EURADWASTE '19

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EDF Suggestions and Strategy on ways and means, including R&D, on pre-disposal and radioactive waste management for enlarging the European Joint Programme on waste disposal for joint implementation of joint programming

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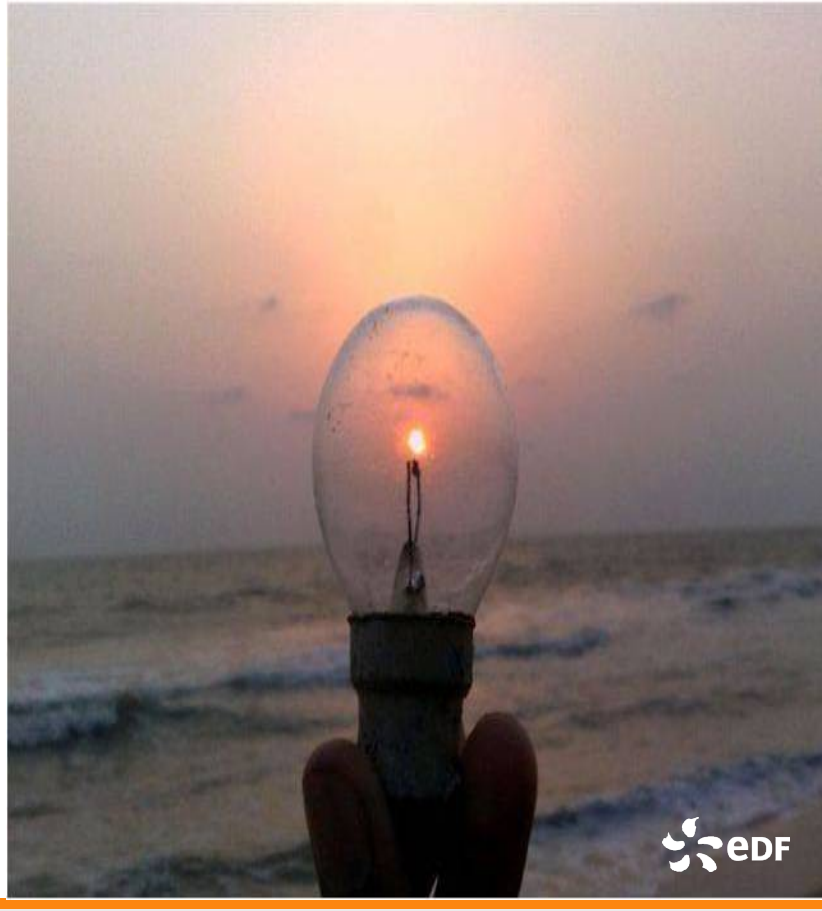
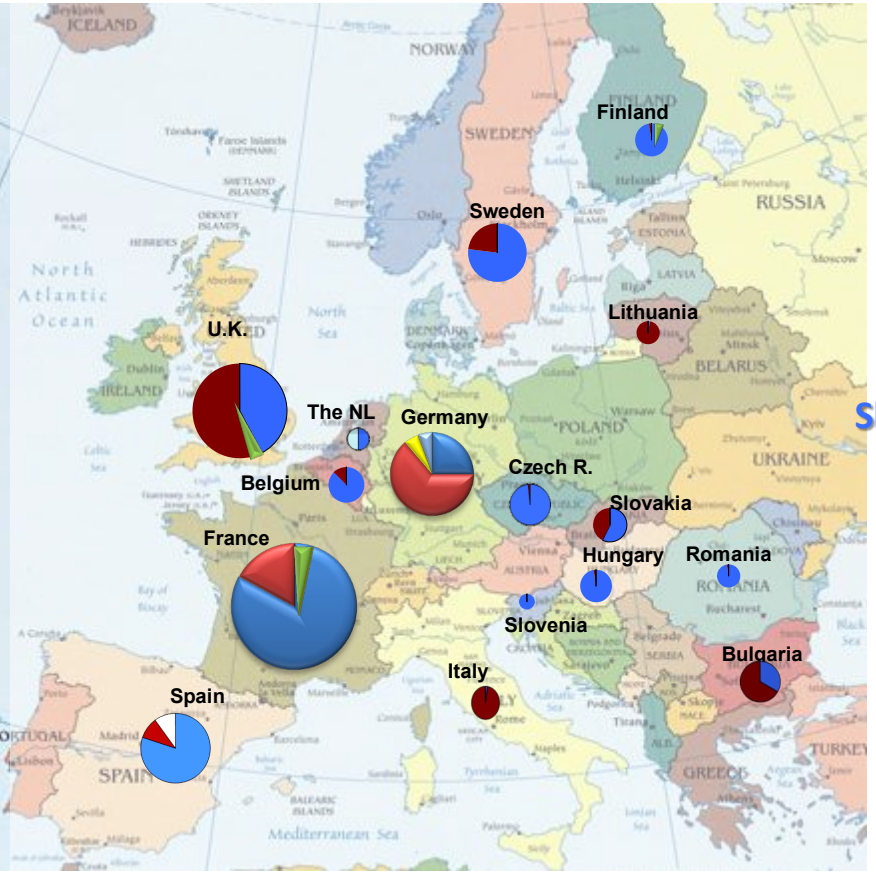
Summary

1. Context – General Considerations
2. EDF overviews & strategy
   - Lessons Learned
3. EDF Suggestions
   - Regulatory improvement
   - Technical & Experimental Aspect
4. Conclusions



1. Context : Situation of nuclear power reactors in the EU



- New Build / Under Construction
- Operational
- Shutdown – Dismantling
- Fully Dismantled
- Long Term Safe Enclosure

TOTAL

Power reactors in EU: 222

Operating reactors: 128 (/451 worldwide)

Shut down/under decommissioning : 94 in EU (/171 worldwide)

Decommissioning

A worldwide growing market

One normal step in a nuclear facility life cycle

1. Context : Decommissioning a normal step of Nuclear Facilities life cycle

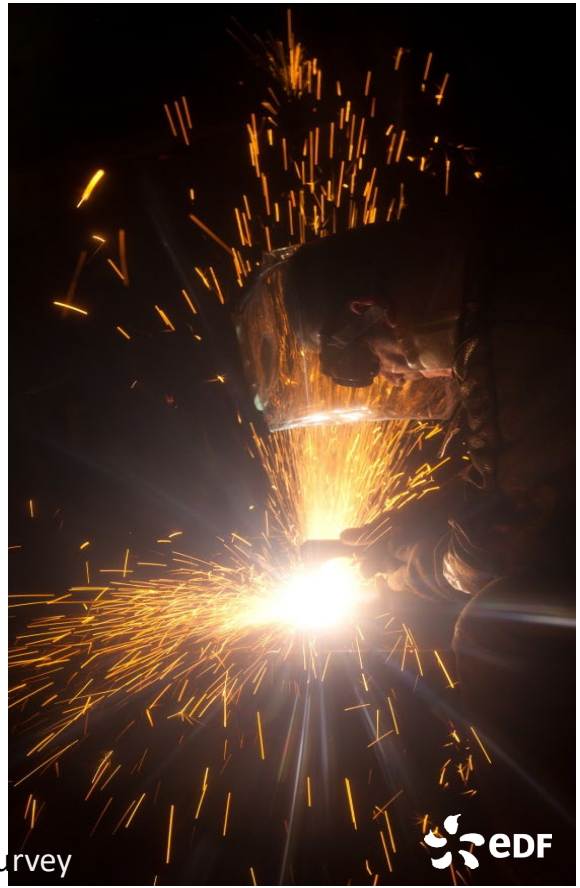
- **3 steps** in a Nuclear Plant Life cycle :
  - Design & Build,
  - Operation,
  - Decommissioning & Dismantling (D&D)
- **Materials and Waste are generated all along the 3 steps.**

Materials to be characterized and sorted

Inventories,
Characterization,
Treatment,
Reuse,
Recycling, …

Real Radioactive Waste to be disposed of

Waste volume reduction,
Environmental impact mitigation,
Preservation of storage capacities as rare resources,
Packaging, control, Transportation, survey



1. Context : Decommissioning a normal step of Nuclear Facilities life cycle

- **Technical & Financial Mastery at each step , , are key to strengthen :**
  - **nuclear industry credibility ,**
  - **Public Acceptance.**

- **Waste Management Capabilities, "From cradle to grave" ,** (Skills, Labs, treatment facilities, disposals, …) have become the **cornerstone** of this mastery,
- **D&D** appears as the **main source of radioactive waste** production ,
- **Improving** Techniques & **Means**, including devoted **R&D**, **Environmental considerations** are a **worldwide stake**
- **Fostering International Cooperation** to mutualise tools, techniques and to **share experiences** enables optimisation, risk mitigation approach, … leading to :
  - Greater efficiency, Safety, Sustainability and gain productivity,
  - Stakeholders' confidence,
  - Public Acceptance

2. EDF Overviews & Strategy in Radioactive Waste Management & Decommissioning Activities

- NPPs owners or operators are responsible for the safe and efficient running of each of the 3 phases

- As NPPs owner/operator, EDF ensures its role through an Architect Integrator model all along these 3 steps, applying, for each of them, the same quality consideration and level of requirements.

EDF : - is currently operating **58 NPPs** in France + **15** in UK

but

- has also acquired a sound robust experience in Waste management & Decommissioning, particularly during the last 2 decades .

- Strong of this OPEX in WM&D, EDF created a dedicated directorate : **DP2D** in charge of all decommissioning and Waste Management Projects completed by its holding : cyclife GROUPE EDF

DP2D, and its holding cyclife GROUPE EDF gather :

- All WM&D projects addressed within the Group
- All Skills, Resources and Industrial means,

In order to :

- Reinforce EDF Capacity & leadership in this field,
- Identify & Address pragmatically R&D aspects,
- Include wise and adapted operators'training,
- Experiment, test, adjust innovative technologies,
- Prepare Future internal challenges,
- Provide services to partners,
- Enhance complementary partnerships,
- Foster International Cooperation and the share of experiences…

2 - Brennilis
Finistère, à 70 km de Brest
Réacteur à eau lourde
Mise en service : 1967
Date d'arrêt : 1985

Partial Dismantling Decree: 2011

1 - Chooz
Ardennes, à 60 km de Charleville-Mézières
Réacteur à eau pressurisée
Mise en service : 1967
Date d'arrêt : 1991

Dismantling Decree: 2007

3 - Saint Laurent A
Loir-et-Cher, à 35 km d'Orléans
2 réacteurs UNGG
Mises en service : 1969 et 1971
Dates d'arrêt : 1990 et 1992

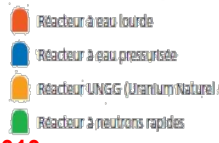
Dismantling Decree: 2010

5 - Bugey 1
Ain , à 40 km de Lyon
Réacteur UNGG
Mise en service : 1972
Date d'arrêt : 1994

Dismantling Decree: 2008

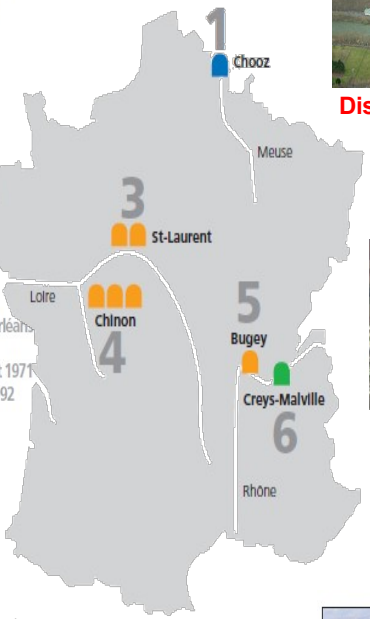
4 - Chinon A
Indre-et-Loire, à 45 km de Tours
3 réacteurs UNGG
Mises en service 1963, 1965 et 1966
Dates d'arrêt : 1973, 1985 et 1990

Dismantling Decree (Chinon A3) : 2010



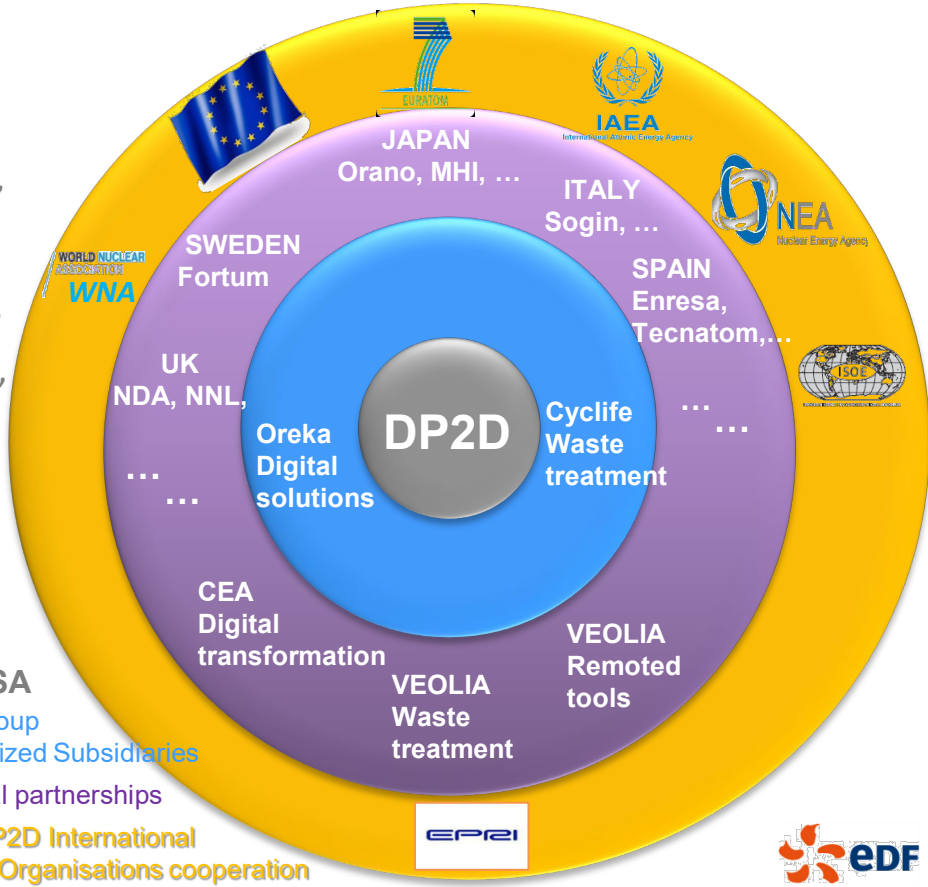
6 - Creys-Malville
Isère, à 75 km de Lyon
Réacteur à neutrons rapides
Mise en service : 1986
Date d'arrêt : 1998

Dismantling Decree: 2006

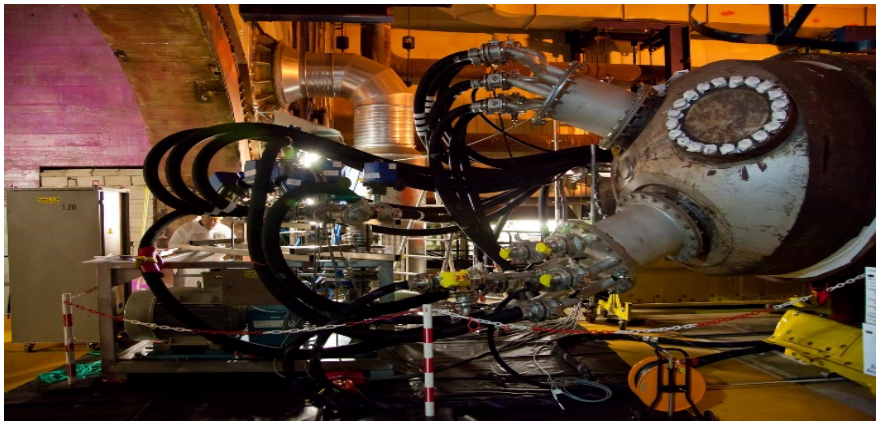


DP2D industrial organisation **encourages International cooperation to :**

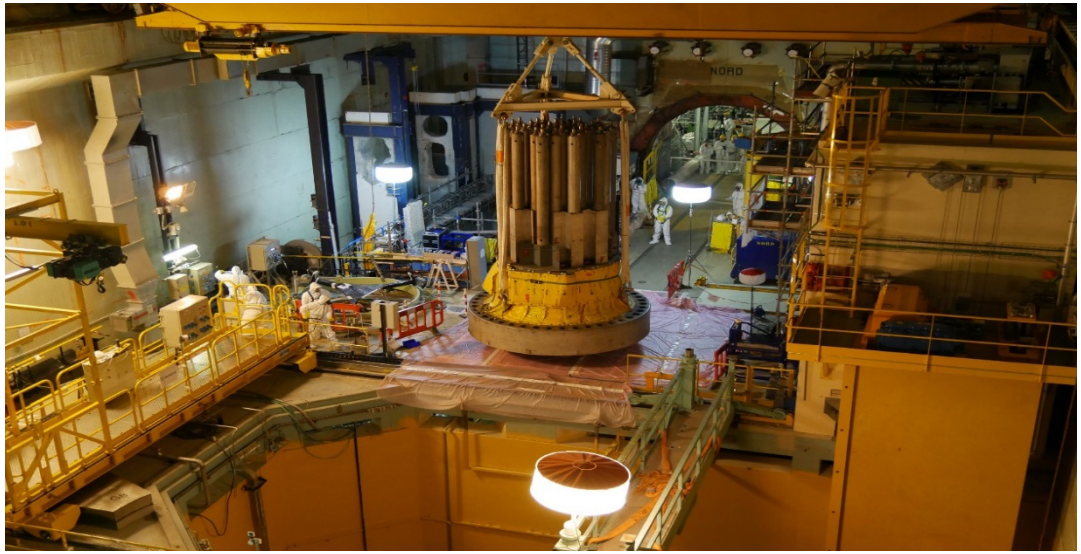
- Continuously improve its know-how and operators' ability,
- Foster the share of experiences, identify partnerships,
- Be up-to-date regarding innovation, regulatory evolutions,
- Understand Customers'needs and provide them tailored, optimised solutions,
- Test, Qualify, Benchmark and optimise new techniques,
- Support and adapt dedicated **R&D,** Operators'training,

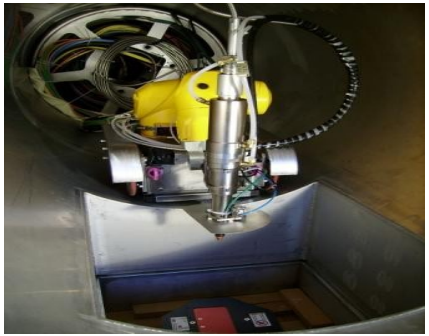


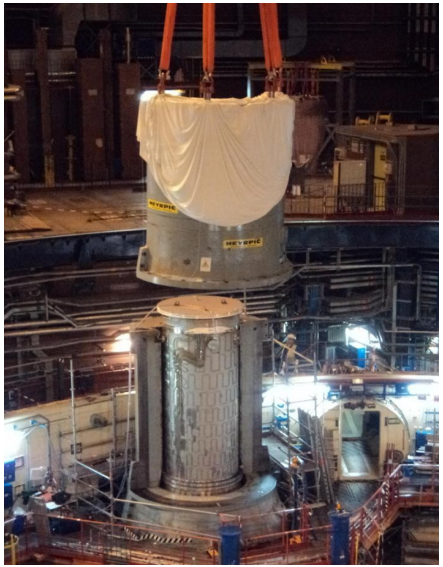
2. EDF Overviews & Strategy : Waste management driven Decommissioning



2. EDF Overviews & Strategy : ~20 years of experience in Waste management & Decommissioning

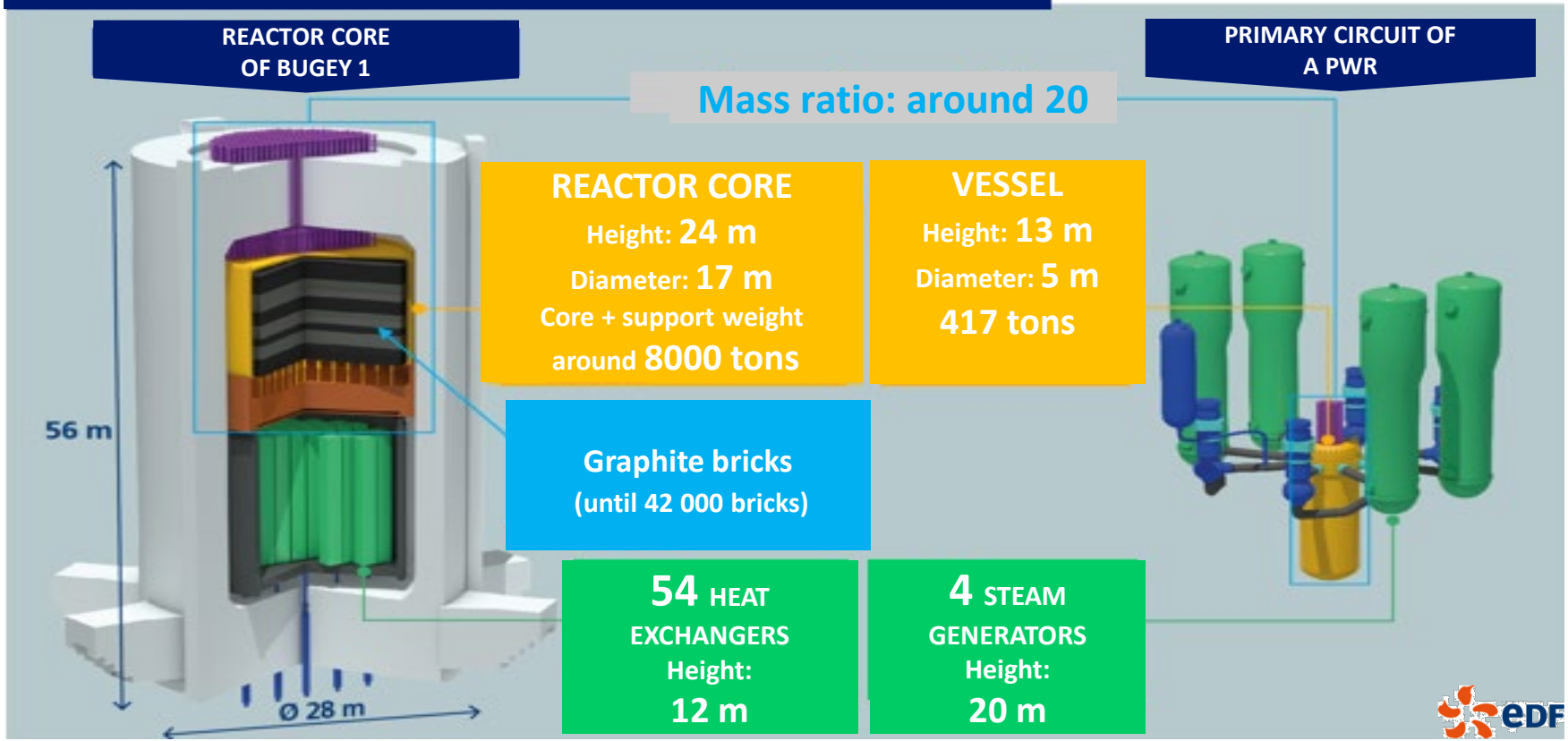






2. EDF LESSONS LEARNED : All reactors are not equal considering dismantling…

ILLUSTRATION OF GAS COOLED REACTOR COMPLEXITY



2. EDF LESSONS LEARNED : All reactors are not equal considering dismantling…

- **Different Nuclear reactor technologies are not equal regarding decommissioning**
  - PWR (Current operating French Fleet) : Scenarios & Feasibility regularly assessed & checked → focusing optimisation and serial effect
  - EDF Graphite reactors dismantling will be a First of a kind for such huge structures :
    - → means and innovative tools still under development
    - → Graphite Management remains a stake

    } → Significant dismantling timeframes to be expected

- **EDF Risk Mitigation Approach allows anticipation, flexibility, reactivity, …**
- **Experience in Projects/program management + waste driven decommissioning are keys**
- **Complete and efficient national Waste Management system is essential for nuclear decommissioning**
  - improvements can still be envisaged :
    - clearance levels, homogeneisation of references & criteria to enable relevant benchmarking of techniques, ability,
    - anticipation of regulatory evolutions and associated communication with locals and stakeholders,
    - notion of Immediate dismantling to be referred back to its origin (asap after shutdown vs rapidly at any risks and costs) to avoid misinterpretation instead of sharing rules and education which fosters technical, financial & environmental impacts mastery

2. EDF LESSONS LEARNED : All reactors are not equal considering dismantling…

- **WM&D strategic considerations can't be addressed without embedding Costs :**
  - Assessment, provision, availability, timeframe, …
  - Relevance of scenarios & Chosen Processes → Benchmarks , audits,
  - Financing of R&D programs,

- **Compliance of R&D expected innovations with identified/scheduled needs on site :**
  - Multiple International workshops & Cooperation
  - Multiple Benchmarks

→ In D&D, R&D is preferable when devoted to improving :
- Efficiency of existing means,
- Operators'ability and training,
- Criteria definition (for both technical or regulatory aspects)

- **Communication Improvement from the early stages of any D&D projects to embed :**
  - Officials and Local Authorities
  - Public Acceptance

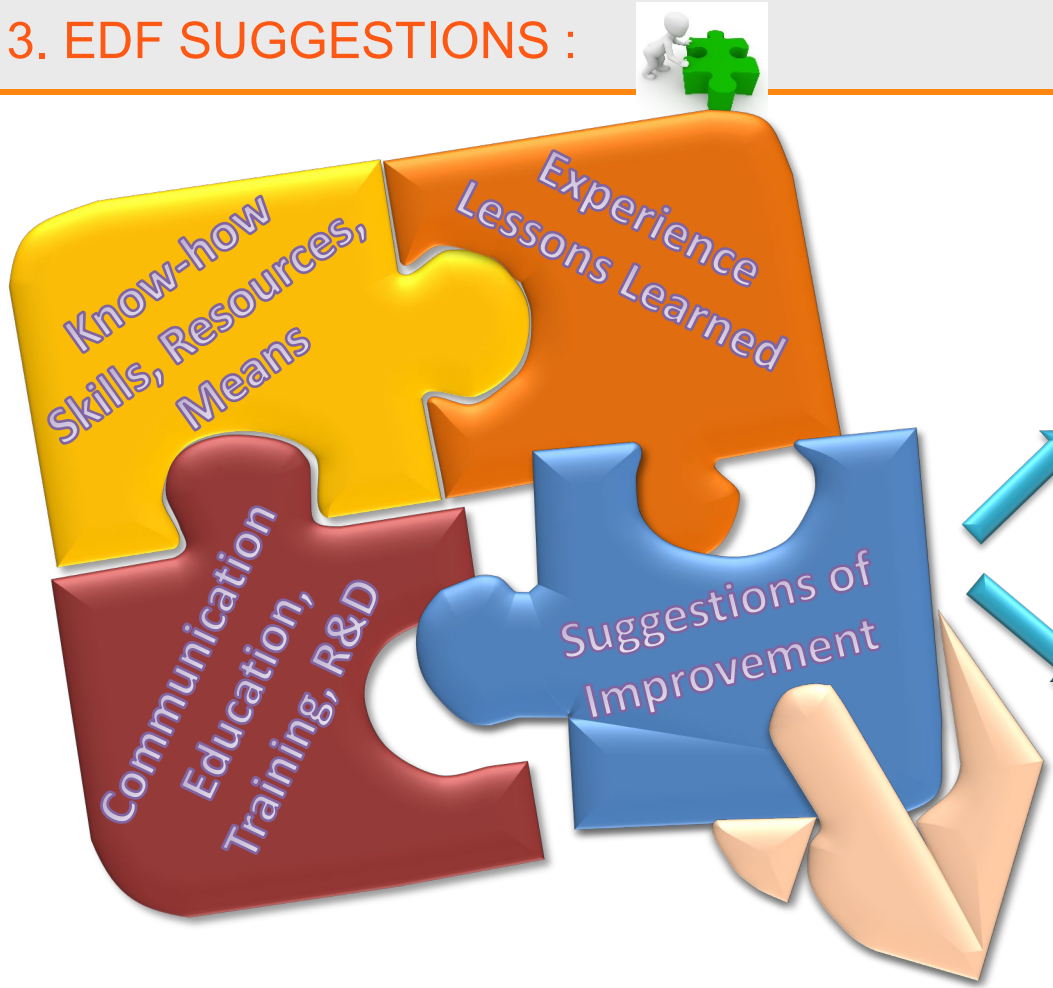
→ to improve information sharing, fostering compromise, coutnerparts'commitment

- **Need to :**

→Improve/ease education and acceptance,
→Define shared and common criteria,
→Assess & Improve pragmatically efficiency, relevance of scenarios based on agreed common references,
→Avoid confusion inducing loss of credibility and confidence

→ **Suggestions**

3. EDF SUGGESTIONS :

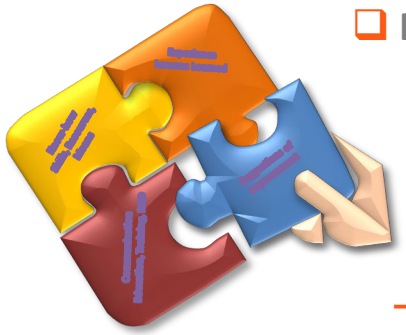


Regulatory Considerations :

- **to foster Circular economy**
- **to improve international cooperation**

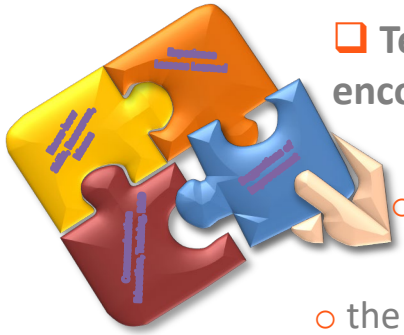
Technical, Experimental Improvements

3. EDF SUGGESTIONS : REGULATORY IMPROVEMENT



- **Regulatory Considerations evolutions to be taken into account :**
  - Common and agreed International Guidelines / Directives leading to national adjustments
  - Need to harmonise regulations between countries to :
    - → Foster circular Economy, particularly in Waste Management & Materials recycling
  - → Improve Environmental and raw resources presevation,
  - → Avoid any risk of confusion in population's perception leading to dwindling confidence in nuclear industry, including regulators !!!
- → Allow, thanks to common rules & criteria, realistic, sound and representative assessment of :
  - Processes and techniques,
  - Operators'ability and mastery,
  - Holistic Efficiency (including regarding environmental impacts, storage capacities preservation as rare resources, waste volume reduction, transportation reduction, …),
  - Ease and foster international cooperation, sharing/improving/implementing treatment solutions, mutualising equipments or facilities (i.e. MNR , Treatment facilities, Training centers, operators certification, tools qualification, …),
  - To illustrate the usefulness & assets of earliest as possible regulators'involvement.

3. EDF SUGGESTIONS : TECHNICAL, EXPERIMENTAL IMPROVEMENT



❑ **Technical Improvement, and Experimental development including R&D to be encouraged in order to increase :**

- Already existing means efficiency (Conclusion of OECD/NEA/NI2050 2019 report),
- Operators'ability and effectiveness, by strenghtening their training, on representative configurations & Mock-ups, designed or adjustable for any kind of nuclear technologies,
- the availability of industrial demonstrators, enabling Operators to optimise the effectiveness of tools, to be trained to face unexpected situations, test alternative solutions safely at mastered delays & costs, accurately assessing types & amounts of secondary waste up to packaging to optimise predisposal actions, increasing confidence, responsibility & credibility,
- Treatment efficiency (eg. Melting) → R&D program to assess, on a common shared basis, the real remediation capacity of such materials treatment → enhancing Joint R&D programmes,
- International cooperation, (ie. R&D programmes on long lived ILW treatment/conditionning/packaging),
- the implementation & development of innovative techniques enhancing virtual reality, digital simulation, remote handling/autmated operations, remote exoskeleton to progressively replace human operators by machines where know-how and on time adjustment is inevitable despite high dose rate exposure.

3. EDF SUGGESTIONS : TECHNICAL, EXPERIMENTAL IMPROVEMENT

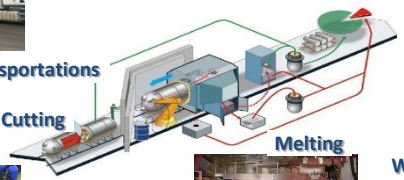
❑ EDF Fosters and leads 2 New projects in compliance with these suggestions:

Future Centralized Treatment Facility

ingots for recycling

SG

Multi modal transportations



Cutting

Melting

Waste devoted to repositories

Decontamination

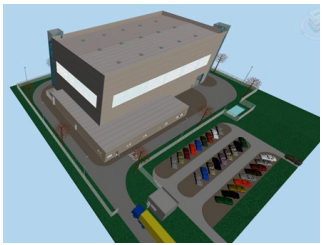
Decommissioning Industrial Demonstrator

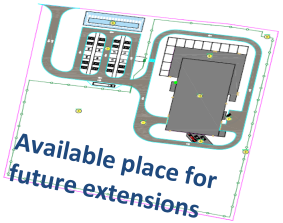
3. EDF SUGGESTIONS : TECHNICAL, EXPERIMENTAL IMPROVEMENT

❑ EDF Decommissioning Industrial Demonstrator

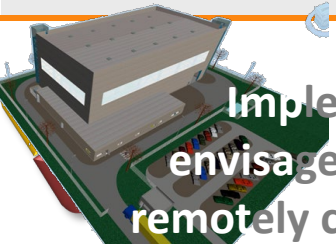
First designed for graphite reactors Decommissioning, this scalable facility will enable operators from all potential stakeholders to :

- Check the feasibility of new decommissioning scenarios, including alternative solutions to face unexpected situations that will undoubtedly occur,
- Allow intense use of realistic 3D modelling based on on-site 3D scanning,
- Train workers to the choice and use of most suitable techniques,
- Increase safety, control delays and costs : determining appropriate tools, cutting speeds, volumes of secondary waste or releases, reducing dose rate exposure, optimising packaging, control and handling procedures
- Implement automated means, remote handling tools, test the efficiency of cutting tools on real scale mock up, adapt and adjust to any kind of identified needs





3. EDF SUGGESTIONS : TECHNICAL, EXPERIMENTAL IMPROVEMENT



❑ EDF Decommissioning Industrial Demonstrator

Implementation of Automated Means will let us envisage progressive replacement of humans by robots remotely controlled using exoskeletons when need to:

- require human know-how and on time analysis despite high dose rate exposure conditions,
- improve safely Labor efficiency (up to ~2 times) increasing working time in ionized radiations conditions but reducing collective dose,
- enable larger fragments without compulsory heavy handling means,
- ease worksite preparation (no prior decontamination, no multiple airlocks, …),
- better consideration to secondary induced waste volume reduction as a source (less washing, clothings, effluents, waste, ashes, drums…),
- mitigate risk of injury, electric shock, falling objects, work from heights,
- motivate and educate operators as well as public consideration towards back-end activities.

4. CONCLUSIONS :

❑ EDF WM&D Strategy, including R&D aspects on pre-disposal, are strongly influenced by Lessons learned over the last 20 years of real sound worksite experience and future challenges,

❑ **Fields of Improvement remain regarding :**

- ❑ **Suitable regulatory Criteria fostering :**
  - Circular economy in materials & waste Management among countries,
  - Common basis of comparison of techniques efficiency (volume reduction for instance),
  - Operators'common certification and training rules (to address WM&D as a growing worlwide market),

  → ***To clearly identify remaining lacks and needs worldwide leading to R&D developments***

- ❑ **Experimental and technical innovations facilitating :**
  - international cooperation and share of experiences,
  - implementation of new techniques,
  - operators'training, tools testing, multi criteria optimisation of scenarios including Waste volume reduction,
  - operators'commitment as well as Public acceptance towards back-end activities,

❑ **International Official Organisations continuous Support to operators'initiatives is key to promote EU Know-how in this very competitive market…**