

DECOMMISSIONING AND PRE-DISPOSAL WASTE HANDLING NEEDS

A FRENCH PERSPECTIVE

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4th February 2021



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SUMMARY

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DP2D

DP2D = EDF's Business unit in charge of Decommissioning Projects and Waste Management Services

Objectives :

- Successfully achieve the decommissioning of shut-down nuclear reactors (9 NPPs in progress; 2 NPPs under preparation)
- Prepare the future dismantling of EDF's operating nuclear fleet (56 operating NNPs)
- Develop efficient industrial solutions for managing all types of waste
- Promote EDF's know-how in decommissioning and waste management internationally
- Approximetly 1150 people dedicated to DP2D's missions with 600 of which are working for different EDF subsidiaries :
 - □ Cyclife France, Cyclife UK and Cyclife Sweden → Waste Management / Treatment
 - □ Cyclife Engineering → Studies and Project Management for PWR and FNR decommissioning and Waste Management Facilities
 - □ Cyclife Digital Solutions → Decommissioning scenarii preparation thanks to numeric simulation
 - □ Graphitech → Technology development for graphite reactor dismantling



Decommissioning



DECOMMISSIONING

- 4 different technologies to decommission
- 3 Pressurised Water Reactors PWR (1 under 2 in preparation)
 - □ Chooz A 5 years in advance on forecasts
 - Demonstrate that EDF is able to decommission a PWR in 15 years

6 Natural Uranium Graphite Gas reactors

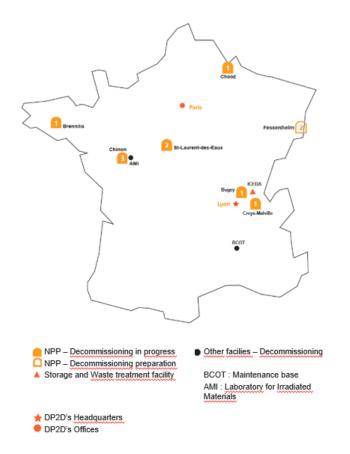
- □ 1st of a kind in the world one of the most complicated technology to dismantle
- 10 to 30 times the volume of waste generated by PWR's decommissionning
- Risk mitigation thanks to the Industrial demonstrator
- Decommissioning should be realised in 25 years

1 Fast Neutron Reactor – FNR

- World's biggest reactor
- 1st industrialist to dismantle that technology → Japanese operator requires EDF's experience for Monju decommissioning
- 15 years to decommission (now that sodium was retrieved and eliminated)

1 Heavy Water Reactor – HWR

- Technology difficult to decommission: very compact, no REX, no pool to perform cutting of the vessel under water...
- Administrative complexities lead to serious delays
- □ 15 to 20 years (after the decree obtaining) will be necessary to finish the decommissioning



FOCUS - GRAPHITE REACTOR DISMANTLING

- NUGG decommissioning = technical issues due to conception and very limited experience on graphite reactor decommissionning (2 small reactors in the UK and US)
 - Cutting pre-stressed concrete (up to 9 m thickness)
 - Cutting metallic components (up to 20 cm thickness)
 - Graphite dust management
 - Deployment of remote handling tools on large dimension (up to 30 m)
 - → DP2D' solution: Creation of Graphitech subsidiary, Building of an industrial demonstrator and lauching of a collaborative project Inno4graph
- Graphitech (subsidiary created in 2019 by EDF and VEOLIA) is in charge of technology developments and engineering studies preparing graphite-reactor decommissioning
- Inno4graph = a collaborative project funded by European Commission (3 M€), supported by SNETP and Nuclear Valley, gathering 13 partners
- Inno4graph's technical objectives :
 - Develop a multi-criteria grid to chose between dismantling scenarios
 - Develop and test digital and physical tools and models to characterise graphite properties and forecast its behavior during decommissioning
 - Develop and test tools for extraction of graphite bricks
 - Develop a set of tools to evaluate, optimise and qualify operational dismantling tools and final scenario
 - Generate new 3D models to evaluate different dismantling scenarios (costs and safety)

FOCUS - GRAPHITE REACTOR DISMANTLING

- Industrial demonstrator (provisional commissioning: 2022) facility enabling risk mitigation with objectives to :
 - Increase safety by securing decommissioning planning thanks to optimised scenario
 - Ensure radioprotection and security of workers (thanks to formation)
 - Reduce waste volumes
 - Control costs by testing tools (notably those developed by Graphitech) at full scale
 - Facilitate collaboration between stakeholders







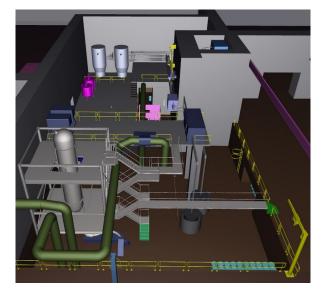


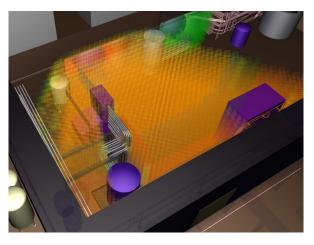


DEM PLUS®

- DEMplus® for nuclear is a decision-making and operation-simulating tool developped by Cyclife Digital Solution
 - → Perfect tool for DP2D's needs to analyse decommissioning scenarii
- The software enables to:
 - Enhance intervetion safety
 - Realise ALARA studies
 - Optimise waste management
 - Reduce costs and delays
- Gains for decommissioning projects can be up to :
 - □ -30% on study costs
 - -20% on intervention costs
 - □ -30% on risk provisions
 - -30% on waste mangement expenses





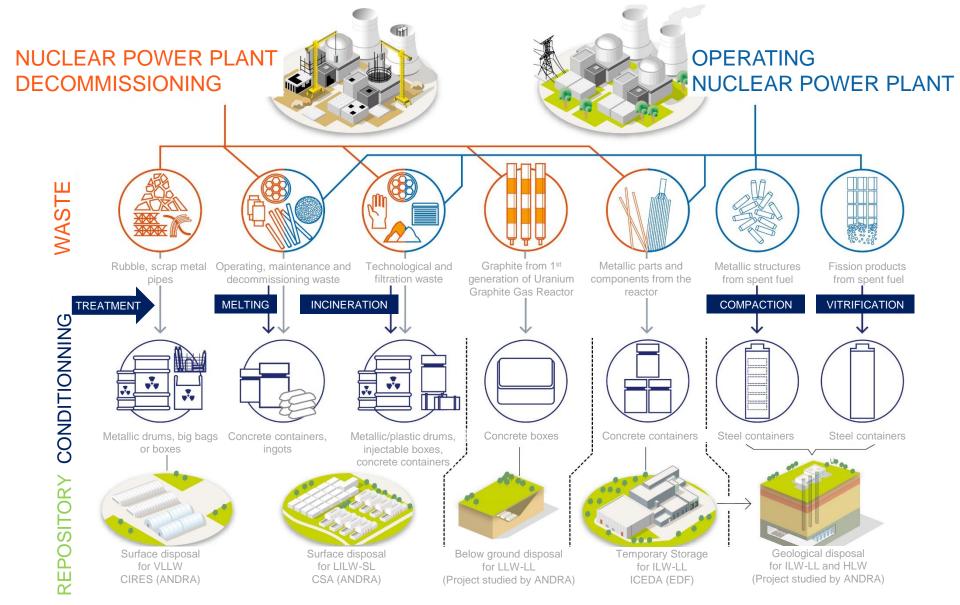




Waste Management



NUCLEAR WASTE MANAGEMENT





WASTE MANAGEMENT SOLUTIONS

Available solutions from Cyclife's platform:

CENTRALISED SOLUTIONS



MOBILE SOLUTIONS

> MERCURE: IER stabilisation



> UMC: Borated concentrate grouting



> UMIS: Outside process to invetory and prepare for transport waste container



> UM2B: Sludge grouting (to be commission)



ICEDA

- ICEDA = facility for conditioning and storing activated IL- LL waste
 - ICEDA is in operation since September 2020
 - Nearly 2000 t of activated waste processed coming from first generation NPP decommissioning and currently operating reactors

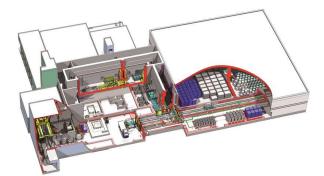
Waste conditioning process

- □ Remotely handled from transport container (R73 TM or TN TM)
- Cut into smaller pieces if necessary
- Grouted inside concrete containers C1PG SP (manufactured by a Cyclife's subsidiary)
- Radiologically characterised

Waste storing :

 3000 m² available to store about 2000 concrete packages C1PG SP in 2 halls waiting until the geological disposal (CIGEO) availability











TECHNOCENTER

- Very low level (VLL) metallic materials → Already part of regular waste streams generated by operation of NPPs and nuclear facilities
- Currently, French reglementation does not authorize free-release to recycle (unlike European reglementation authorizes it)
 - → Management = Melting + Surface disposal for VLLW
 - →A change in the regulations, making possible recycling of very low level metallic waste, is currently open for public consultation
- Acceleration of nuclear facilities decommissioning = Large amounts of metallic materials and large metallic components (steam generators from NPPs and gas diffusers from GB1 - U enrichment facility) ≈ 600 000 t
 - → Direct disposal hundreds of thousands of tons of metallic materials and components = Not compliant with minimisation of environmental impact and preservation of disposals
 - → Special effort has to be made from both regulatory and industrial point of view to manage this stream

→ DP2D's decision: Project for an industrial facility dedicated to melting and recycling of VLL metallic materials = Technocenter (provisional commissioning 2030)



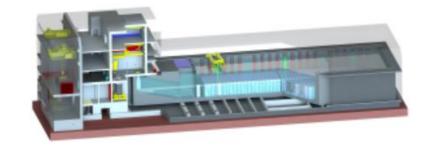






CENTRALISED FUEL STORAGE POOL

- Nearly 1200 t of fuel are unloaded each year in average :
 - □ 1100 t of spent fuel is treated (96% recycled; 4% vitrified)
 - 100 t of spent MOX (unloaded from 900 MW reactor) → Material that cannot be used into current EDF's reactors but into future reactor technology
- EDF needs to increase its storage capacity for spent fuel by 2030 because :
 - NPPs'pools will not be sufficient in the medium term
 - Long term storage (> 100 years) of spent-fuel assemblies that are not reprocessed currently (MOX, URT and FNR fuel)
 but that will be in the future
 - → DP2D's Project: Centralised Fuel Storage Pool
- Underwater storage is chosen in order to:
 - Manage thermal power
 - Ensure good state of assemblies
 - Facilitate access



- The facility (provisional commissioning: 2034) will be composed of:
 - Transport terminal
 - Buildings for the management of transport packages
 - Two buildings for under-water storage of spent fuel constructed in two steps; total capacity = 21000 assemblies > 2034: Provisional commissioning of the first storage (13000 assemblies / 6500 t)
 - Ancillary buildings

CONCLUSION

- EDF is going to decommission a huge number of reactors in a short and middle-term point of view
- EDF has to dismantle different reactor technologies Among them, UNGG and HWR which are difficult to decommission
- EDF innovates in order to be as most efficient as possible for EDF's or clients decommissioning:
 - □ Graphitech, the industrial demonstrator and Inno4graph → To tackle difficulties of NUGG decommissioning
 - □ DEMplus® → To be efficient with specific and reproducible operations
- To manage nuclear waste EDF and its clients lean on Cyclife' solutions: centralised and mobile
- When a solution is not directly available, EDF is also able to carry out new-facility projects in order to deal with fuel and waste management problematics:
 - ICEDA (commission in 2020): Conditionning and storing of activated waste (ILW-II)
 - Technocenter (provisional commissioning in 2030): Melting and recyling of a large quantity of VLLW metallic materials and large components
 - Centralised fuel storage pool (provisional commissioning in 2034): Storing of 21000 spent-fuel assemblies waiting for a reactor new technology (enabling the use of materials)



CONCLUSION

- In order to prepare the future, EDF also participates and/or helped the inception of European R&D Projects regarding decommissioning and waste management
 - → Among them: Inno4graph, SHARE, THERAMIN, PREDIS, INSIDER, CHANCE...
- Regarding EDF's point of view, new topics could be subject to work at an European level in order to coordinate efforts:
 - For graphite reactors decommissioning: Specificities of the technology other than graphite (already dealt with Inno4graph)
 → E.g.: Cutting of very thick and pre-stressed concrete, means of investigation for inaccessible areas,...
 - For the decommissioning of other reactor technologies: To enhance the efficiency of complex remote operations



THANK YOU



APPENDIX - DECOMMISSIONING MAP

