HyTechCycling

End-of-life of FCH products: a review of the current situation

A. Ferriz – Head of the Consultancy and Training Dep.
Foundation for the Development of New Hydrogen Technologies in Aragon

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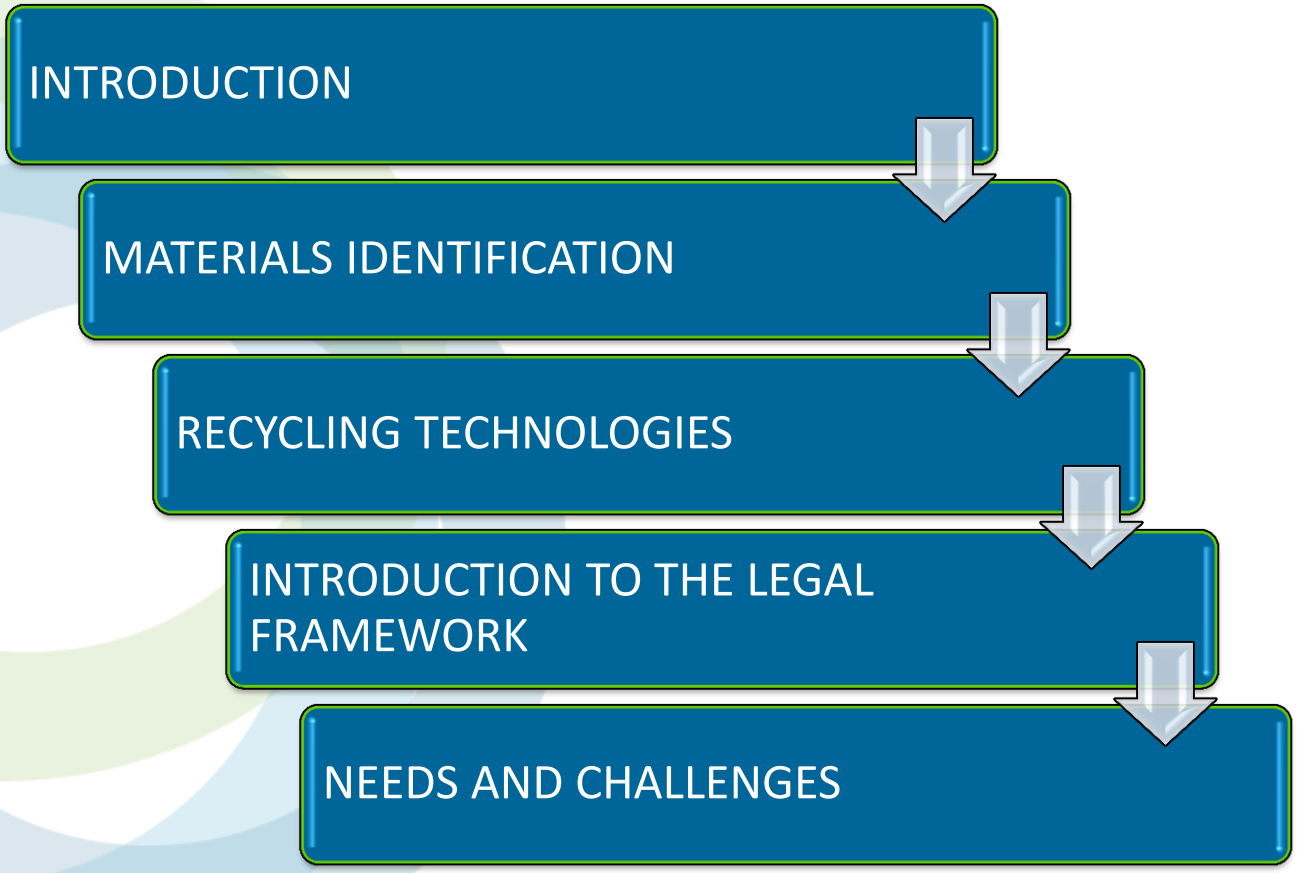

INTRODUCTION
MATERIALS IDENTIFICATION
RECYCLING TECHNOLOGIES
INTRODUCTION TO THE LEGAL FRAMEWORK
NEEDS AND CHALLENGES

Project introduction

5 European partners

3 years long

0,5 M€

Topic **FCH-04.1-2015 Recycling and Dismantling Strategies for FCH Technologies**, dentro de la **Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU)**

Partners

FOUNDATION FOR THE DEVELOPMENT OF NEW HYDROGEN TECHNOLOGIES IN ARAGON

University of Ljubljana

institute IMDEA energy

GRUPO LÓPEZ SORIANO

ENVIRONMENT PARK Parco Scientifico Tecnologico per l'Ambiente

Project introduction

MAIN OBJECTIVE

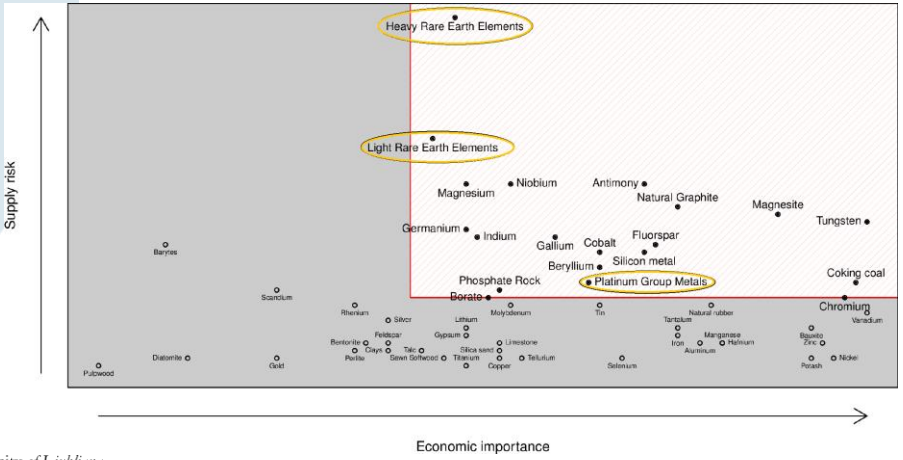
HyTechCycling aims to deliver **reference documentation** and studies about existing and new recycling and dismantling technologies and strategies applied to FCH technologies, paving the way for f**uture demonstration actions** and advances in legislation and **business models**.

- First European project related with FCH technologies recycling.
- Involves the hole FCH technologies life's cycle.

Project introduction

IDENTIFYING THE PRESENT. LOOKING TO THE FUTURE:

- Identification and characterization of critical materials.
- Current End-of-Life technologies and strategies.
- Regulatory framework and barriers.
- Needs and challenges in the End-of-Life.



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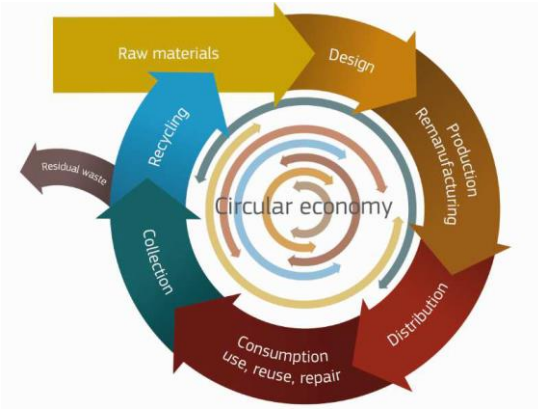
Project introduction

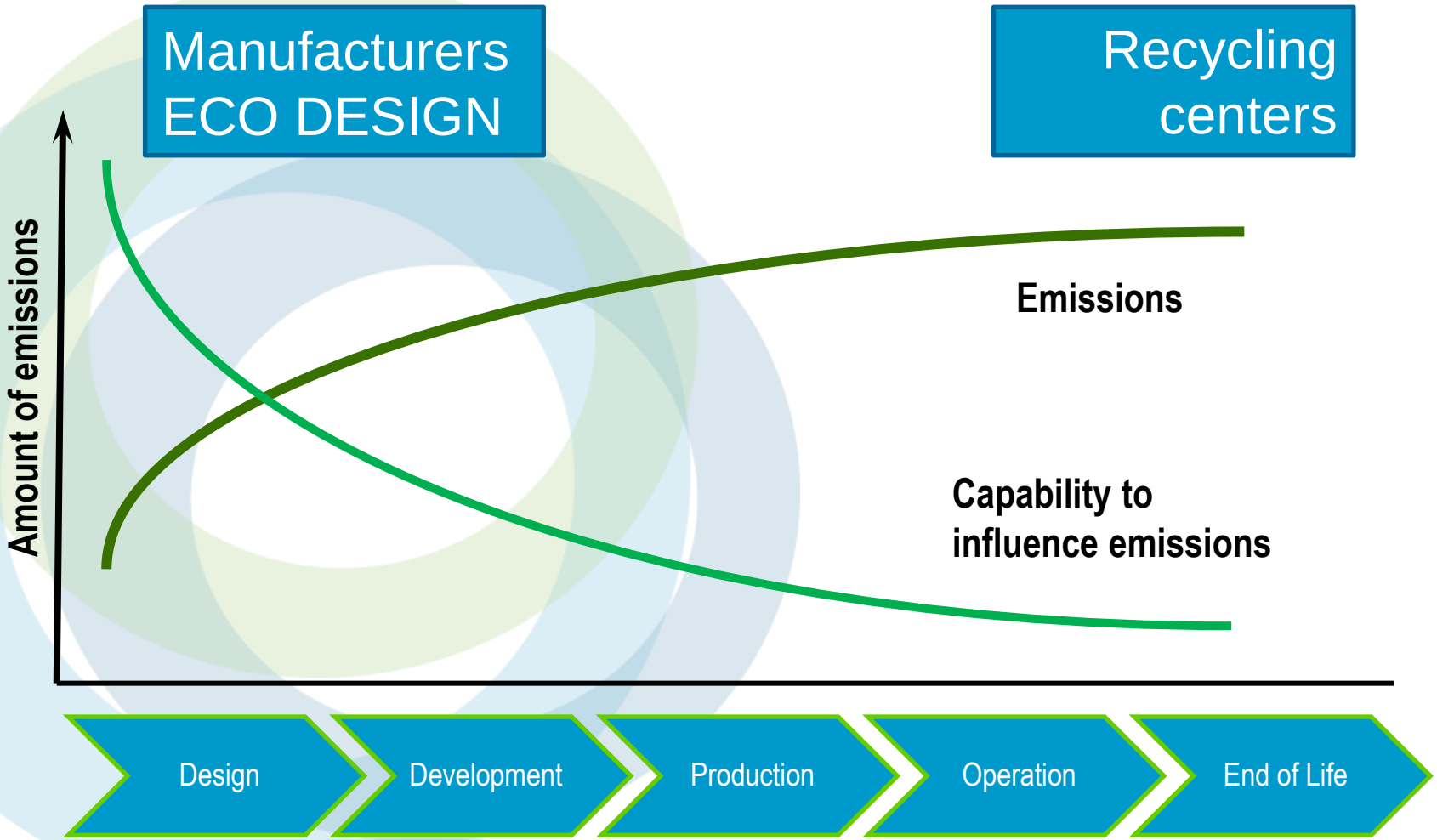
Life Cycle Assessment (LCA)

Covering not only the manufacturing process but also the customer use of the FCH technology, to asses a better understand of FCH technologies environmental affections.

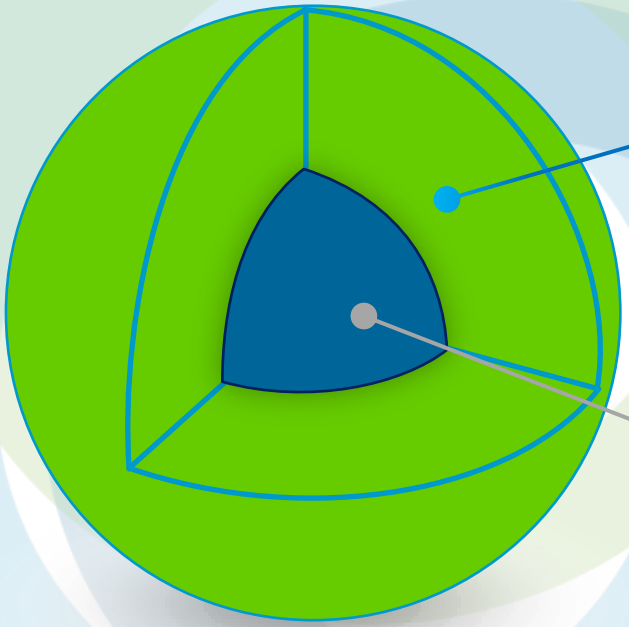
Considering the BoP complete. Different LCA for each technology study in the project (AWE, PEMWE, PEMFC, SOFC)



Emissions evolution



ECO-DESIGN



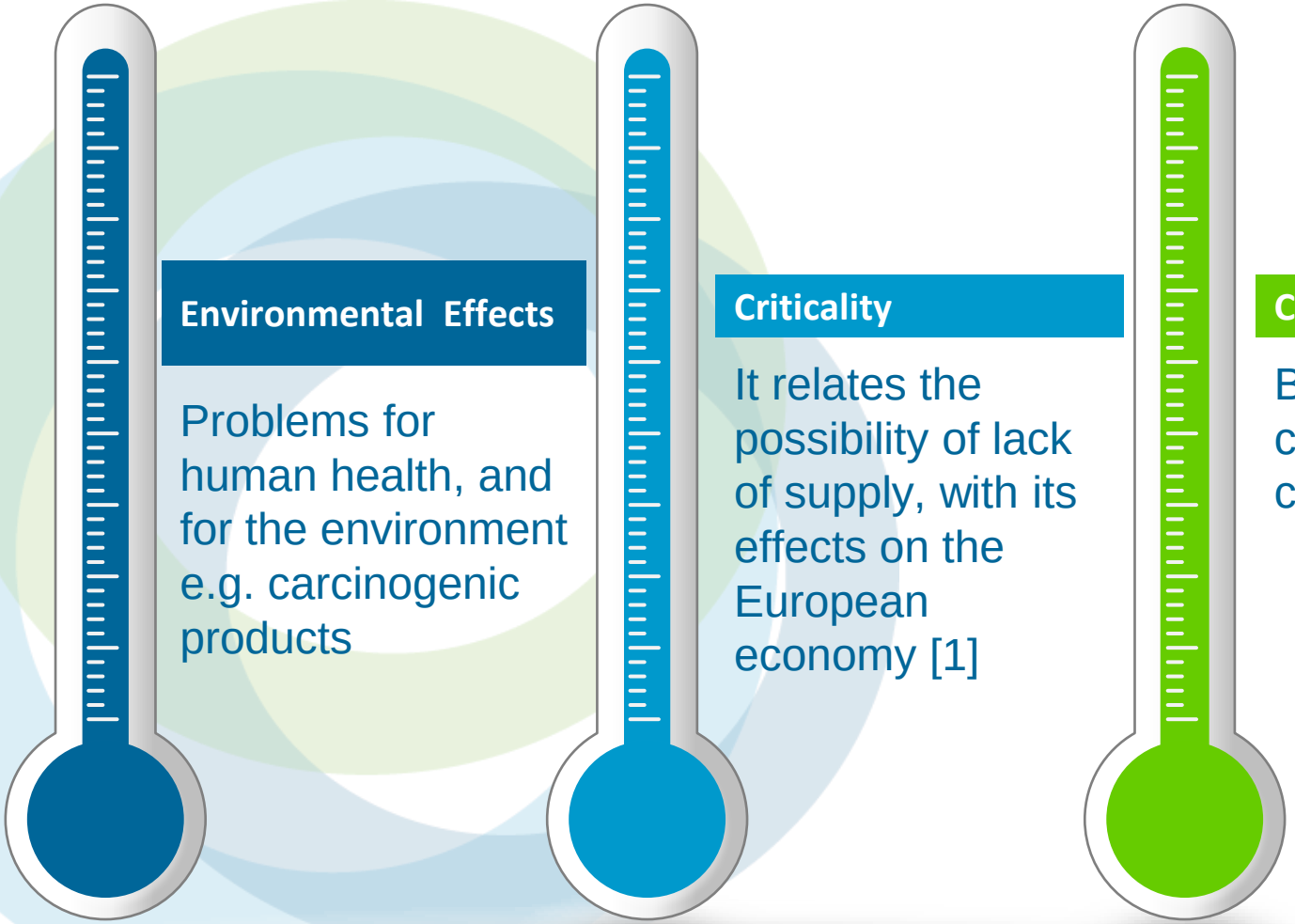
Eco-design

The eco design is based on a desire for continuous improvement, marking indicators that allow the manufacturer to improve both its product and its process to work more efficiently.

Materials selection

Inside the eco-design as a tool for improvement

MATERIALS IDENTIFICATION



Environmental Effects

Problems for human health, and for the environment e.g. carcinogenic products

Criticality

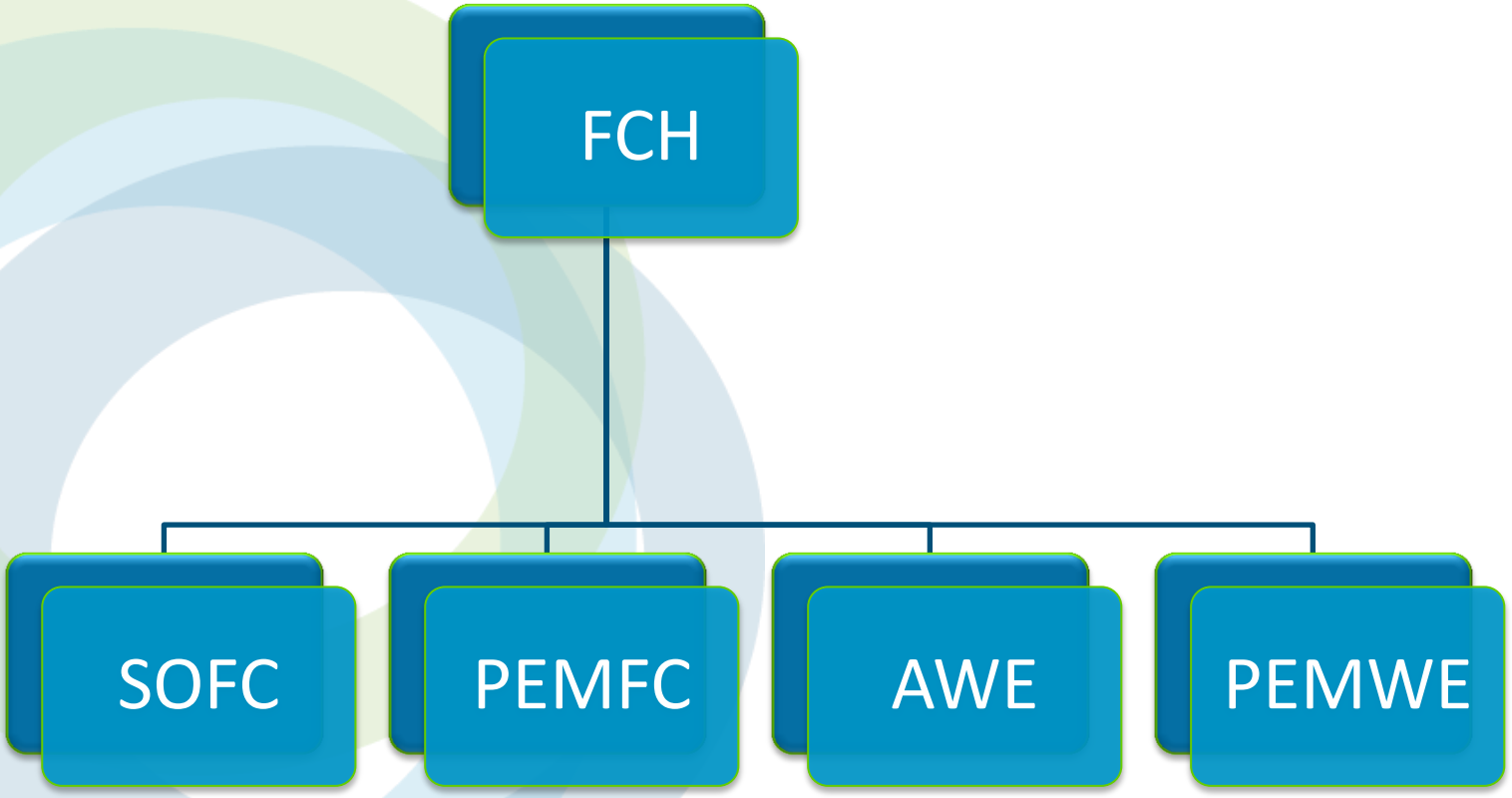
It relates the possibility of lack of supply, with its effects on the European economy [1]

Cost

Based on the current market costs.

[1] European Commission, "Report on critical raw materials for the EU: Report of the Ad hoc Working Group on defining critical raw materials," 2017.

Technologies analysed



SOFC

Component	Material	Material hazardousness	Material value	Material Criticality
Electrolyte	Yttria-stabilised zirconia	Non-hazardous	Medium	High
Anode	Nickel-based oxide doped with YSZ	Hazardous (Cat. 1 carcinogen)	Medium	High
	Nickel	Hazardous (Cat. 1 carcinogen)	Medium	High
Cathode	Strontium-doped lanthanum manganite	Hazardous (Irritant)	Medium	High
Interconnect	Doped lanthanum chromate	Hazardous (Irritant, harmful)	Medium	Medium-High
	Inert metals/alloys	Non-hazardous	High	Medium-High
Sealant	Glass/Glass-ceramic	Non-hazardous	Low	Low
	Mineral	Non-hazardous	Low	Low
	Precious metals	Non-hazardous	High	High
Substrate	Ceramic	Non-hazardous	Low	Low

PEMFC

Component	Material	Material classification	Material value	Material Criticality
Electrolyte	Perfluorosulphonic acid (PFSA)	Non-hazardous	Medium	Medium
	Sulfonated polyether ether ketone (s-PEEK)	Non-hazardous	Medium	Low
	polystyrene sulfonic acid (PSSA)	Non-hazardous	Low	Medium
	polybenzimidazole (PBI) doped with H_3PO_4 *	Hazardous (corrosive)	Medium	Low
Anode and Cathode - GDL	Carbon cloth or paper treated with hydrophobic agent	Non-hazardous	Low	Low
	Metallic mesh or cloth (e.g. stainless steel)	Non-hazardous	Low	Low
Anode and Cathode - Catalyst layer	Platinum or Pt-alloys	Non-hazardous	High	High
	Catalyst support (carbon, metal oxides, carbides, etc.)	Non-hazardous	Medium	Low
Interconnect	Graphite or graphite composites	Non-hazardous	Low	High
	Stainless steel	Non-hazardous	Low	Low
Sealant	Thermoplastic	Non-hazardous	Low	Low
	Elastomer	Non-hazardous	Low	Low

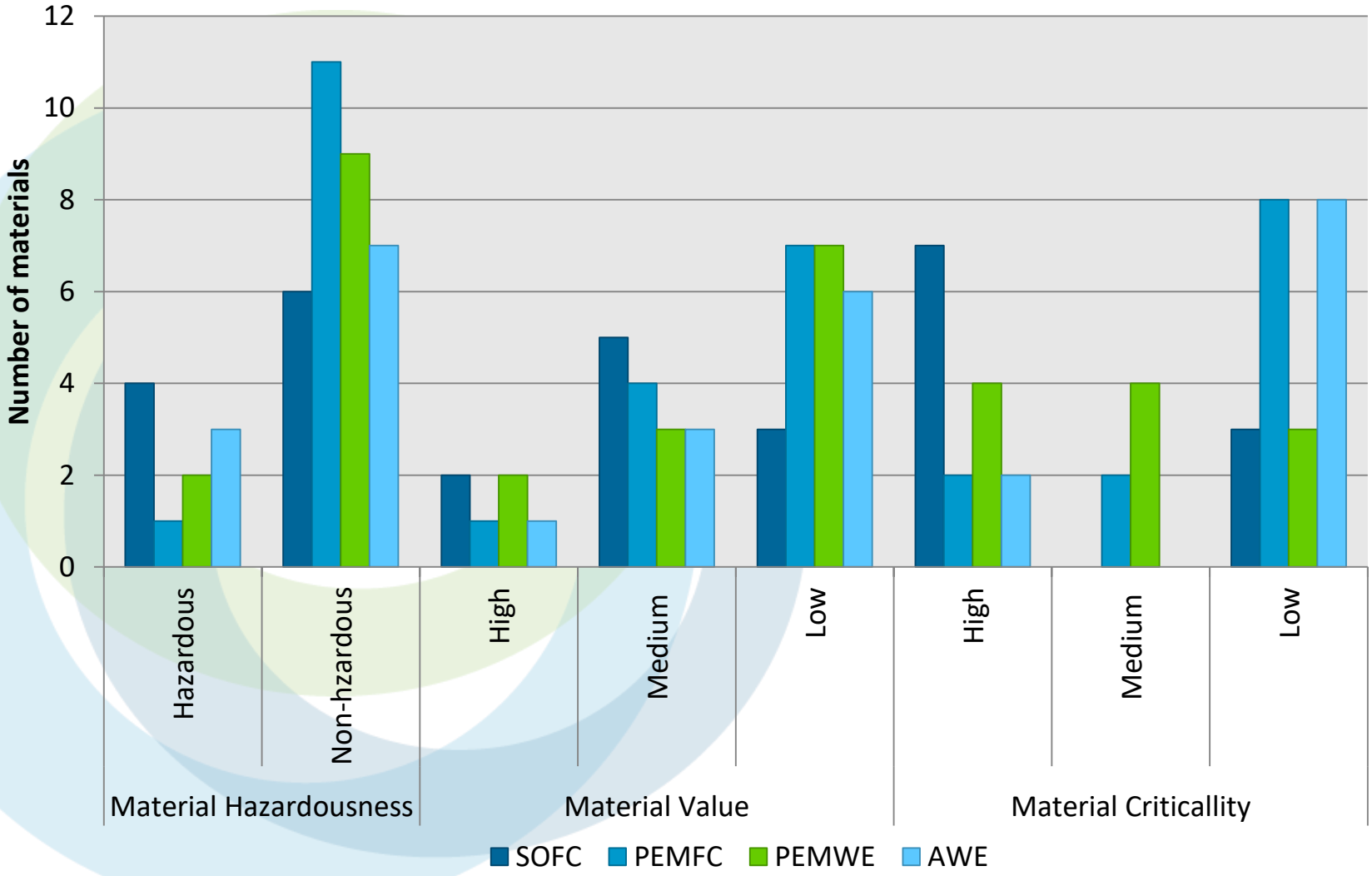
AWE

Component	Material	Material classification	Material value	Material Criticality
Electrolyte	Potassium Hydroxide	Hazardous (corrosive)	Medium	Low
Anode	Precious metals	Non-hazardous	High	High
	Plastic	Non-hazardous	Low	Low
Cathode	Raney-Nickel	Hazardous (carcinogen)	Medium	High
	Plastic	Non-hazardous	Low	Low
Interconnect	Plastic	Non-hazardous	Low	Low
Sealant	Thermoplastic	Non-hazardous	Low	Low
	Elastomer	Non-hazardous	Low	Low
Diaphragm	Asbestos	Hazardous (carcinogen)	Low	Low
(membrane)	Polymers	Non-hazardous	Medium	Low

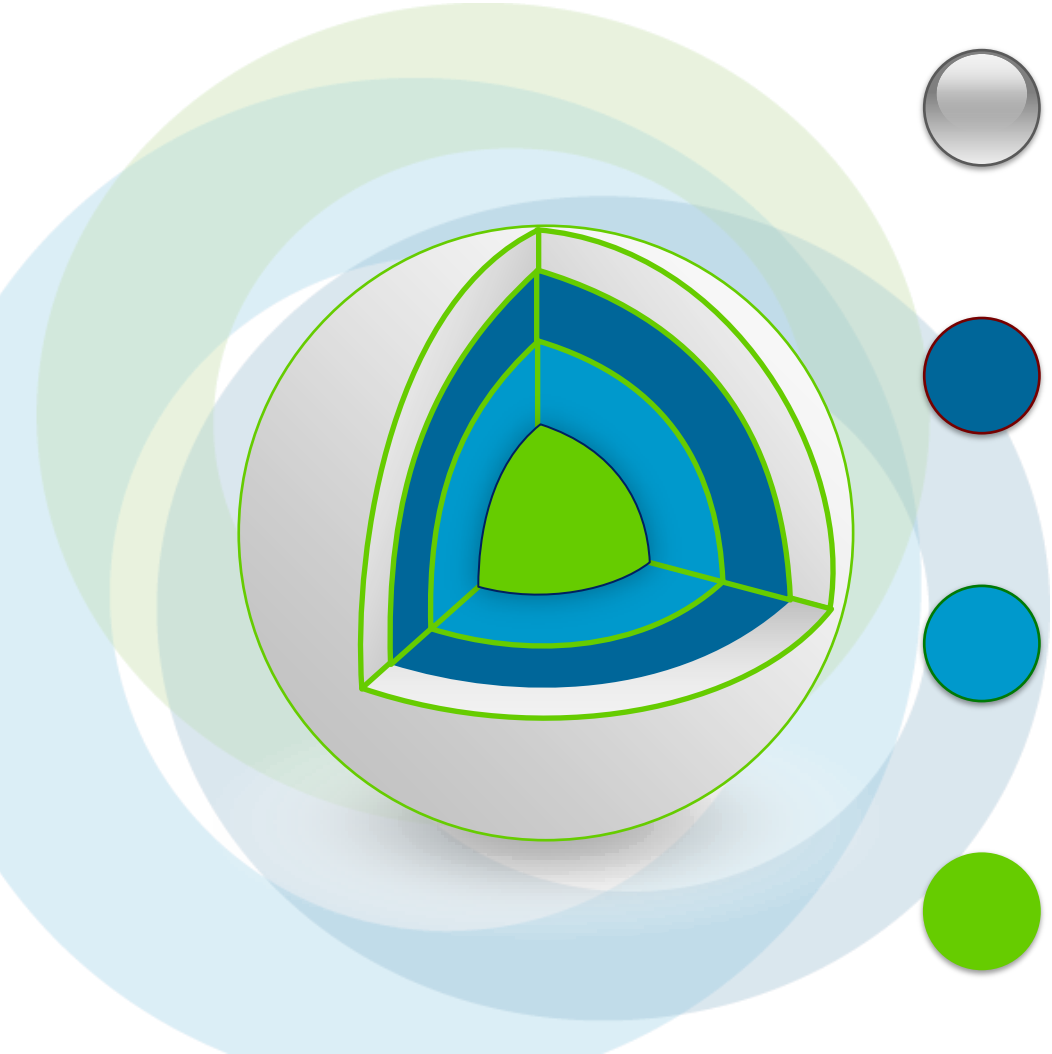
PEMWE

Component	Material	Material classification	Material value	Material Criticality
Electrolyte	Perfluorosulphonic acid (PFSA)	Non-hazardous	Medium	Medium
	Sulfonated polyether ether ketone (s-PEEK)	Non-hazardous	Medium	Low
Catalyst layer - Cathode	Pt or Pt-alloys	Non-hazardous	High	High
Catalyst layer- Anode	Iridium and Ir-alloys	Hazardous (irritant, harmful)	High	High
	Ruthenium and Ru-alloys	Hazardous (toxic, carcinogen)	Medium	High
Anode and Cathode - GDL	Thermally sintered Ti	Non-hazardous	Low	Medium
	Ti or stainless steel mesh	Non-hazardous	Low	Medium
	Graphite or graphite composites (only possible on cathode side)	Non-hazardous	Low	High
Interconnect	Coated titanium or Ti-alloys	Non-hazardous	Low	Medium
Sealant	Thermoplastic	Non-hazardous	Low	Low
	Elastomer	Non-hazardous	Low	Low

Critical Materials



Recycling process



Separation

Manual disassembly

Separation

Selection of cables, base plates, electrolytes and electrodes and other elements.

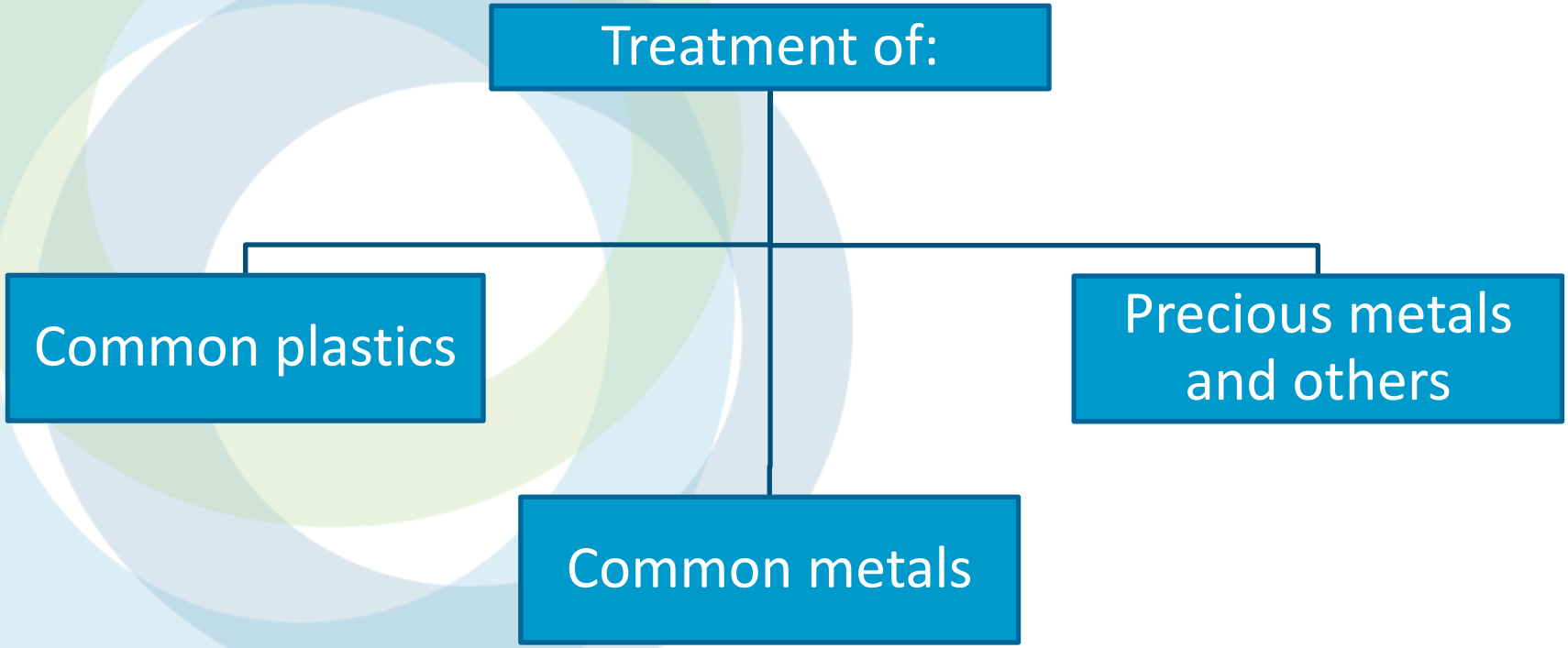
Size reduction

By means of processes such as grinding or pulverization.

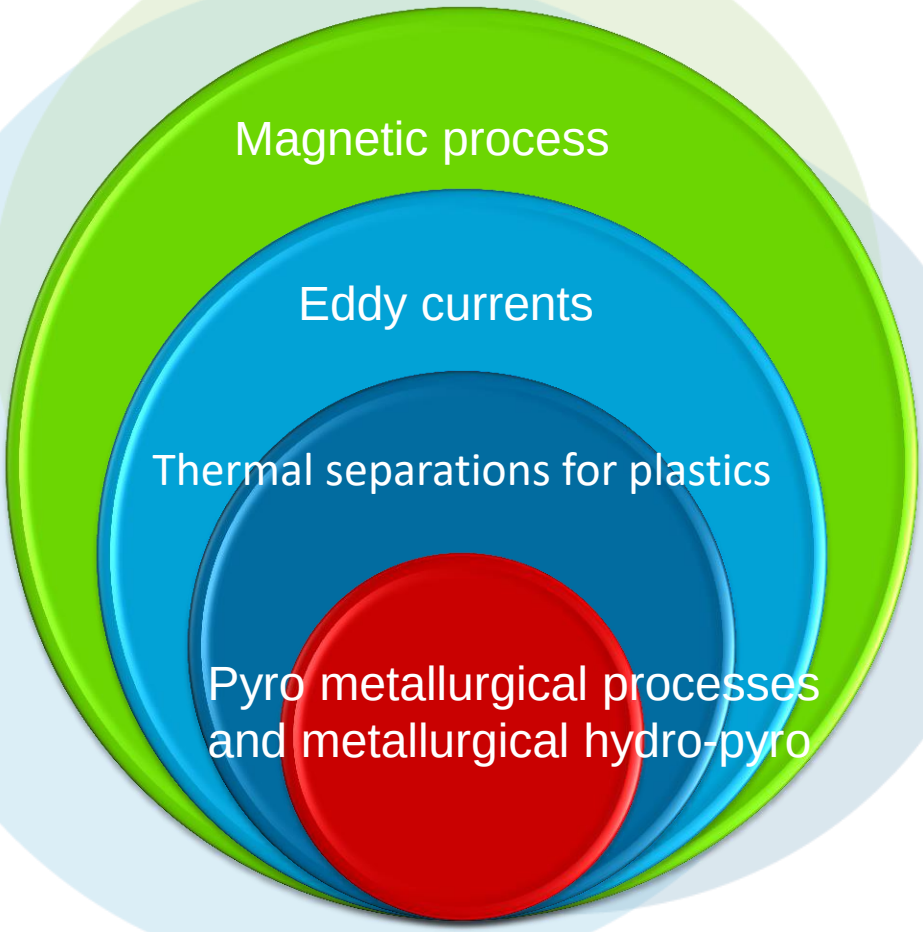
Recovery treatments

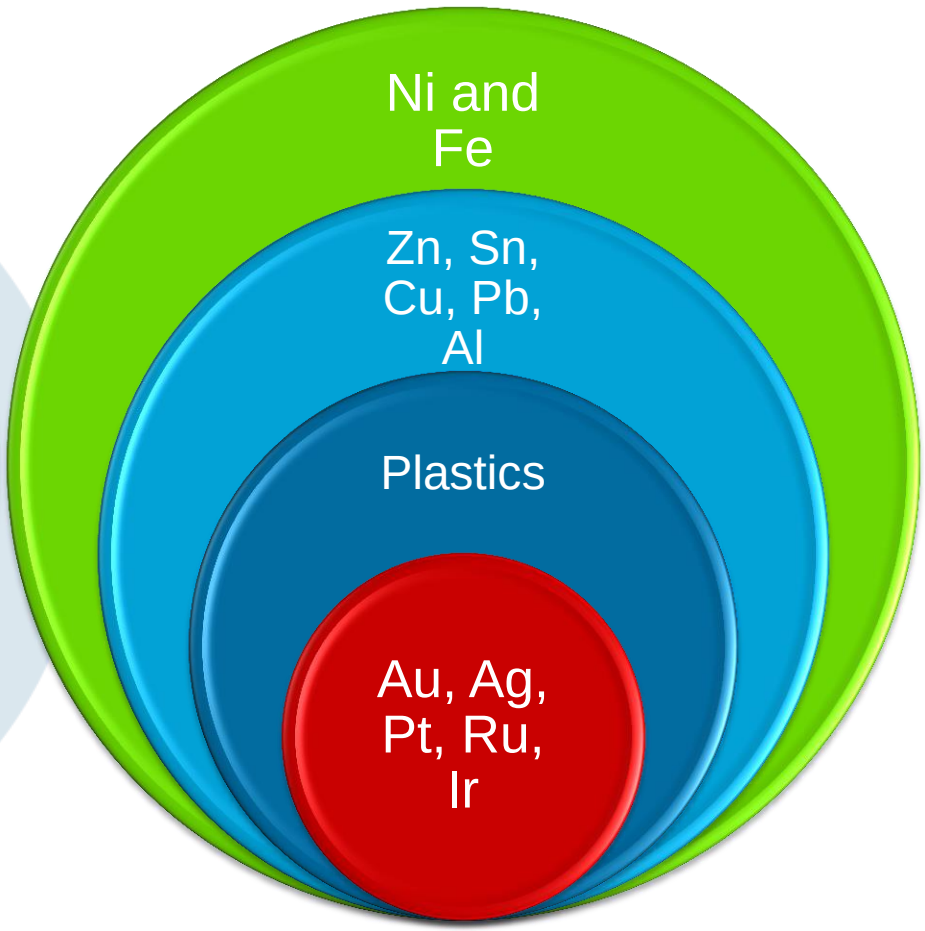
Specific processes depending on the material.

Recycling process

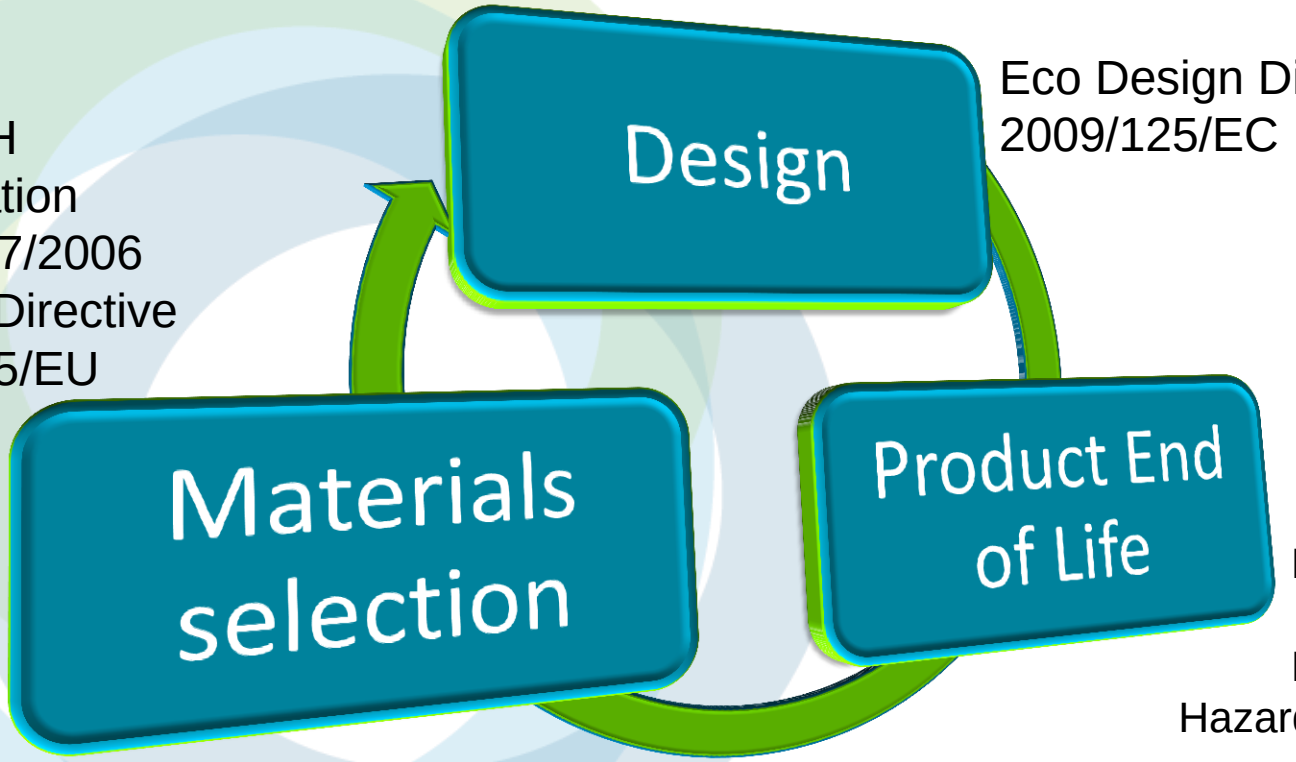


Specific technologies





Legal framework



REACH
Regulation
N° 1907/2006
RoHS Directive
2011/65/EU

Eco Design Directive
2009/125/EC

WEEE
Directive 2012/19/EU
Landfill
Directive 1999/31/EC
Hazardous Waste Directive
91/689/EEC
ELV Directive 200/53/EC
Batteries Directive 2006/66/EC

Challenges in recycling

Challenges

Develop recycling techniques to the maximum to improve efficiencies.

Promote the use of recovered materials at the time of manufacture

Establish appropriate mechanisms to encourage the recycling of these technologies.

Needs in recycling

Needs

- Develop specific protocols for action for the FCH.
- Ensure that the processes are attractive for all the agents involved
- Adapt the technologies to the legal framework.
- Reduce the environmental impact of recycling processes

Inputs from workshop with business representatives

CREATION OF NEW BUSINESS MODELS

Looking how to apply the developments of the project, business models will be created, with relevant companies of the FCH technologies life, to implement all the knowledge and outcomes of the project.

Inputs from workshop with business representatives

FCH
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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Conclusions

- Nowadays, the development of the FCH technologies has not taken into account their **recycling and dismantling**, nor their possible re-uses inside a future context of commercialization.

- Some **critical materials** that are used are:
  - PEMFC and PEMWE: **Platinum group materials as Iridium, Platinum or Ruthenium.**
  - SOFC: **Rare-Earth compounds as Lanthanum and Yttrium**.
  - Alkaline electrolysers: **Platinum** and **Asbestos**

- A lack of strategies around the End of Life of this technologies exists. There is also an absence in the reuse of this products.
- There is a markets for business models derivate from material saving and recycled raw materials.

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 700190. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme from and Hydrogen Europe and N.ERGHY.

HyTechCycling

Thank you for your attention

More information:

www.hytechcycling.eu

aferriz@hidrogenoaragon.org

Follow our project!

SOFC

Componente	Material	Efecto ambiental	Coste	Criticidad
Electrolito	Itria estabilizada con Zirconia	No peligroso	Medio	Alto
Ánodo	Óxido de Niquel dopado con YSZ	Peligroso	Medio	Alto
	Níquel	Peligroso	Medio	Alto
Cátodo	Manganita de lantano dopada con estroncio	Peligroso	Medio	Alto
Conexiones	Cromato dopado con lantano	Peligroso	Medio	Medio- Alto
	Metales inertes	No peligroso	Alto	Medio- Alto
Sello	Metales preciosos	No peligroso	Alto	Alto

PEMFC

Componente	Material	Efecto ambiental	Coste	Criticidad
Capa catalítica	Pt o aleaciones de Pt	No peligroso	Alto	Alto
Sello	Grafito o composites de grafito	No peligroso	Bajo	Alto

AWE

Componente	Material	Efecto ambiental	Coste	Criticidad
Electrolito	KOH	Peligroso	Medio	Bajo
Ánodo	Metales preciosos	No peligroso	Alto	Alto
Cátodo	Niquel Raney	Peligroso	Medio	Alto

PEMWE

Componente	Material	Efecto ambiental	Coste	Criticidad
Capa catalítica- Cátodo	Pt o aleaciones de Pt	No peligroso	Alto	Alto
Capa catalítica- Ánodo	Iridio o aleaciones de Ir	Peligroso	Alto	Alto
	Rutenio o aleaciones de Ru	Peligroso	Medio	Alto