HyTechCycling

New technologies and strategies for fuel cells and hydrogen technologies in the phase of recycling and dismantling

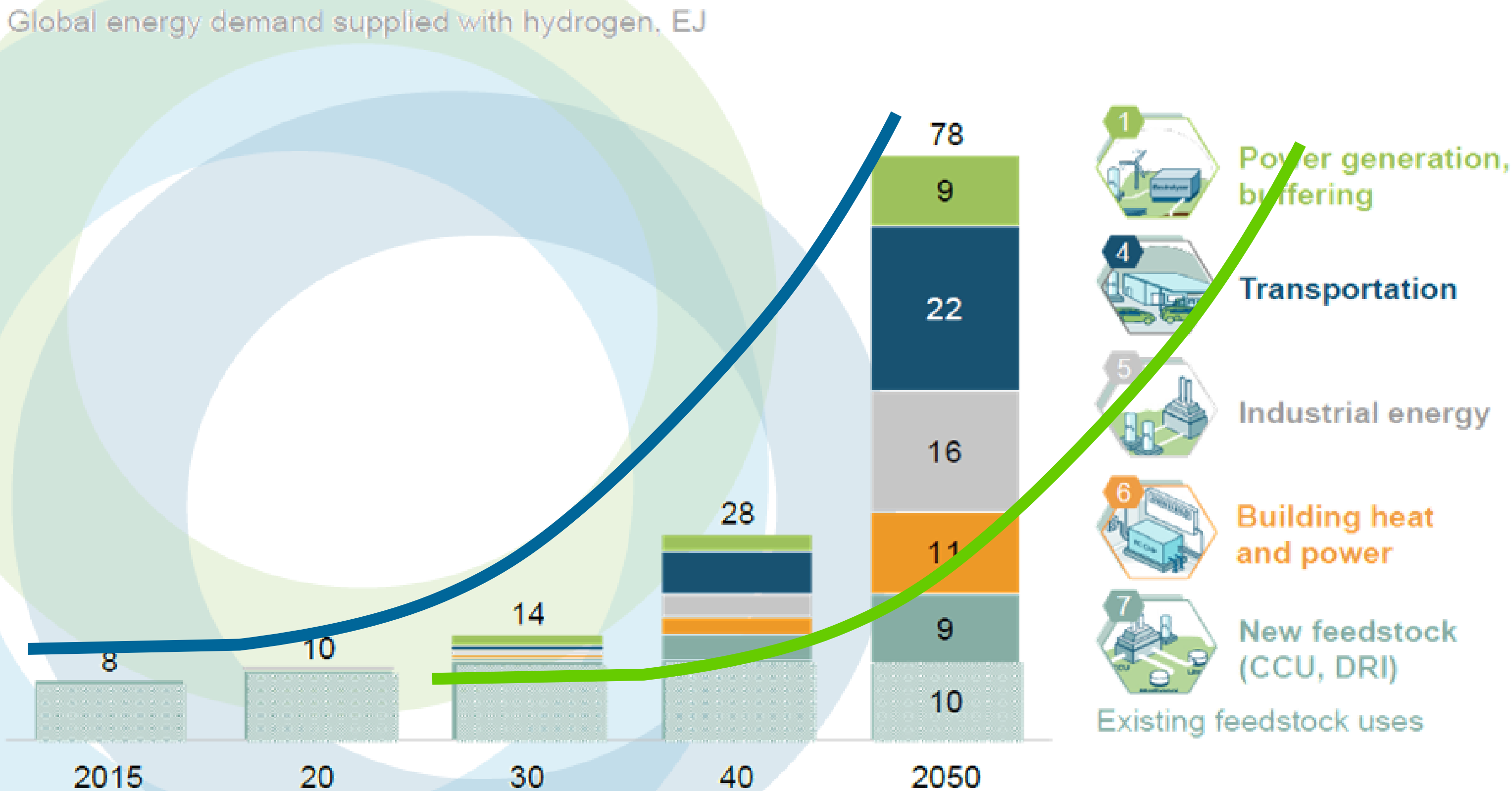
The project in a nutshell

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 **future 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.

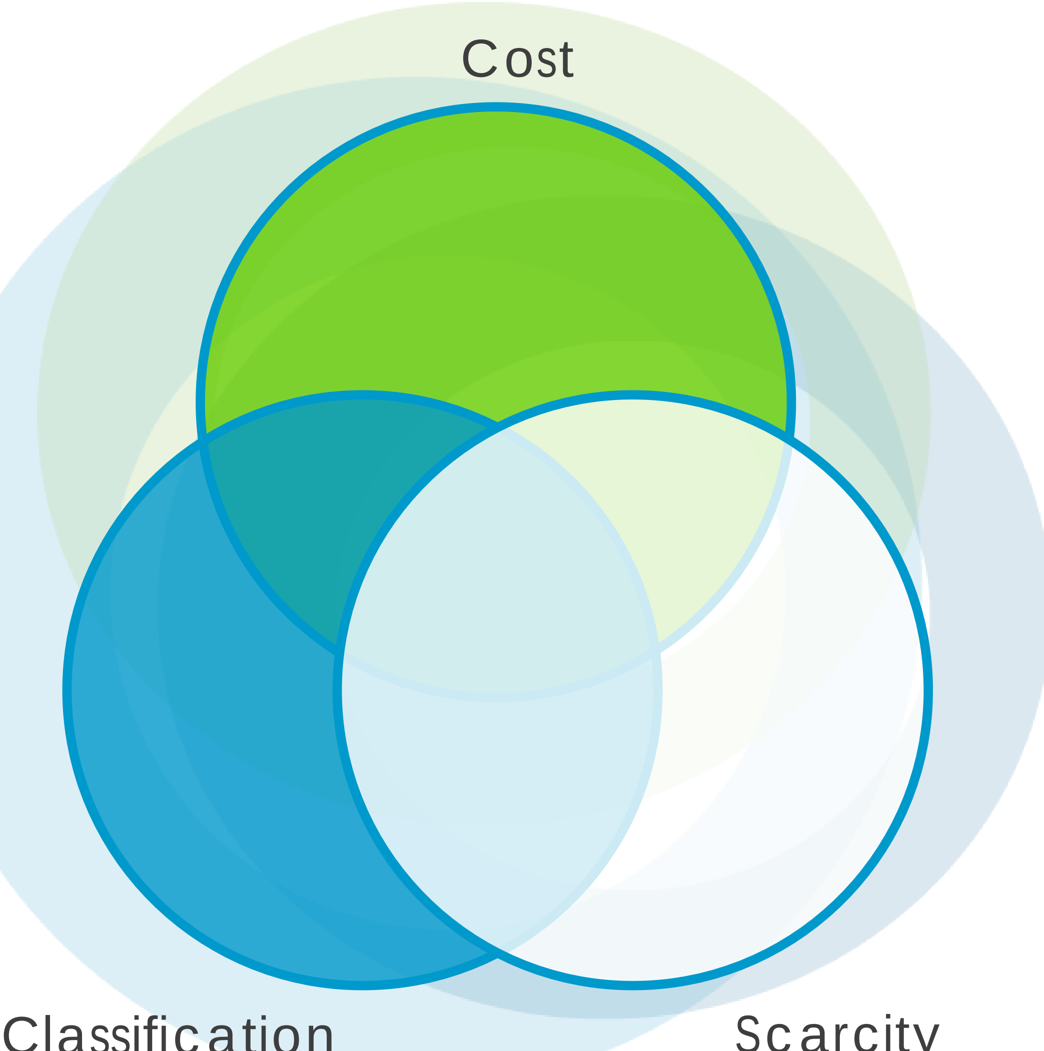
Perspectives and new concerns



SOURCE: Hydrogen Council

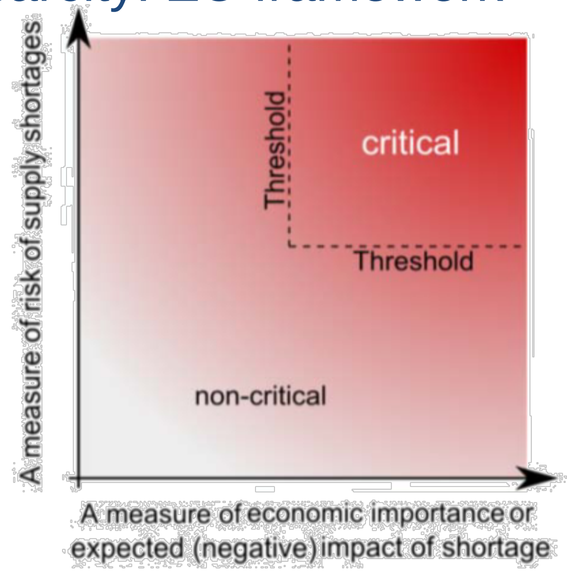
University of Ljubljana
FOUNDATION FOR THE DEVOLOPMENT OF NEW HYDROGEN TECHNOLOGIES IN ARAGON
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING
institute IMDEA energy
GRUPO LÓPEZ SORIANO
ENVIRONMENT PARK Parco Scientifico Tecnologico per l'Ambiente

What is a critical material?

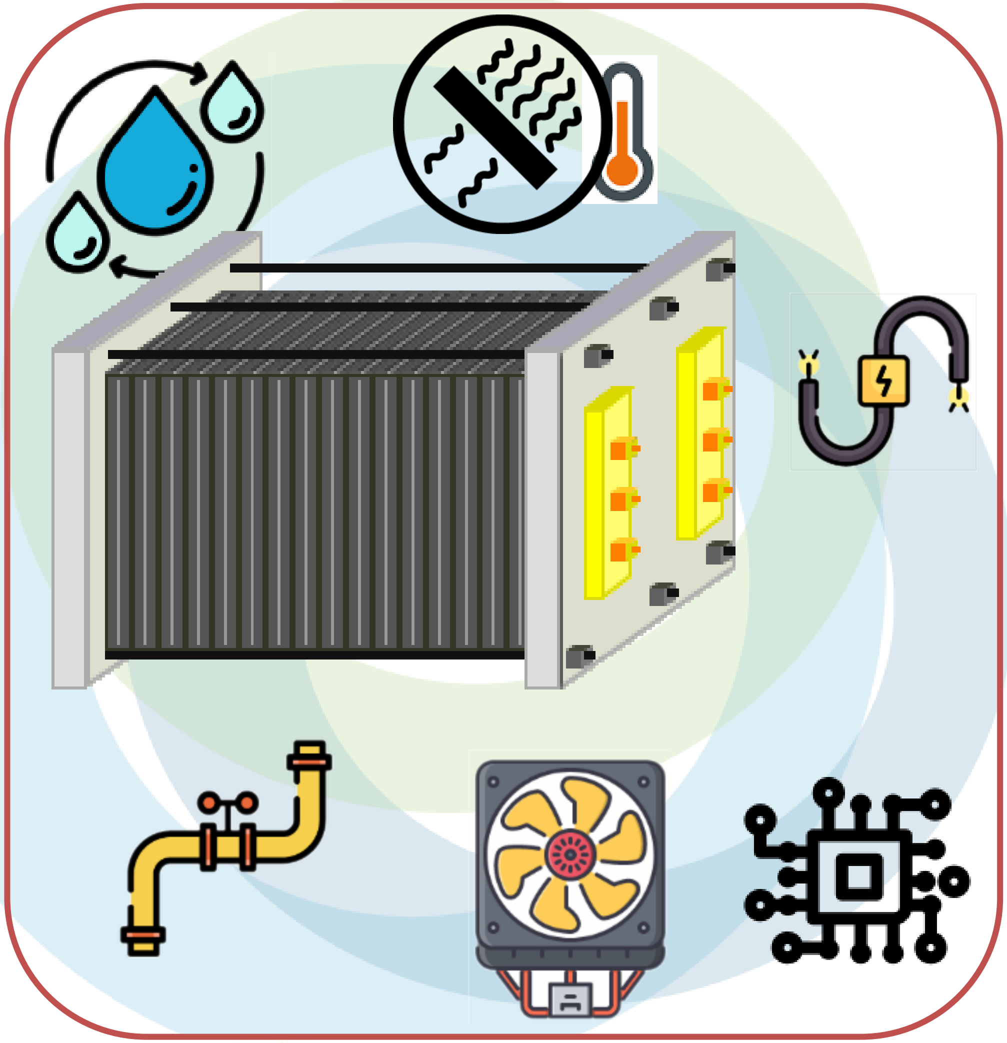


The most critical materials belong to the common zone.

Scarcity: EU framework



Components of this technology



Stack components

BoP components

4 technologies, multiple problems

PEMFC

PEMWE

SOFC

AWE

SOFC

Solid Oxide Fuel Cells (SOFC)

Component	Material	Material classification	Material value	Material criticality
Electrolyte	Yttria-stabilised zirconia (YSZ)	Non-hazardous	Medium	High
	Cerium gadolinium oxide*	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
	Lanthanum Strontium Cobalt Ferrite*	Hazardous (Irritant)	Medium	High
Interconnect	Doped lanthanum chromate	Hazardous (Irritant, harmful)	Medium	Medium-High
	Inert metals/alloys	Non-hazardous	Medium	Medium
	Ferritic stainless steel*	Non-hazardous	Low	Low
Sealant	Glass/Glass-ceramic	Non-hazardous	Low	Low
	Phyllosilicates (e.g. Vermiculite, Mica)	Non-hazardous	Low	Low
Substrate	Ceramic	Non-hazardous	Low	Low

AWE

Alkaline Water Electrolyser (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 (membrane)	Asbestos	Hazardous (carcinogen)	Low	Low
	Polymers	Non-hazardous	Medium	Low

HyTechCycling

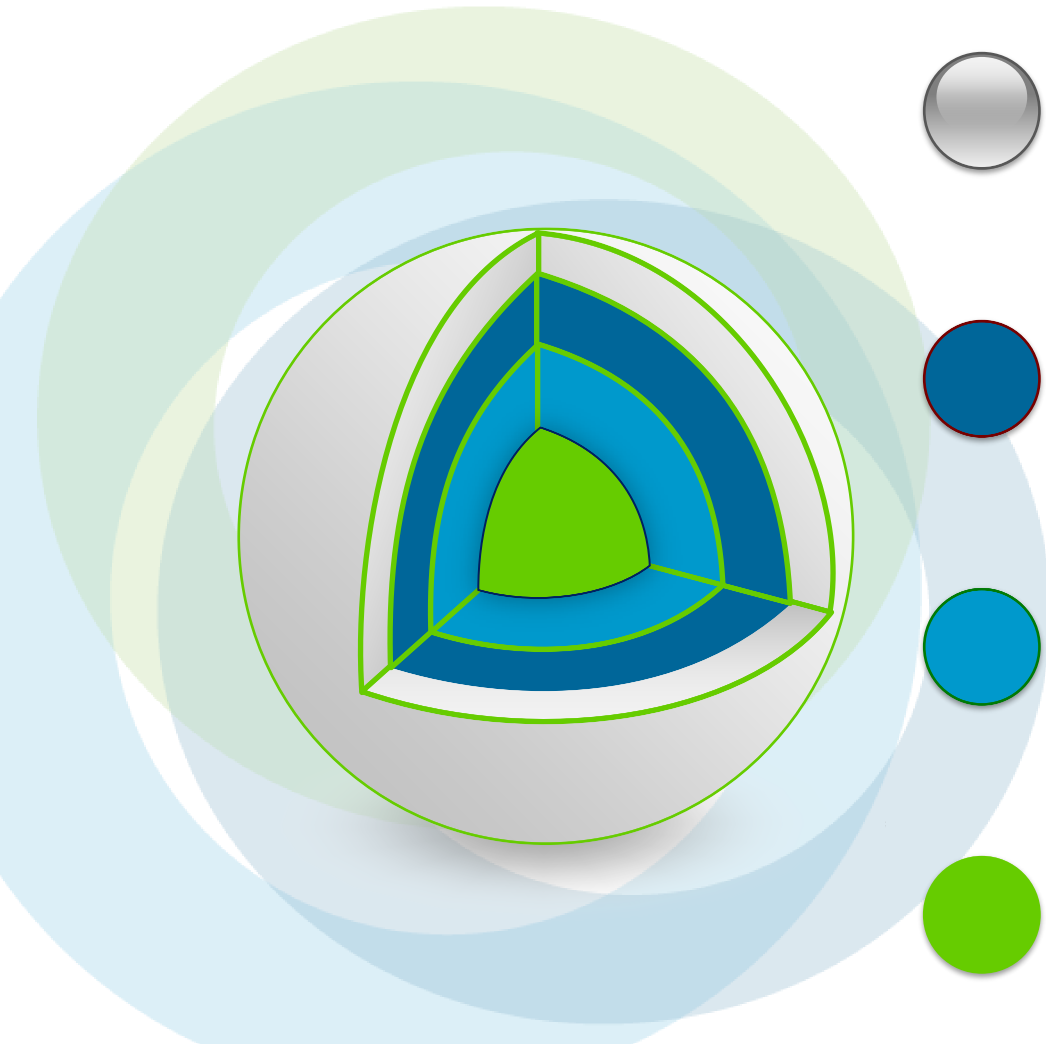
PEMWE

Polymer Electrolyte Membrane Water Electrolyser (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)	High	High
Anode and Cathode - GDL	Thermally sintered Ti	Non-hazardous	Low	Medium
	Ti or stainless steel mesh	Non-hazardous	Low	Medium
	Synthetic graphite or graphite composites (only possible on cathode side)	Non-hazardous	Low	Medium
Interconnect	Coated titanium or Ti-alloys	Non-hazardous	Low	Medium
Sealant	Thermoplastic	Non-hazardous	Low	Low
	Elastomer	Non-hazardous	Low	Low

PEMFC

Polymer Electrolyte Membrane Fuel Cell (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 H3PO4 *	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	Low	Low
Interconnect	Synthetic graphite or graphite composites	Non-hazardous	Low	Medium
	Stainless steel	Non-hazardous	Low	Low
Sealant	Thermoplastic	Non-hazardous	Low	Low
	Elastomer	Non-hazardous	Low	Low

How to dismantle a fuel cell?



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.

Traditional technologies

	Economic consideration	Legal consideration
Magnetic separation	Low	No
Eddy current separation	Low	No
Finder	Low	No
Densimetric table	Low	Yes if water is used
Flotation	Medium	Yes
Thermal processing	High	Yes
Mechanical processing	Low	No
Optical processing	High	No
Incineration processing (energetic valorisation)	High	Yes
Pyrolysis	High	Yes
Hydrometallurgical processes	High	Yes
Pyro-hydrometallurgical processes	High	Yes
Re-use of ceramic waste	Medium	Yes
Incineration of mineral wool	High	Yes

New technologies: What we need?

- ECO DESIGN
- MATERIAL REDUCTION
- NEW RECYLING TECHNOLOGIES
- ACTORS INVOLVMENT
- PROFITABILITY AND EFFICIENCY IN THE NEW PROCESSES

Actors involvement

HyTechCycling project has been working with all the actors, from manufacturers to recycling centers, to see if they realize of the importance of the end of life of the product.

60% of FCHs manufacturers have already signed with the actors mentioned, in order to have profit for the Company:

- refund system for old systems is already in planning, contracts to PGM recycler
- platinum recycling agreement
- specifics agreement depending on the wastes
- they are include in the selling contract
- providing a discount on new materials if the older are returned.

Actors involvement

RCs are interested in specific agreements with manufacturers:

The agreements between manufacturers and recyclers favor the correct management of the waste, enabling the amortization of investments to implement new treatments in a longer term. In addition, they stabilize cash flows by improving the economic returns of these businesses.

- Frame Agreement for end-of-life FCH

End users are interested in specific agreements with RCs and manufacturers.

- 40% evaluate the transport of old devices paid by manufacturer or recycling center economically advantages
- 60% evaluate economically advantages to pay directly the transport of old devices but with economic incentives: example a reduced price for a new or remanufactured device → agreements

Next Steps of the project

- **Identification of the problem**
- **Laws, regulation and critical materials**
- **Identification of recycling technologies**
- **Identification of the best practices and new technologies**
- **Business Model Development**
- **Business Model Implementation**

A business model will be developed for each technology, taking into account the logistics, costs, concerns, optimal flows and current state of the art.

This business model aims to implement this new technologies in the dismantling and recycling phase in the optimal way.

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 and Hydrogen Europe and N.ERGHY.

Thanks for your time.

More info in

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