DigiDecom 2021 – DIGITAL

Online international workshop focusing on digital transformation, robotics and other game changing trends in nuclear decommissioning

3D DIGITAL SIMULATION OF COMPLEX D&D PROJECTS

Use case : Chinon A2 dismantling

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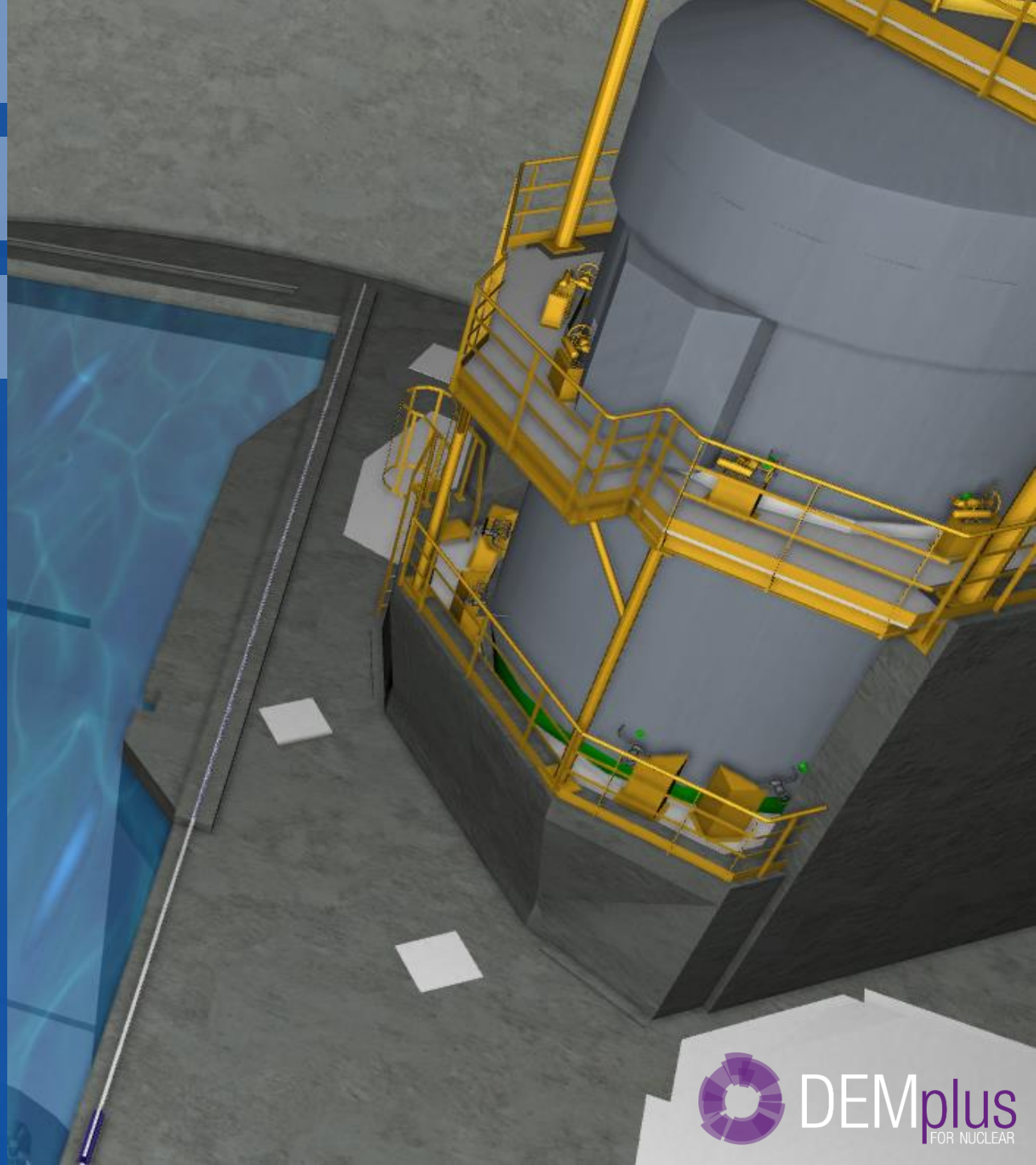
March 24th 2021



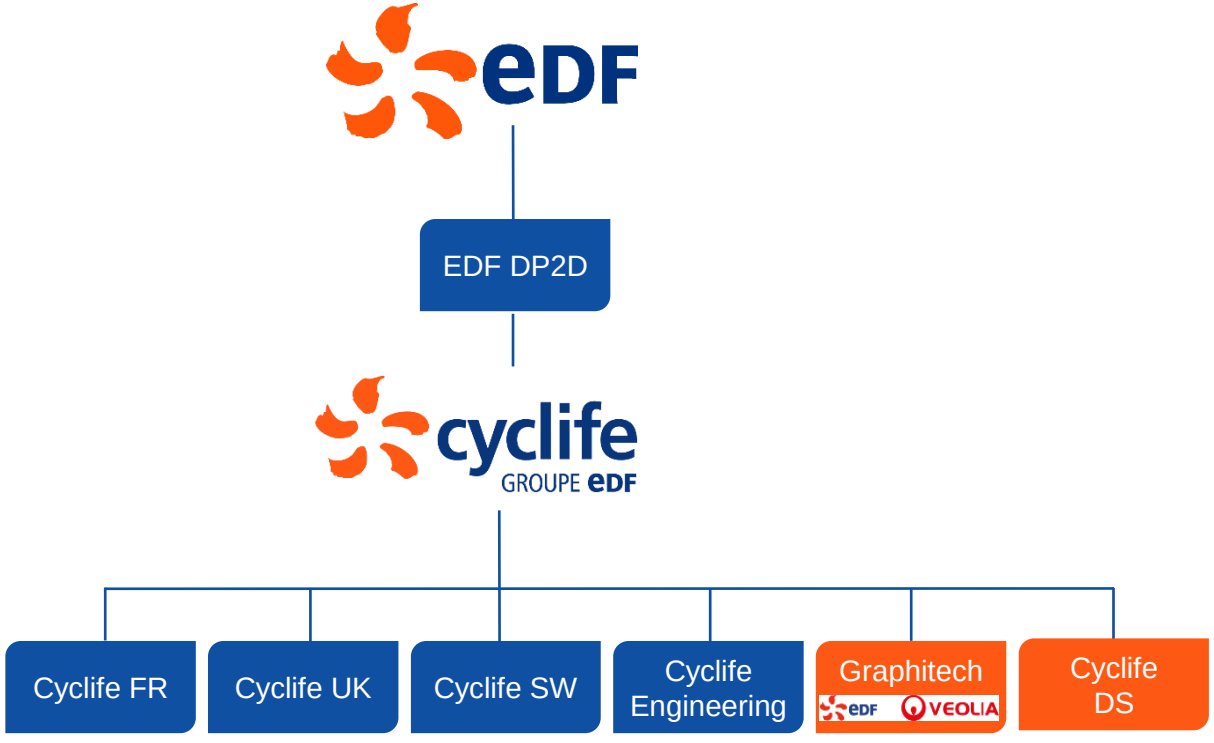
SUMMARY

WHO ARE WE?

EDF, Electricité De France
French electricity producer

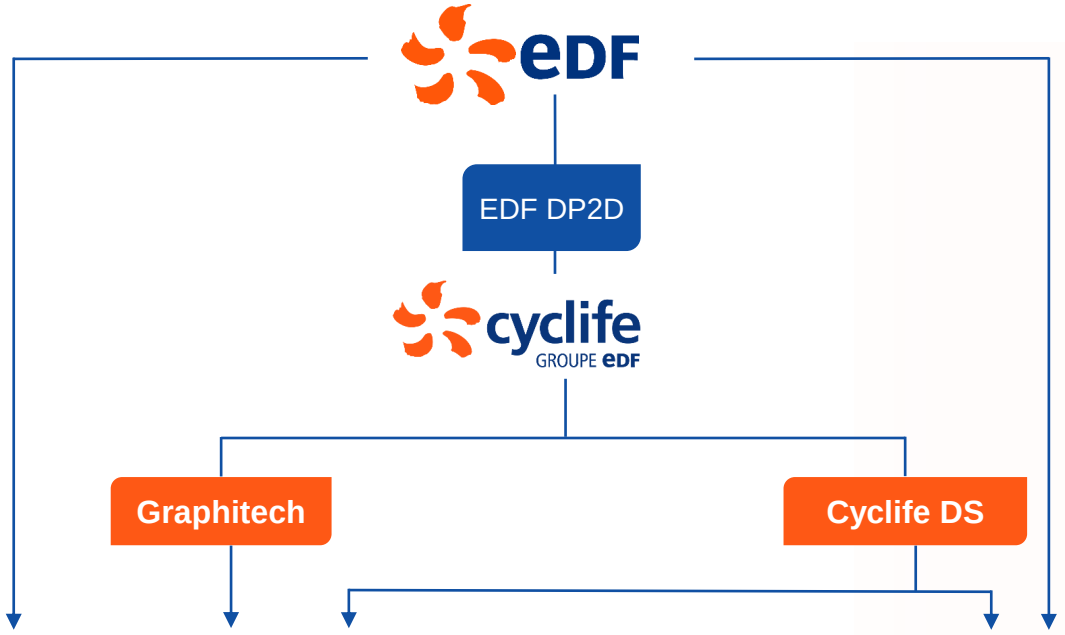
Graphitech, A JOINT VENTURE EDF VEOLIA
Graphite reactors D&D and engineering technologies

Cyclife Digital Solutions, Digital solutions and simulation experts of nuclear interventions, waste management and D&D



Cyclife, key player with an European platform in nuclear waste management and decommissioning of nuclear facilities

INVOLVEMENT IN H2020 PROJECTS



INNO4GRAPH

PLEIADES
Smarter Plant Decommissioning

cyclife digital solutions
GROUPE EDF

INNO4GRAPH PARTNERS

INNOvative tools FOR dismantling of GRAPHite moderated nuclear reactors

INNO4GRAPH PROJECT

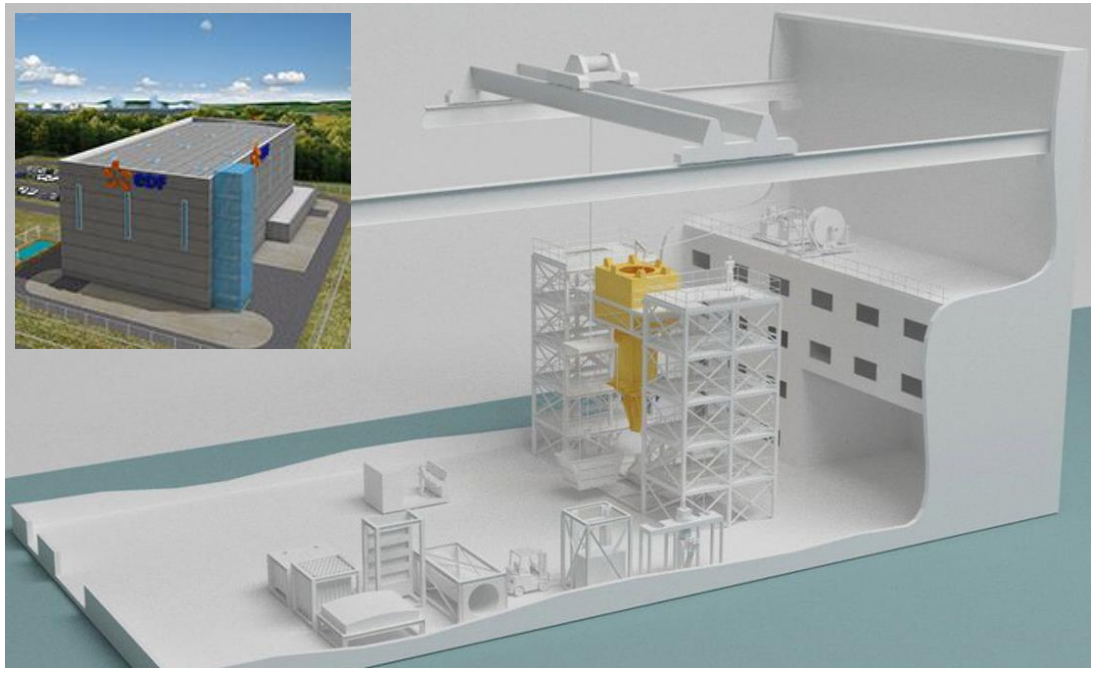
INNOvative tools FOR dismantling of GRAPHite moderated nuclear reactors

- Development of different types of innovative physical and digital tools and methods that can be used during graphite reactor dismantling operations, but also in the pre-dismantling study phase to assess the feasibility and interest of adopting these new tools and methods.
- Optimization of dismantling operations and minimization of risks as part of an intensive testing process prior to real operation.

FULL-SCALE GRAPHITE REACTOR DEMONSTRATOR INSIDE INNO4GRAPH

INNOvative tools FOR dismantling of GRAPHite moderated nuclear reactors

Beyond INNO4GRAPH: development of full-scale graphite reactor dismantling demonstrator in Chinon, France; with the aim of testing new physical and digital tools, methods and alternative scenarios in industrial conditions.



Full-scale graphite reactor demonstrator – 2 500 m² (Chinon - 2022)

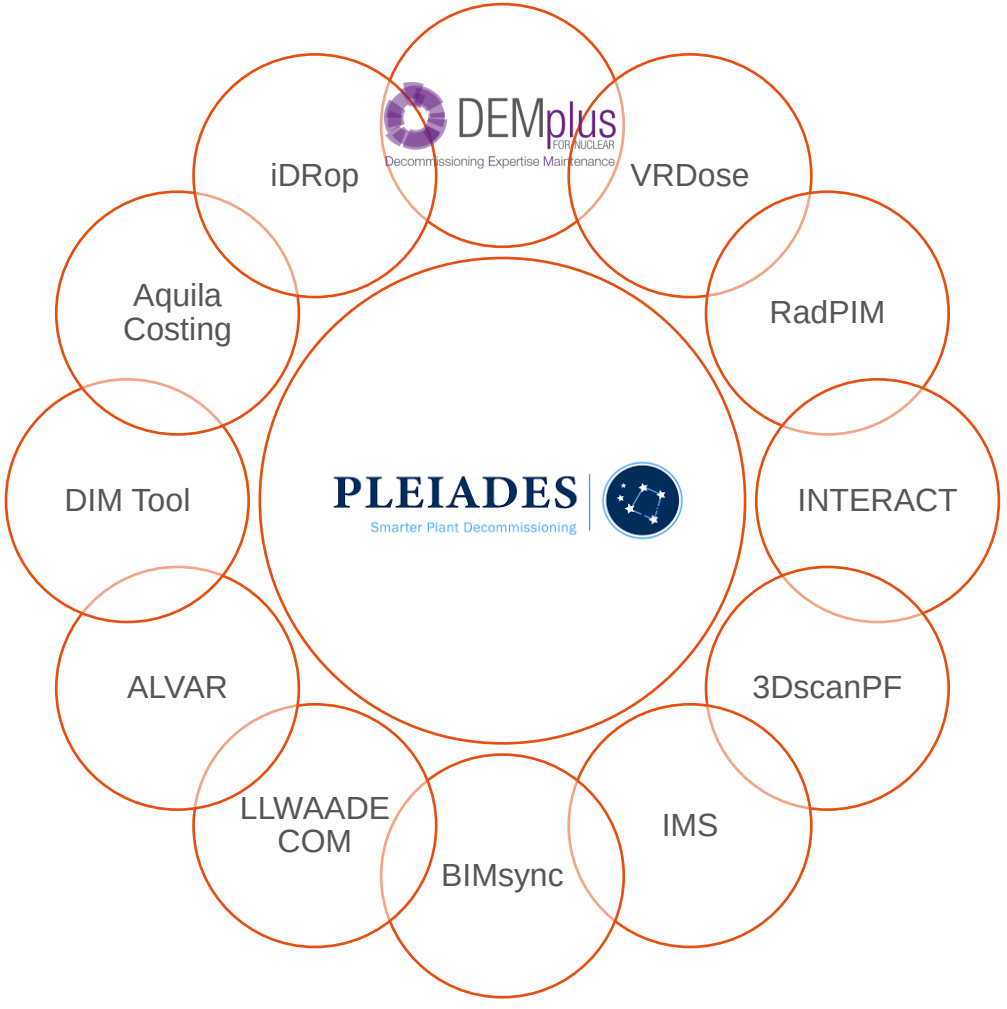
PLEIADES PARTNERS

PLatform based on Emerging and Interoperable Applications for enhanced Decommissioning processES

PLEIADES PROJECT

PLatform based on Emerging and Interoperable Applications for enhanced Decommissioning processES

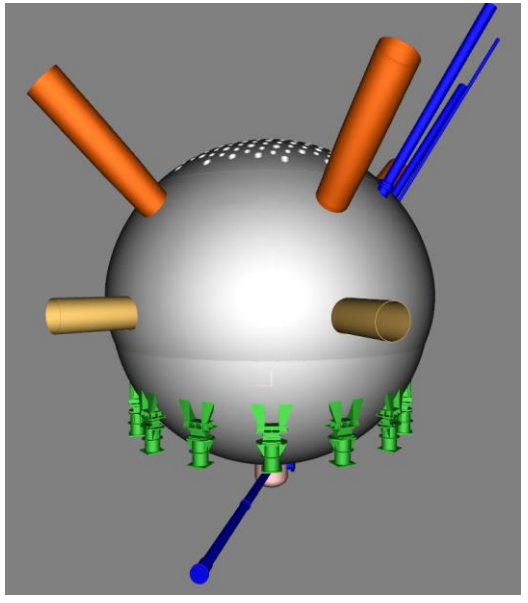
- Gathering of cutting-edge digital tools needed for D&D all in one place

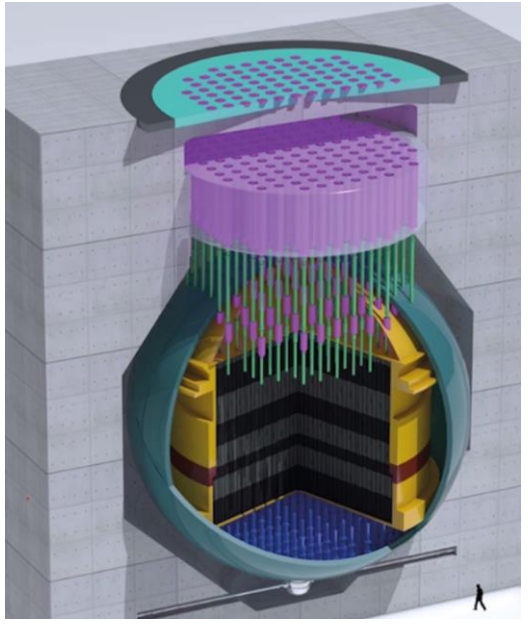


SUMMARY

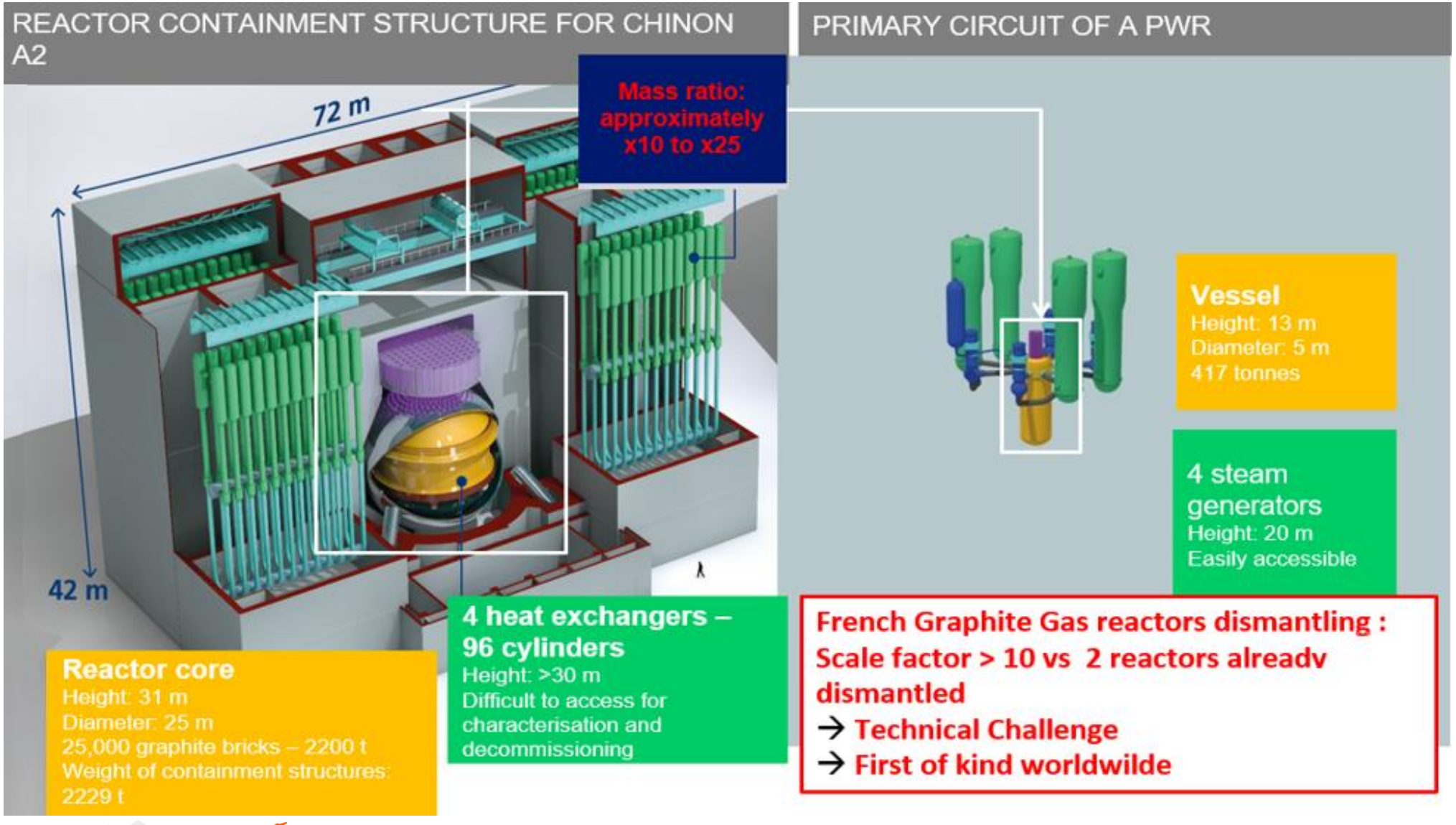
CHINON A2 TECHNICAL INFORMATION

Caracteristics	Value
Type/model	GCR / UNGG
Electric power	210 MWe
First net connexion	24 feb, 1965
Permanent shutdown	14 jun, 1985
Vessel mass	2 200T of graphite and 1 470T of steel
Shielding dimensions	22m high x 24,5m of diameter
Spherical vessel dimensions	18,3m of diameter, 100mm thick
Graphite core dimensions	8,4m high x 14,2m of diameter
Total activity of the vessel	2,25E+2 TBq at 01/01/2019





CHINON A2 REACTOR



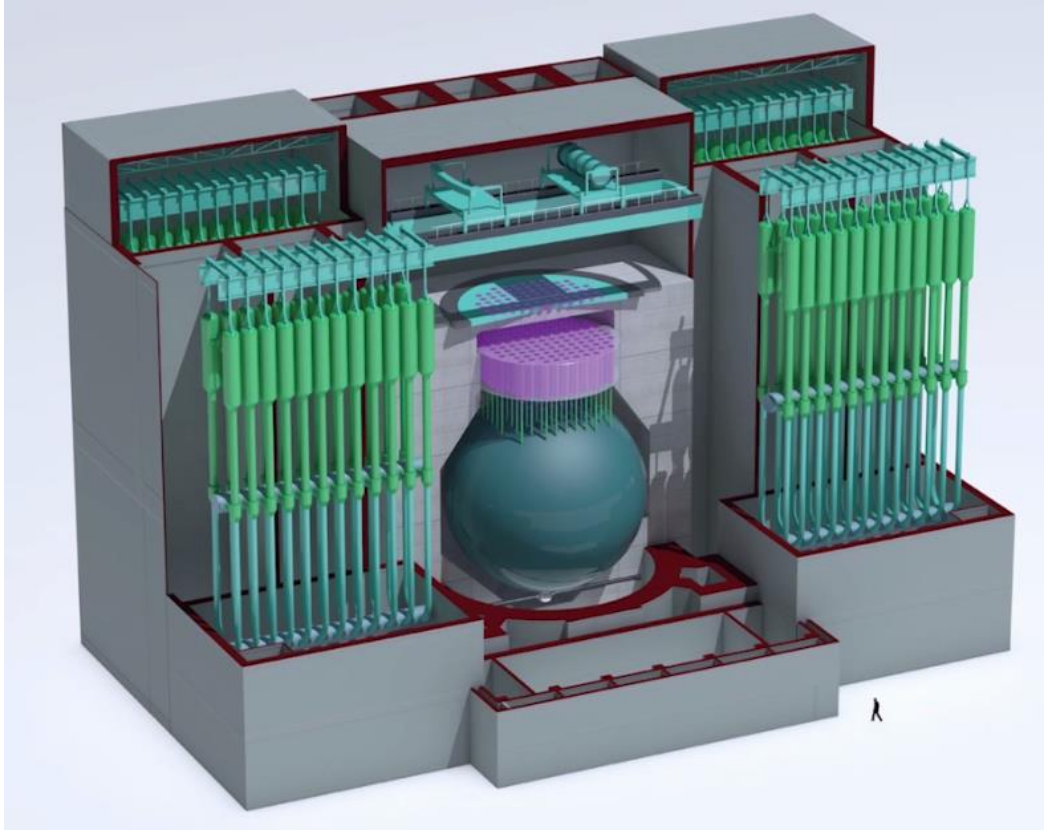
COMPLEX DISMANTLING PROJECT

Worldwide scoop

First graphite reactor of this type to be dismantled

Technical challenge

- Almost fully remote-controlled mode scenario
- 14 000 tons of waste
- 27 years of total duration



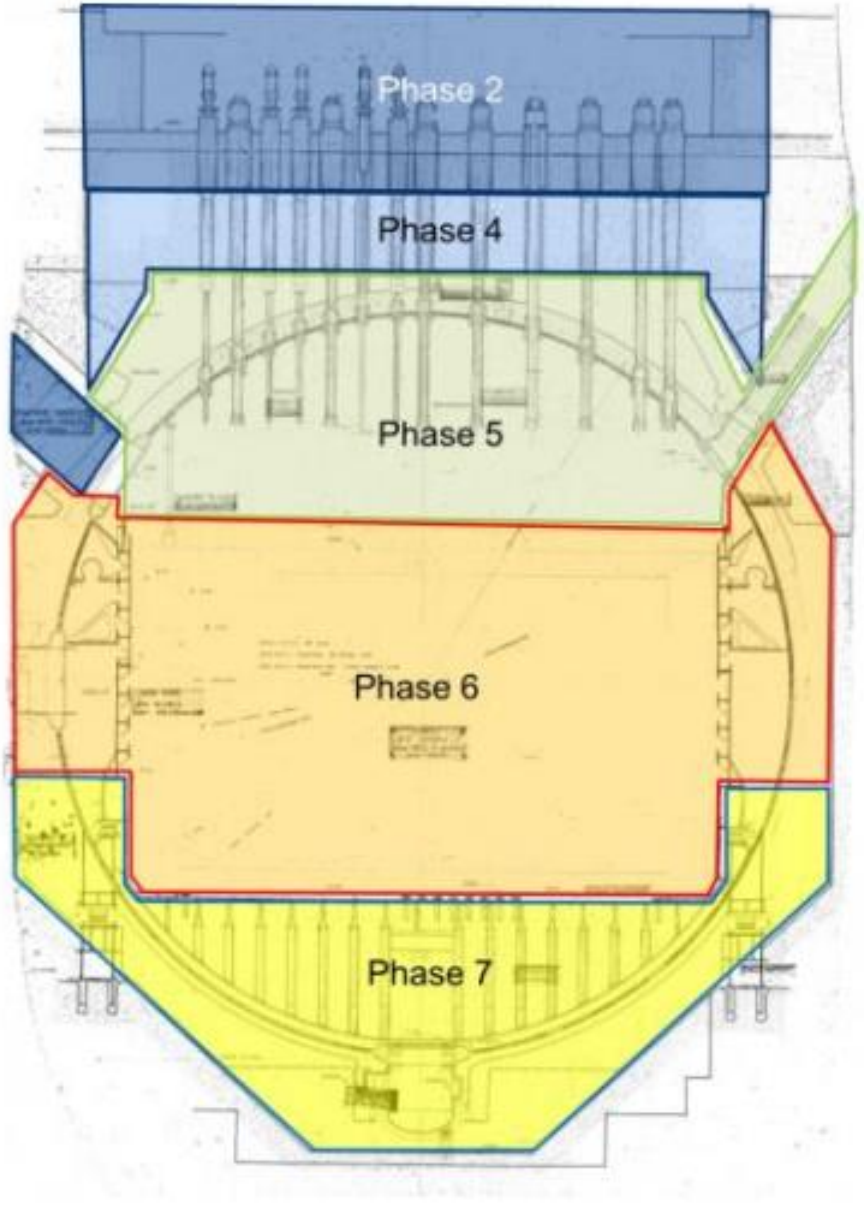
Dismantling platform installation

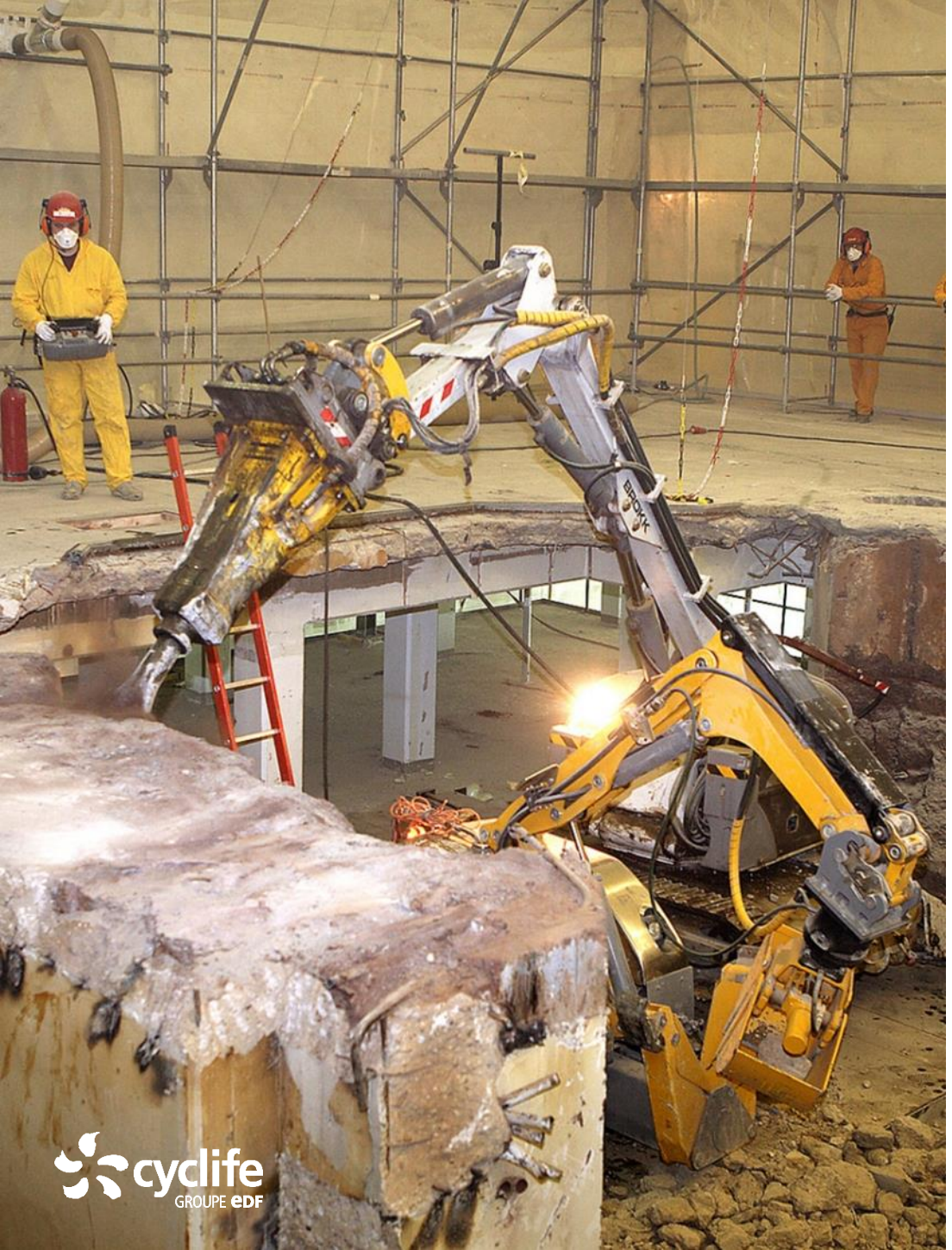
“top-to-bottom” approach

SCENARIO'S PHASES

Phase	Phase name
1	Equipment installation
2	Preliminary works
3	Dismantling platform installation
4	Opening of the shielding
5	Removal of structures above the core
6	Removal of the core (graphite bricks and corset), restraint system and peripheral
7	Removal of structures below the core
8	Decontamination and cleaning of RPV's radiological protection (reinforced concrete)

Total duration of 27 years





SUMMARY

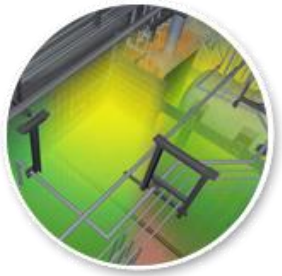
1. Company overview
2. Chinon A2 reactor dismantling project
3. **Simulation of the dismantling project**
4. Feed back and conclusions

DEMplus FOR NUCLEAR

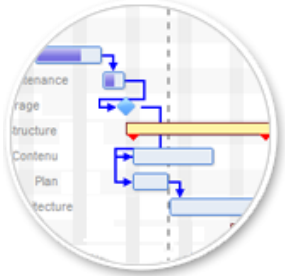
Decommissioning Expertise Maintenance

Simulation and decision making tool for nuclear projects

Costs

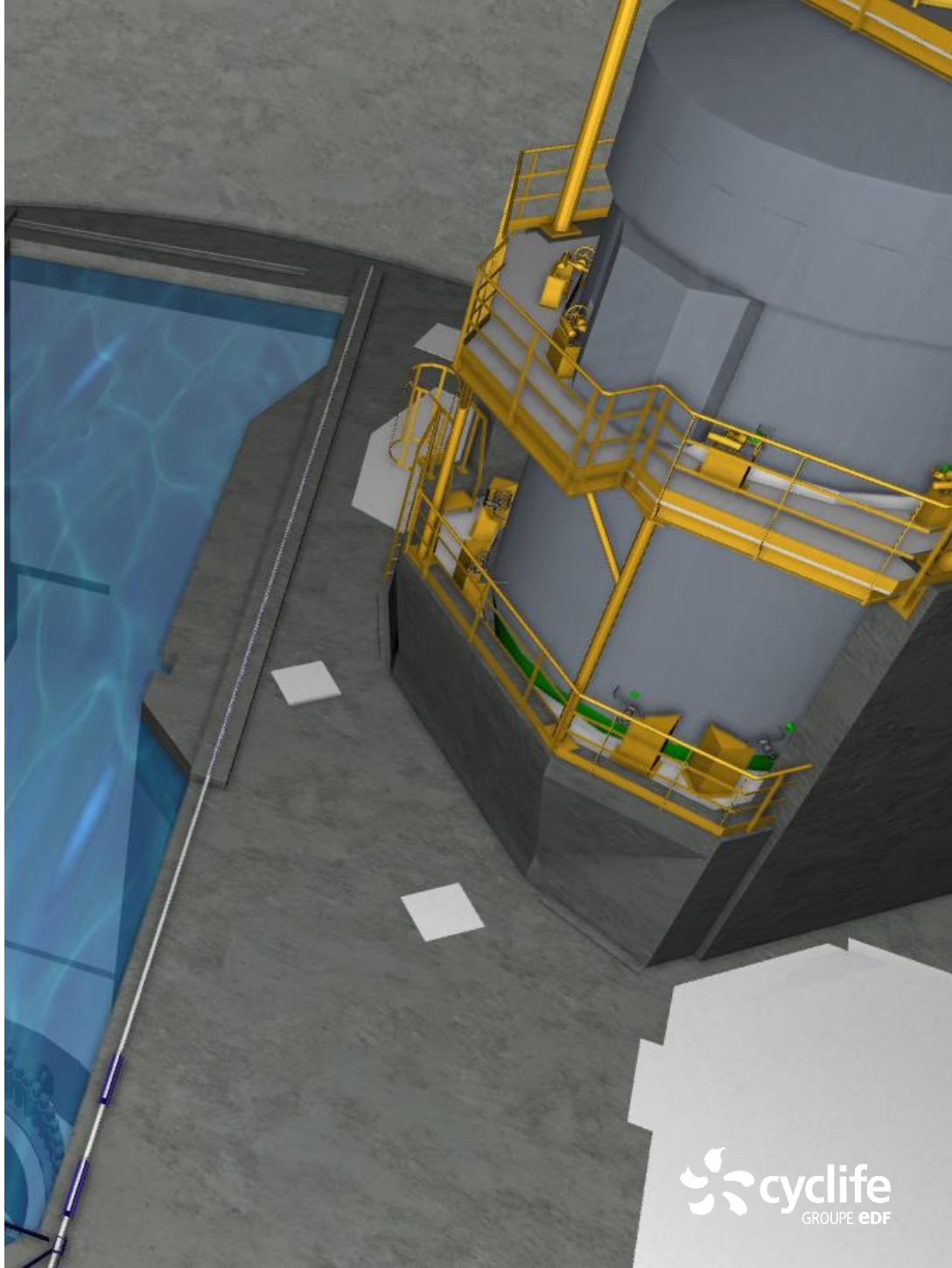


Dosimetry



Planification

Waste management



DIGITAL PROJECT

Waste produced

Radiological risks

Planning

Kinematics

Costs

Digital worksite

Hiring

Logistics

Training

Operations approval

Ergonomics

Scenario

Preliminary Works ▶ Dismantling ▶ Waste management ▶ Transport ▶ Storage / final disposal

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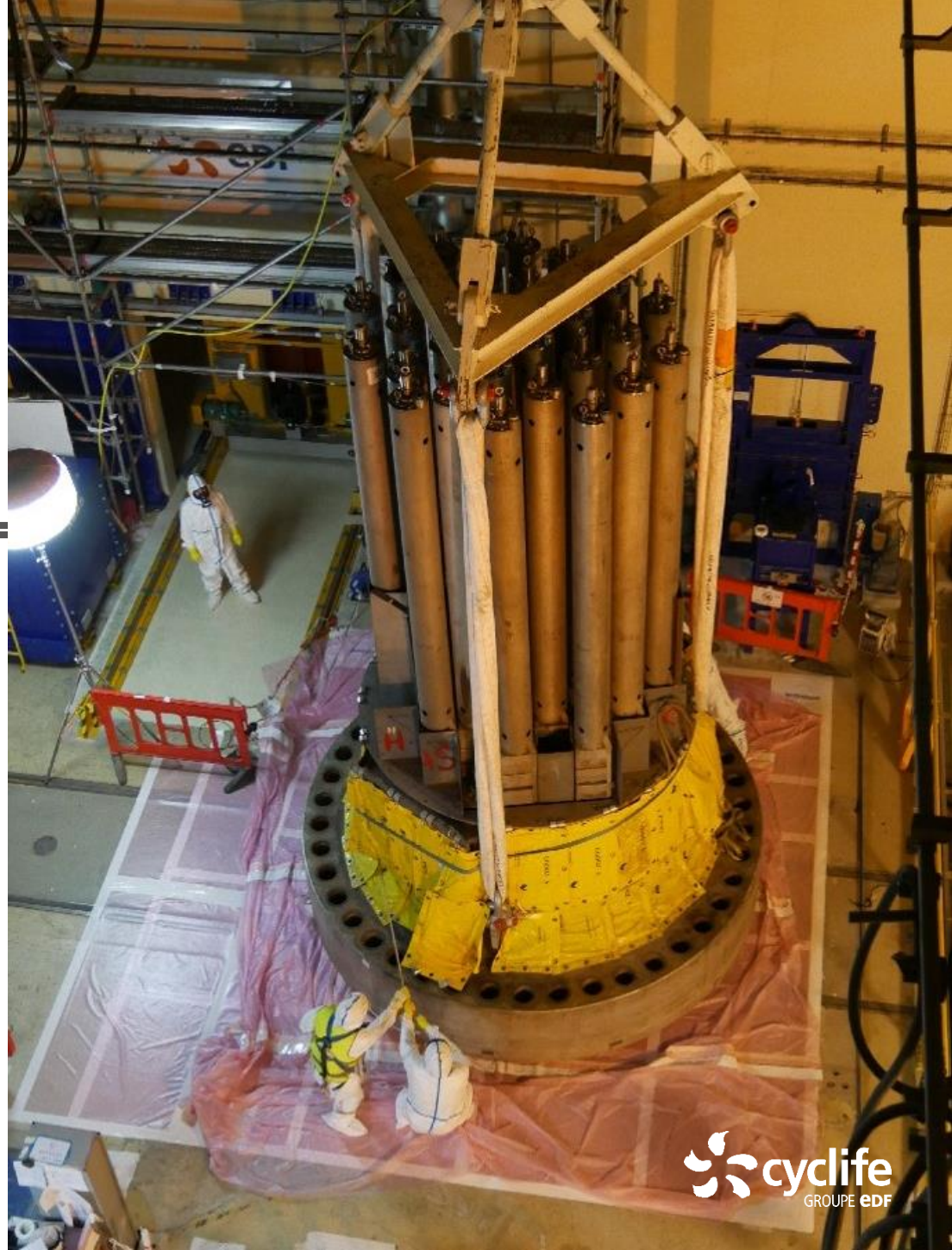


CHINON A2 DISMANTLING SIMULATION

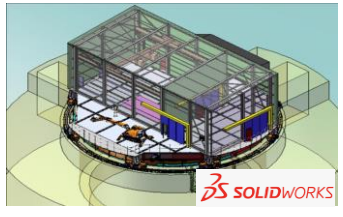
Inputs

Script of 400 lines

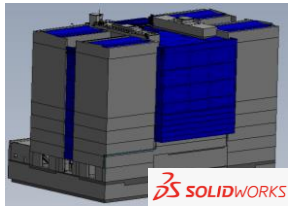
Documents available

- Physical inventory
- Script
- Waste production hypothesis
- Dose assessment
- Planning
- Kinematics

3D model



Platform

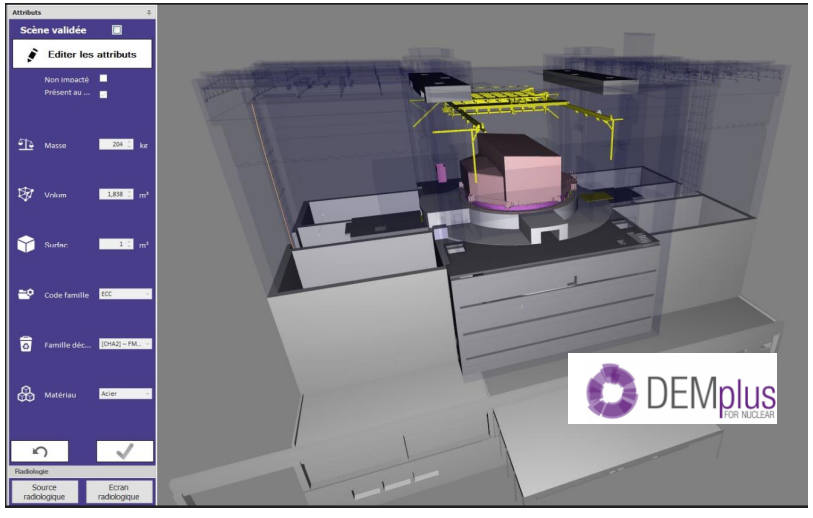


Chinon A2

Virtual view

DEMplus Worksite

≈ 400 3D objects



Dismantling scenario

≈ 400 operations

- Baseline scenario
- Optimizations
- Waste kinematics

DEMplus FOR NUCLEAR

BASELINE SCENARIO

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Dismantling simulation of Chinon A2 reactor

DEMplus® *for nuclear*

- Information centralized
- Input validation
- Operations verification
- Real time results evolution

- Kinematics
- Tools accessibility
- Better scenario understanding
- Scale representation

CHINON A2 DISMANTLING SIMULATION WITH DEMPLUS

Methodology
- **Operation duration models per category**
  - Cutting, surface decontamination, volume decontamination, transport from A to B, radiological control, other (set of tasks)
- **Tools/equipment associated to each type of operation**
  - Depreciation cost (total or partial), purchasing cost, hourly cost, consumable cost, performance (m/h, m²/h, etc)

Inventory
- **Physical**
  - Volume, masse, type, composition, etc
- **Radiological**
  - Activity, HS position, RN spectre

Processes and resources per operation
- **Operating conditions**
  - Human or robot + non prod. h/day + efficiency coef.
- **Staff Profile + Teams definition**
- **Calendar definition**
- **Model definition + tool**
- **Background definition (µSv/h)**

3D model + Physical Inventory (IFC format)

3D model
(IFC, STEP, SolidWorks, Collada)

DEMplus FOR NUCLEAR
Decommissioning Expertise Maintenance

Real time scenario evolution plus:
- Planning
- Waste produced
- Dose assessment
- Manpower costs

Export format : .pkgprj, IFC, Collada

Waste management
- **Waste process / strategy**
  - Time and packaging
- **Waste containers**
  - Cost, max. weight, ext. volume, max. volume, etc
- **Waste type (category)**
  - VLLW, ILW, HLW, etc

Radioprotection: exposition of operators f(time)
- **Waste process / strategy**
- **Maintenance**
- **Contact and distance operations**

Shielding studies
Finger print definition

IDENTIFIED CHALLENGES

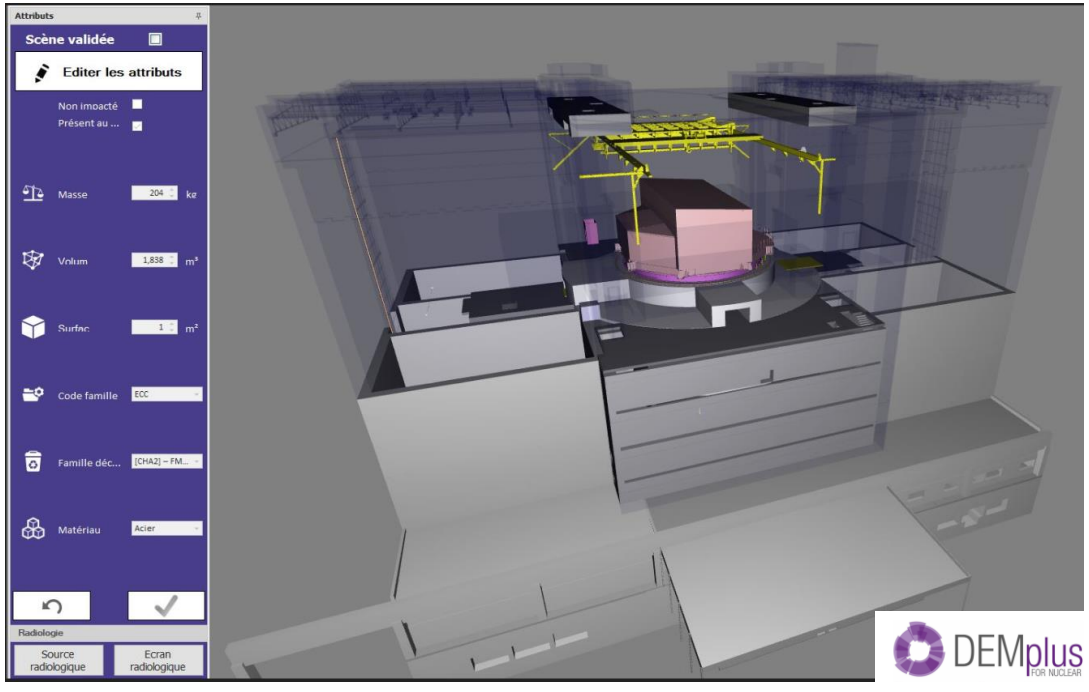
- The dimension and complex geometry of such reactors
- A huge quantity of irradiated and contaminated materials to remove
- Little information concerning mechanical behavior of graphite bricks
- Access difficulties for remote operated tools
- Operators' training

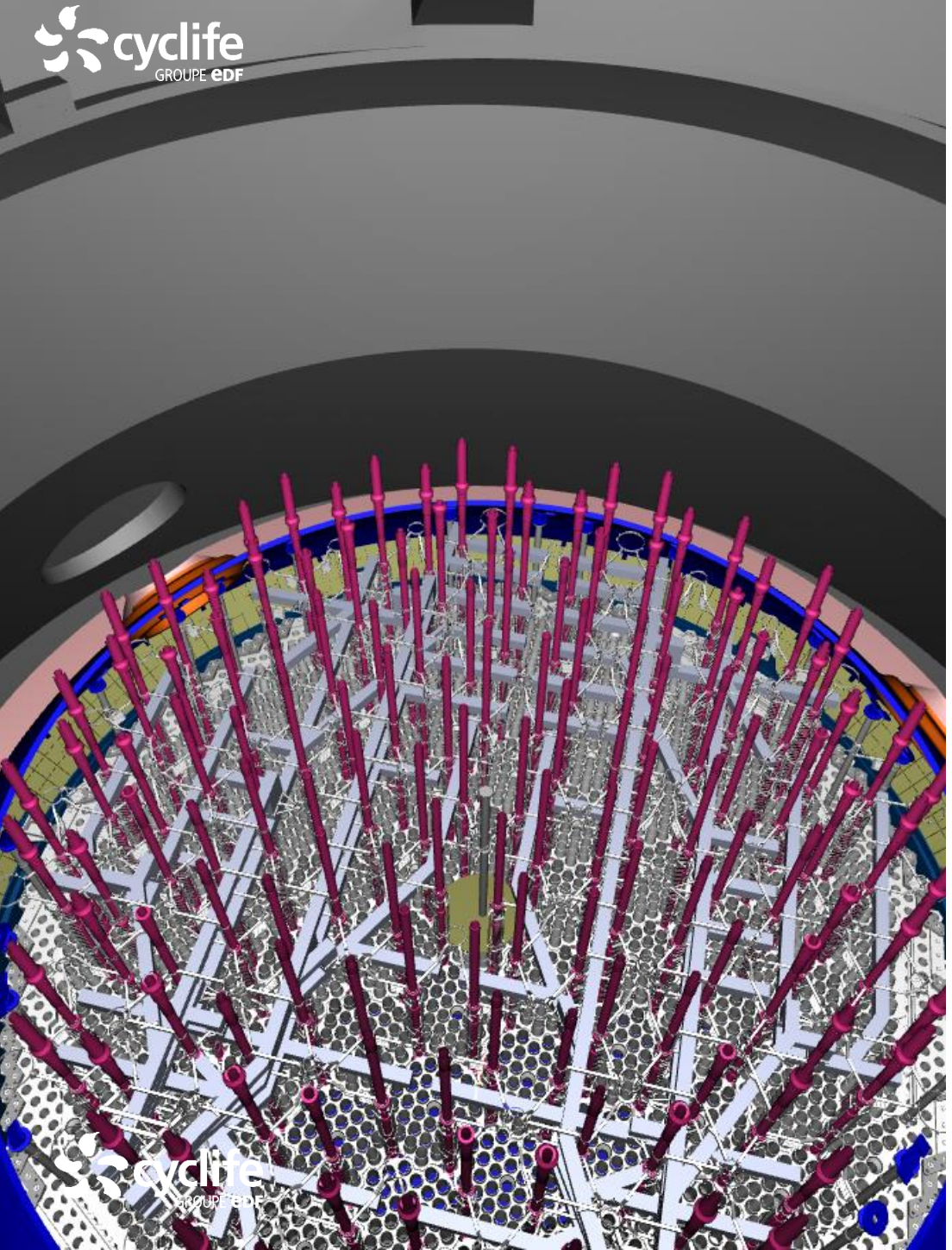
INNO4GRAPH project is focused on graphite bricks retrieval challenges

DEMPLUS INSIDE INNO4GRAPH

INNOvative tools FOR dismantling of GRAPHite moderated nuclear reactors

- Scenario simulation of the brick retrieval (core reactor dismantling) for each use-cases
- Feasibility assessment of non-standard tools use for brick retrieval thanks 3D simulation
- Safety and cost analysis
- Development of “Graphite retrieval decision support module”

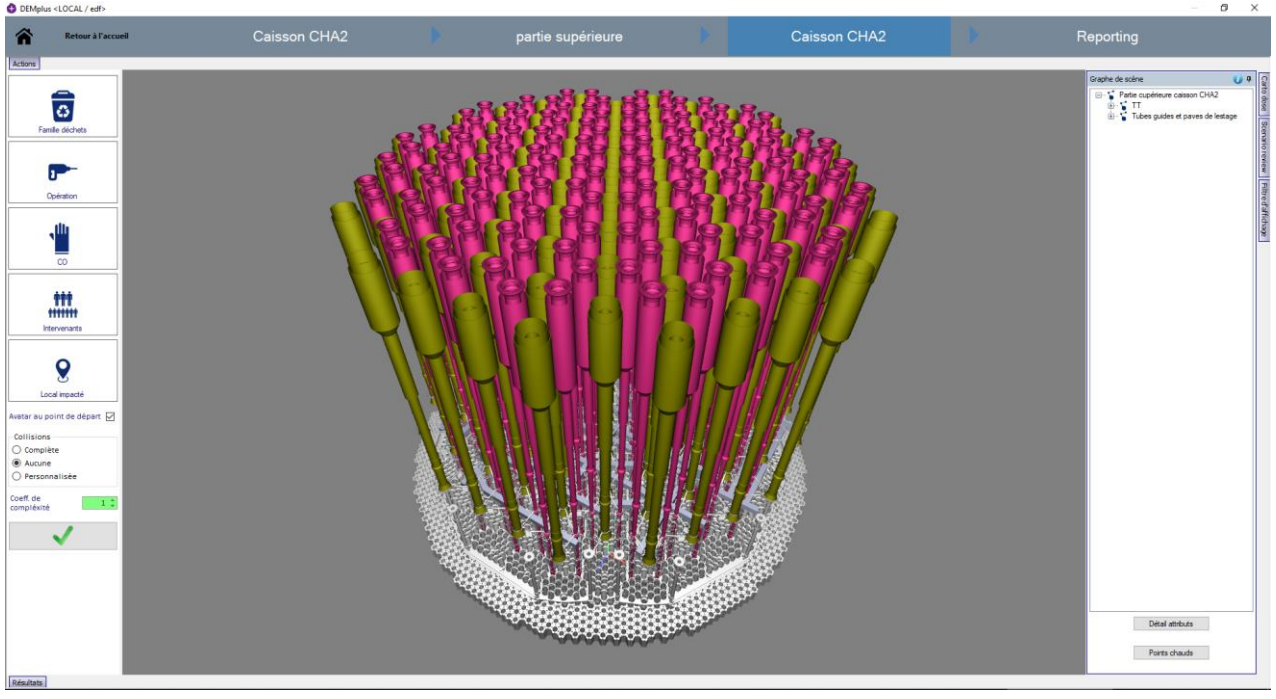




SUMMARY

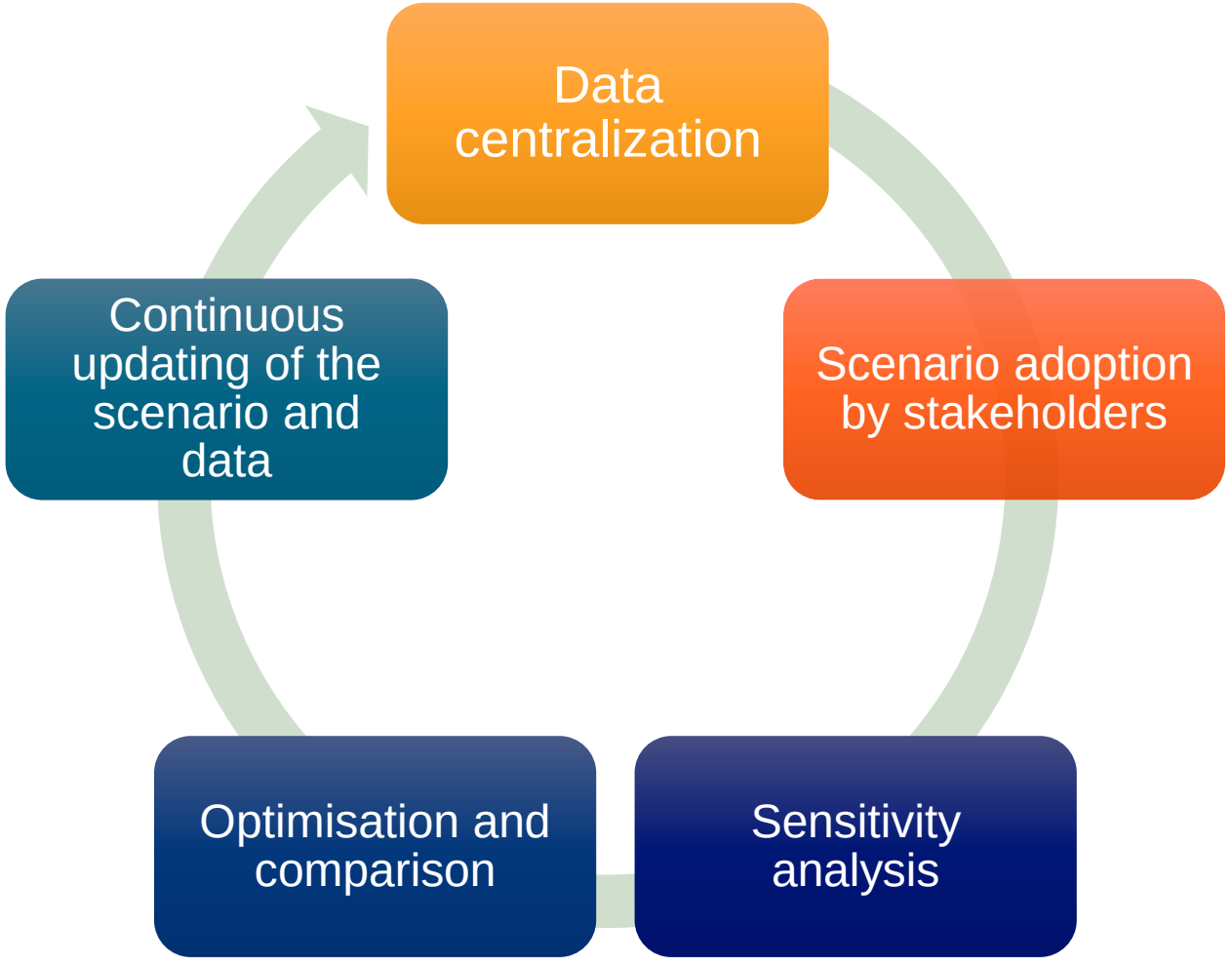
FEEDBACK

- Complete baseline scenario reproduced
- Identification of gaps, missing data and inconsistencies among all available information
- Highlight of hypothesis impact thanks to the results provided by DEMplus®
- Highlight of gaps through the scenario:
  - missing equipment inside the RPV,
  - non-cut RPV parts at the end of the scenario,
  - tools wrongly placed or wrongly sized.



CONCLUSIONS

- Data and feedback created of easy access for all stakeholders
- Optimisation and sensitivity analysis will be easier to handle and test
- Collaborative work and remote access




Thank you
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