WASTE MANAGEMENT: IMPORTANCE & IMPACT OF VOLUME REDUCTION AND RECYCLING IN NUCLEAR DECOMMISSIONING

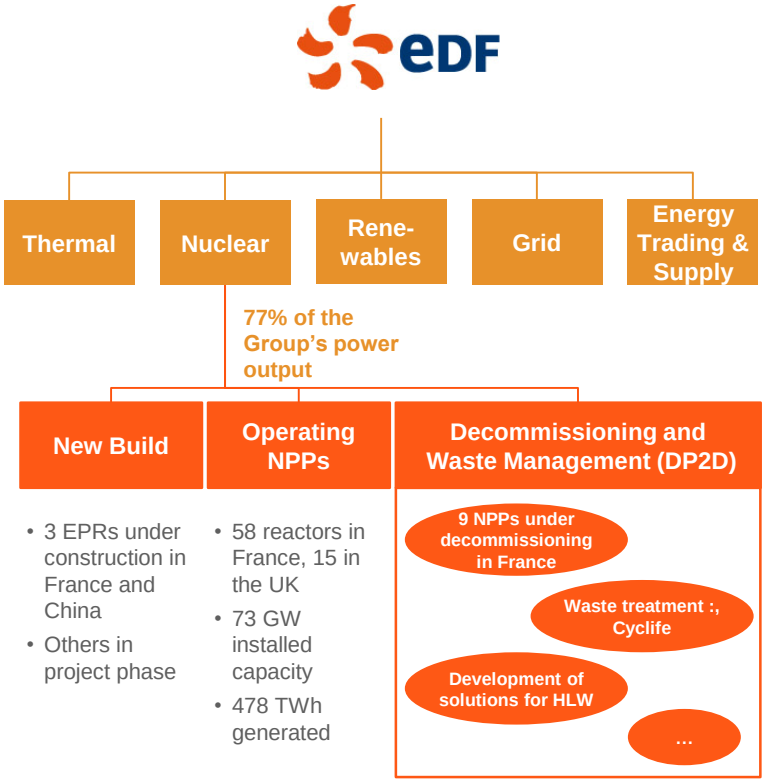
Application of Sustainability Principles and Circular Economy to Nuclear Decommissioning,
Rome 18-21 June, 2019

AGENDA

1. **Dismantling and Waste Management within the EDF Group**
2. **Material and Waste Inventory in Dismantling**
3. **Recycling of Materials in Dismantling**
4. **Waste-Led Decommissioning: the EDF Cyclife Approach**
5. **Zoom on Chapelcross Gas Ducts (UK 2018): a Successful Integrated Project Achieved by EDF Cyclife**

Dismantling & Waste Management within the EDF Group

Waste management and dismantling are keys in the EDF Group strategy



Generating low-carbon electricity from **nuclear power** and renewables is a top priority of the CAP 2030 strategy

As a responsible nuclear operator, **demonstrate our full control along the entire life cycle**, by efficiently managing decommissioning projects and waste generated by our power plants in operating or dismantling phase.

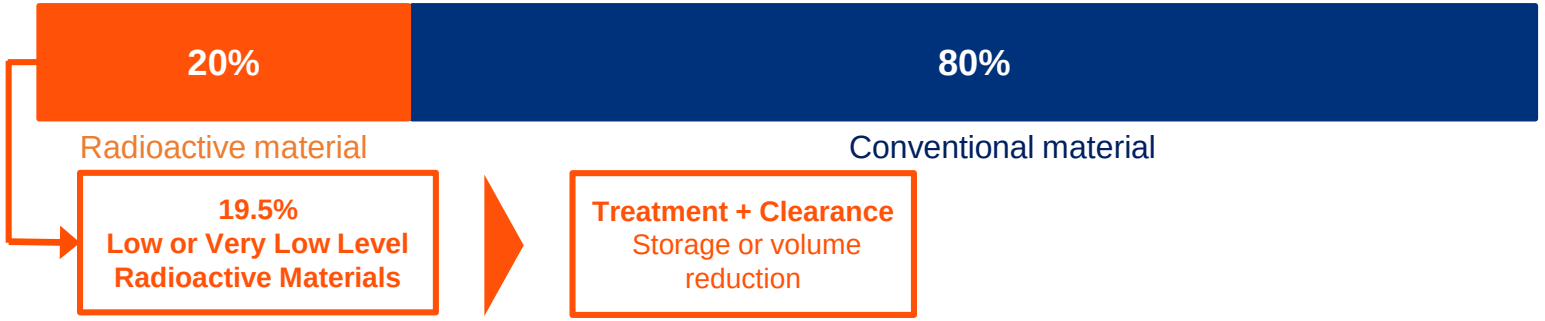
Dismantling & Waste Management within the EDF Group

EDF supports its nuclear customers through each phase of the nuclear lifecycle with a comprehensive range of services and expertise

cyclife the specialist delivery organization dedicated to decommissioning and radioactive waste management within the EDF Group

Material and Waste Inventory in Dismantling

The major part of material produced by a dismantling project is conventional.
The huge majority of the remaining part is VLLW and can be treated and reduced.



Radioactive waste quantity can be very low (~ 2%) if volume reduction and clearance is feasible.

Two examples from Germany:

BWR Würgassen

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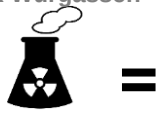
255,000 tons of waste released, 3,000 of controlled recycling and 4,600 tons of Radioactive waste after clearance and volume reduction

Source: TÜV, EON, VGB



PWR Stade

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124,000 tons of waste released, 500 tons of controlled recycling and 3,000 tons of radioactive waste after clearance and volume reduction

Source: TÜV, EON, VGB

The Radioactive Waste Hierarchy

Avoidance	Avoid the introduction of additional material into the controlled area during decommissioning activities, *e.g.* packaging material, additional tools, temporary equipment.
Re-use	Re-use dismantled equipment (after appropriate cleaning/ decontamination and maintenance) within the nuclear industry.
Recycling	Recycle material from decommissioning within or outside the nuclear industry.
Reclassification	Reclassify radioactive waste using more accurate activity measurement techniques, as well as by increasing the degree of segregation and decontamination.
Volume reduction	The remaining radioactive waste should be treated to reduce the volume as much as is reasonably achievable.
Disposal	Proper conditioning, qualification and safe disposal of remaining waste.

Source: WNA

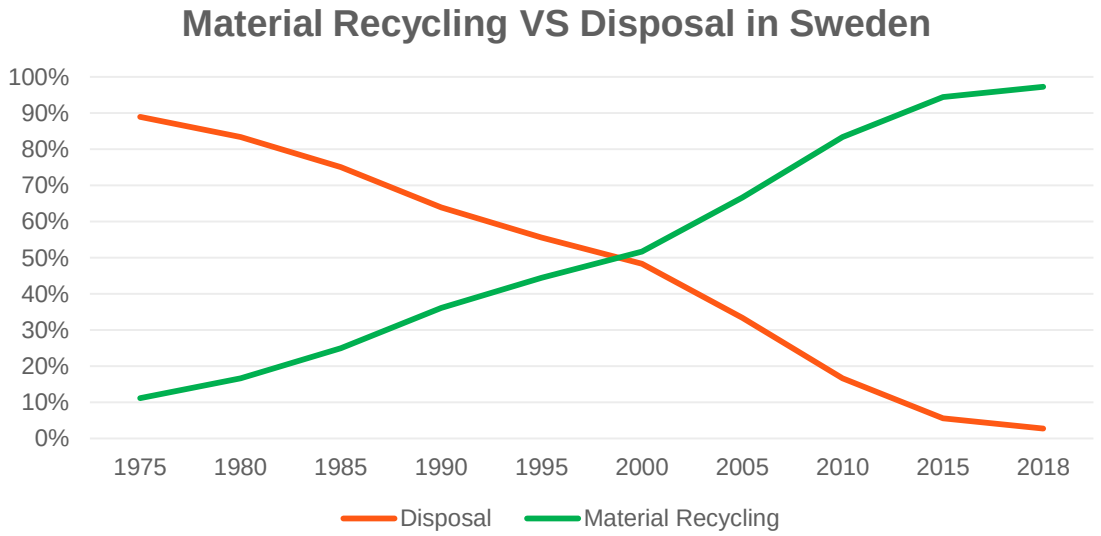
Recycling of Materials in Dismantling

Conventional recycling in Sweden: an inspiring success story

In mid 1970s, only 38% of household waste was recycled. At that time it was mainly to recover energy

In 2017 more than 99% of all household waste in Sweden is recycled (material and energy recovery)

More than 98% of the metal in a car can be and is recycled

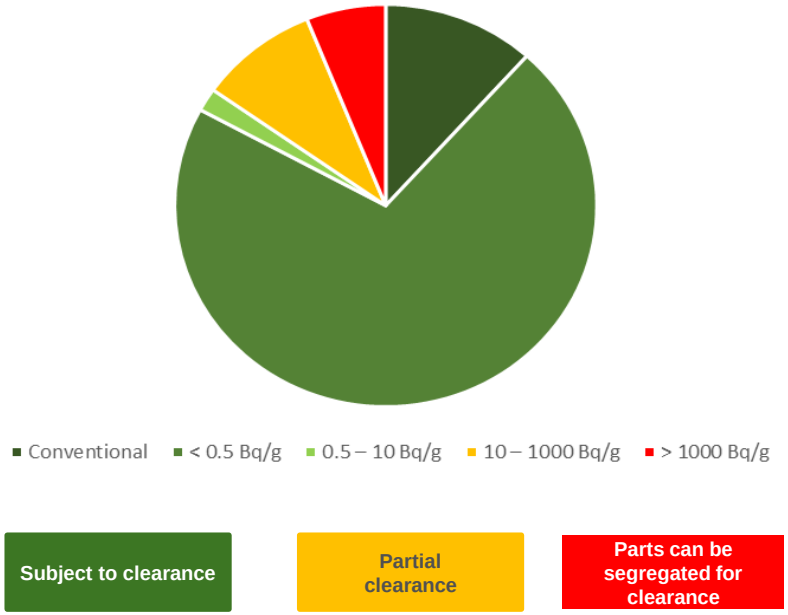


Recycling of Materials in Dismantling

Recycling focus on decommissioning

- It is proven that approximately **98%** of the material within the controlled area **can be made subject to clearance**.
  - Most decommissioning waste materials have **excellent properties for clearance and recycling.**
  - Recycling allows to **preserve scarce and valuable resources.**
  - **High disposal costs** and limited availability of storage are also a driver for recycling.
- A cost-efficient clearance program requires **efficient and effective cost processes.**
- **Public acceptance and trust** is a key criteria for success.

Clearance potential – metals controlled area



Recycling of Materials in Dismantling

There are multiple options to perform clearance of metals

OPTION	+ ADVANTAGES	- DRAWBACKS
Clearance of material as it is (original shape)	• Low investment in equipment • Can be applied in-situ	• Labor intensive • Requires accessible surfaces • Requires low background
Shredding of material and clearance	• Material is opened up and mixed • Labor and energy efficient • Reduced uncertainties	• Requires low background for measurements • Significant investment in equipment/facilities
Melting and clearance recycling	• Material is fully homogenized • Fully representative sampling • Decontamination of Cs and alphas in treatment process • Significantly larger “clearance window”	• Large investment in equipment/facilities • Melting consumes energy (furnace heating and ventilation)

Waste-Led Decommissioning: the EDF Cyclife Approach

What is waste-led decommissioning ?

The definition and implementation of optimized waste routes, before starting the dismantling, improves the project schedule, cost effectiveness and therefore its success.

Through its dedicated waste treatment facilities, EDF Cyclife:

develops innovative cost effective solutions for waste management

deploys the waste-led decommissioning approach on its own fleet and for its clients

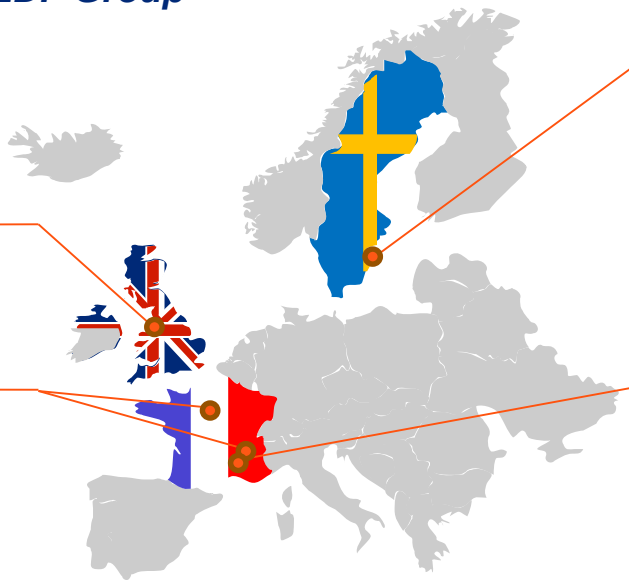
The waste treatment solutions contribute to the:

1. **reduction of interfaces and risks** in decommissioning projects by integration across the value chain
2. **reduction of waste management and disposal costs**
3. **optimization of scarce radioactive disposal capacity**

Our experience is based on D&D projects for various technologies, LWR, FBR, HWR and GC.

Waste-Led Decommissioning: the EDF Cyclife Approach

Cyclife is the European platform for Dismantling and Waste Management of the EDF Group



105 – staff

SWEDEN | Nyköping facility

- Melting: 5,000 tons per year
- Incineration: 600 tons per year
- Pyrolysis: 50 tons per year
- Clearance: 2,500 tons per year

75 – staff

UK | Workington facility

- Size-reduction and shot blasting: 3000 tons per year

850 – staff

France | Paris and Lyon

- 700-staff dedicated to decommissioning, characterization, waste management solutions, safety and environmental studies
- 150-staff dedicated to NPP dismantling Engineering in Framatome

310 – staff

France | Centraco facility

- Melting: 3,500 t/y
- Incineration: 6,000 t/y
- Manufacturing concrete containers for nuclear waste transportation
- Manufacturing and operating mobile conditioning units

…and an ambition to grow in the decommissioning and waste treatment segment

Decommissioning Services	Waste Treatment
Decommissioning Scenario & Costing Strategies Characterization and Categorisation Transition Management and POCO Decontamination and Dismantling Training	Melting : up to 8 500 t/y *Scrap and metallic large components* Incineration : up to 5 600 t/y Metal Recycling Facility : up to 2 500 t/y Clearance facility 2500 t/y Pyrolysis : 50 t/y

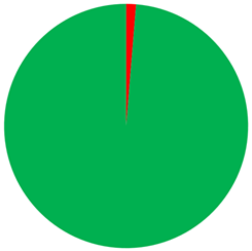
Zoom on Chapelcross Gas Ducts (UK 2018): a Successful Integrated Project by EDF Cyclife

16 gas ducts with gantries shipped to Sweden for treatment

- ~ 900 tons of complex internally contaminated material, including asbestos.
- Gantries for size reduction and clearance ducts, bellows and elbows for decontamination and melting

Value delivered:

- 900t LLW removed >90% recycle rate thanks to a high decontamination factor
- All gantries have passed direct clearance
- 98.4% of the metals ingots will be subject to clearance
- Faster & cheaper than processing on-site



Chapelcross, Scotland

Nyköping Sweden

Conclusion

Volume reduction and recycling are key solutions for an optimized waste management and a circular approach

Efficiency - The overall recycling rate from NPP LWR decommissioning can be as high as 98%

Responsibility - Clearance is a well-established safe procedure with a high environmental profile which can reduce liabilities

Flexibility - Clearance can be performed in different ways, locally or in external dedicated facilities

Complementarity - Melting in combination with clearance allow a significantly larger acceptance window for clearance

The EDF Group is committed to offer competitive and sustainable solutions for volume reduction and recycling to support the nuclear industry through its 100% subsidiary, Cyclife.