HyTechCycling

New strategies according the End of Life

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Selection of critical materials

Cost

According with sources as LME market for Precious Metals

Classification

According sources as the Priority List of Hazardous Substances and reports.

Criticality

According the EU Criticality methodology which considers the economic importance or expected impact of shortage and the supply risks. Updated in 2017.

AWE

Materiales

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

PEMWE

Materiales

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
	Coated titanium or Ti-alloys	Non-hazardous	Low	Medium
Interconnection	Thermoplastic	Non-hazardous	Low	Low
Sealant	Elastomer	Non-hazardous	Low	Low
	Perfluorosulphonic acid (PFSA)	Non-hazardous	Medium	Medium

PEMFC

Materiales

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

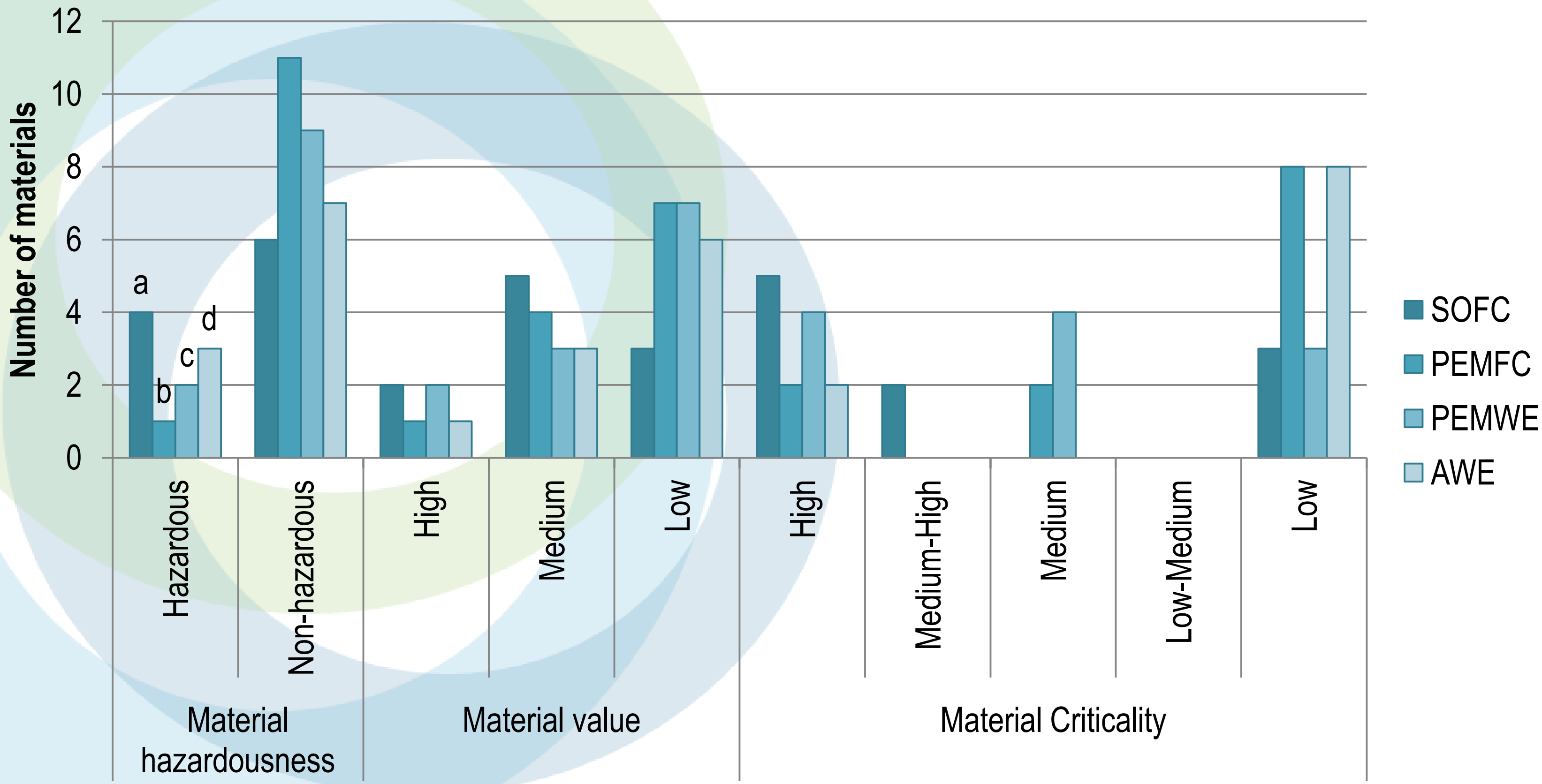
SOFC

Materials

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

Replacement of critical materials

MATERIAL SELECTION



Substitution of critical materials

In SOFC stacks

Full ceramic cells are a promising alternative to the conventional Ni-based anode

No alternative materials identified for SOFC cathode

In AWE stacks

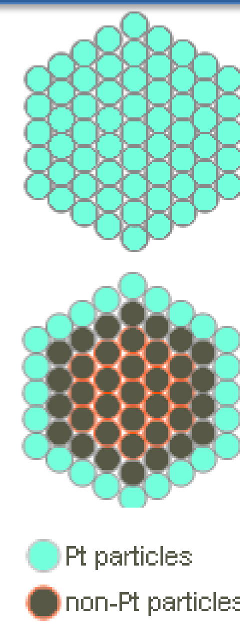
Old AWEs still in use may involve asbestos membranes. Zifron membranes are suitable substitutes showing an appropriate performance

In PEMFC and PEMWE stacks

Core-shell catalyst structure

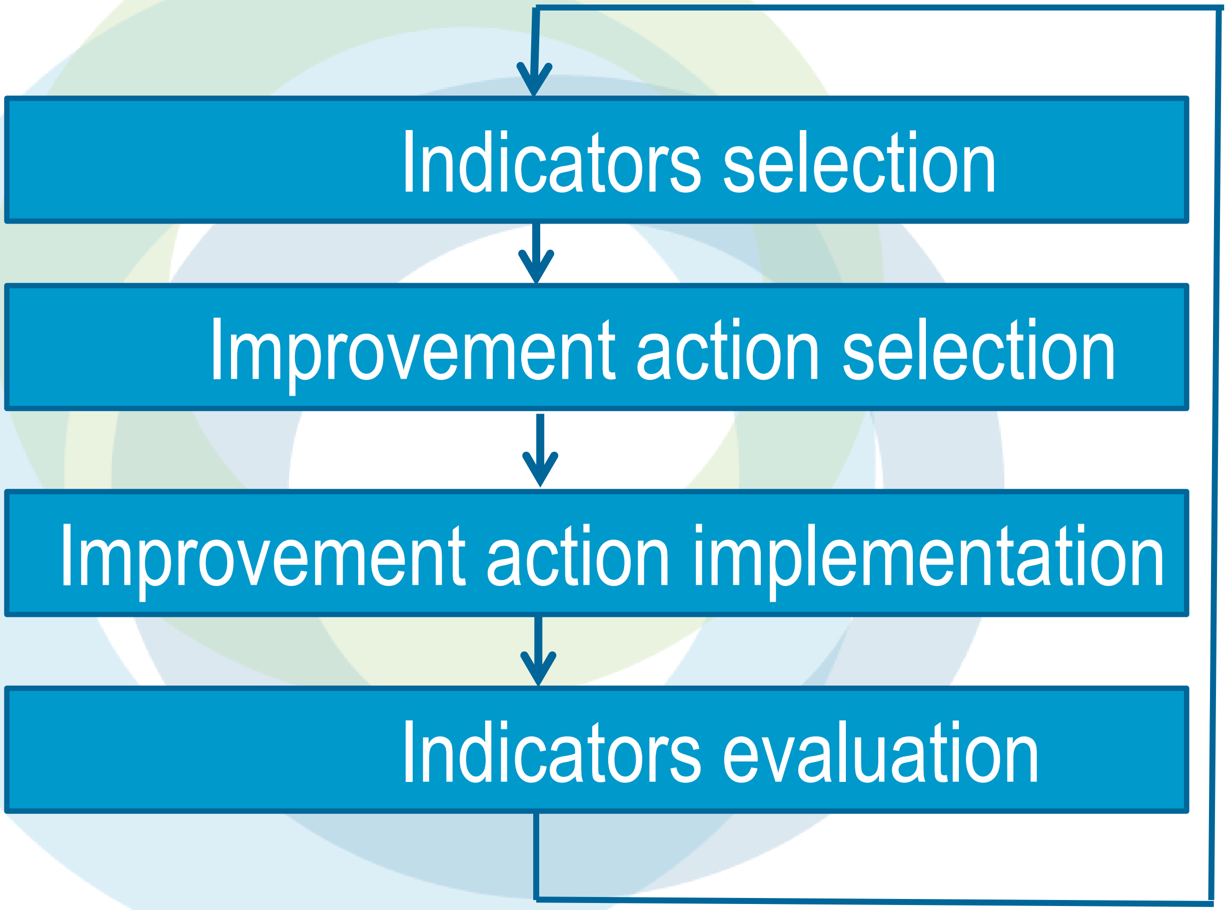
Conventional structure

Core-shell structure



Core-shell structure allows replacing a significant amount of PGMs with non-PGMs

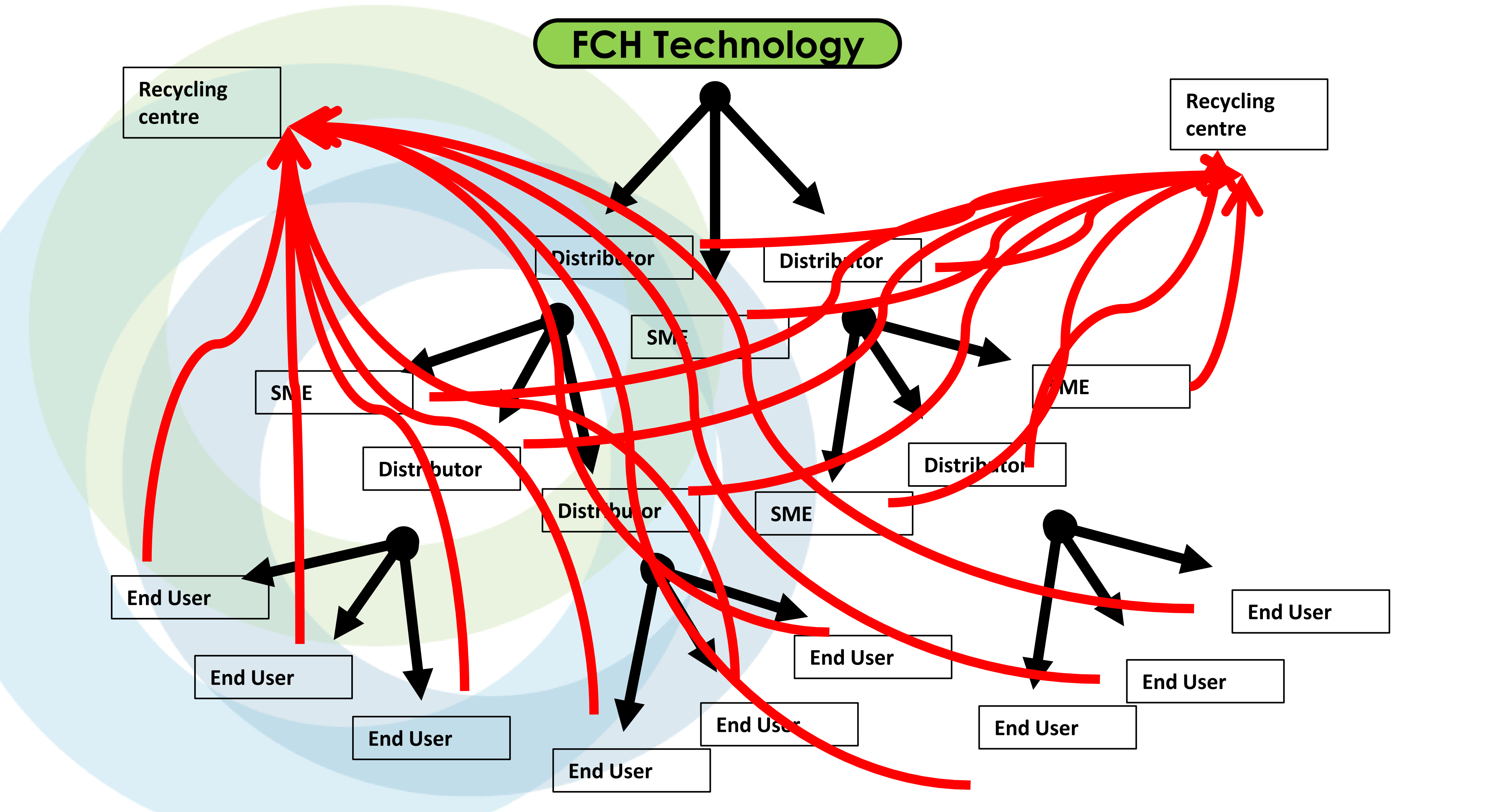
EcoDesign



Ideas?

- Reduction in weight and volume of the product.
- Reduction in the consumption of energy, water and other resources throughout the life cycle.
- Incorporation of used components.
- Design of durable parts for the extension of the lifetime .
- Reduction of amounts of waste generated, with particular attention to hazardous waste.
- Standardization and modularity.

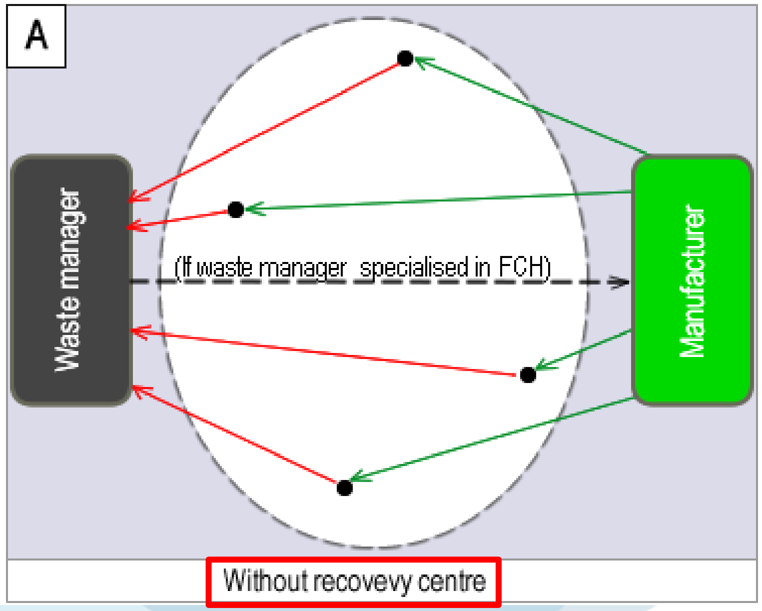
Reverse Logistics

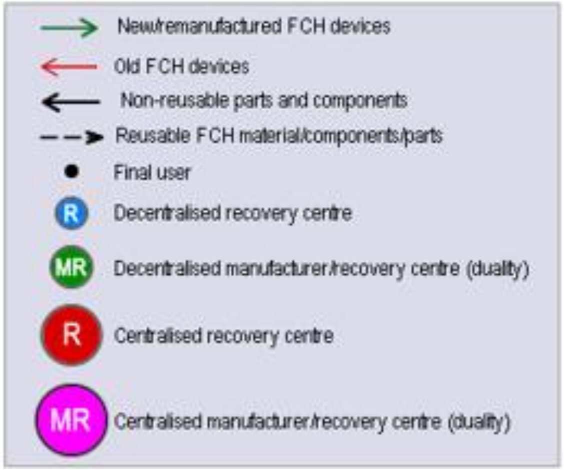


Scenarios

✓ The roles and the operations performed by **raw material suppliers**, FCH **component suppliers**, FCH **manufacturers**, FCH **users**, **waste managers** were defined. In particular, the role of a specialised **recovery centre** is emphasised in different scenarios of FCH market deployment.

Short-term scenario





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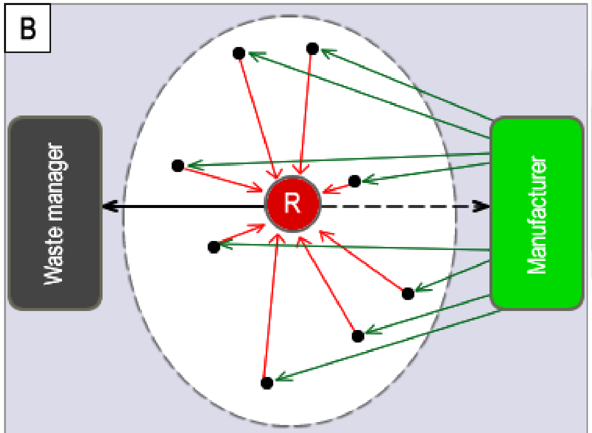
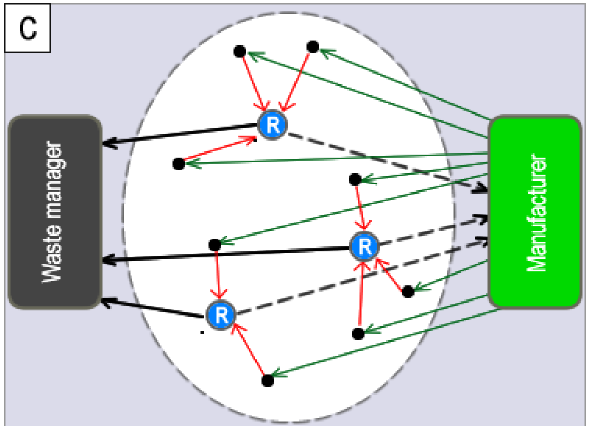
Scenarios

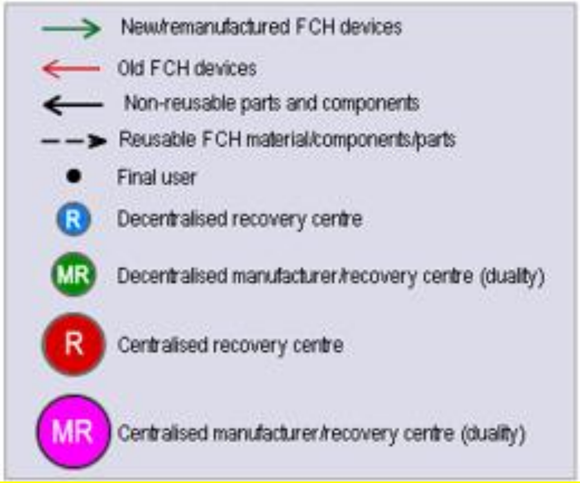
Mid-term scenario



Centralised recovery centre



Decentralised recovery centre



-RCs reduce the need for regular waste management

-Promote the reuse of components and materials → reducing costs of FCH products

-Novel EoL technologies may start to be used together with existing ones

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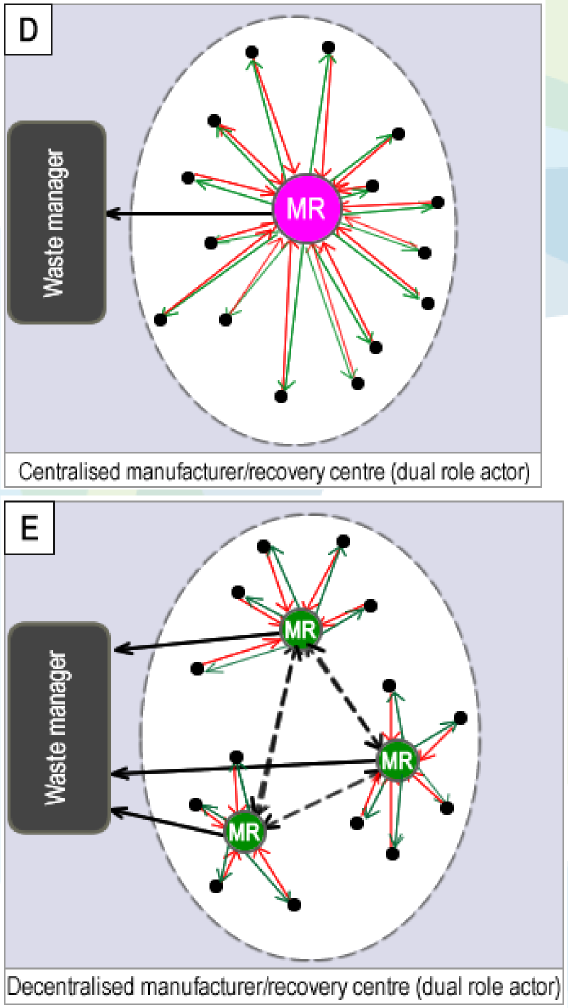
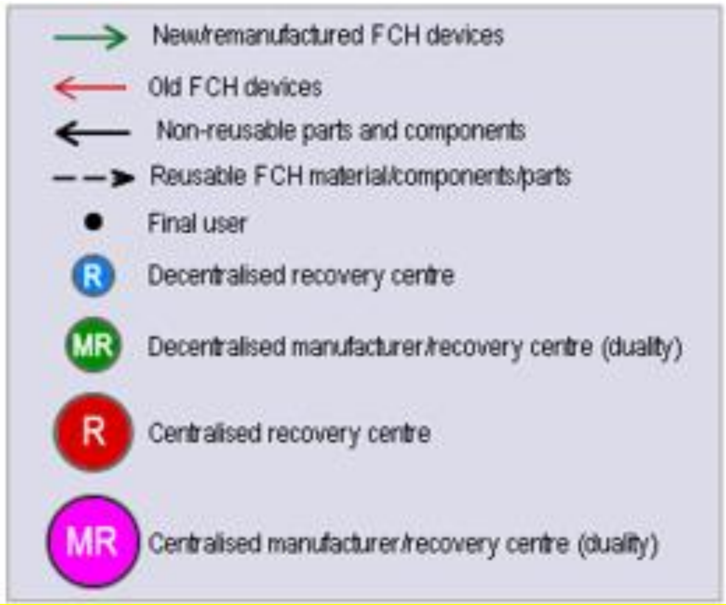
Scenarios

Long-term scenario

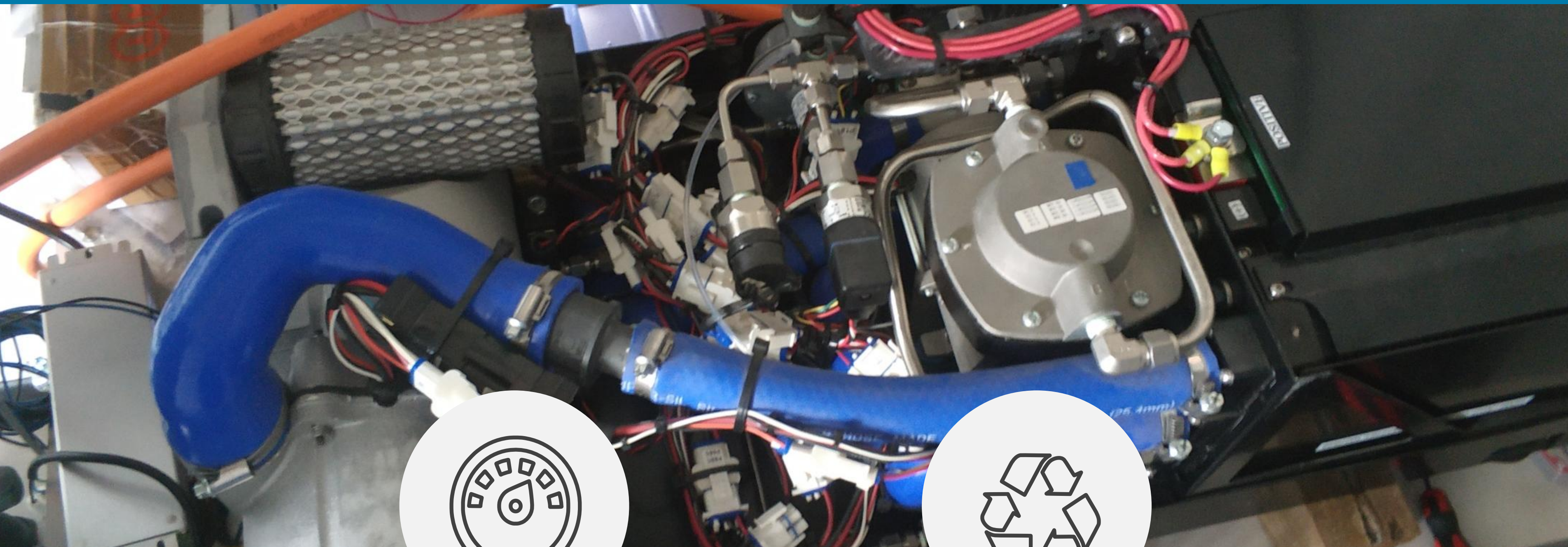




Dual role ->higher control on the life-cycle-> optimisation of the supply chain

Need for logistic optimisation

The optimal solution



Maintenance

Preventive maintenance allows manufacturer to track equipment and to expand lifespan of the FCH technology, and increase the reuse ratio

Recycling

The last step in the End-of-Life. Properly managed for current recycling centres wit traditional and new technologies

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