Life Cycle assessment of very low-level radioactive waste from decommissioning of the Fessenheim nuclear power plant: Case of the very low-level radioactive waste treatment

Zineb Guendouz[1], Ahmed Sahel[2], Michal Kozderka[2], Gaetana Quaranta[2]
[1]University of Chemistry and Technology, Prague, Prague, Czech Republic
[2]University of Strasbourg, Strasbourg, France

1. Context and objectives

The decommissioning of French nuclear power plants results in a significant volume of low-level radioactive waste (VLLW), presenting considerable environmental challenges. In light of the anticipated saturation of the French waste disposal center by 2028 and the need for an additional facility, our research focuses on the VLLW generated during the decommissioning of the Fessenheim Nuclear Power Plant and its storage at Andra's facility. We examine various aspects, including the packaging, transport, and construction of the storage center. Through a life cycle assessment, we evaluate the environmental impact in terms of air and water quality, soil conditions, emissions, and energy consumption. This study shall help decision makers regarding VLLW management, contributing to the improvements of sustainability within France's nuclear industry and broader global waste management endeavors.

3. System boundaries

The analysis primarily focuses on evaluating the environmental impacts of 12,000 tons of very low-level radioactive waste (VLLW) generated from the decommissioning of the Fessenheim nuclear power plant. The assessment takes into account the various stages involved, including packaging, transportation, and site construction of Andra storage center.

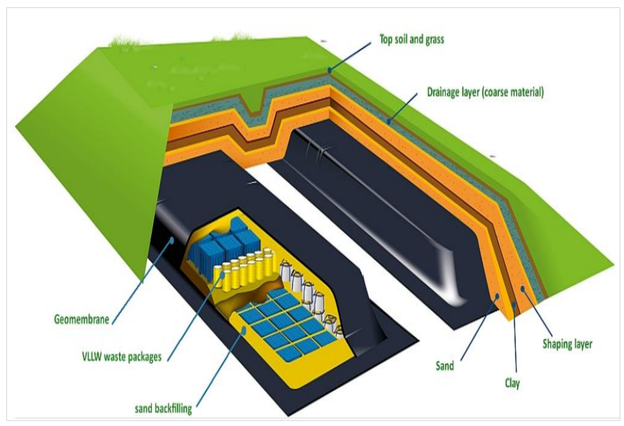


Figure 01: Composition of the Storage cell

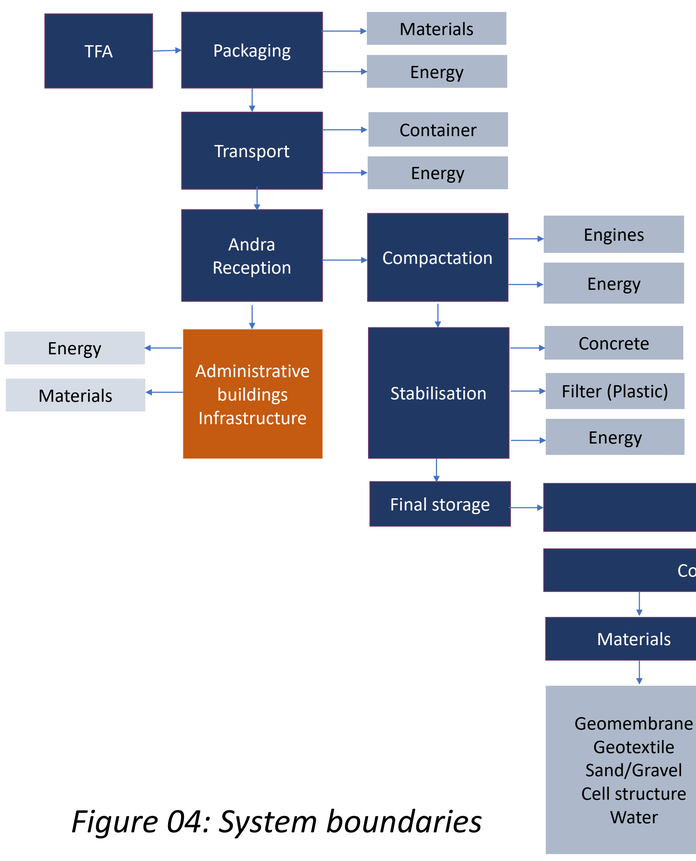


Figure 04: System boundaries

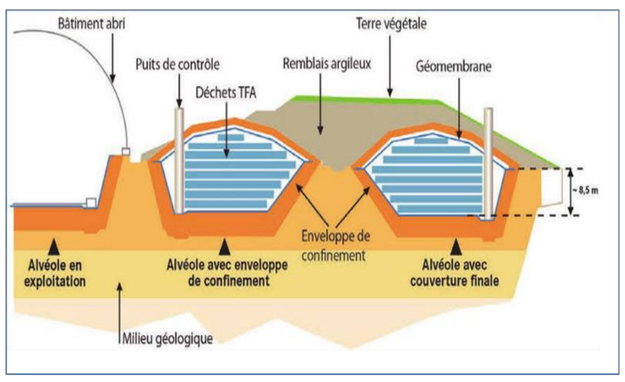


Figure 03: Concept of VLLW Storage

5. Impact Assessment and Interpretation

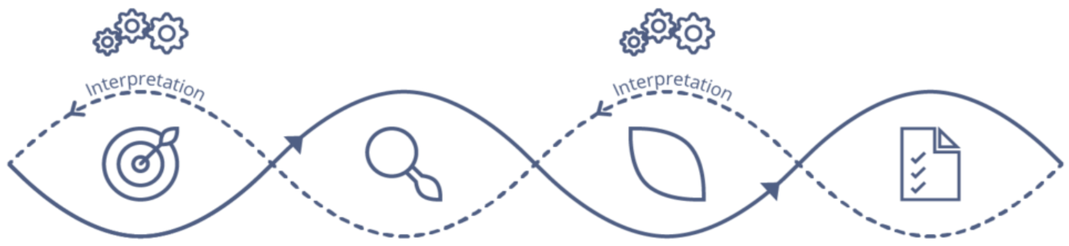
Impact categories	Unite	Packaging	Transport	Stabilisation	Site construction
Human health	DALY	50%	10%	<5%	35%
Ecosystem quality	PDF*m2*yr	25%	15%	<5%	60%
Climate change	kg CO2 eq	45%	15%	5%	30%
Resources	MJ primary	35%	20%	<5%	40%

Table 02: Impact assessemnt of VLLW result

The impact assessment of very low-level radioactive waste from the decommissioning of the Fessenheim nuclear power plant was carried out using **SimaPro** software and the **Impact 2002+** method. The preliminary analysis reveals that packaging and site construction have the most significant impacts across multiple categories. The packaging process accounts for **5*0*%** of the impact on **human health**, while site construction contributes **60%** to the impact on **ecosystem quality**. Additionally, the packaging process is responsible for ***50*%** of the impact on **climate change**, and site construction consumes **40%** of **the primary energy resources**. Transport and stabilization processes, although contributing to the overall impacts, have comparatively lower magnitudes. It is important to prioritize optimization efforts in packaging and site construction to mitigate their substantial effects. By implementing measures to minimize these impacts, we can effectively manage the treatment and disposal of radioactive waste while ensuring the preservation of human health, ecosystem quality, and climate stability.

2. Method

The potential impacts of very low-level waste (VLLW) generated from nuclear power plants have been assessed using the Life Cycle Assessment (LCA) methodology.



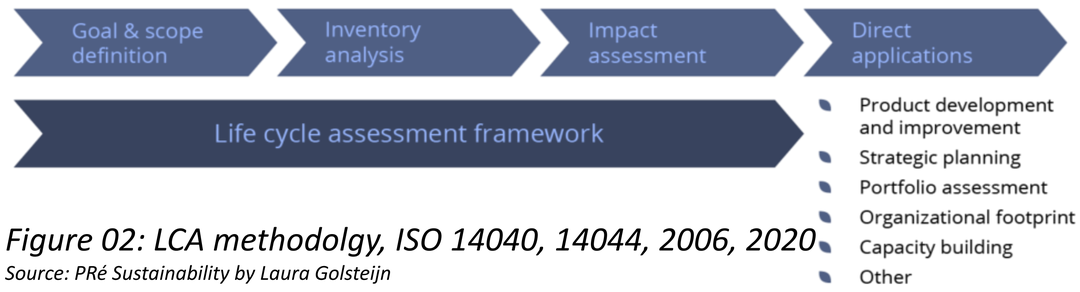
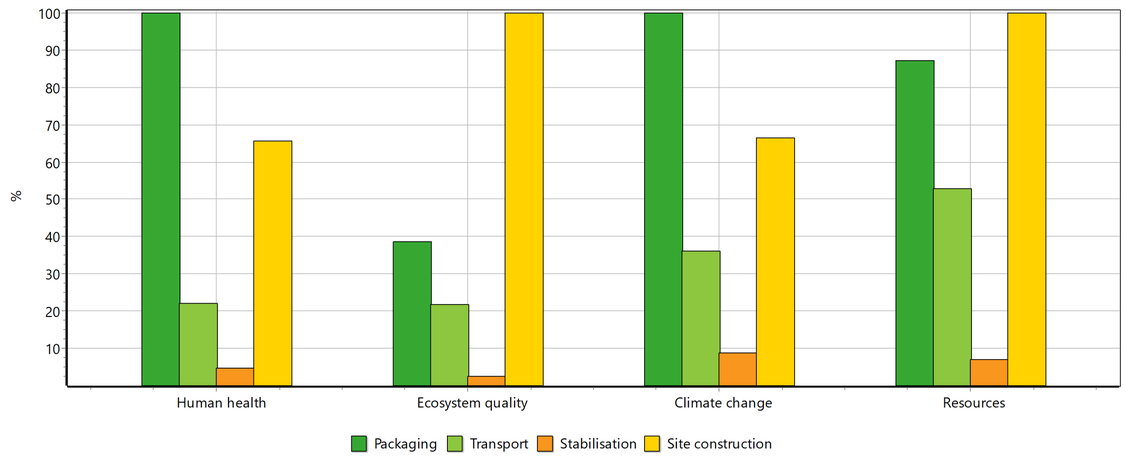


Figure 02: LCA methodolgy, ISO 14040, 14044, 2006, 2020
Source: PRé Sustainability by Laura Golsteijn

4. Inventory analysis

Process step	Procedures	Material imput	Distance
Waste Packaging preparation	Packaging	Metal 1275 t Plastic 4.8 t	400350 tkm 1272 tkm
Transport	Transport 01 Empty packaging		408000 tkm 1536 tkm
	Transport 02 Packaging + VLLW		4249536 tkm
TFA Control	Compactation		
TFA Traitement	Stabilisation	Concrete 1380 t	200100 tkm
	Construction of Storage site (1 Alveol)	Geomambrane 29 t Geotextile 14.5 t Sand 25539 t Gravel 24466 t Plastic 13.14 t	7192 tkm 3596 tkm 3703155 tkm 3547570 tkm 4507,02 tkm
	Use		
	Closure		

Table 01: Iventory analysis



Comparaison de 1 p 'Packaging', 1 p 'Transport', 1 p 'Stabilisation' et 1 p 'Site construction', méthode: IMPACT 2002+ V2.15 / IMPACT 2002+ / Étude de dommages

Figure 05: The comparison of impact categories associated with the treatment processes of (VLLW)

6. Conclusion

The impact assessment of very low-level radioactive waste from the Fessenheim nuclear power plant reveals The packaging and site construction processes emerge as the primary contributors to the impacts on human health, ecosystem quality, climate change, and resource consumption. The initial analysis is based on preliminary data, and as the project continues and more real data becomes available from reliable sources like ASN and Andra, more accurate assessments can be conducted. Additionally, a site visit helped in estimating certain values. The study will be part of a larger packaging of work that includes a comparison to a hypothetical recycling approach, which shows promise in reducing the environmental impacts of treating very low-level waste (VLLW).