eGHOST

eco-design
Guidelines for Hydrogen
Systems and Technologies

eGHOST Spring School (20-24 May 2024)

ECODESIGN WORKSHOP

Agata HORWACIK (FHa)

Jade GARCIA (SYMBIO France)

Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166.
This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

ECODESIGN WORKSHOP

TABLE OF CONTENT

1. INTRODUCTION
2. GOAL OF THE WORKSHOP
3. RESULTS FOR PEMFC AND SOEC
4. GROUP ACTIVITY
5. RESULTS PRESENTATION & DISCUSSION
6. CONCLUSION

Co-funded by the European Union
Clean Hydrogen Partnership
This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

1. INTRODUCTION

SH2E/eGHOST
SPRING
SCHOOL

Co-funded by the European Union
Clean Hydrogen Partnership
This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

- Jade GARCIA – jade.garcia@symbio.one
- LCA Project Manager at Symbio for 1,5 years
- 15 years of experience in Life Cycle Assessment and Eco-design

- Part of the eGHOST and SH2E projects:
  - **eGHOST**: provide data for the PEMFC, expertise to define the eco-design actions and write the eco-design guidelines for PEMFC
  - **SH2E** : provide data for the FCEV, conduct the LCA for the BEV in OpenLCA

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

eGHOST

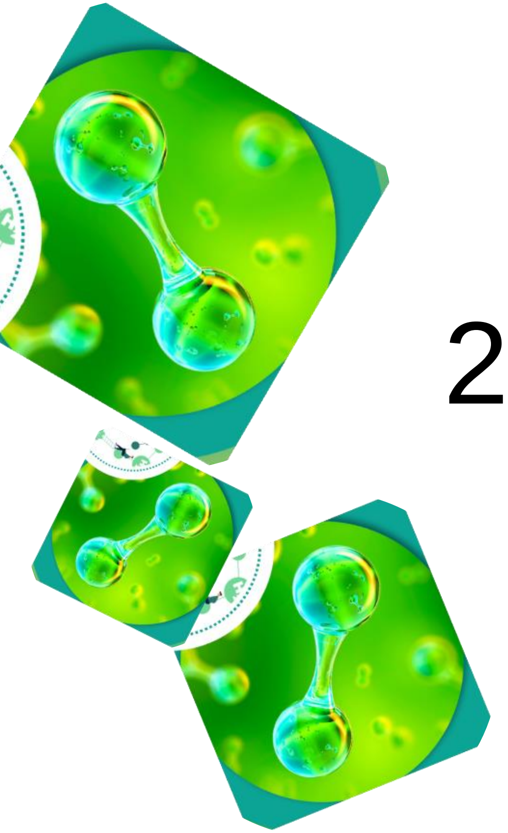
- Agata HORWACIK – ahorwacik@hidrogenoaragon.org
- Sustainability and Environment Coordinator at Consultancy and Training Dep. | Aragon Hydrogen Foundation since 2021
- Expertise in FCH technology and applications and Social Life Cycle Assessment

- FHa´s contribution to the eGHOST and SH2E projects:
  - **eGHOST**: product concept with the initial design of PEMFC/SOEC, exploitation, communication and development of the roadmap towards standardization
  - **SH2E** : LCA inventory for the FC vehicle H2 production via electrolysis and SMR, exploitation tasks and development of the roadmap towards standardization

FOUNDATION FOR THE DEVELOPMENT OF NEW HYDROGEN TECHNOLOGIES IN ARAGON

Co-funded by the European Union
Clean Hydrogen Partnership
This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

eGHOST



2. GOAL OF THE WORKSHOP

Co-funded by the European Union

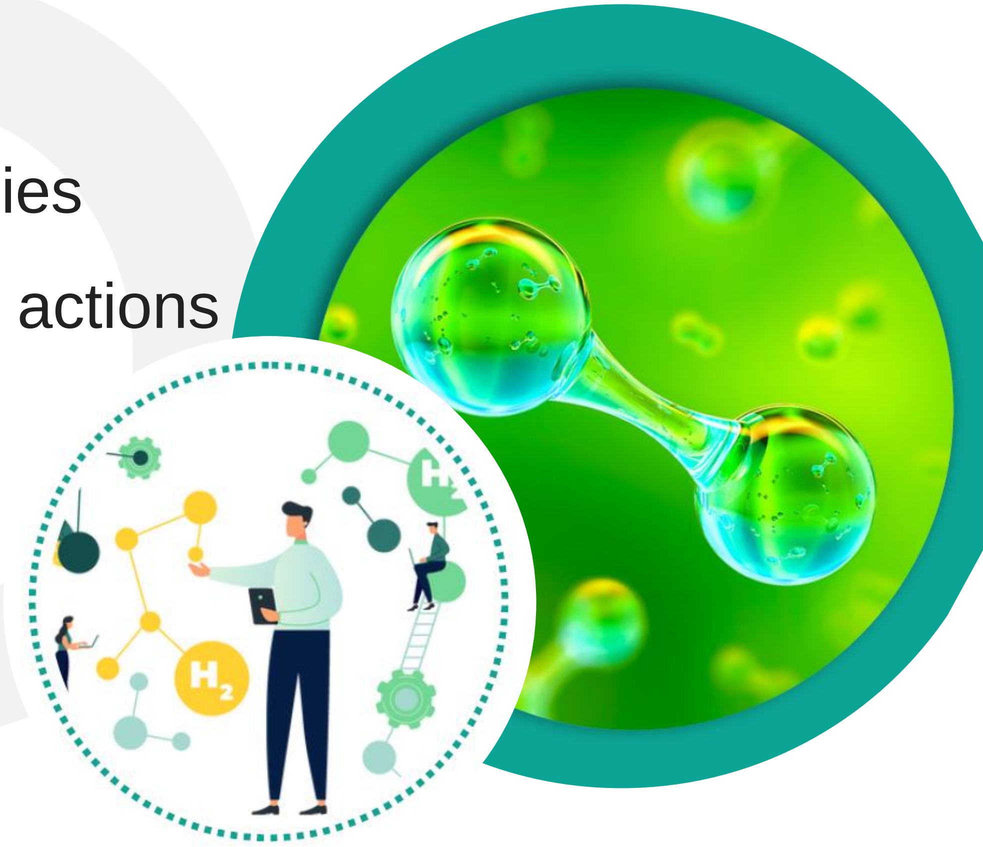
Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

Main objectives

eGHOST

- Exploit the knowledge gained during the eGHOST/SH2E Spring School
- Work on a concrete LCA and eco-design case studies
- Reflect on the challenges of integrating eco-design actions for FCH technologies



Co-funded by the European Union
Clean Hydrogen Partnership
This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

How does it work?

- Create 5 teams
- Randomly choose 1 out of 5 proposed FCH technologies
- Work together to provide LCA objective and eco-design guidelines for the assigned technology (50min)
- Present the results (5 -10 min each team)

Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

Material available

- A presentation card with short description for each technology and eco-design template
- Relevant generic data on the impact of different materials, hydrogen types,
- You can use all media you want 😎!

Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

What we are expecting

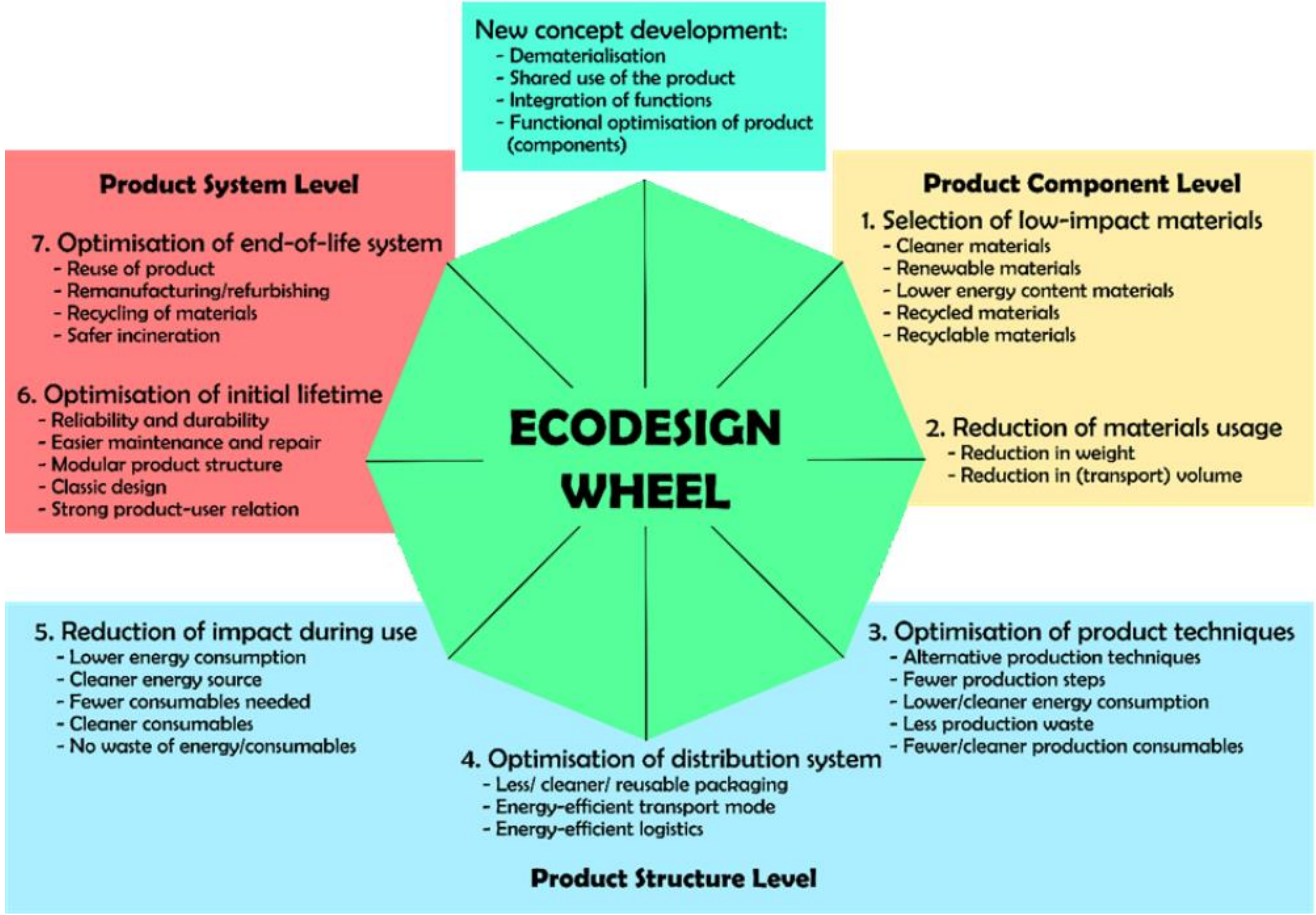
In 5-10 min, shortly present the results of your study: proposition for the eco-design concept of the technology including:

- A presentation of the reference technology, the LCA application and the data to consider
- The eco-design choices
- The potential challenges to implement these actions
- The main difficulties that you have in the exercise

Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.



Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

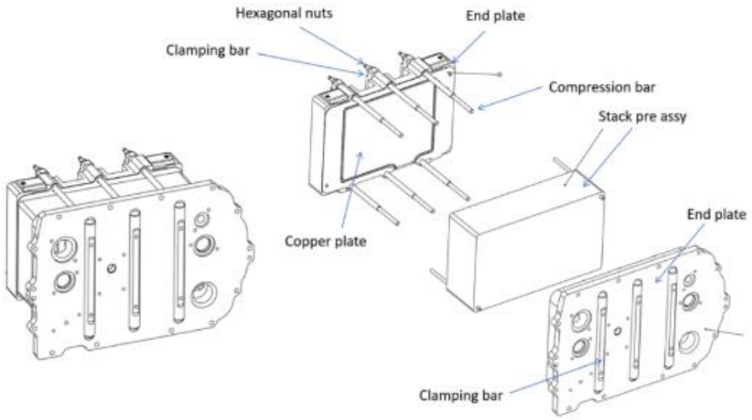
3. RESULTS FOR PEMFC AND SOEC

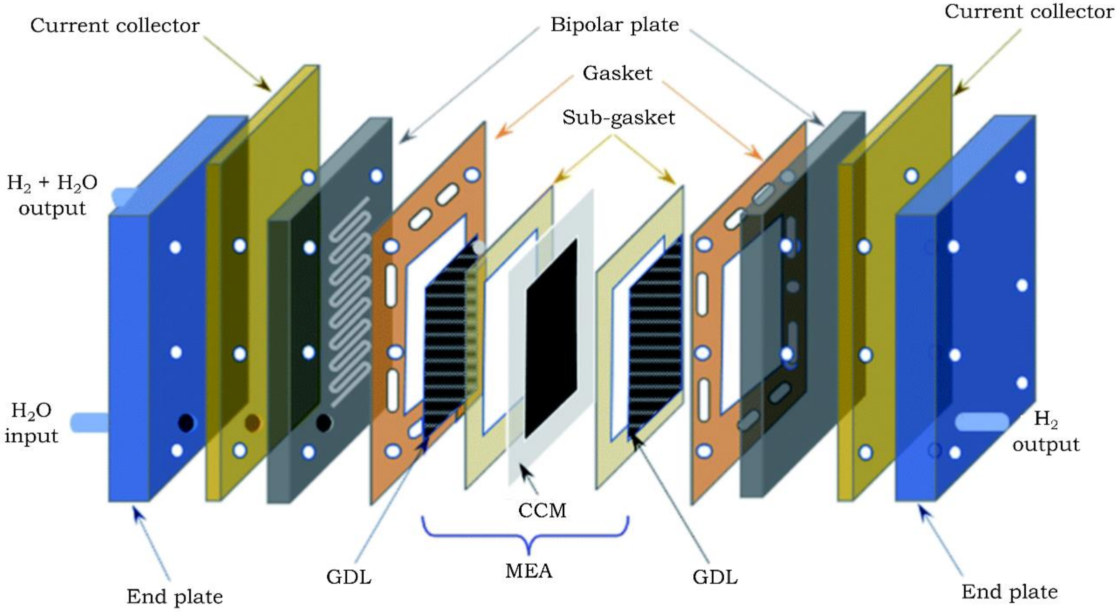
Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

The product : PEMFC



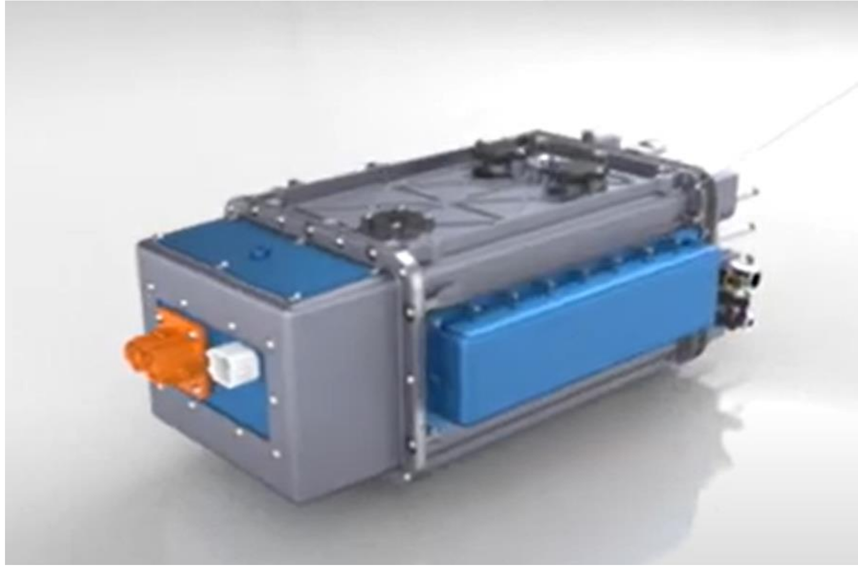


Component	Material
Pt/C	Platinum nanoparticles
	Carbon black
Ionomer	PFSA (Nafion®)
/	Water[1]
/	Alcohol[1]
Subgasket	PEN/PET film with thermo active glue
Gas diffusion layer	Carbon cloths fibres
Bipolar plates	Stainless steel
Gaskets	Silicone
Endplate	Glass reinforced thermoplastic
Current collector	Copper
Compression bar	Chromium steel
Hexagonal screws	Chromium steel
Spring	Steel
Clamping bar	Steel

Co-funded by the European Union
Clean Hydrogen Partnership
This ... Agreement No 101007166. This Joint Undertaking receives support from the
Eur...

The application : eco-design a FC used in a LCV

- Eco-design a Fuel Cell used in a light commercial vehicle
- Functional Unit : Provide 48 kW to an electric LCV for 15 years and 225 000km.

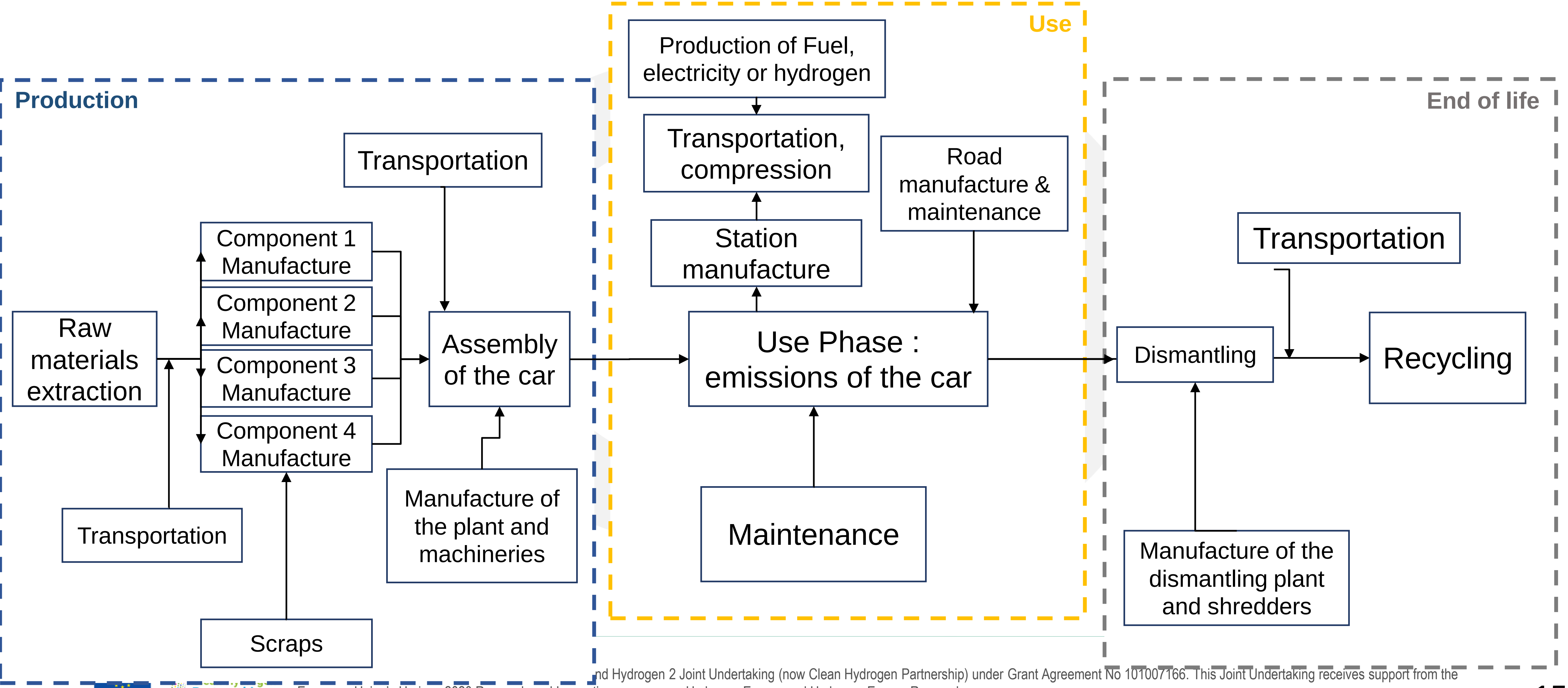


Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

The scope and the data needed



Co-funded by the European Union
Partnership
nd Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

PEMFC ecodesign : MATERIALS & MANUFACTURING

Ecodesign actions	Challenges, limits
Use recycled platinum, first from autocatalyst and jewelry recycling and in medium/long term, from Fuel Cell recycling	Work with suppliers to get more recycled platinum and to have certificates for it.
Reduce/optimize the quantity of Platinum used (loading)	Without increasing the hydrogen consumption in use.
Use recycled metals for other parts: aluminum (carter), stainless steel (BPP) and copper (collector and bus bar)	It could be difficult for security parts (carter) or for very thin components (BPP : around 80 µm)
Reduce/optimize the amount of fluorinated polymer component in the MEA	All components of the MEA are linked : platinum, carbon, membrane and ionomer
Optimize the cutting patterns of the membrane to decrease the scrap in the process	Adapt the design to the roll dimension or the roll to the design

Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

PEMFCC ecodesign : USE

Ecodesign actions	Challenges, limits
Use low carbon Hydrogen	Low carbon is not yet available in high volumes. The deployment depend on the global policies and the users of the products.
Use components with the same lifetime than the product ➔ no need to replace them	
Facilitate the accessibility of the FC in the vehicle for the maintenance.	Need exchanges with the car manufacturer and the garage responsible of the maintenance

Co-funded by the European Union
Clean Hydrogen Partnership
This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

PEMFC ecodesign : END OF LIFE

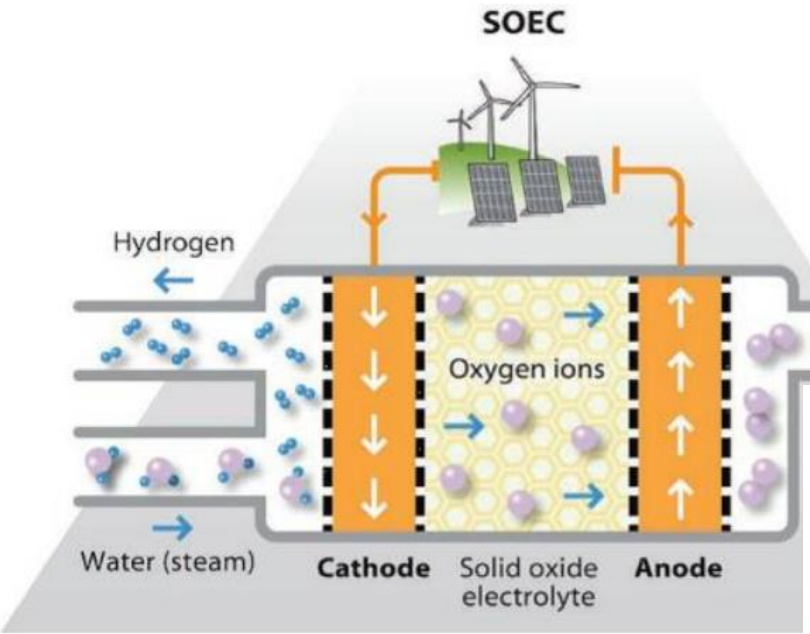
Ecodesign actions	Challenges, limits
Ensure that the FC will be collected in the End of Life ➔ organise the collection chain	Need exchanges with the car manufacturers and the recyclers centers
Facilitate the recovering of the Platinum (higher value) in designing the stack and the MEA	Find a compromise between performance and dismantling
Facilitate and optimize the dismantling processes in using screws instead of welding (non destructive dismantling)	Manage the risks during the use as vibrations or bumps.
Develop more eco-friendly recycling scenarios ➔ avoid pyrolysis that create HF acids and consumes lots of energy	Medium TRL and need to be less expensive than the value recovered to develop
Reuse some components after eventual remanufacturing	Mechanical and thermal properties have to be checked. The design of these component must remain the same in time!

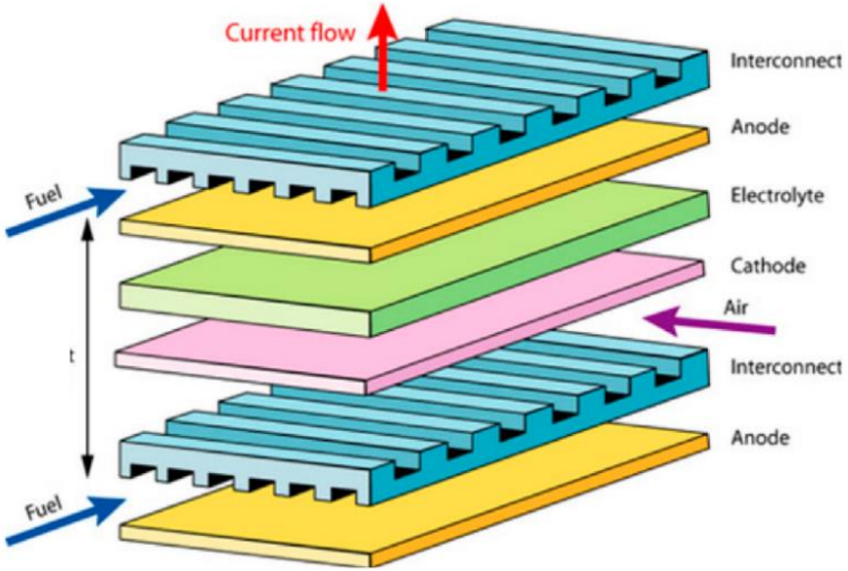
Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

The product : SOEC





Component	Material
Electrolyte	8% mol YSZ [g]
/	Binder Dow B-1000 [g]
/	Ammonium polyacrylate[1] [g]
/	Water[1] [g]
Cathode	8% mol YSZ [g]
	Nickel oxide [g]
/	Binder Dow B-1000[1] [g]
/	Ammonium polyacrylate [g]
/	Water [g]
Anode	LSCF [g]
	YSZ/LSM [g]
	YSZ/LSM [g]
Interconnects/Frames	Stainless steel [g]
	Perovskite coating [g]
Anode and cathode mesh	Stainless steel [g]
Sealant	Lanthanum oxide [g]
	Boron-silicate glass [g]
End plates/Tie rods	Stainless steel [g]

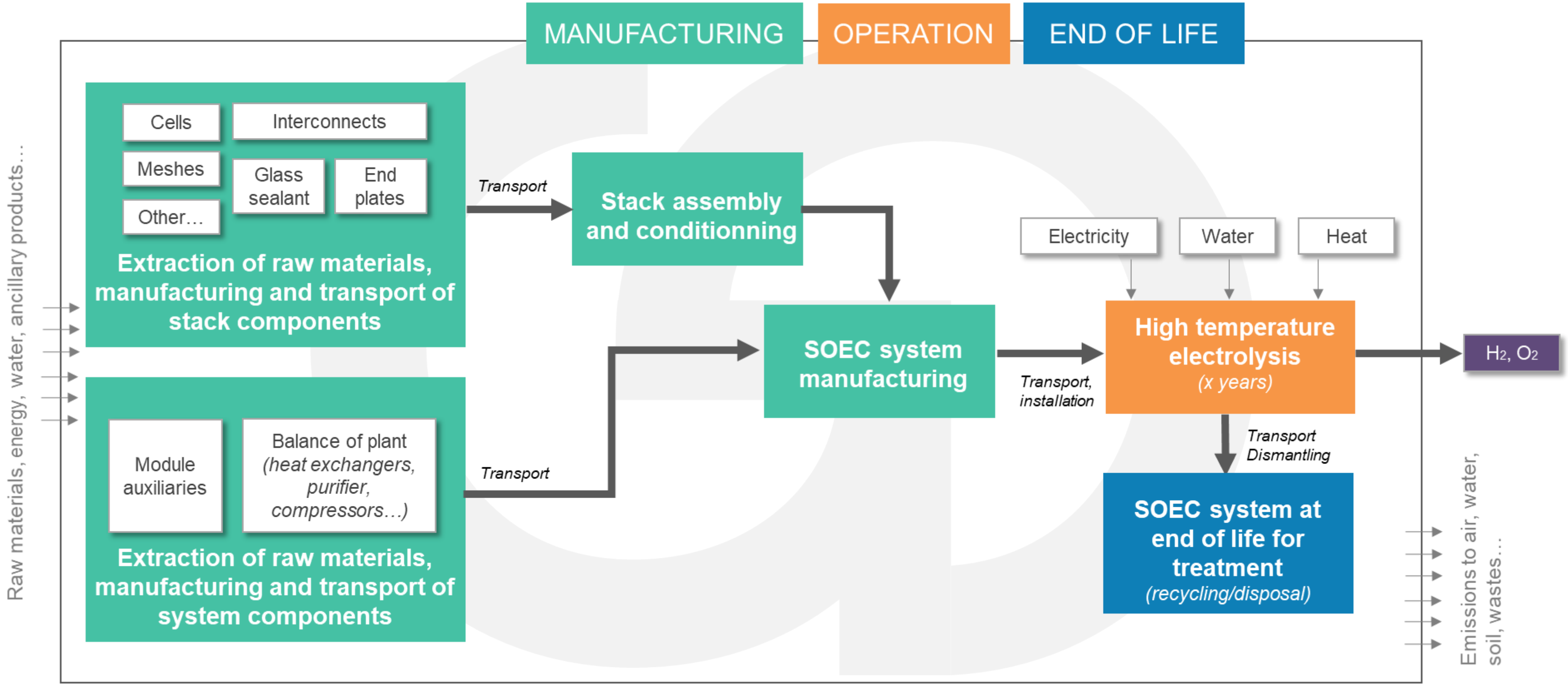
Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

eGHOST

LIFE CYCLE OF A SOLID OXIDE ELECTROLYZER



Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

SOEC eco-design : MATERIALS & MANUFACTURING

Medium term eco-design actions (feasible within 3 to 10 years)
Medium to long-term eco-design actions (feasibility > 10 years)

01 - MATERIALS		
1.1 Selection of low impact materials		
Selection of clean materials	► Choose materials with low energy content for stack manufacturing with equivalent or better performance ► Choose materials with low toxicity for human health and environment for stack manufacturing (*use environmental databases for materials selection)* with equivalent or better performance	
Selection of renewable and sustainable materials	► Use innovative doping strategy for the catalysts on cells to reduce the amount of rare earth elements (REE) in the stack ► Reduce the use of nickel in stack components to prevent environmental impacts such as acidification	
Selection of materials with low energy content	► Integrate innovation in the choice of electrolyte materials to reduce the amount of rare earth elements materials	
Integration of recycled materials	► Use recycled steel for components in the stacks, modules, systems	
Integration of recyclable materials	► Make architecture of the stack easy to disassembled for recyclability without compromising the sealing of the stack (especially : improve the reusability of end plates which represent an important part of the weight and metal content of the stack)	

Co-funded by the European Union
Clean Hydrogen Partnership
This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

SOEC eco-design : MATERIALS & MANUFACTURING

02 - MANUFACTURING		
2.1 Optimization of manufacturing techniques		
Reduce the number of production steps	► Optimize number of manufacturing steps to reduce production costs (e.g. "co-sintering" of cell layers as this process step is the most energy consuming)	
Reduce the energy consumption in production	► Use less energy on production lines (especially on cell sintering step which is energy consuming) to reduce environmental impacts and costs. Optimize time and temperature. ► Use cleaner or renewable energy on production lines (especially on cell sintering step which is energy consuming) ► Revalorize thermal losses in production steps to reduce environmental impacts and costs ► Revalorize H2 produced during the final conditioning test to produce electricity or heat	
Limit and reduce production wastes	► Integrate internal recycling loops for production wastes as much as possible (for steel in priority, then for rare earth elements and critical materials) to reduce environmental impacts and costs ► Optimize production techniques to reduce material losses (e.g. important use of materials conditioned in coil and involving important quantity of offcuts: work with supplier to provide the good width to reduce losses – work on a recycling process to reinject these offcuts in production.)	
Reduce consumables in production and use clean consumables	► Reduce/optimize the amount of chemicals and solvents used in all production steps ► Select water based solvent instead of organic solvents in production steps (colloidal processing based on water instead of organic solvents)	

Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

SOEC eco-design : OPERATION

04 - OPERATION		
4.1 Reduction of impact during use		
Reduce energy consumption in use	▶ Optimize the Balance of Plant (BoP) to reduce the overall energy consumption (e.g. To heat up only active materials and not structural elements such as the end plates) ▶ Reduce operating temperature of the system, to reduce energy consumption ▶ Optimize cell performance ▶ Use H2 management system (HMS) to optimize the system in term of performance and durability according to the demand. ▶ Find good compromise between performance and durability (part of the HMS function)	
Use clean energy and consumable sources for operation	▶ Supply the system with renewable electricity to lower environmental impacts in use ▶ Produce low impact steam to run the system (use steam from steam networks)	
Use less consumables and materials for operation	▶ Use water recirculation to reduce overall water consumption (in particular the condensate of H2 purification step.)	
4.2 Optimization of product lifetime		
Improve the reliability and durability of the system	▶ Develop harmonized protocols/recommendations to start/operate the system ▶ Reduce operating temperature of the system, to limit stack degradation, while maintaining good contacts within the stack. The optimization of temperatures with the hot box inside the different zones of the stacks could limit stack degradation. ▶ Reduce cell degradation	
Ensure easy maintenance and repair	▶ Make cells replacement feasible in the stack	
Provide a modular structure for the system	▶ Improve stack modularity to optimize part load operation and limit degradation	
Standardize reparation and maintenance procedures	▶ Develop harmonized standards to measure stack degradation	

Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

SOEC eco-design : END OF LIFE

05 - END OF LIFE		
Integrate possibility of reuse of components, products	► Develop processes and protocols to facilitate the reuse/remanufacturing of steel components (end plates, interconnects, module and BoP components) – in particular offcuts	
Possibility for remanufacturing / refurbishing of the components	► Develop automated and industrialized processes for efficient stack dismantling (mechanical disassembly techniques) ► Today components of the stacks are glued using glass seal that makes mechanical dismantling very difficult. Find new technic of sealing without compromising gasproofness (e.g. inclusion of the stack in a box) ► Design for modularity and disassembly at end of life	
Possibility of recycling	► Develop recycling streams and processes for SOEC materials (find ways to disassemble the stack, and recycling processes for valuable materials in the stack). Envisage hydrometallurgy processes for critical raw materials recovery. ► Reuse of terminal plates developed in "material part" ► Use existing recycling streams for steel recovery ► Improve the recyclability of steels ► Improve the total recycling rate of SOEC systems	
Safe incineration if no possibility for recycling	► *Ensure safe incineration of the components if recycling is not possible*	

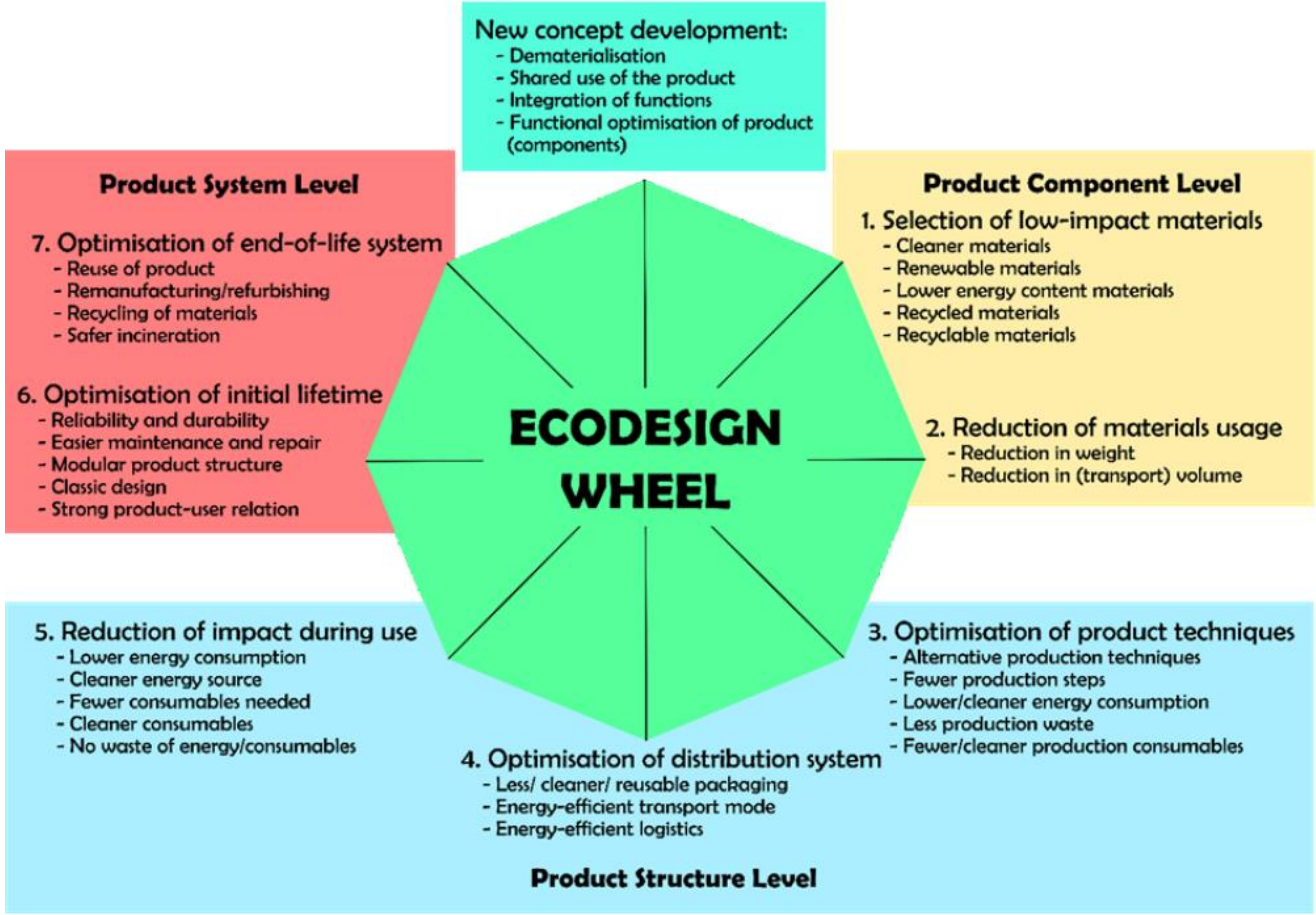
Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

4. GROUP ACTIVITY

Co-funded by the European Union
Clean Hydrogen Partnership
This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.



Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

eGHOST

eco-design Guidelines for Hydrogen Systems and Technologies

Thank you for your attention!

jade.garcia@symbio.one

ahorwacik@hidrogenoaragon.org

Co-funded by the European Union

Clean Hydrogen Partnership

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 101007166.
This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.