

"Analyse du cycle de vie (ACV) prospective du démantèlement du CNPE de Fessenheim"

Mehdi Iguider

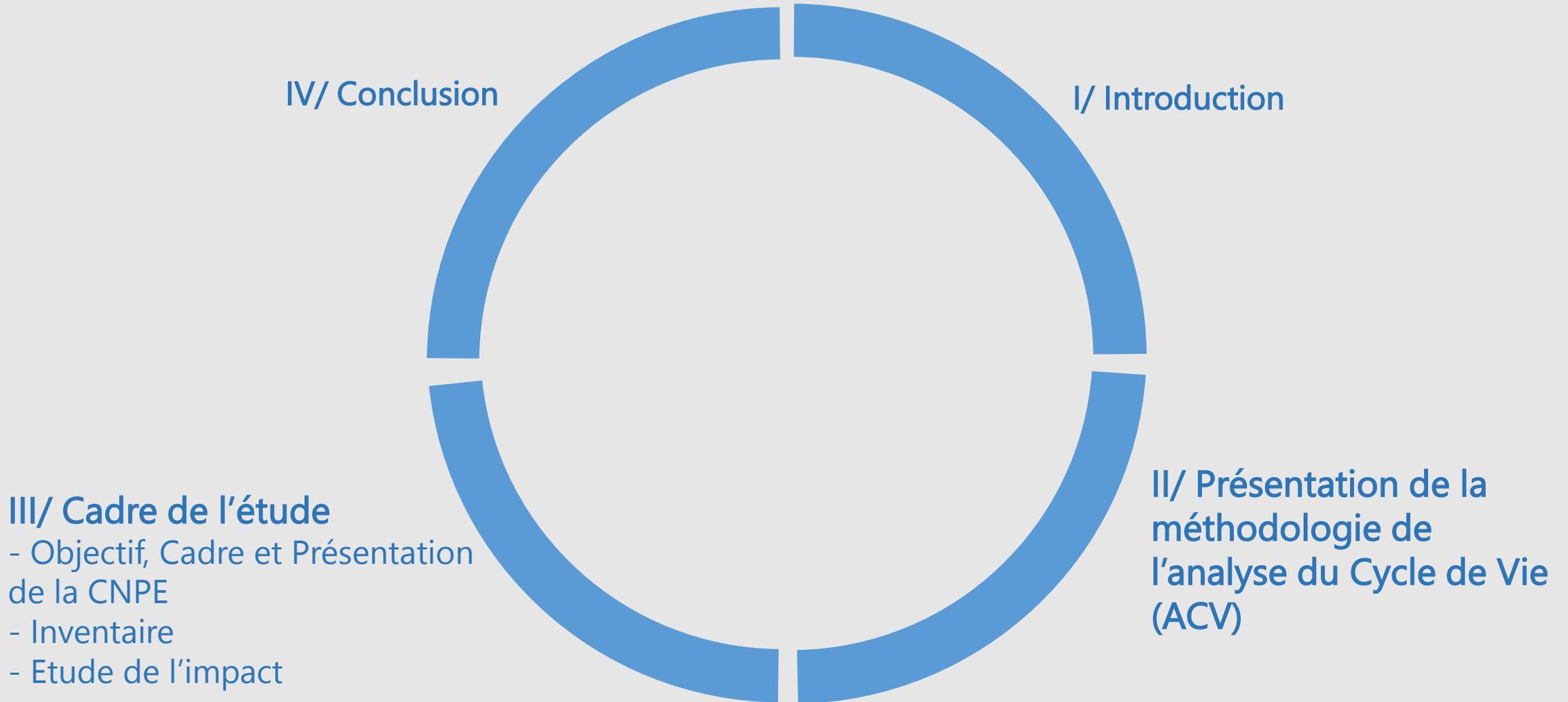
Maître de stage : Dr. Gaetana QUARANTA
Tuteur de stage : Dr. Michal KOZDERKA

Membres du Jury :
Gaetana QUARANTA
Michal KOZDERKA
Abdou BENSALIDA

Master M2 GICE
2021-2022

Université
de Strasbourg

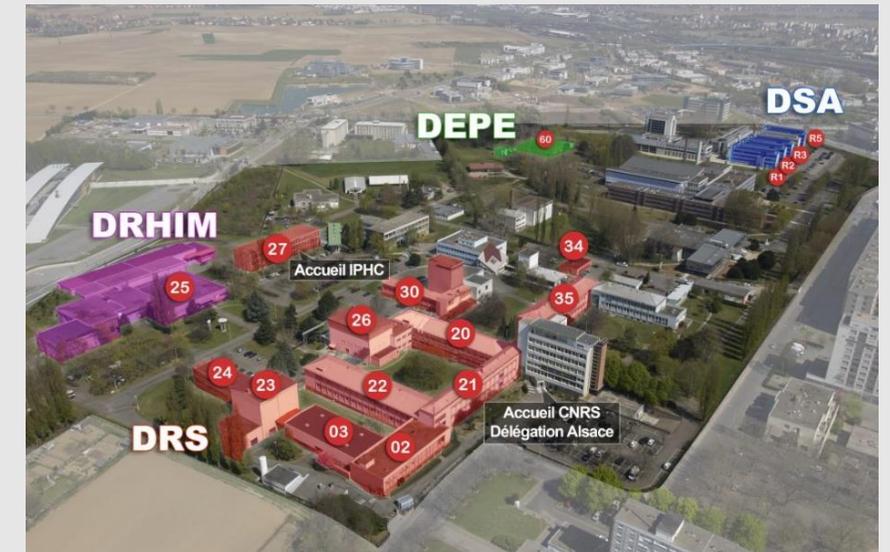




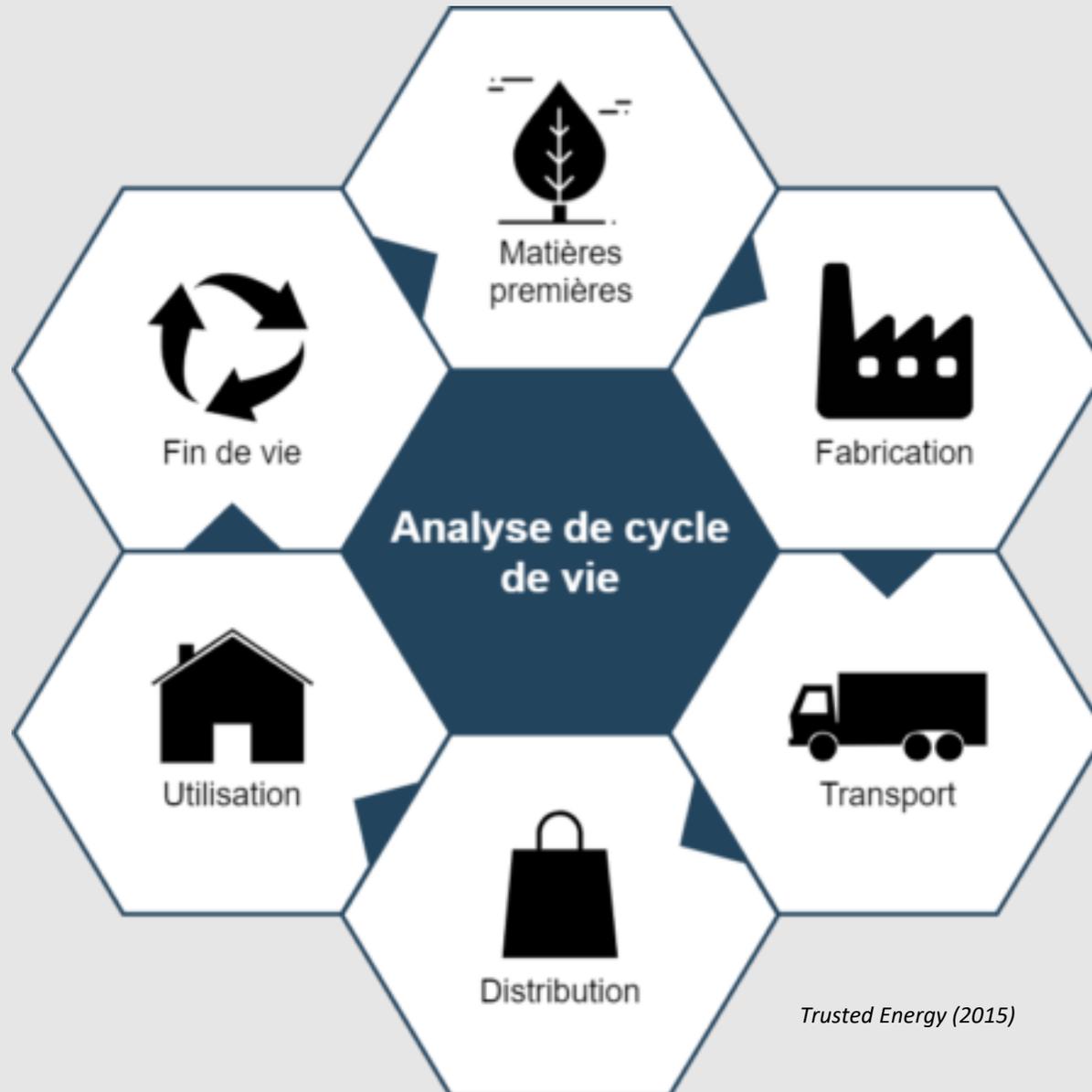
Présentation de l'organisme

Institut pluridisciplinaire Hubert Curien

- DEPE : Département Écologie, Physiologie et Éthologie
- **DRS : Département de Recherche Subatomique**
- DSA : Département de Recherche Analytique
- DRHIM : Département de Radiologie, Hadronthérapie, et d'Imagerie Moléculaire

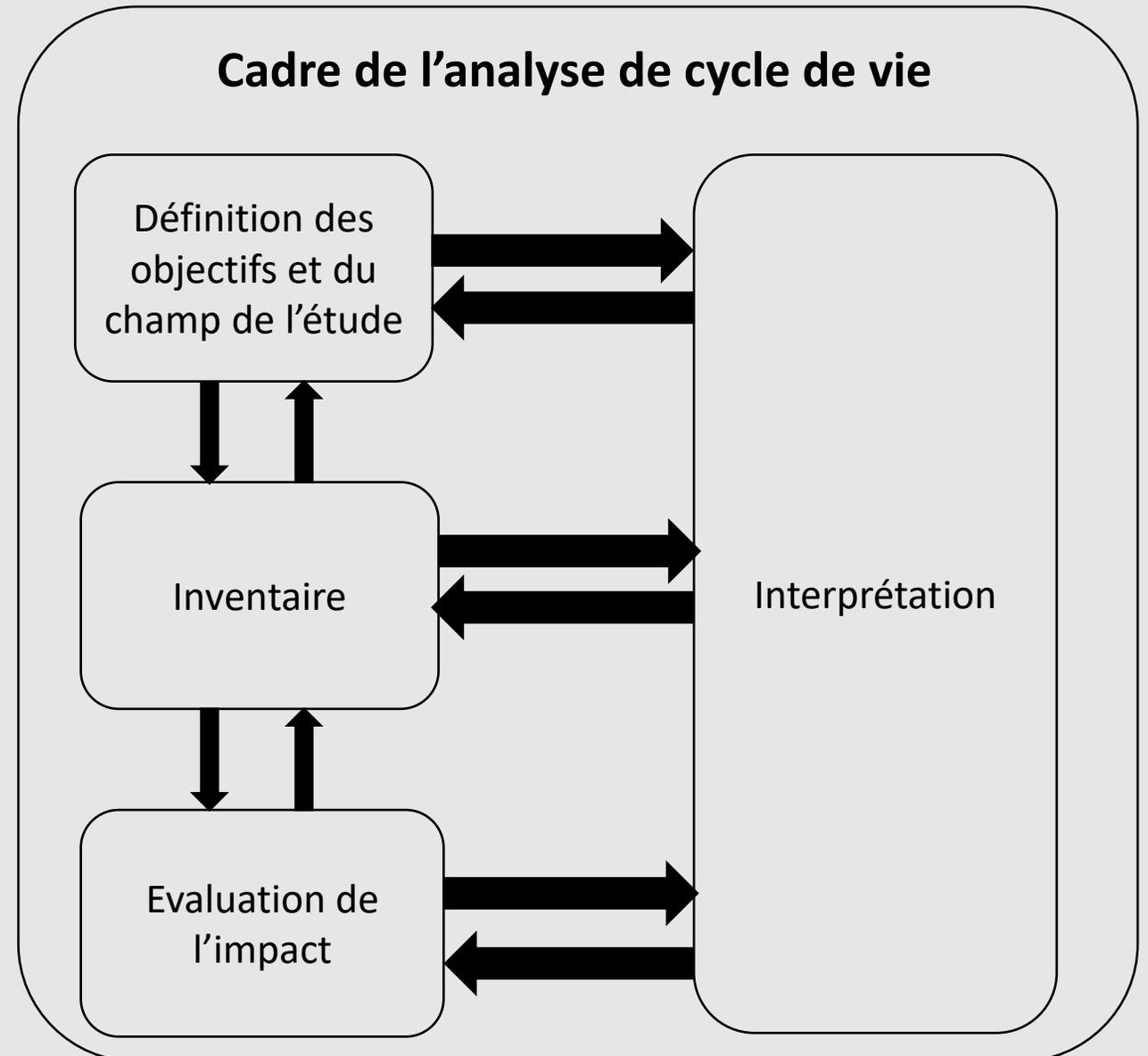


IPHC (2018)



“ L'ACV , normalisée par ISO 14040,
ISO 14044, 2006; 2020

Trusted Energy (2015)



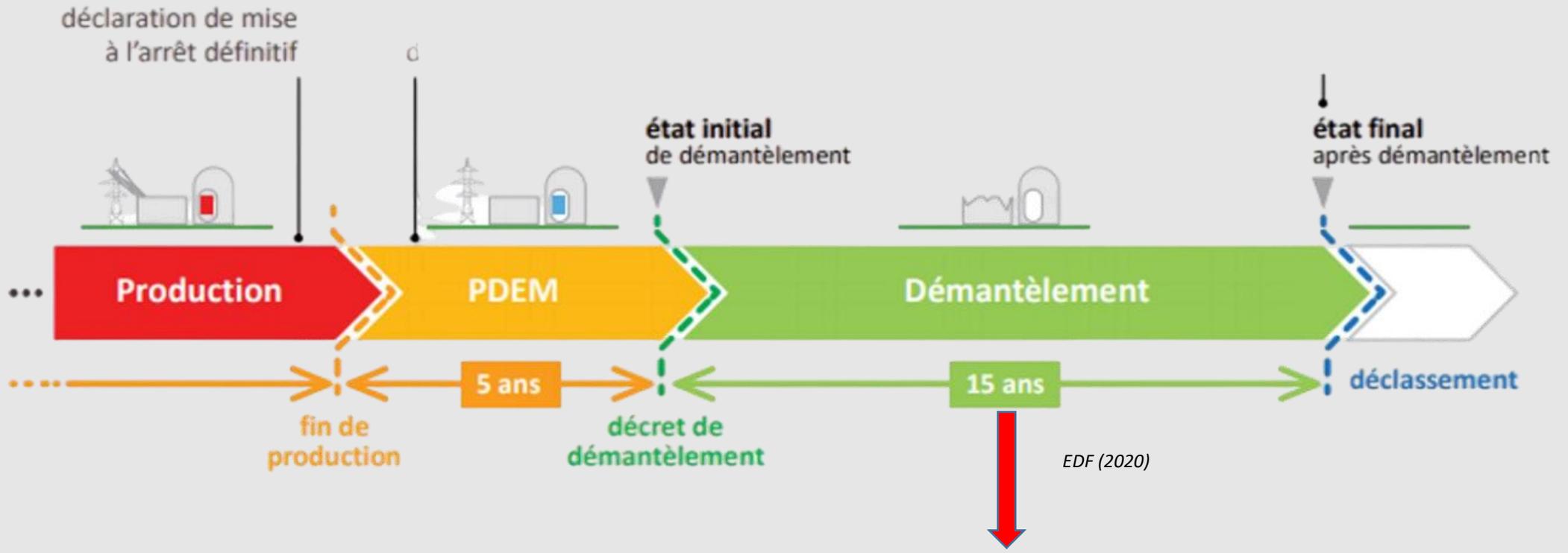


EDF (2020)



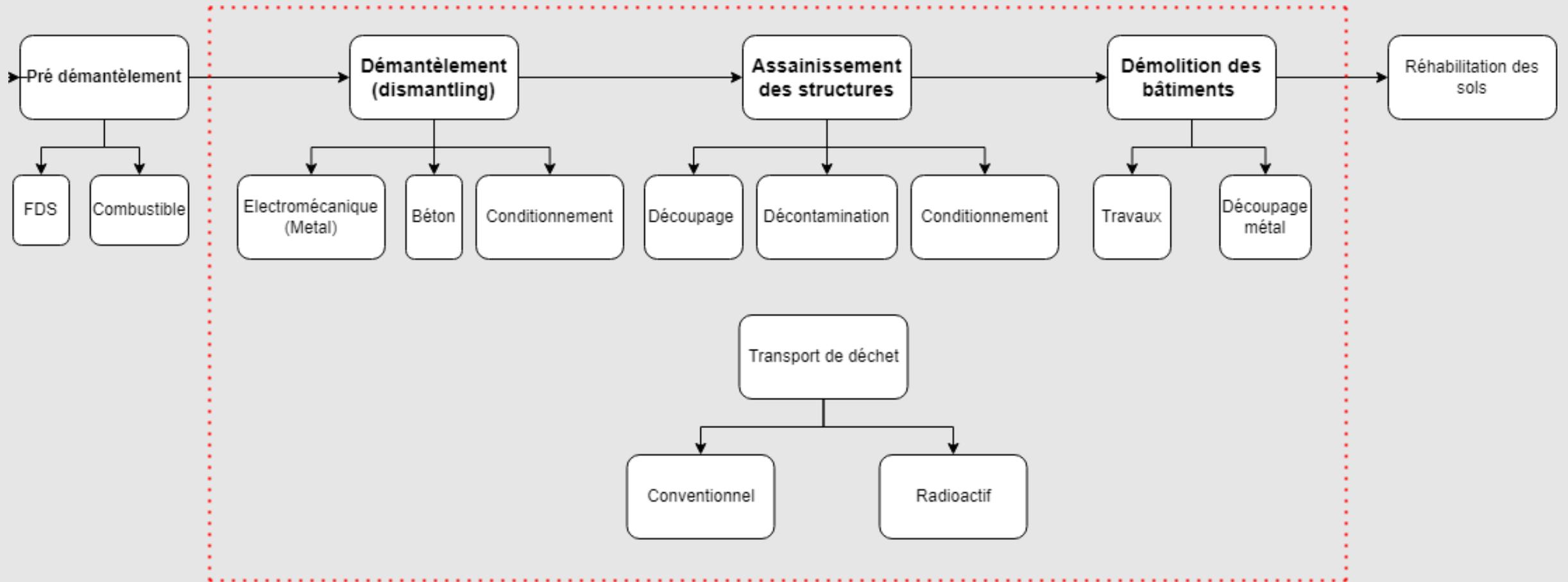
EDF (2020)

- **CNPE Fessenheim: 2 réacteurs REP 900MW**
- **Mise en service: 30 décembre 1977 et 18 mars 1978**
- **Mise à l'arrêt définitive: 30 juin 2020**
- **Production totale: 447 TWh**



- Étape 1 : Démantèlement électromécanique
- Étape 2 : Assainissement des structures
- Étape 3 : Démolition des bâtiments

- **Objectif scientifique:** Modélisation prospective des impacts environnementaux lors de la phase de fin de vie du CNPE de Fessenheim
- **But :** Aider à la décision politique en matière de gestion de déchets radioactifs et de gestion environnementale territoriale.



Limite du système

Unité fonctionnelle: « Le démantèlement d'une centrale nucléaire (Fessenheim) »

Functional unit: « One decommissioning of Fessenheim NPP »

- Composition de l'inventaire (54 documents):

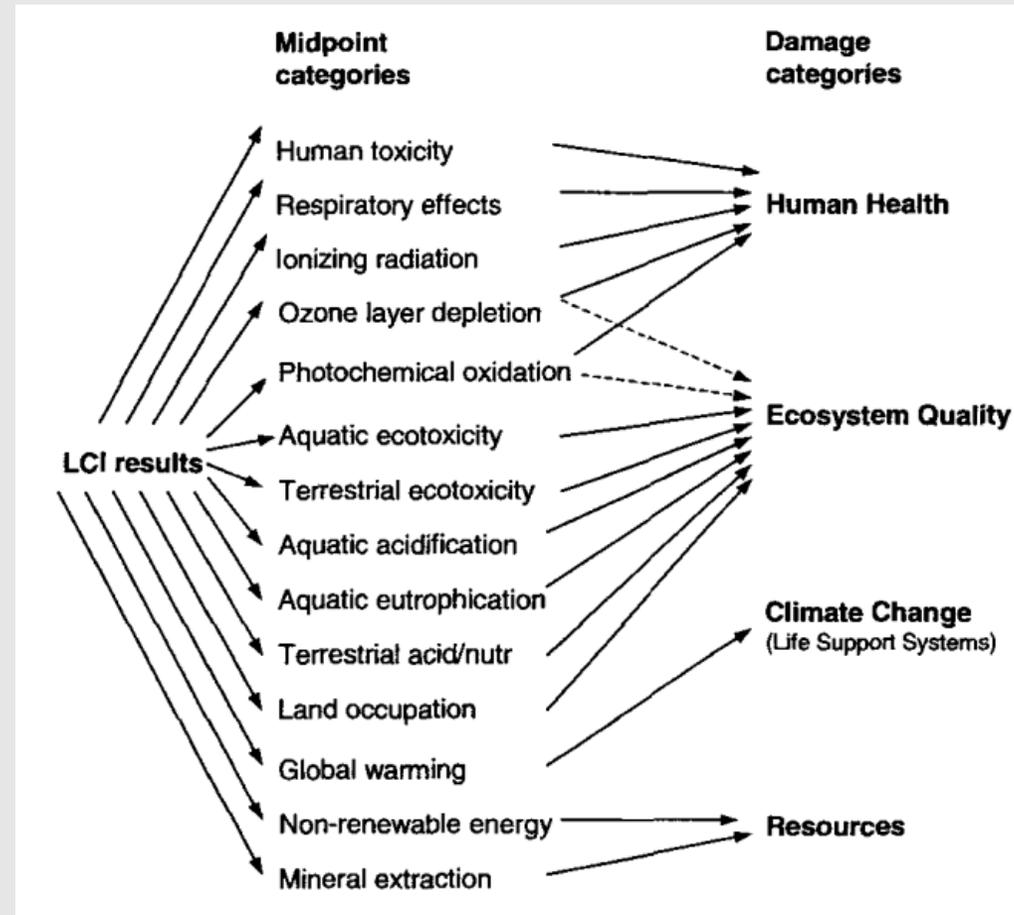
- Articles scientifiques
- Rapports de démantèlement
- Règlementation
- Cartes routière et ferroviaire

Auteur	Nature des données	Sujet étudié
Bozdağ <i>et al.</i> (2007)	Consommation d'électricité par m ²	Consommation d'énergie des bâtiments lors de leurs cycles de vie
EDF (2020)	Quantité de déchets conventionnels et radioactifs	Plan de démantèlement du CNPE de Fessenheim
ANDRA (2018)	Quantité de mortier besoin Modalité de transport de déchet radioactifs	Règlementation liée aux classifications des déchets nucléaires, leurs conditionnements et leurs transport
Rohde (EWN) (2008)	Assainissement Découpage de métal	Démantèlement du CNPE Lubmin
Lunser/Seier (2014)	Quantité de diesel besoin pour le béton	Démantèlement du CNPE Lubmin
Koltun (2018)	Quantité de différents types de déchets conventionnel	ACV du CNPE GT-MHR
Open Street Map	Superficie des bâtiments du CNPE de Fessenheim	Carte « open source » avec image satellite
Open Railway Map	Distance pour le transfert des déchets radioactifs Source d'énergie pour les trains	Carte « open source » des chemins de fer

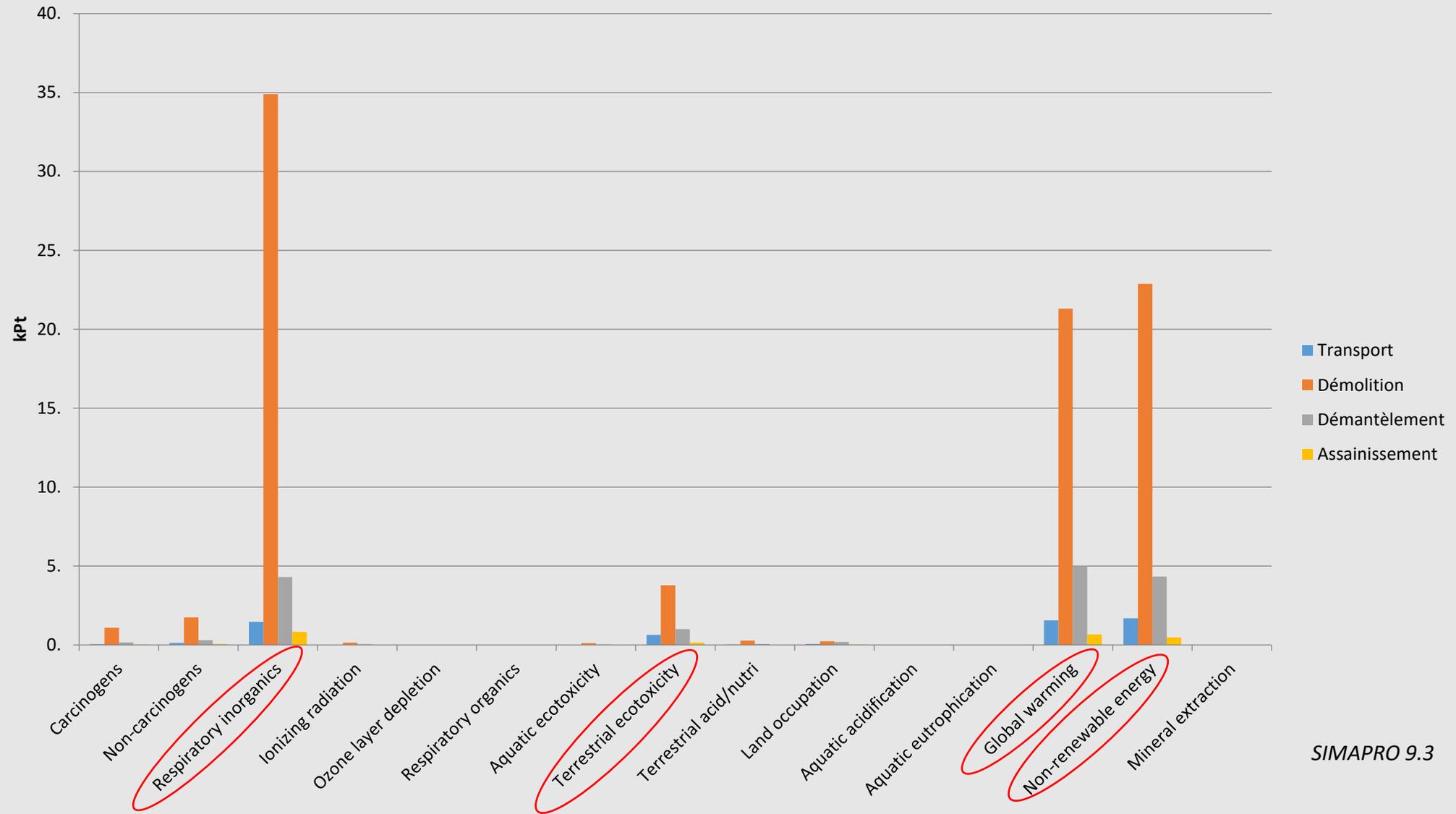
- SIMAPRO 9.3: logiciel de modélisation d'ACV
- Base de donnée: ECOINVENT3

	Démantèlement			Assainissement			Démolition		Transport de déchet	
	Entrée d'énergie									
Type de traitement	Électromécanique	Béton	Conditionnement	Décontamination	Découpage	Conditionnement	Travaux	Découpage metal	Démolition	Radioactif
Energie totale(kwh)	-	-	-	-	-	-	414166	-	-	-
Diesel total (l)	-	6699.8	-	-	-	-	1311811	-	-	-
Transport en (tkm) route	-	-	-	-	-	-	-	-	15120000	61014800
Transport en (tkm) train électrique	-	-	-	-	-	-	-	-	-	73800000
Transport en (tkm) train diesel	-	-	-	-	-	-	-	-	-	5200000
	Entrée de materiaux									
Oxygène (m ³)	34426	-	-	-	2979.1	-	-	265735	-	-
Acétylène (m ³)	18118.5	-	-	-	1567.9	-	-	139861	-	-
Hydrogène (m ³)	3623.7	-	-	-	313.6	-	-	27972	-	-
Argon (m ³)	3623.7	-	-	-	313.6	-	-	27972	-	-
Eau (m ³)	-	-	-	1280	-	-	-	-	-	-
steel gravel (tonnes)	-	-	-	61.4	-	-	-	-	-	-
Acide phosphoreux (m ³)	-	-	-	30	-	-	-	-	-	-
Acide oxalique (tonne)	-	-	-	16.6	-	-	-	-	-	-
Mortier pour FAMA VC (tonnes)	-	-	129773	-	-	15987	-	-	-	-
Mortier pour MAVL (tonnes)	-	-	911.1	-	-	-	-	-	-	-

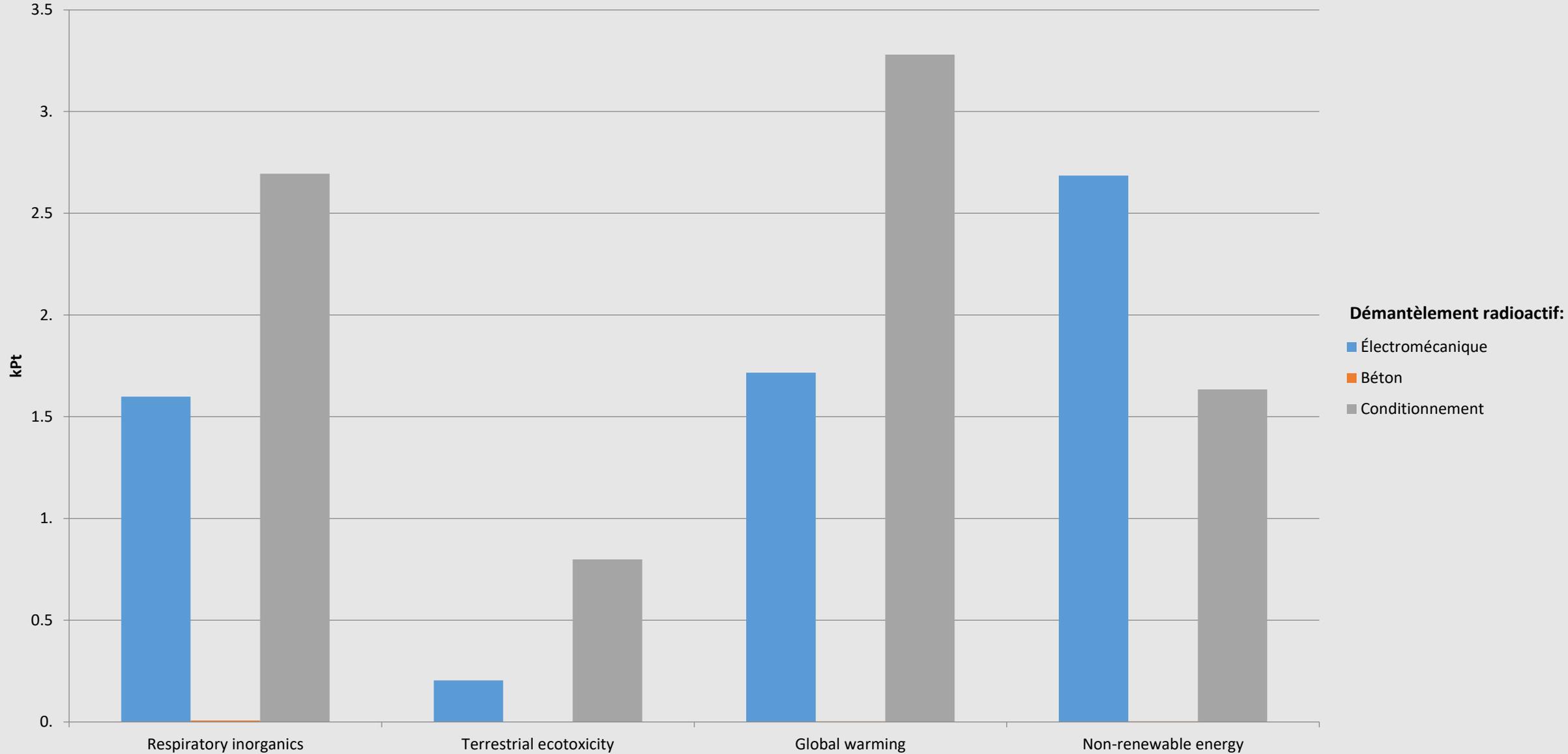
- Méthode IMPACT 2002+ :Eco-indicator 99 , CML 2002, IPCC 2001 et IMPACT 2002

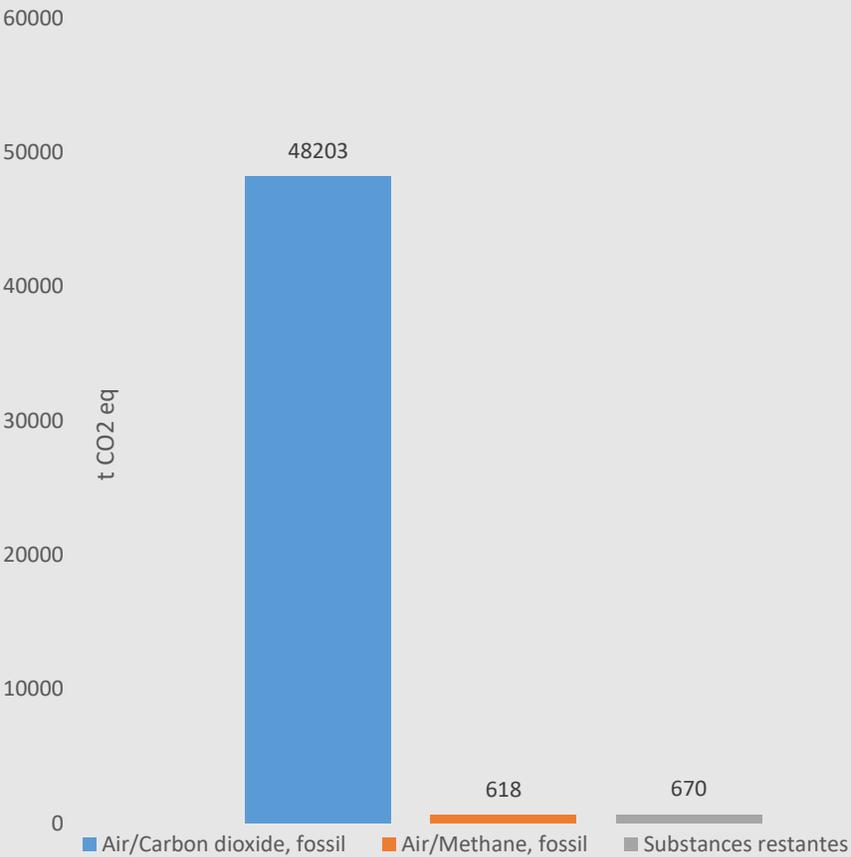


Olivier Jolliet (2003)

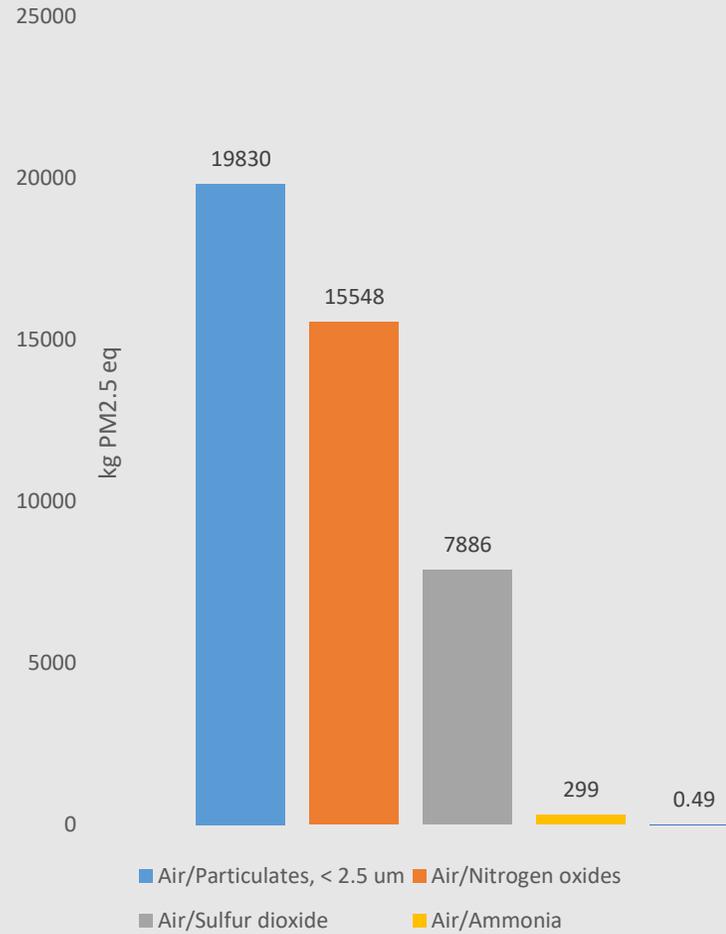


Catégorie d'impact (mid-point)	Unité de référence
Effets respiratoires (inorganiques)	kg PM2.5 eq
Écotoxicité terrestre	kg Triéthylène glycol eq
Réchauffement global	kg CO ₂ eq
Utilisation d'énergies non renouvelables	MJ

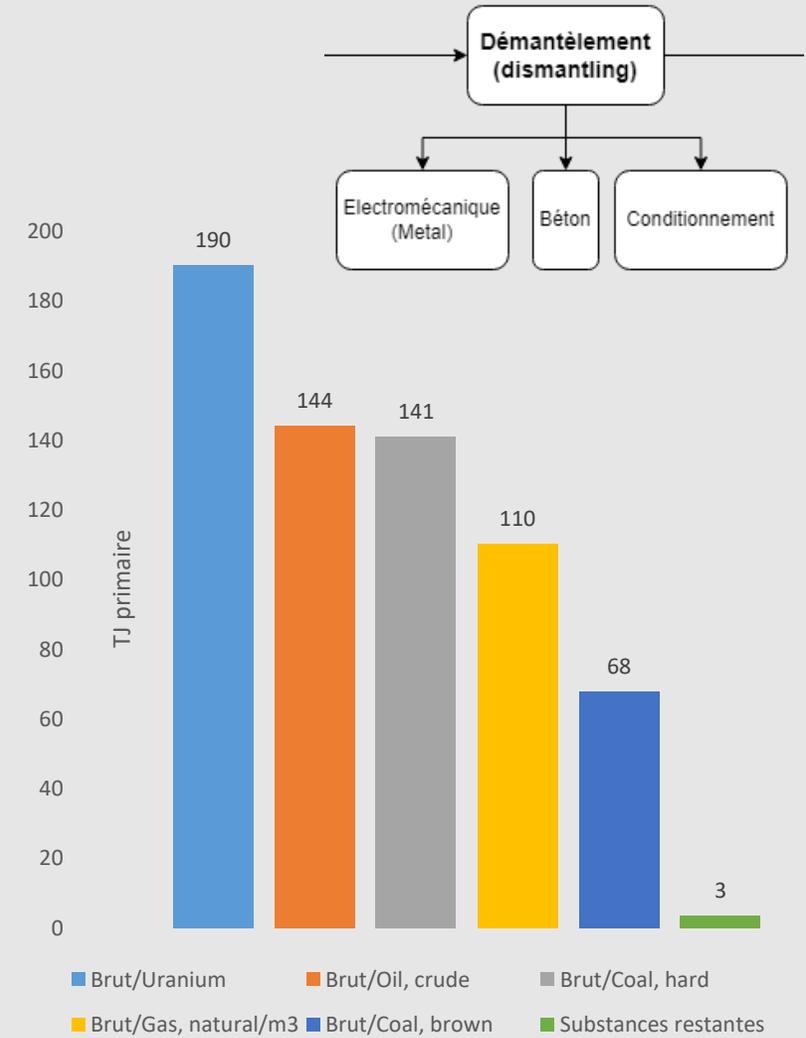




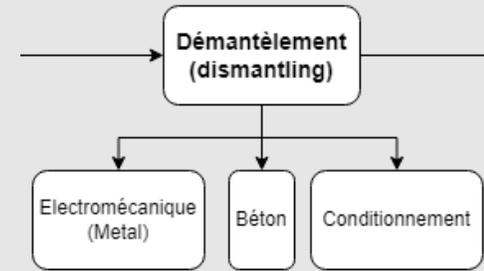
Réchauffement climatique

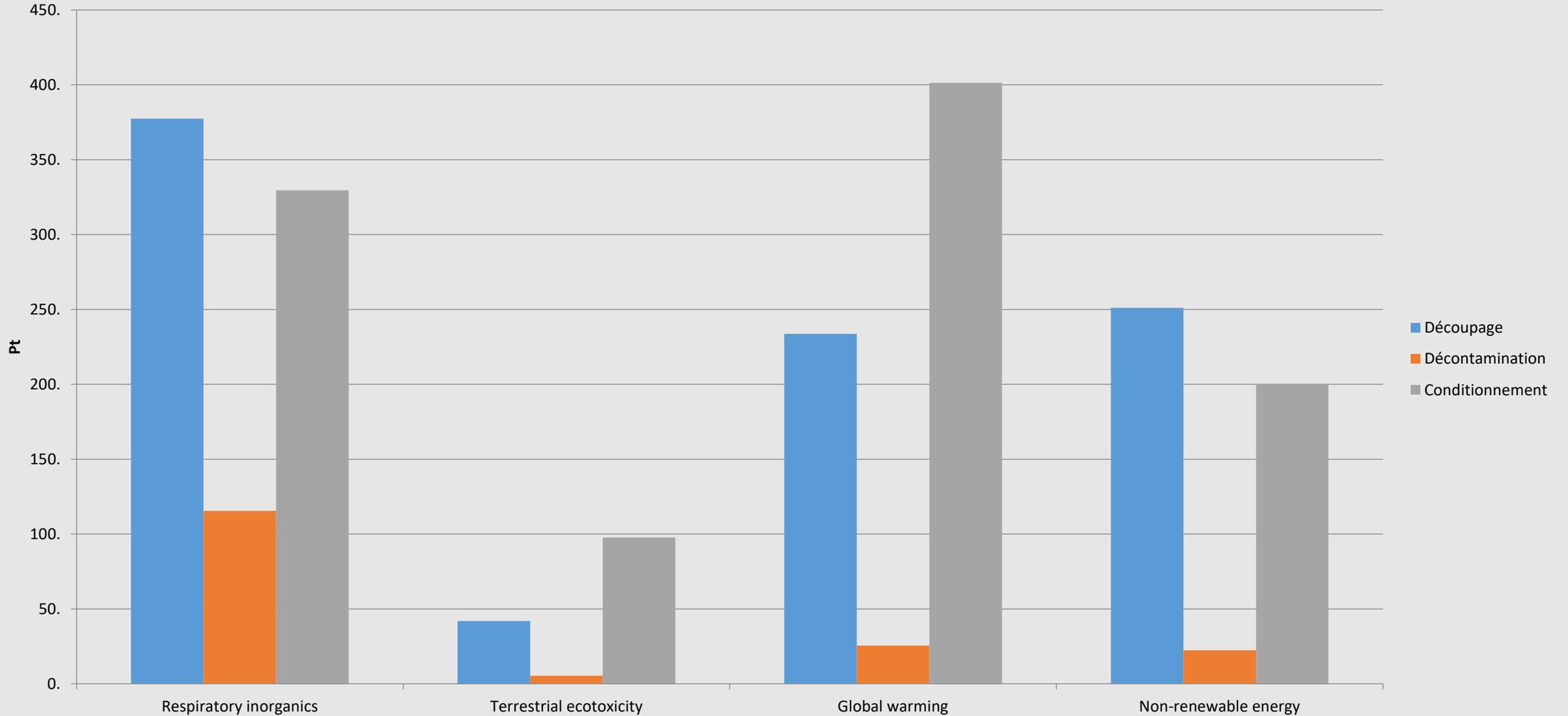


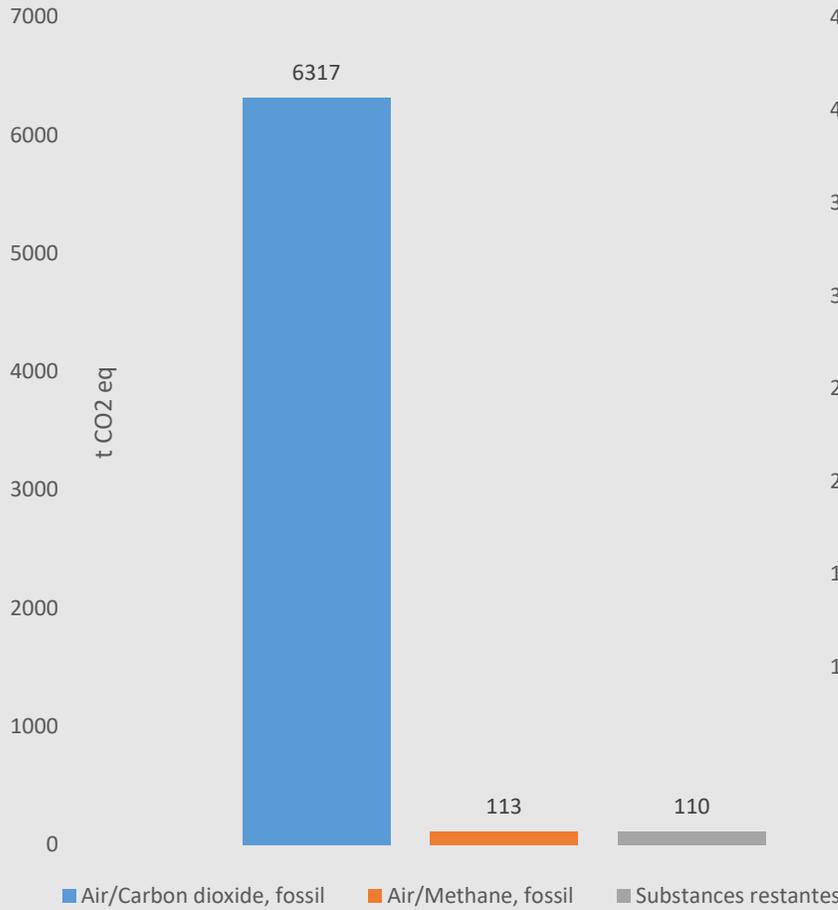
Effet respiratoire inorganique



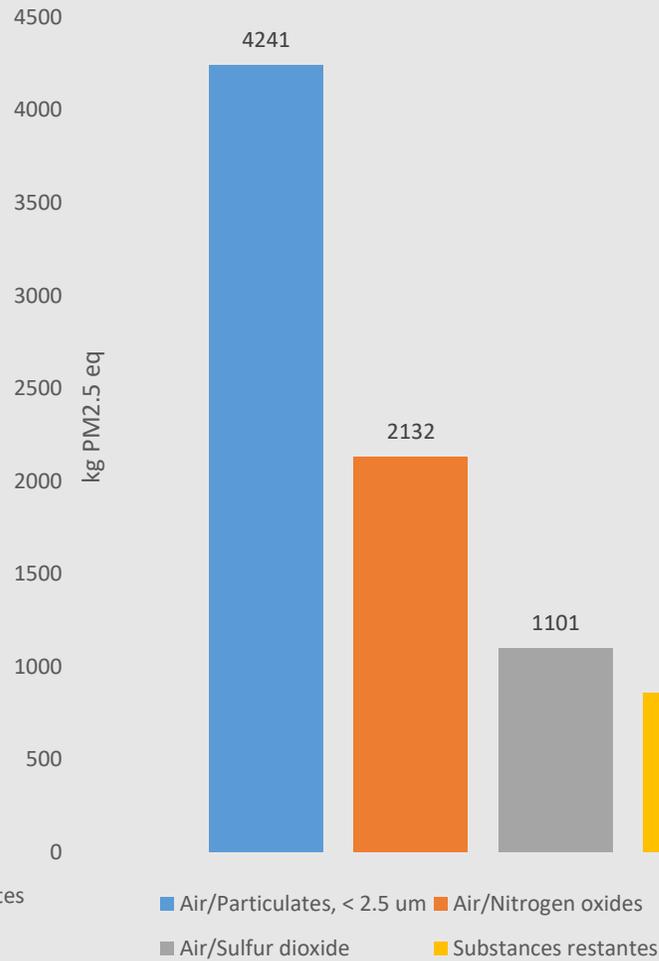
Utilisation de ressources non-renouvelable



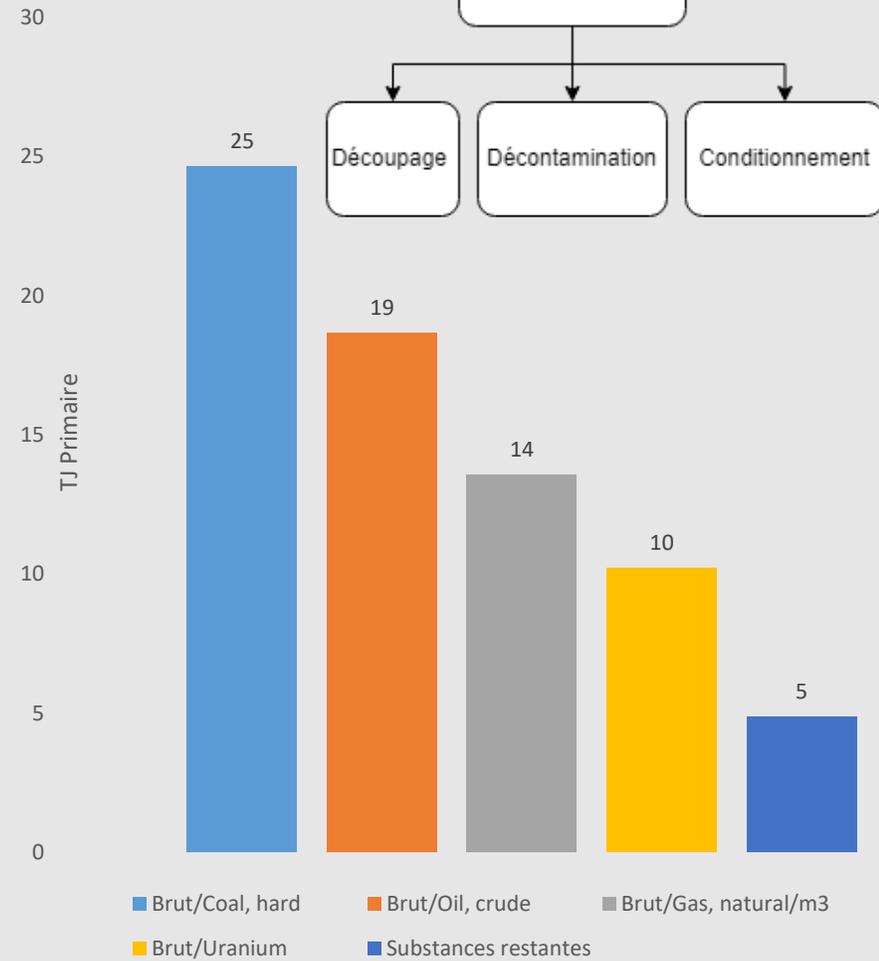




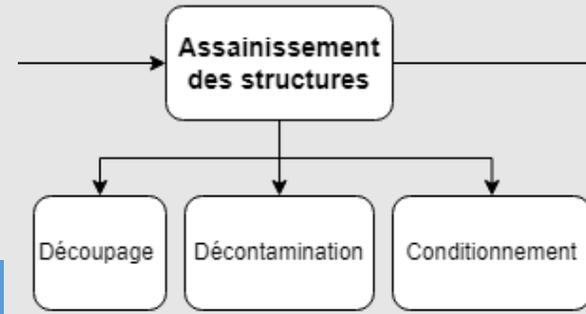
Réchauffement climatique

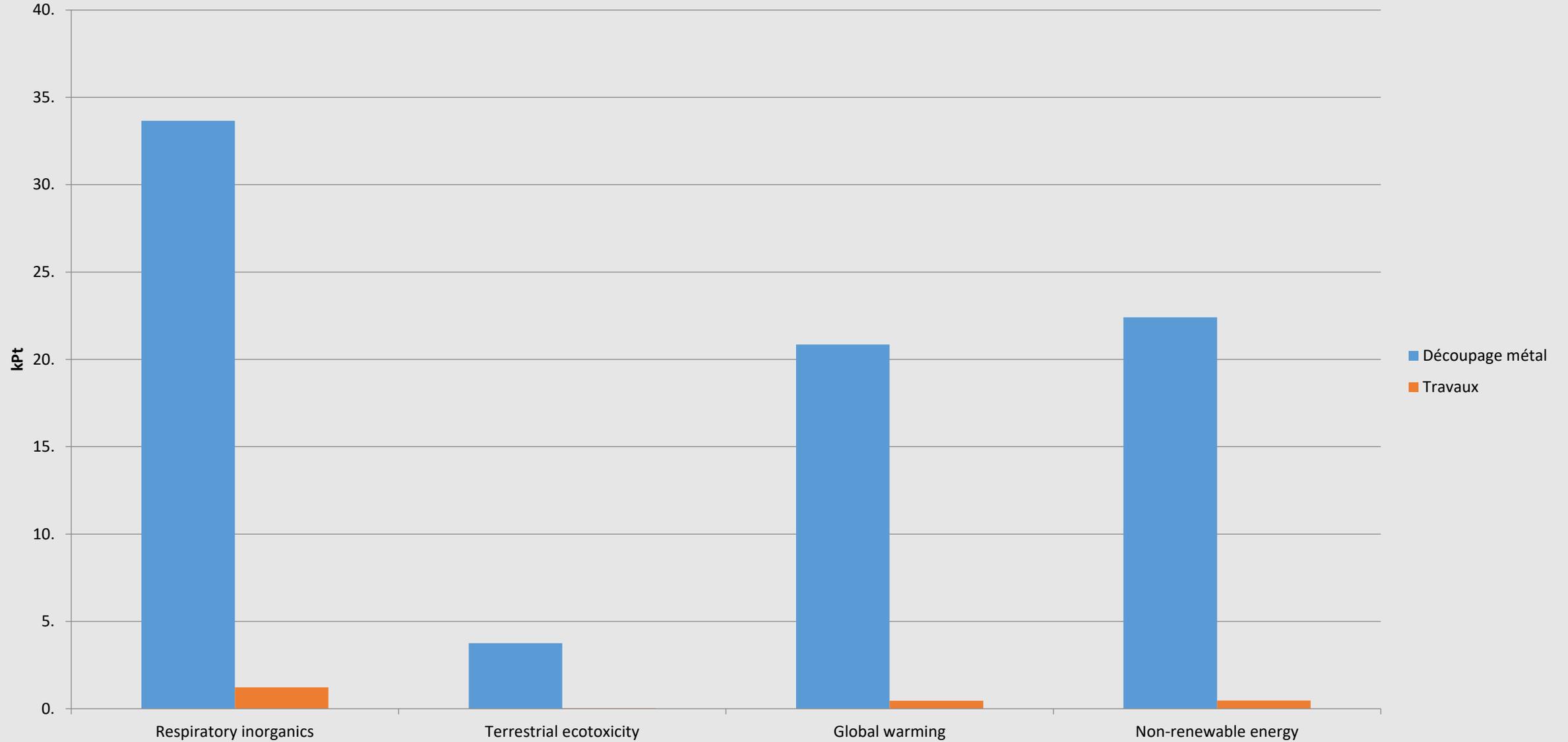


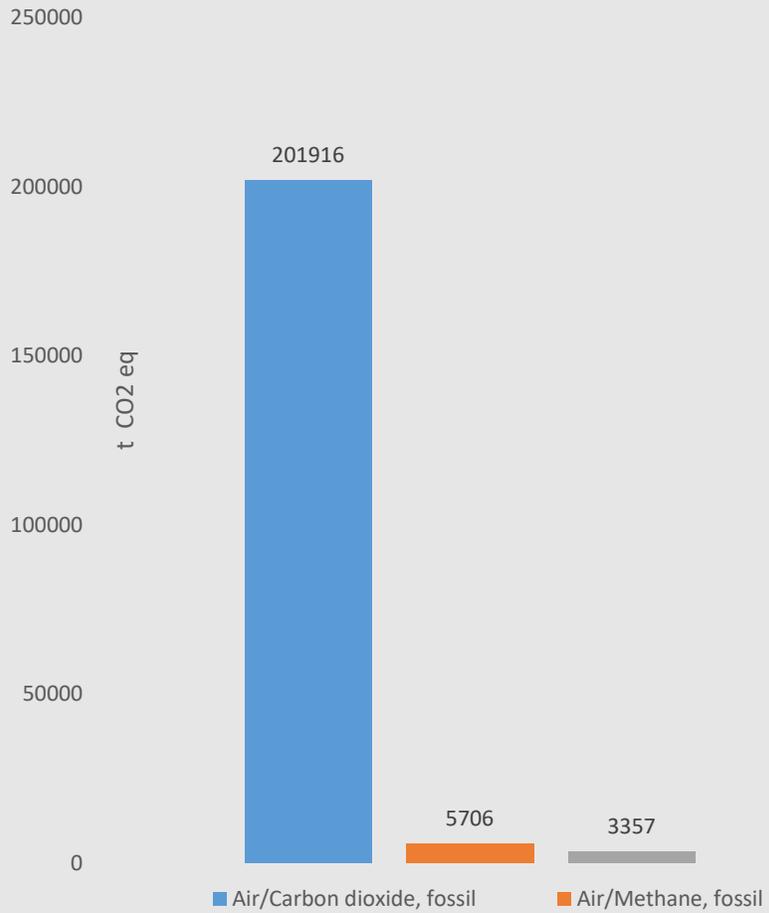
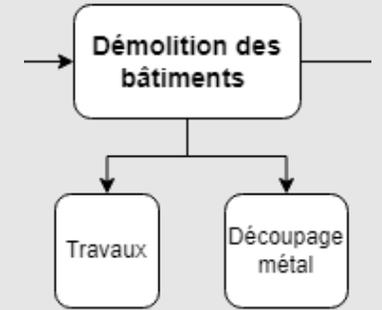
Effet respiratoire inorganique



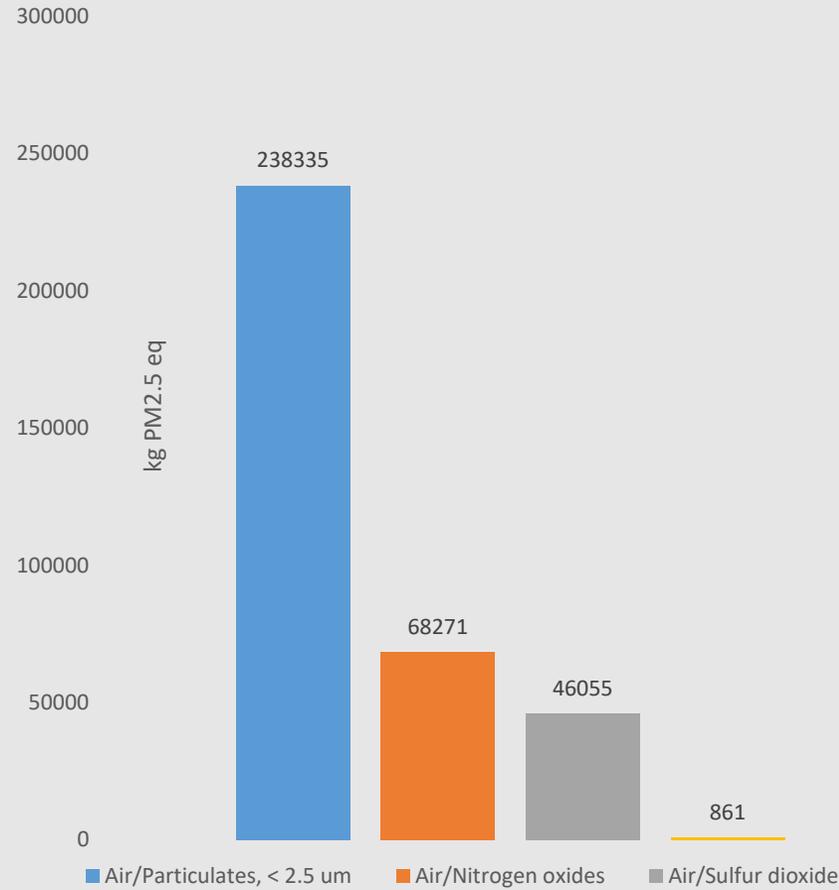
Utilisation de ressources non-renouvelable



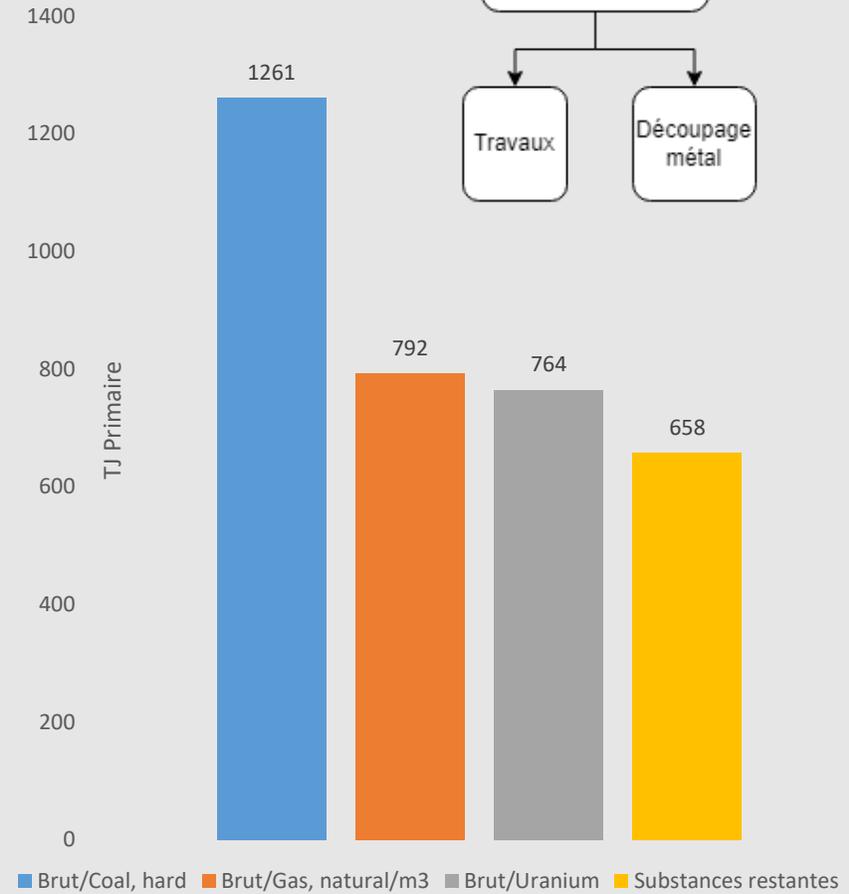




Réchauffement climatique



Effet respiratoire inorganique

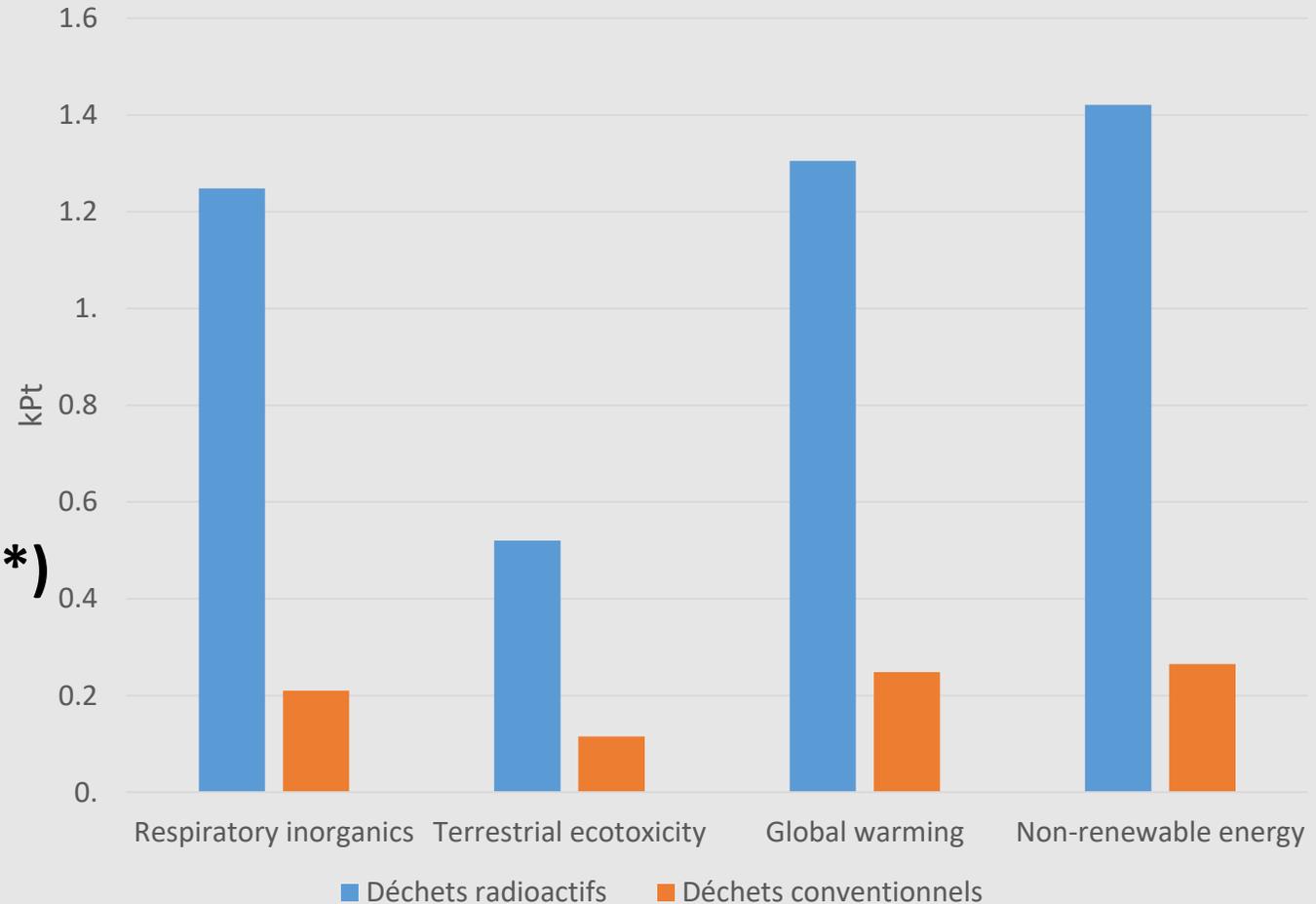


Utilisation de ressources non-renouvelable

Déchets radioactifs: 5% des déchets global



**Impact 3 à 6 fois plus important
(conditionnement et distance de transport*)**

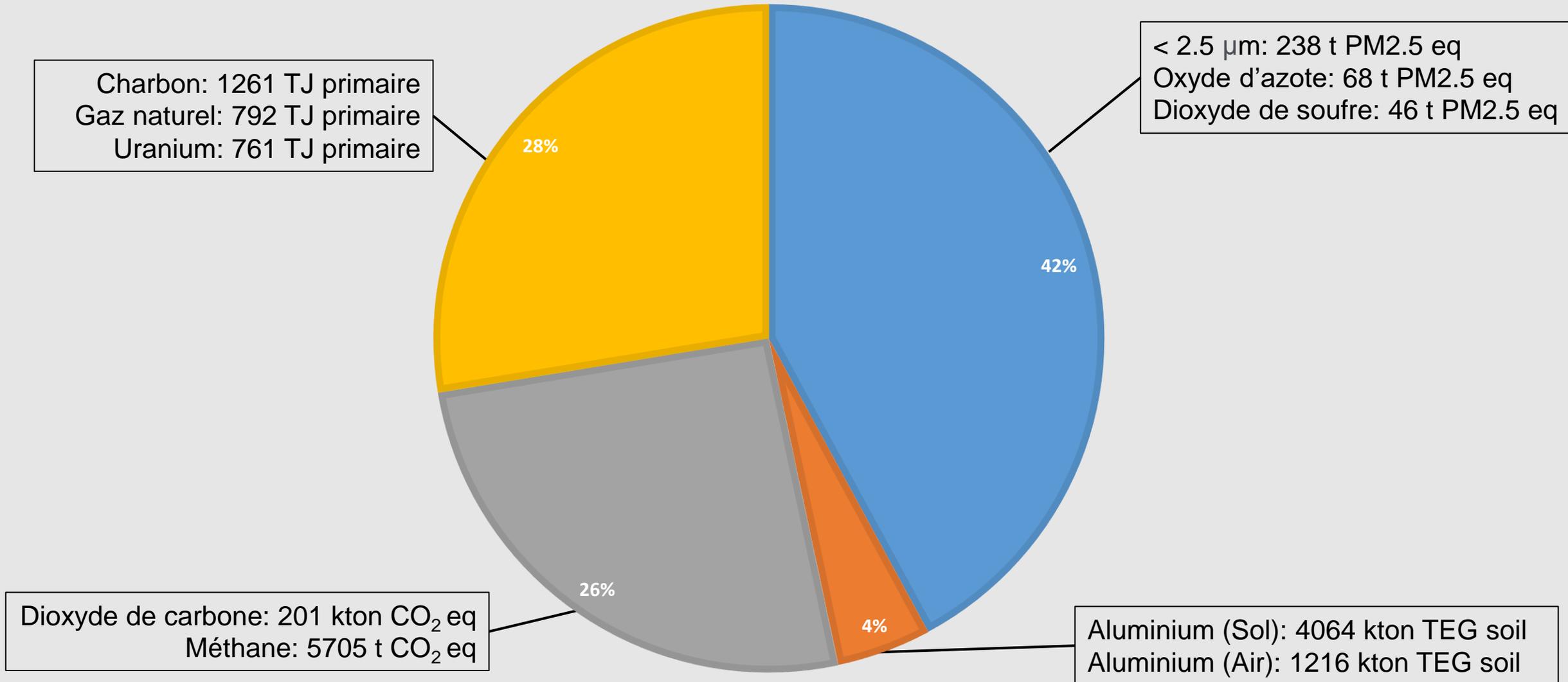


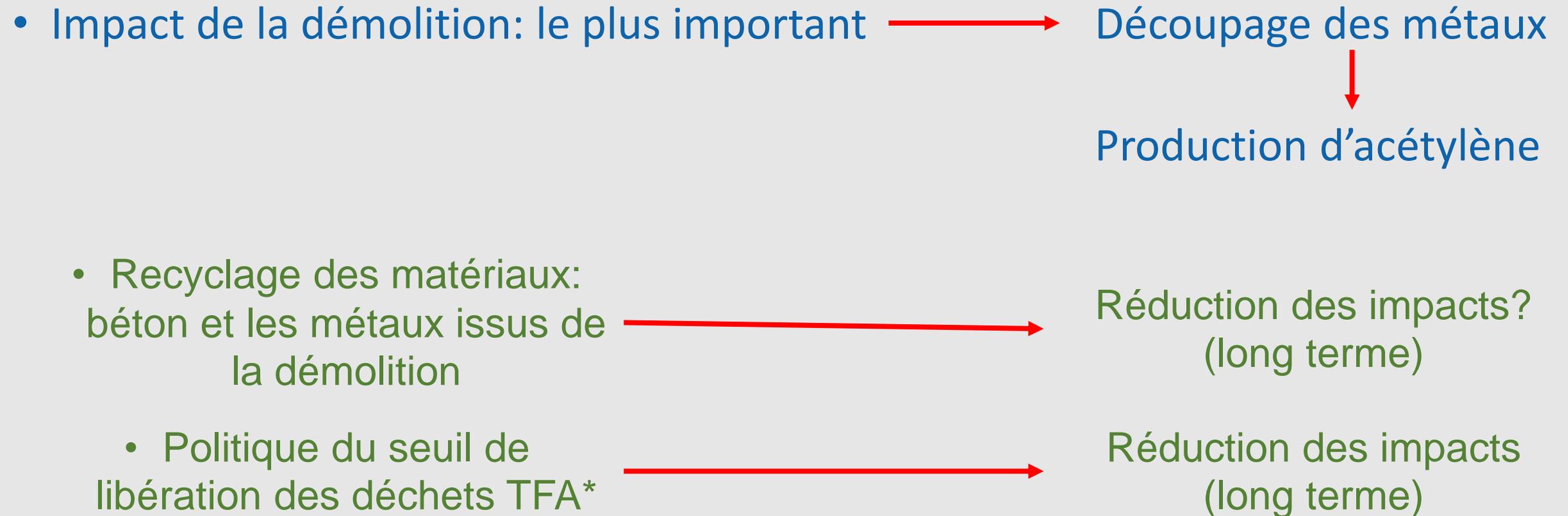
*CIRES (Aube): 317km du CNPE

*CSA (Aube): 314km

*ICEDA (Ain): 395km

■ Respiratory inorganics ■ Terrestrial ecotoxicity ■ Global warming ■ Non-renewable energy





*Déchets radioactifs très faible activité

I/ II/ III/ IV/ Apports personnels

Connaissances	Compétences
<ul style="list-style-type: none"> - ACV - Modélisation Simapro - Législation Démantèlement CNPE 	<ul style="list-style-type: none"> - Recherche bibliographique - Rédaction rapport - Travail en équipe - Communication Scientifique

Communication scientifique - Poster

- « Prospective life cycle assessment (LCA) of the decommissioning of the Fessenheim nuclear power plant »

Mehdi Iguidir, Marc Allemann, Haldan Koffi, Maria Boltoeava, Michal Kozderka, Gaetana Quaranta
International Symposium of Labex DRIIHM, juin 2022, Nantes

Prospective life cycle assessment (LCA) of the decommissioning of the Fessenheim nuclear power plant (NPP)

Mehdi Iguidir, Marc Allemann, Haldan Koffi, Maria Boltoeava, Michal Kozderka, Gaetana Quaranta
Université de Strasbourg, CNRS, IPHC UMR 7178, F-67037 Strasbourg, France

Context and objectives

In February and June 2020, the Fessenheim NPP respectively went through the shutdown of its first and second reactors. The question that now arises is whether the dismantling of the CNPE will be significant in terms of environmental impacts. This study consists in evaluating the environmental impacts during the decommissioning phase of Fessenheim NPP.

2 System definition

The system studied breaks down into three phases: dismantling, decontamination and demolition (see Fig.2)

1 Methods

To assess the potential impacts of the NPP, the LCA methodology has been applied.

3 Inventory analysis

Process step	Procedure	Energy Input	Material Input
Dismantling	Electromechanical		Oxygen: 34426 m ³ Acetylene: 248126 m ³ Hydrogen: 2623.7 m ³ Argon: 2623.7 m ³
	Conditioning of RW		Cement mortar for RW: 30068.1 t
Decontamination	Disinfection		Water: 1280 m ³ Steel Gravel: 61.4 t Phosphoric acid: 30 m ³ Oxalic acid: 13.4 t Oxygen: 2079.2 m ³ Argon: 562.9 m ³ Hydrogen: 51.3 m ³ Argon: 51.3 m ³
	Conditioning of RW		Cement mortar for RW: 891.156 t
Demolition	Decontamination process	Electricity: 434156 kWh Diesel: 131181.1 t	
	Metal Cutting		Oxygen: 265795 m ³ Acetylene: 27882 m ³ Hydrogen: 2792 m ³ Argon: 2792 m ³
Waste transport	Conventional waste	Road: 15130000 km Road: 61218000 km	
	Radioactive waste	Electric train: 7800000 km Diesel Train: 520000 km	

4 Impact Assessment and interpretation of results

The greatest impact in terms of "points" is observed on the category "Inorganic respiratory effect" during the decommissioning of the Fessenheim NPP with 41.5 pts. (4020 t PM10.5 eq. total). The decommissioning emits 282000 t CO₂eq, which contributes strongly to global warming (28.5 Mt total). Regarding the use of non-renewable energies, the decommissioning process uses 4460 Tj of energy (29.3 MWh total) with a share of 27% of uranium. It is deduced that this comes from the French energy mix. Conventional waste accounts for 95% of the decommissioning waste.

However, the impact of transporting radioactive waste (RW) is 3.2 to 6.1 times greater (depending on the considered impact category) than transporting conventional waste. It is found that the conditioning imposed by ANDRA and RW transport distance from the NPP to the treatment centers (CRES: 31.7km, CSA: 314km, CSCA: 395km) (conventional waste: 420m) are the reasons for this.

Importance of the demolition step

Demolition is responsible for 75% of the global warming. This emission is generated by metal cutting with 190000 t CO₂ eq. Regarding the use of non-renewable energies, demolition contributes essentially to this impact due to the cutting of metals with 96.13% of emissions and especially the use of 1.3.10¹⁰ MJ from coal and 7.9.10¹⁰ MJ from natural gas. Demolition contributes to 88% in the terrestrial eco-toxicity impact category. Demolition also represents 64000 t of trichloro ethylene (TCE) eq. emitted in the soil (3.77 Mt).

Conclusion

It was found that the demolition process contributes the most to the different studied impact categories for the NPP decommissioning. A detailed analysis of the process shows that this is linked to the production of acetylene used during the cutting of metals. The question raised is that of a possible replacement of acetylene during the metal cutting process. The question of the French policy on the threshold of release of radioactive waste is also raised because a modification of these thresholds would allow a better valorization and/or recycling of the wastes as well as a reduction of the distances of transport, which would reduce the global warming.

International Symposium of Labex DRIIHM - 2022
Inter-Disciplinary Research Facility on Human-Environment Interactions - ANR-11-LABX-0010
30-31 June 2022 - Nantes (France)

Merci pour votre
attention!