very complex – The quantity of materials to extract is 10 to 30 x higher than in a PWR – No experience feedback on a large-scale reactor dismantling worldwide
→ A **progressive approach, dismantling of a first of a kind after derisking period** in a dedicated "demonstrator'

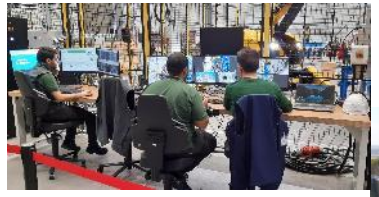
2 A **lot of works in parallel** performed by a dedicated cutting-edge entity (Graphitech) including **design, manufacture and testing of the dismantling platform, the tool deployment system and remotely**
3 **operated equipments** (cutting tools, graphite handling tools…) to propose a stabilized scenario and platform design



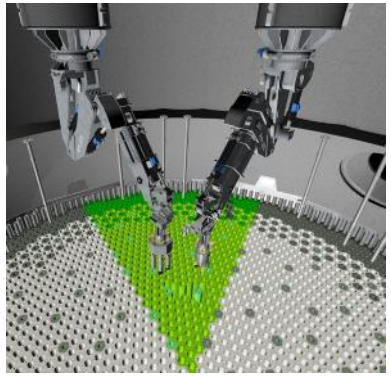
The complex design of French UNGG (Chinon A2 and Saint Laurent reactors)



Decision to use digital/physical twins tests to validate the global dismantling scenario (example of graphite removal

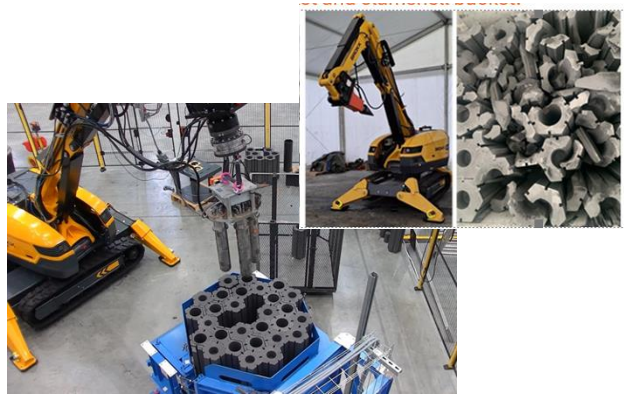


An industrial demonstrator commissioned in 2022, (Chinon, France) to check the feasibility of decommissioning Scenarios and train workers



Design of the deployment system under manufacture

Tests on several teleoperated cutting techniques



Graphite retrieval technologies

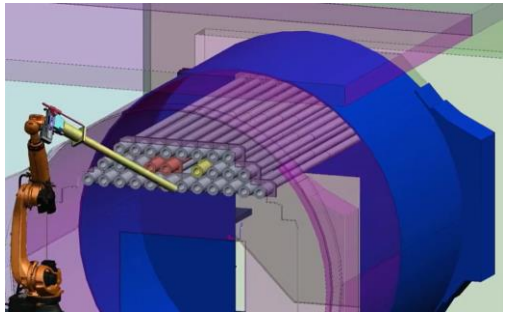
Case Studies 3 & 4

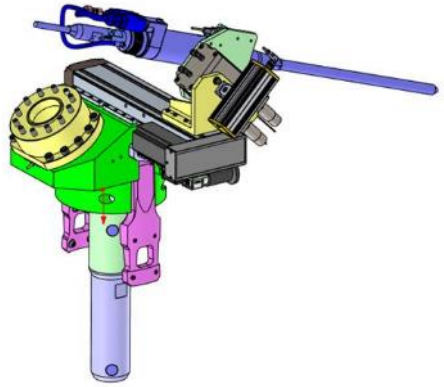
BRENNILIS HWR DISMANTLING SAINT LAURENT GRAPHITE SLEEVES RETRIEVAL

Brennilis Heavy water reactor - Shut down in 1985 – Final phase of reactor dismantling

Key issues:
- Use advanced robotics technologies to deal with a very constraint environment
- Optimize dismantling operations / on site waste management

1. Brennilis reactor is very compact – Materials are difficult to handle
→ Use of advanced robotics solutions with automatic calculation of the trajectory to extract pieces (ex; pressure tubes)



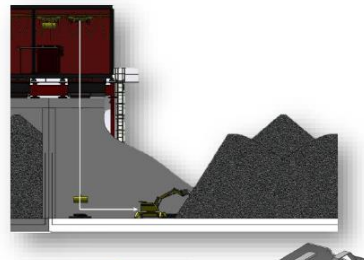


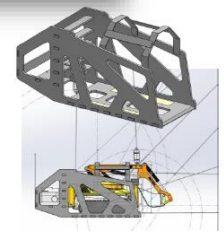
2. Development of in situ cutting tools (special laser heads to minimize the functionalities of dedicated cells for waste treatment

Saint Laurent graphite silos – Thousands of graphite sleeves to be retrieved and stored in a new facility

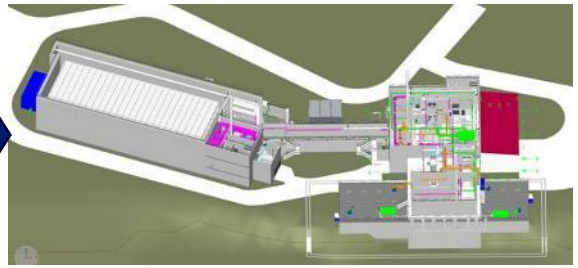
Key issues:
- Use robots and remoted tools to deal with a very uncertain environment
- Optimize waste management

1. Development/tests of a specific remotely operated vehicles to retrieve graphite sleeves





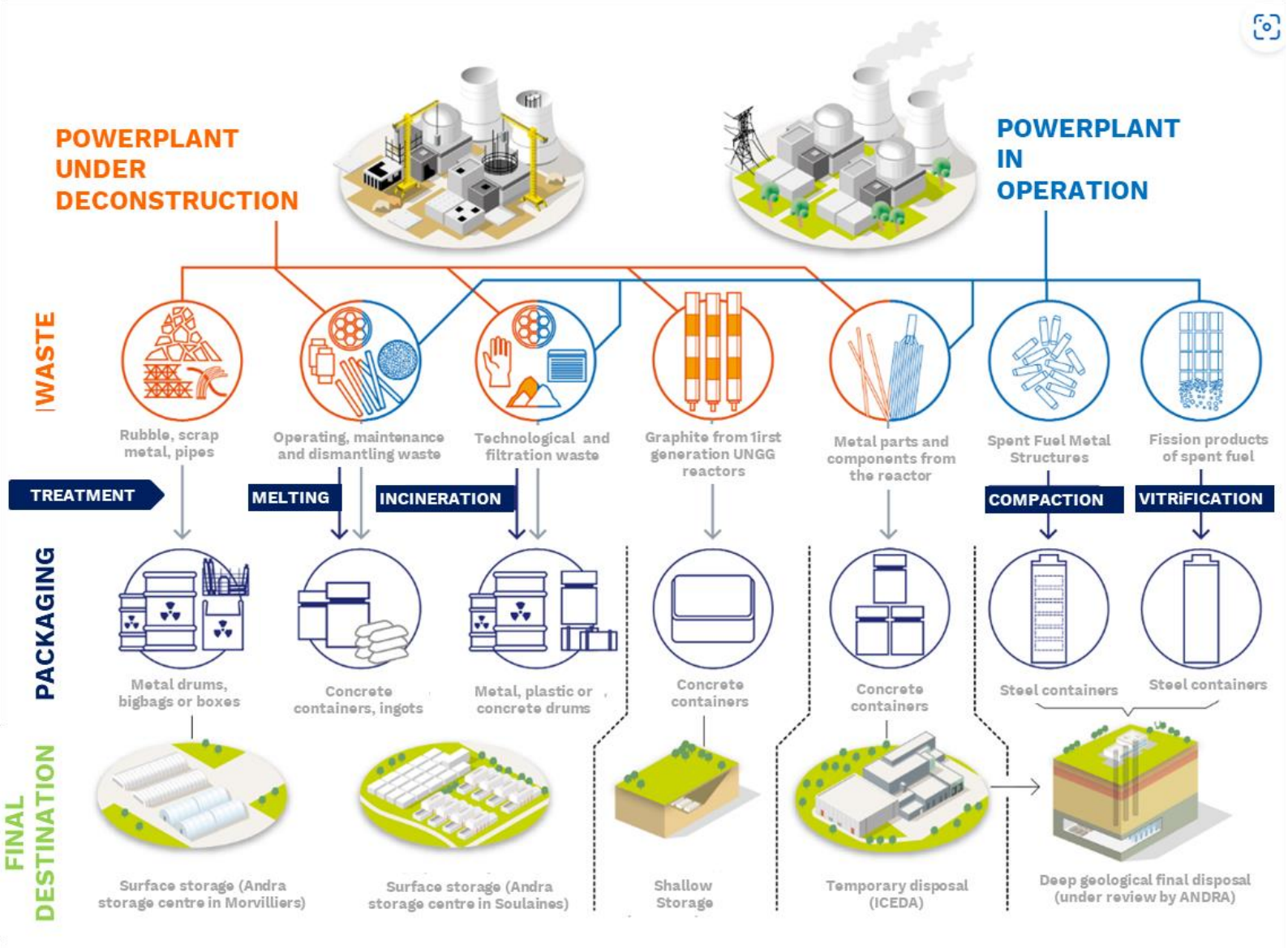
2. Sleeves crushing tests in the industrial demonstrator – Dust management – Limiting the volumes to be stored in a new disposal facility



4. Waste Solutions and Clearance in France

Overview of Waste Classification, Treatment Routes, and Infrastructure

Waste Management Solutions and Routes in France



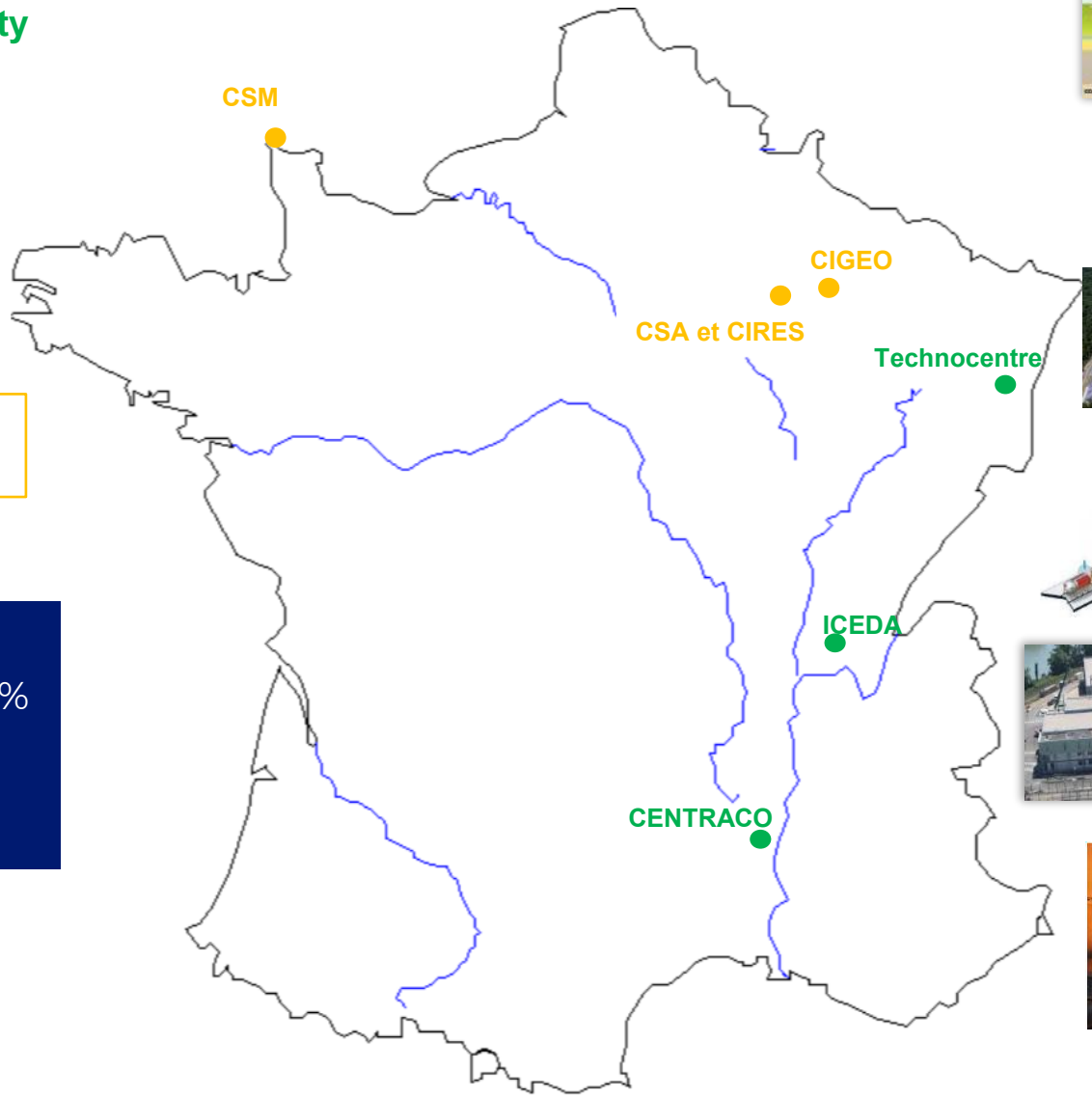
Key Messages

- A panel of solutions for waste generated by operations and D&D
- Final solutions exist or are underdevelopment
- Efficient processes/devices for waste characterisation, conditioning, treatment (asbestos, sludges…)
- Solutions/regulatory evolutions to maximise reuse/recycling (metallic components, concrete…)

Mapping France's Infrastructure

- **EDF/Cyclife facility**
- **Andra facility**

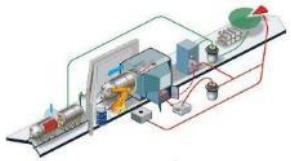
CSM
Waste repository (LL/IL waste)
1969 - 1994



CIGEO (Bure)
Geological final repository (project)
For HL/IL LL wastes
Commissionning planned on 2050

CSA
Waste repository (LL/IL waste)
Start of operation : 1992

CIRES
Waste repository (VLL waste)
Start of operation : 2003



Technocentre (project)
Metal treatment facility aiming to recycle LLW
Commissionning planned on 2031

ICEDA
Conditionninng and interim storage facility for IL waste long life
Start of operation : 2020

CENTRACO
Waste treatment facility
(melting & incineration)
operated by Cyclife France
Start of operation: 1990

Key Message

- In France, 100% of radioactive waste have a waste route

5. Optimizing Metallic Waste Streams

EDF Technocentre project

Project Rationale and Objectives

The Waste Challenge

The **volume** of short-lived Very Low Level Waste is expected to **increase** due to the growing number of facilities **undergoing decommissioning**.

In the absence of current solutions, a significant **quantity** of **recyclable metals** is being sent to a radioactive waste **storage** facility (CIRES), representing **450,000 m³.**

Regulatory evolution

Public debate on the 5th National Radioactive Materials and Waste Management Plan (PNGMDR 2022-2026): discussion on the possibility of **recycling metals** from nuclear facilities.

Changes to the Public Health Code in February **2022** enabled the valorization, and **harmonization** of French regulations with those of **other EU members**.

EDF's Strategic Response

EDF is committed to replacing disposal with recycling for VLLW metallic waste, in line with its long-term sustainability goals.

This supports the development of a circular economy model within the nuclear sector, reducing environmental impact and resource consumption.

The Technocentre is EDF's flagship industrial initiative to deliver on this strategy—transforming recyclable metals into valuable resources through a controlled and scalable process.

Facility Concept and Location

- **Circular economy approach**: The Technocentre is designed as an industrial facility for recycling very low-level radioactive metals (VLLW), contributing to resource preservation and CO_2 reduction.
- **Environmental classification**: The facility will be classified as an ICPE (Installation Classified for Environmental Protection), ensuring compliance with environmental and safety standards.
- **Production output**: After melting, the facility will produce conventional metal ingots (~20kg), suitable for use in foundries and steel mills.
- **Proven operational model**: While this is the first unit of its kind in France, the concept builds on Cyclife Sweden's long-standing experience in metal melting and decontamination.
- Strategic location – Fessenheim: Located near the former Fessenheim nuclear power plant, the site offers:
  - Proximity to downstream users such as foundries
  - EDF-owned industrial land
  - Multimodal access (road, rail, river)

KEY FIGURES

450 M€ 2020
investment

200
jobs in the operating phase

85 %
This is the objective of recycling very low-level radioactive metals.

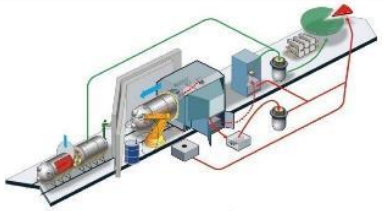
40 %
The energy saved by producing steel from recycling instead of steel from mining.

Recycling Process & Technical Scope

Large components (SG)

Metal cutting
(GB1 diffusers, other)

Cutting / mechanical decontamination (blasting…)



Melting
Electric arc furnace: 25t

Homogenization of the material to allow representative & reliable sampling and control Separation of main radioelements (slag & fume recovery): managed as radioactive waste

Induced radioactive waste conditioned & sent to final repository

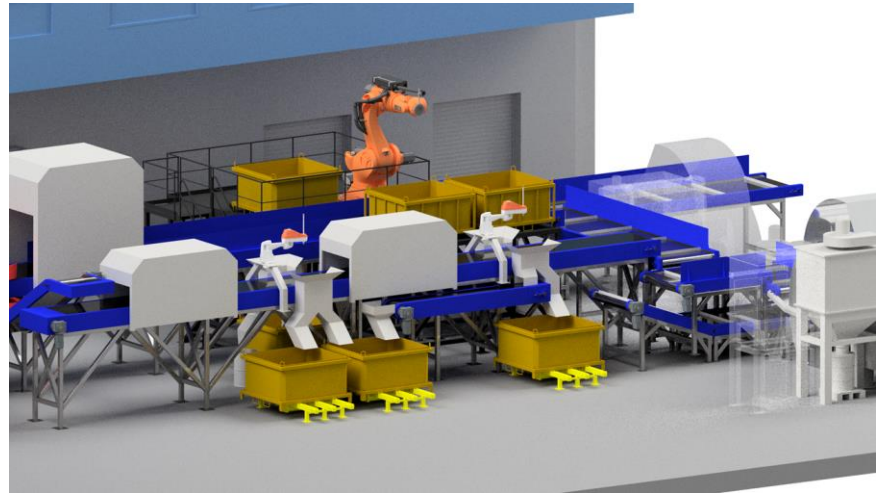
Ingots for use in conventional industry

Progress and Network of Partners

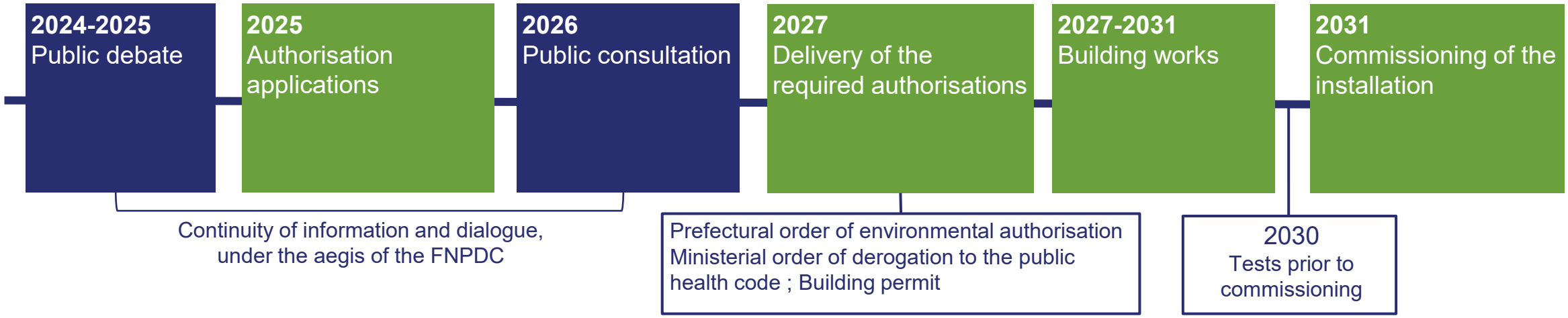
- Current Phase: The project is currently in the engineering and regulatory preparation stage. Authorization applications are being developed following the public debate concluded in early 2025.

- Project Coordination: Cyclife, a subsidiary part of EDF Group, is driving the initiative through a dedicated project entity. This entity oversees the technical scope, regulatory compliance, and coordination of all contributors.

- Stakeholder Ecosystem: The Technocentre project brings together a wide network of partners:
  - Industrial suppliers supporting design and equipment delivery
  - Regional authorities involved in site development and economic revitalization
  - Technical experts contributing to safety, process integration, and environmental compliance



Implementation Timeline and Market



- **Market potential**: France is expected to generate approximately 500,000 tons of very low-level radioactive metals (VLLW) through nuclear decommissioning activities. The Technocentre is designed to address this domestic need while also offering capacity to treat international volumes
- **Strategic outlook**: The Technocentre supports EDF's broader waste management strategy, led by Cyclife, and contributes to the development of a circular economy model for metallic waste. By combining industrial innovation with environmental responsibility, the project aims to reduce long-term storage needs, lower carbon emissions, and provide a reliable supply of recycled metals for conventional industry.

6. Conclusion

Key Messages and Collaborative Outlook

Conclusion / Key Messages

- Dismantling and waste management are **key issues for a sustainable future of nuclear industry**. Integrating these issues throughout the life of the facilities is essential (from the design of the installations, during operations, preparation phase of the dismantling, dismantling itself)

- Decommissioning is a **waste-driven process**. In other words, the waste produced (type and rate) and the ability to manage it can be a constraint to efficient decommissioning. The waste infrastructure to handle waste produced is a critical resource to decommissioning. This is probably the largest challenge facing decommissioning projects in most countries

- In France, a **centralized and structured approach** supports large-scale decommissioning. **Recent progress in clearance** regulation and industrial initiatives like the Technocentre reinforce France's position as a **reference for sustainable and scalable dismantling and waste management**.

Franco-Japanese Collaboration in Dismantling and Waste Management

- **International collaboration is essential** to address the shared challenges of nuclear decommissioning, from technical innovation to regulatory evolution and public acceptance.
- The signing of the EDF–Fukui collaboration agreement is a strong example of the **importance of bilateral partnerships**, enabling knowledge exchange, joint development, and mutual support in dismantling and waste management.
- **EDF is fully committed to long-term cooperation in Japan**, through operational exchanges, technical workshops, and ad hoc agreements through Cyclife with Japanese stakeholders, aiming to build a robust and mutually beneficial framework for D&D excellence.
- **Strong commonalities between France and Japan**, including similar reactor technologies, ongoing development of waste solutions (metal waste treatment, interim storage), and shared objectives for safe and cost-effective decommissioning.

Merci

Contacts

Patrick Dupeyrat
> +81 (0)90 5403 8291
> patrick.dupeyrat@cyclife.com