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ASSESSMENT OF CRITICAL MATERIALS AND COMPONENTS IN FCH TECHNOLOGIES TO IMPROVE LCIA IN END OF LIFE STRATEGY

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The project in figures

- Consortium of 5 European partners (Spain 3, Italy 1 and Slovenia 1)
- Duration of the project 3 years
- Funds approximately 0,5 M€

Start
05/2016

Dissemination and awareness plan
11/2016

Needs and challenges in the phase of recycling and dismantling established
07/2017

LCA inventory of hazardous materials in FCH technologies
01/2018

New recycling technologies and strategies in the phase of recycling and dismantling
01/2018

Set up of reference case studies with new strategies in dismantling and recycling state
11/2018

Guidelines on readaptation of existing recycling centres
01/2019

New business model and roadmap for implementation
05/2019

Recommendations and guidelines on the introduction of new technologies and strategies for recycling and dismantling of FCH products in the EU
05/2019

End
05/2019

Funded by the Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU)

FCH
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Partners in the project

FOUNDATION FOR THE DEVOLOPMENT OF NEW HYDROGEN TECHNOLOGIES IN ARAGON

University *of Ljubljana*

institute imdea energy

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Motivation and objectives

Motivation:

One thing among others that also prevents commercialization of Fuel cell and hydrogen (FCH) is the recycling and dismantling stage:

- no uniform lists of critical materials
- no established pathways for recycling processes
- incomplete legislation, lack of uniform guidelines and directives

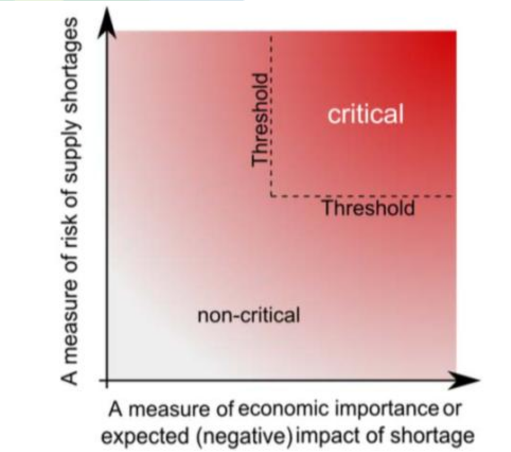
Objectives:

- Assess the criticality of materials used in core components of the FCH technologies under consideration (AWE, PEMWE, PEMFC, SOFC).
- Form a list of relevant materials (LCIA table) that will serve as an input for Life Cycle Assessment (LCA).
- Produce the LCA numerical model (appropriate methodology to properly cover the whole scope of the LCA study) → emphasis on the end of life (EoL) phase.

Methodology

Three main criteria were defined which were later used for material classification:

- **Hazardousness** – Material properties that make it dangerous, or capable of having a harmful effect, to human health or the environment [1], [2].
- **Scarcity or criticality** - The EU methodology [3] is a combination of two assessment components: economic importance or expected (negative) impact of shortage and risk of supply or poor governance.
- **Price** - Prices of elements and their compounds list was estimated from actual price on the market.



Antimony	Beryllium	Borates	Chromium	Cobalt	Coking coal	Fluorspar
Gallium	Germanium	Indium	Magnesite	Magnesium	Natural Graphite	Niobium
PGMs	Phosphate Rock	REEs (Heavy)	REEs (Light)	Silicon Metal	Tungsten	

EU-20 critical raw materials.

[1] Agency for Toxic Substances and Disease Registry (ATSDR): Methodology Used to Establish Toxicity/Environmental Scores for the Substance Priority List.
[2] W. M. Liu J, Goyer RA, "Toxic effects of metals.," in Casarett and Doull's toxicology: the basic science of poisons., 2008, pp. 931–979.
[3] European Commission, "Report on critical raw materials for the EU: Report of the Ad hoc Working Group on defining critical raw materials," 2014.

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List of critical materials

- FCH technologies in question are broken down to their core components.
- Materials are compared according to function (or location) in the core components, environmental aspects, costs, criticality.

FCH technology	Component	Material	Material classification	Material value	Material Criticality
AWE	Electrolyte	Potassium Hydroxide	Hazardous (corrosive)	Medium	Low
	Anode	Precious metals	Non-hazardous	High	High
	Cathode	Raney-Nickel	Hazardous (carcinogen)	Medium	High
PEMWE	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
PEMFC	Catalyst layer	Platinum or Pt-alloys	Non-hazardous	High	High
SOFC	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	Precious metals	Non-hazardous	High	High

FCH – Fuel Cells and Hydrogen Joint Undertaking

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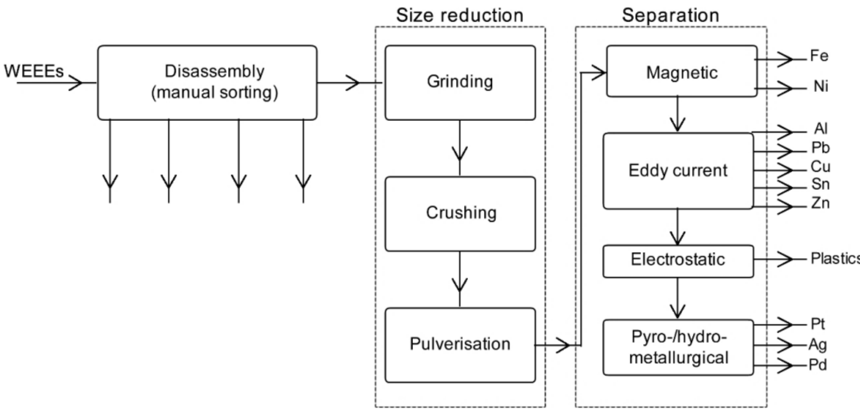
EoL strategies

- The recovery of high-value and hazardous materials is a priority for the EoL strategies.
- EoL strategies for the FCH products can be similar to those used for waste electrical and electronic equipment (WEEE).
- Currently, EoL strategies for FCH technologies are mostly based on hydrometallurgical and pyrometallurgical methods (recovery of catalysts).
- Other available mature or immature recycling technologies will also be addressed.



Common steps in EoL strategies (based on WEEE).

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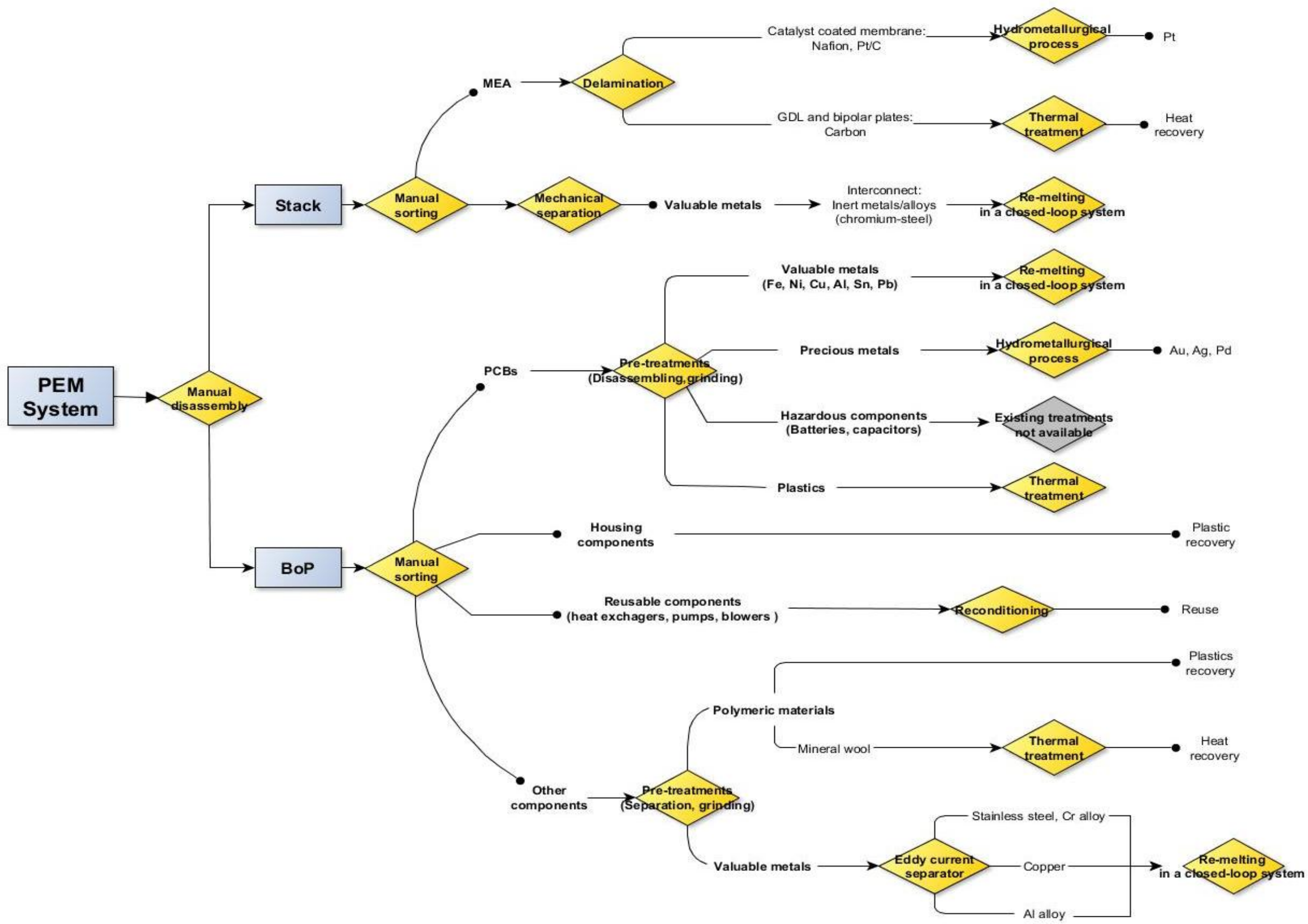
EoL strategies



Example of hydrometallurgical recovery process for PEM technologies.

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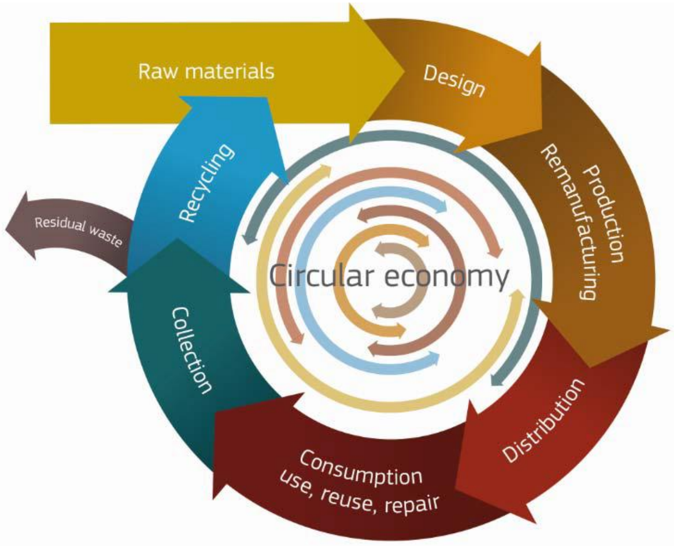
Key input data for future work

- The list of critical materials was used to form the LCIA table that will be used in the LCA numerical model.
- Scope of the study will be cradle-to-grave.
- The functional unit of the considered FCH technologies is set to be 1kWh of exergy in the form of electricity, heat and/or fuel, depends in which part of life cycle phase the results are analyzed.
- The life cycle impact assessment methodology will be primarily midpoint approach method (CML2001) with possible endpoint approach if seemed useful.

Future work

- Determine possible recycling and dismantling technologies applied to FCH technologies under consideration.
- LCA approach:
    1. Critical materials will be assessed with LCA methodology to get a first impression of their environmental impact.
    2. Afterwards a reference model will be built for each considered FCH technology.
    3. Different scenario analyses will be done to evaluate the influence of reuse, recycle and other possible EoL scenarios (landfill as the worst case).



Circular economy envisioned by the European Commission.

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http://hytechcycling.eu/

Thank you for your attention!

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