HyTechCycling

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

Grant No. 700190

WP7 Dissemination & Exploitation

D7.6 Final report on dissemination activities and materials

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(PU: Public, CO: Confidential, only for members of the consortium (including the Commission Services))

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Executive Summary

The final report on Dissemination and Awareness Plan (DAP) aims to describe and analyse all the communication activities that have been carried out in the life of the HyTechCycling project. The Project Grant Agreement (GA), through the Description of Action (DoA), contained the draft of the Dissemination and Awareness Plan as part of the measures to maximize the impact of the Project. The final report of the DAP describes the dissemination goals, target audience and appropriate channels that have been done to improve the flow of information.

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Abbreviations

AWE	Alkaline Water Electrolyser
CA	Consortium Agreement
CRM	Critical Raw Material
DAP	Dissemination and Awareness Plan
DOE	Department Of Energy
DoA	Description of Actions
EC	European Commission
EoL	End of Life
EU	European Union
FC	Fuel Cell
FCEV	Fuel Cell Electric Vehicle
FCH	Fuel Cell and Hydrogen
FCH 2 JU	Fuel Cells and Hydrogen 2 Joint Undertaking
FHA	Fundación para el desarrollo de las nuevas tecnologías del Hidrógeno en Aragón
GA	Grant Agreement
HYTECHCYCLING	New technologies and strategies for fuel cell and HYdrogen TECHnologies in the phase of reCYCLING and dismantling
ILSSA	Industrias López Soriano S.A.
JTI	Joint Technology Initiative
JU	Joint Undertaking
IMDEA Energía	Instituto Madrileño de Estudios Avanzados en Energía
LCA	Life Cycle Assessment
PC	Project Coordinator
PEMFC	Proton Exchange Membrane Fuel Cell
PEMWE	Proton Exchange Membrane Water Electrolyser
PGM	Platinum Group Metal
REE	Rare Earth Element
SETIS	Strategic Energy Technologies Information System
SEO	Search Engine Optimization
SOFC	Solid Oxide Fuel Cell
USA	United States of America
WEEE	Waste Electronic and Electrical Equipment
WHEC	World Hydrogen Energy Conference

1. Objectives

The objective of Deliverable 7.6 is to collect the information on the communicative activities carried out during the life of the project to maximize the impact of the dissemination. The document aims to analyse the general communication tools and methods that have been accomplished by the partners of the Project to ensure a proper dissemination of the results towards the main stakeholders addressed in the project and all the interest actors involved (public and private).

The dissemination and awareness plan is an important set of tools that has been complementary to other Project developments, having the common goal of maximising the impact. It is important to remark that the final goal of HYTECHCYLING project is to serve as a basis for future implementation of the concepts arising from it, so it must be ensured all the dedicated guidelines and recommendations reach the key stakeholders and Fuel Cell and Hydrogen (FCH) actors.

Moreover, given that the intention is that the results of the Project are also market oriented, an exploitation strategy and business plan has been developed throughout the project. Therefore, the plan definition and the updates have been also dedicated to maximize the impact to the interested stakeholders according to the studies on assessment of market potential and the strategic plans for commercial exploitation of the results.

Then, it can be considered that the main objective of the plan hereby documented has been to describe the schedule, audience, methods and tools to maximize the impact of the Project and its results.

2. Introduction

HYTECHCYLING project (New technologies and strategies for fuel cell and HYdrogen TECHnologies in the phase of reCYCLING and dismantling) is part of the European Horizon 2020 program, The EU Framework Programme for Research and Innovation. Horizon 2020 is the biggest EU Research and Innovation programme ever done, with nearly €80 billion of funding available during 7 years (2014 to 2020).

Figure 1. Horizon 2020 logo.

By coupling research and innovation, Horizon 2020 emphasizes on excellent science, industrial leadership and tackling societal challenges. The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation.

H2020 covers a large number of areas in which energy is included as a priority. The European Union has established the objective of the major "decarbonisation" of its energy system by 2050. To reach this goal, fuel cells and hydrogen technologies are aimed to play a key role due to its properties of energy carriers. It will be possible to generate large quantities of “green” hydrogen from the excess energy from renewable sources for subsequent use in transport (fuel cells to power vehicles), in energy applications (re-electrification, powering stationary fuel cells in cogeneration systems, back-up systems, and the injection of hydrogen into gas systems) and industrial applications (generation of hydrogen mainly for the chemical industry).

In order to accelerate the development of these technologies in the most efficient way, the European Union has joined forces with European industry and research institutes in a public-private partnership, the Fuel Cells and Hydrogen Joint Technology Initiative (JTI), who supports numerous projects such as HYTECHCYCLING. This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU) under agreement No 700190.

Figure 2. FCH JU logo

The topic of the FCH 2 JU in which HYTECHCYLING project is framed is **FCH-04.1-2015 Recycling and Dismantling Strategies for FCH Technologies**. The expected commercial FCH technologies are not prepared for full deployment in what regards to recycling and dismantling stage. Specifically, these devices still involve significant amounts of critical, expensive and scarce materials (e.g. platinum group metals or rare earth elements) and novel dedicated recycling processes for these FCH technologies could be applied. On the other hand, it is critical the involvement of FCH manufacturers to deliver designs looking for compatibility with new recycling processes and allowing full recovery of critical materials (this is, redesign for material compatibility at recycling and dismantling). Furthermore, there is a lack of End of Life (EoL) strategies devoted to reuse and remanufacture FCH technologies to save these materials and take advantage of still valuable components and subsystems. In this field, it is especially important to involve not only manufacturers but also end users to ensure collaboration and provision of FCH products for reverse logistics processes.

The main goal of HYTECHCYCLING is to deliver reference documentation and studies about existing and new recycling and dismantling technologies and strategies applied to fuel cells and hydrogen technologies, paving the way for future demonstration actions and advances in roadmaps and regulations.

In order to achieve the main goal, the Project must meet the following objectives:

- Identification of critical materials and components in hydrogen technology products.
- Mapping of existing and new recycling technologies applicable to these materials and components, taking into account the experiences of the different Member States in selecting the most appropriate strategies.
- Analysis of the challenges to be addressed, bearing in mind the limitation of the current situation in terms of recycling and dismantling hydrogen technology products.
- Development of new strategies and a roadmap for the implementation of recycling and dismantling of the critical materials and components of hydrogen technology products.
- Quantification of the impact of introducing these new strategies and technologies, through lifecycle analysis of a wide range of hydrogen technology products with applications in the fields of energy and transport.

- Evaluation of the needs of the different existing actors in terms of implementing these new strategies and technologies. Re-adaptation of existing recycling centres and the organisation of demonstration events and exhibitions at a recycling centre.
- Ordering, aligning and standardising the new strategies and technologies by means of guidelines and recommendations for their introduction for all actors involved in the service life of hydrogen technology products.
- Creation of a business model to facilitate widespread implementation.

The technologies addressed in the project are Alkaline Water Electrolyser (AWE), Proton Exchange Membrane Water Electrolyser (PEMWE), Solid Oxide Fuel Cell (SOFC) and Proton Exchange Membrane Fuel Cell (PEMFC).

3. Dissemination and Awareness Plan Descriptions

The DAP, included in Work Package 7 (WP7), is one of the first documents of the Project, aimed to ensure its impact, at every level and with different focus of interest of the Project results. Once the plan for communication, awareness and dissemination is developed, it will be periodically updated according to the Plan and the DoA of the Project. The document as first DAP aims to answer the questions of "WHO?", "WHAT?", "HOW?" and "WHEN?" It therefore includes a description of the Project communication methodology (a mythological answer to "HOW?"), target groups (answers to "WHO?" and "WHAT?"), a set of communication tools (a technical answer to "HOW?") and a list of possible activities (answer to "WHEN?").

3.1 Communication management methodology

The dissemination and communication of HYTECHCYCLING to stakeholders and audiences outside the project is managed by the partners within the WP7 of the Project. Besides, all the external communication activities are monitored by the Project Coordinator (FHA), to ensure that the communication activities and methodology are in compliance with the provisions of the agreements. As a general rule, the GA will apply, but some specific provisions are agreed in the Consortium Agreement (CA).

About the dissemination of own results, the partners are committed to inform the consortium about planned publications with enough time to ensure that the results to be published are not in conflict with potential commercial exploitation activities, confidentiality and legitimate interests of the partners. In any case, the objection to any communication activity related to publication, has to be clearly justified and followed by necessary modifications to allow and not block, if possible, the publication and dissemination of results.

Besides, the Consortium is committed to cooperate in the submission, preliminary evaluation and publication of any dissertation or Master thesis related to the Project, subject to the provisions of the CA.

The tasks related to communication and dissemination in the Project involve all the members of the Consortium, so all the partners should work and contribute to dissemination tasks according to the agreements and the DoA. Nevertheless, FHA, as plan, promoting the collaboration of all the partners and finally monitoring and compiling the dissemination Project Coordinator, is the final element in charge of the dissemination, being invested in elaborating and contributing the dissemination and communication activities of the Project.

3.2 Target groups

The following section includes the total amount of the target audiences that are expected to be influenced by the development of the Project and its results. All the stakeholders and FCH actors must be identified and classified, establishing a characterization of their needs and concerns in the design of the most suitable strategy for each of them. In addition, a communication strategy must be developed for the wider public. For each of them it has been specified a series of key messages that will have to be successfully addressed during the development of the Project, always based on the rules of the GA and the CA. At the end of this section, shows, in a very schematic way, the existing relations among target groups in HYTECHCYCLING project.

To **FCH technology providers and manufacturers,** as first group of all actors involved in the life cycle of the FCH products, the message is oriented to explain all the information and results that are susceptible to be public recycling and dismantling technologies and strategies will be shared. However, among these technologies and strategies developed, those including the reduction and replacement of critical materials from the phase of design, reverse logistics and redesign for material compatibility and materials and components separation; they will have a special interest for the FCH providers and manufacturers.

- ATAWEY
- BALLARD
- BOEING
- Calvera
- CeresPower
- Dolomitech srl
- DOOSAN BABCOCK LIMITED
- Elcogen AS
- Electro Power System
- FCES
- Giacomini
- H2B2
- Haldor Topsoe
- Hexagon
- HYDROGENICS
- HyGear
- Icelandic New Energy

- IHT
- IK4 TEKNIKER
- InHouse Engineering
- INTELLIGENT ENERGY
- ITM Power
- LIFTEC
- McPhy
- Nedstack
- NISSAN
- NuCellSys
- Nuvera Fuel cell
- Powercell Sweden AB
- Proton Motor Fuel Cell
- SERENERGY
- Siemens
- SINTEF Materials and Chemistry
- SolidPower
- SWISS HYDROGEN
- Syfen
- SYMBIO
- Toyota
- Toyota Europe
- Toyota Motor Europe
- Toyota Motor Italy
- VTT Technical Research Centre of Finland

To **authorized FCH distributors and logistic companies,** in a very similar way to the manufacturers, all the information and results susceptible to be public will be shared. However, the scope of action of FCH logistic companies will be more limited, not so sensitive to the new technologies but to the new strategies and the proper way to implement them. It will be important also to allude to the key role of logistic sector to achieve reusing and remanufacturing FCH technologies and to engage them in the process.

Recycling centers. All the public information and results regarding recycling and dismantling technologies and strategies for each component and subsystem of the technologies addressed, they will be shared. This will be shown by means of a range of dissemination events and showcases at ILSSA recycling

centre. Additionally, results about business models for recycling centers and guidelines for re-adaptation will be shared. The key messages to be transmitted involve the benefits that the FCH technology recycling and dismantling can introduce to new business models related to the recycling sector.

- Hensel recycling
- Stena Recycling
- Umicore
- Sorecfer
- Reciclaje Aragones de Aparatos Eléctricos y Electronicos S.L.
- Industrias López Soriano S.A.
- FER-Federación Española de Recuperación y Reciclaje
- ASEGRE-Asociación de empresas Gestoras de Residuos y Recursos Especiales
- AEDRA-Asociación Española de Desguazadores y Reciclajes del Automóvil
- El Gremi de Recuperació De Catalunya
- Bureau of International Recycling (BIR)
- Vachez industria
- Recylex
- SNAM
- SIMS Recycling Solutions
- Envirobat
- GRT GROUP
- RECOBAT
- MEFRAGSA

The main goal for the **end users of FCH products** target group has been to engage them to participate in reverse logistics strategies fostering reuse, remanufacturing and recycling of FCH technologies and close collaboration with distributors and manufacturers

- Dolomiti Energia
- DONG Energy Power
- Baxi Innotech
- Bosch Thermotechnik
- Dantherm Power
- Elcore
- Hexis AG

- RBZ
- Vaillant
- Viessman
- Cogen Europe
- GDF SUEZ
- ENGIE
- Cofely
- GNVert
- Engie

The evaluation of potential markets linked to massive deployment of FCH technologies involving sector as recycling and dismantling in the near term, along with the analysis of the European standards and national regulations will be the main input for **policy makers, regulator and public bodies** target group. All the info and results generated must aim to create awareness in needed regulation to promote FCH technologies and include specific codes or guidelines on recycling issues.

The communication efforts towards the **general public** will be focused in showing the benefits of participating in the strategies fostering reuse, remanufacturing and recycling of FCH technologies, in a very similar way to FCH products end users. The additional goal at this point is to reduce the existing resistance to these new technologies and motivating early adopters. Results from additional tasks of the Project, related to the assessment of the market potential and identification and analysis of business cases will serve as additional input to detect new target groups or stakeholders or to focus better the dissemination efforts to reach the target groups. Furthermore, the information obtained through the continuous monitoring of the external projects will also serve as feedback to define specific stakeholders from the different groups.

Post graduate/graduate students and FCH workforce will be addressed as a potential group sensitive to be moved to one of the main FCH technology direct actors (manufacturers, distributors, end users or/and recyclers). Apart of the general presentations and publications, specific training sessions in ILSSA facilities will be offered for them.

Moreover, the participation in the communication events and activities promoted by the FCH 2 JU will be of key importance to reach these stakeholders.

3.3 Communication tools

The following section describes the necessary tools to develop an efficient communication from HYTECHCYCLING Consortium to reach the expected impact towards the target groups established above. These tools involve all the graphic material that will be used for the several congress and fairs that are planned to be attended (as well as for the workshop to be celebrated) and also the digital material, understood as the website and the communications performed through social networks.

3.3.1 Project website

The Project website (www.hytechcycling.eu) aims to become the central part for the diffusion of all the information related to the Project. The website has been designed to provide a general impression of the HYTECHCYCLING's mission through the main page (Figure 3), by showing into three different paragraphs a brief description of its main topic, the partners involved in the Project and funding by the European commission.

Figure 3. HyTechCycling website homepage

For a more detailed view at the characteristics of the project, a number of sections have been implemented to provide the information in an organized way. The "Project" section continues with the development of the Project description briefly introduced at the main page, now introducing all the necessary specifications for a complete understanding of its background, objectives, procedures and other important facts.

The "Partners" section provides a complete description and background of all the companies, research centers and universities involved, including also links to their websites.

The website is completed with the sections “News” and “Downloads”. The first of these sections includes all the press notes and main events related to the Project information, as well as important announcements. The ‘Download’ section, in the other hand, will serve as the main hosting page for all the public content generated by the Project. In this section we have uploaded **fifteen public deliverables** (*D 1.2 – Quality Management Plan, D 1.4 – Minutes of the First Project Meeting, D 2.1 – Assessment of critical materials and components in FCH technologies, D 2.2 – Existing end-of-life technologies applicable to FCH products, D 2.3 – Regulatory framework analysis and barriers identification, D 2.4 – Recommendation and perspective on EU regulatory framework, D 3.1 – New end of life technologies applicable to FCH products, D 3.2 – New end of life strategies for FCH products, D 2.5 – Study on needs and challenges in the phase of recycling and dismantling, D 4.1 – LCA approach in end of life cycle of FCH technologies, D 4.2 – LCA of materials represented in FCH technologies, D 5.1 – Report on requirements from FCH actors, D 7.1 – HYTECHCYCLING Website, D 7.2 – Dissemination and Awareness Plan, D 7.3 – Update 1 Dissemination and awareness plan),* **eight project presentations** (*HyTechCycling poster – III Symposium of the Spanish Network of Life Cycle Assessment (Nov 2016), HyTechCycling project presentation at FHA Board meeting (Dec 2016) (ES), HytechCycling project presentation at SEEP2017 (June 2017), HyTechCycling project presentation at Iberconappice 2017 (ES), HytechCycling project presentatino at Programme Review Days 2017 (Nov 2017), HytechCycling EHEC 2018, HyTechCycling Project Presentation at 1st Hydrogen Innovation Festival MedioTejo21 (June 2018), HyTechCycling Project Presentation at WHEC2018 (June 2018)*), **seven presentation from the project Workshops** (*01_General Presentation of the project, 02_The hytechcycling project till now, 03_Results from “New recycling technologies applied to FCH products” , 04_Results from “New strategies for FCH technologies in the phase of recycling and dismantling” , 05_LCA approach and LCA of materials represented in FCH technologies, 06_Results analysis of QS to manufacturers, recycling centers, 07_Approach to a New Business Model)* the **Corporate Identity Manual for the project** and the **Press Kit and five documents (***EC – Report on critical raw materials for the EU (2014), EC – Towards a circular economy : A zero waste programme for Europe (2014), Guidance Document fo performing LCA on Fuel Cells, Guidance Document for performing LCA on Hydrogen Production Systems, Study on the review of the list of Critical Raw Materials)*

Finally, a 'Contact' section has also been implemented to make it as easy as possible the exchange of information between the user and the Project partners. This section includes a contact form that once fulfilled automatically sends an email to the Project coordinator (FHA), as well as main contact information of the coordinator, like address, telephone number and main webpage.

HyTechCycling's website was launched at the end of October 2016, so it has been online during 2 years and 6 months when this deliverable was prepared. The information regarding traffic, access and user behaviour during the visits to the site has been analysed and it is presented in this section.

The visits to the web of the project have grown exponentially having 2100 users to the web with 2.900 sessions. Both figures have increased compared to the previous year by more than 109.80%

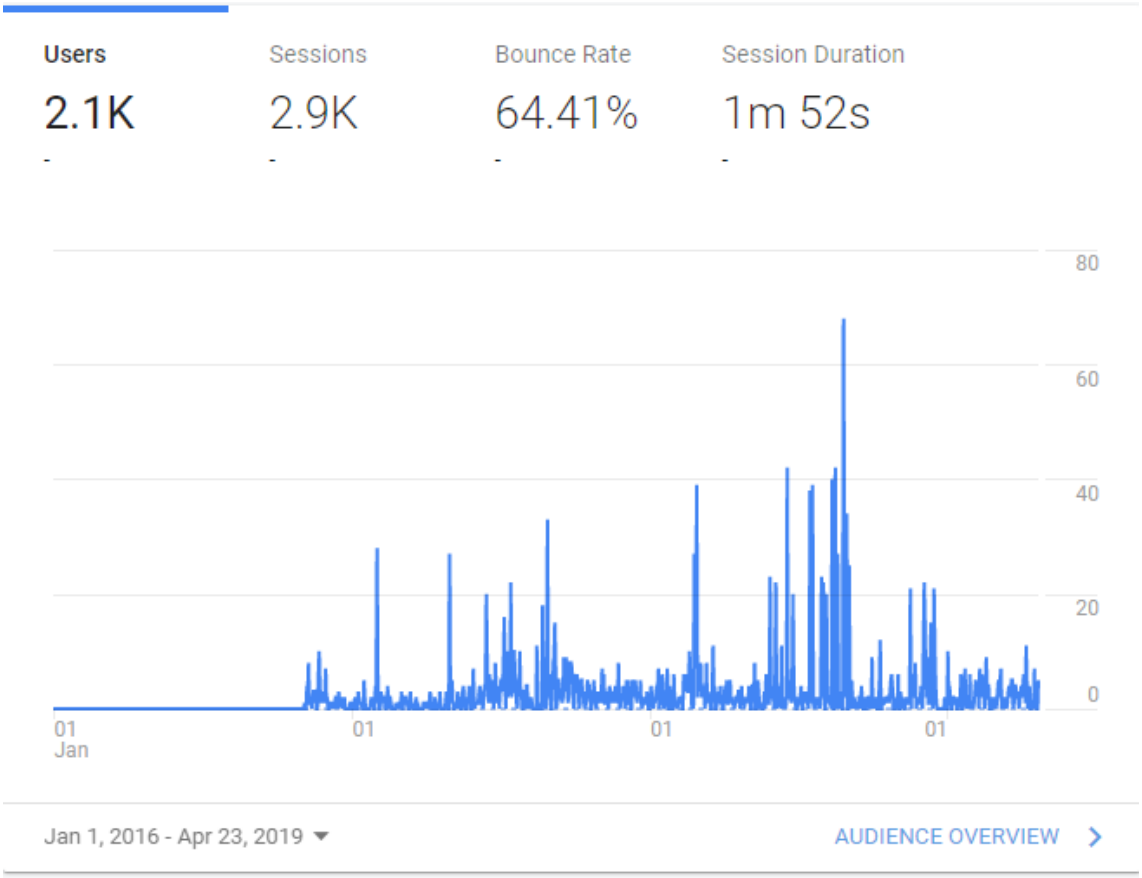

Figure 4. HyTechCycling Website Users and Sessions Overview

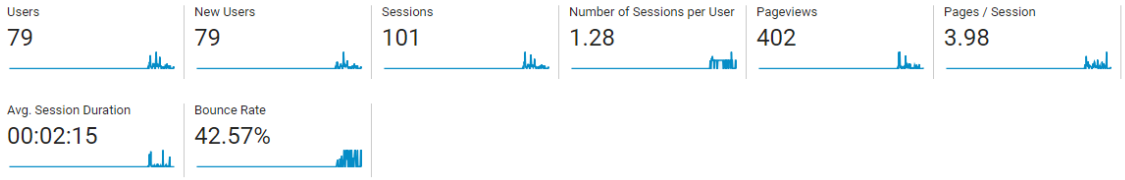

Figure 5. Users 2016

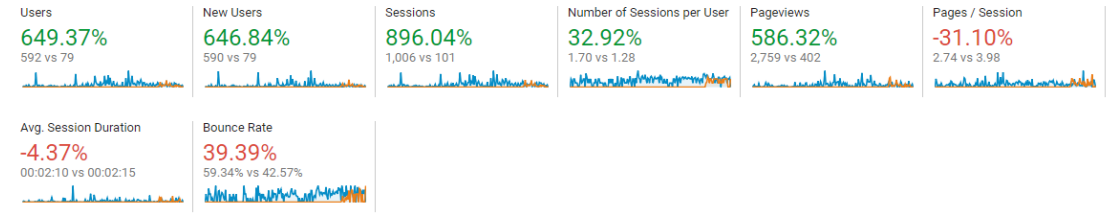

Figure 6. Users 2017

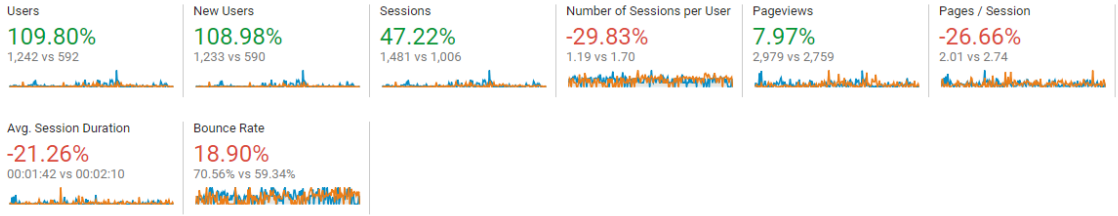

Figure 7. Users 2018

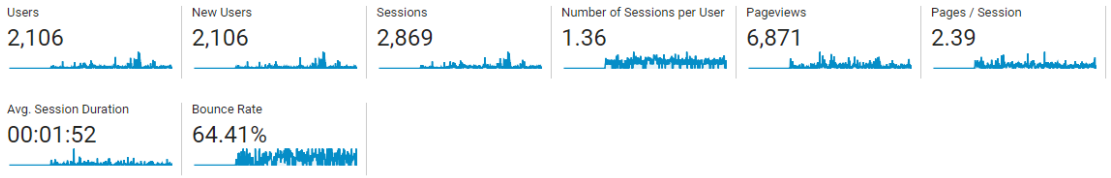

Figure 8. Users 2019

As you can see the number of users and sessions has been increased. It is noteworthy the increase in users in 2017 but we must bear in mind that the comparison with 2016 is only from October to December.

On the one hand, most of the users start the visit to the website in the "home" section, which is logical taking into account that most of the links in news and presentation send the user to the homepage (see Figure 9). It also appoints to the use of Search Engine Optimization systems (SEO) for the project webpage. Unfortunately, there are still a percentage of users or at least, more than desired, that does not

continue navigating the site (36.8%). Although it should be noted that these numbers are considerably lower than those of the previous period where of 230 sessions there were 124 dropouts on the first page.

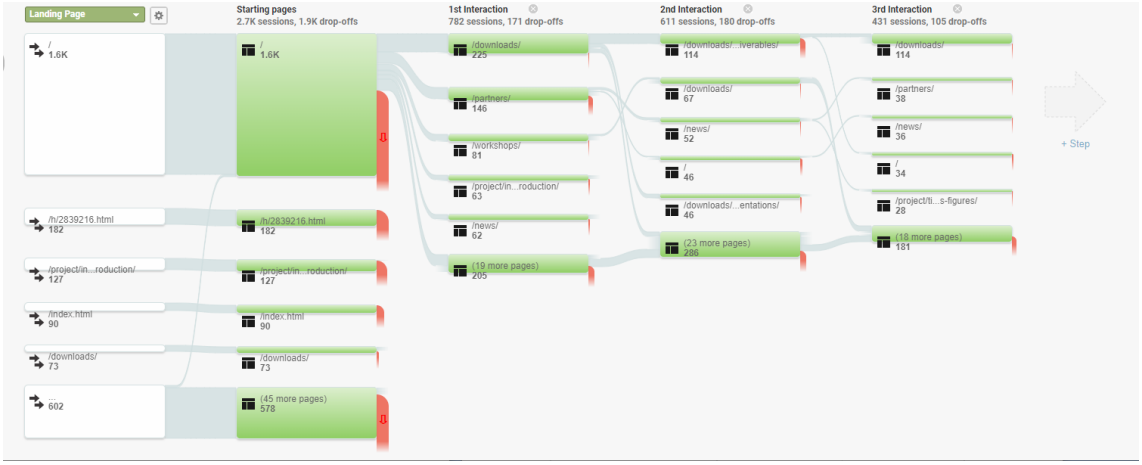

Figure 9. HyTechCycling's website user behaviour flow October 2016 to April 2019

The usual traffic once the visit is continued goes to the download section which it's really interesting as the last update of the DAP the users used to go to the "project introduction" section. This means that people are really interested in the public deliverables that have been uploading to this section. Another important amount of users selects instead of "downloads" the "partners" so it appoints that the users are interested in consulting who is working in this project. On the other hand, the section "project" is also one of the preferred among the visitors of the webpage, so it appoints that the users are interested in consulting the project's results and documents. So, it is logical that most of the visits and users seem to be interested on the project and partners contributing to the development.

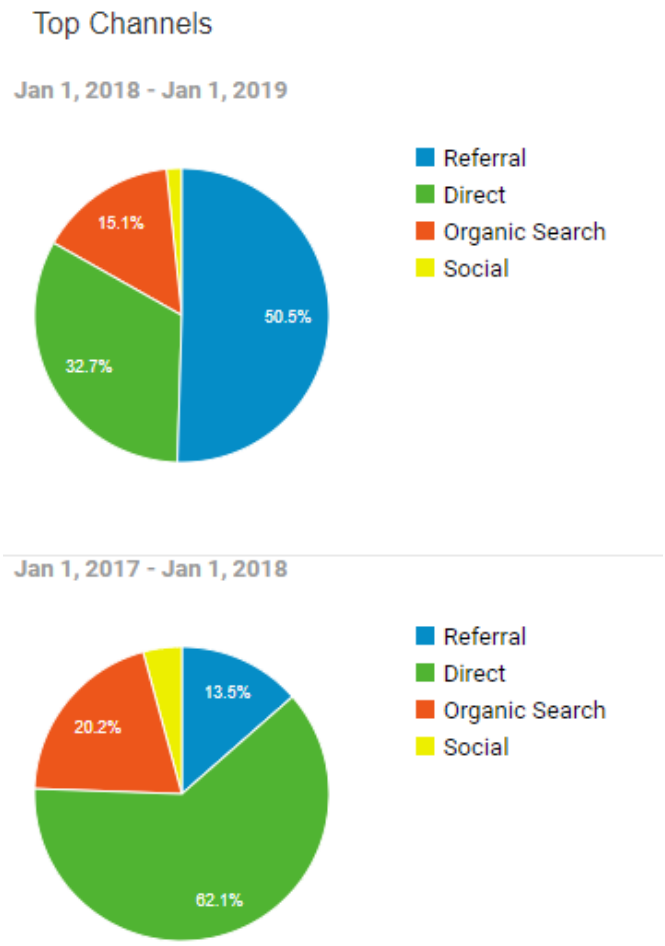

Figure 10 Top Channels Compilations per year

Organic Search takes you to the Keywords report its been improved in comparison to the previous year, this would be users that have looked for the project in searchers as Google; Direct takes you to the top landing pages for direct visitors; Referral takes you to your top referring websites and Social takes you to your top-referring social networks.

Regarding the geographical data, most of the traffic to the website comes from France and Spain, which is mostly related to the extensive dissemination activity from the coordinator in Spanish media. On the other hand, it is related that most of the partners (3 of 5) are Spanish. The rest of the top ten countries where the HyTechClycling website gets most of its traffic are the United States, Brazil (the project was presented in the WHEC2018 in Rio de Janeiro), Italy, Slovenia, Germany, Canada, Ukraine and United Kingdom

Nevertheless, the visits from the website come from all around the world, so it clearly indicates the importance of maintaining active the website in order to maximise the impact of the project.

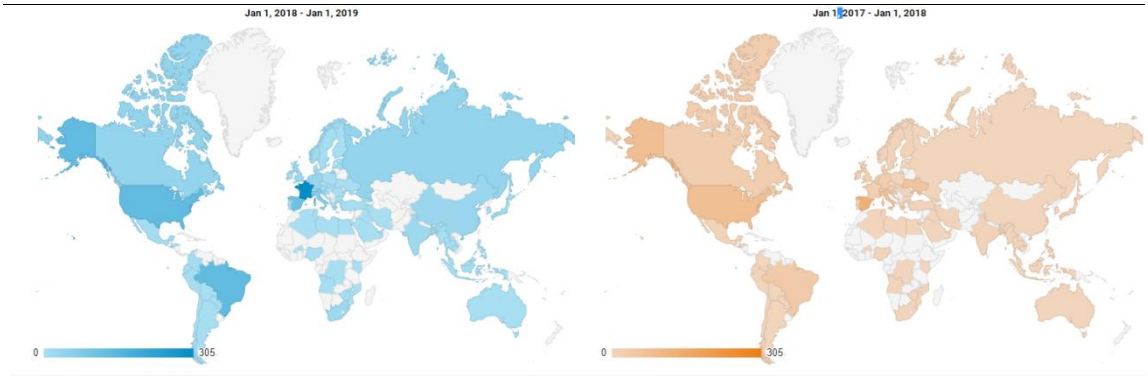

Figure 11. HyTechCycling's website geographical data compilation

3.3.2 Graphic material

Different graphic materials were developed for the project and have been used during the first year, including the logotype, selection of fonts, templates for documents and slides and a poster for public presentations. The graphic material as it has been said before is available in the HyTechCycling downloads section of the webpage. It will be also updated during the project.

Press kit

In order to help partners in the elaboration of their press releases and communications to magazines, a press kit has been developed and distributed among them. The press kit is also available in the webpage, including photos, general description of the project and the concepts related to it (Q&A document). By this it will be possible not only to homogenize all the communications made into the same style, thus promoting the chosen project image, but also to catch the general and specific magazines interest to communicate the project.

Leaflet

The project has developed and designed two versions of the brochure.

Figure 12. First leaflet version outside

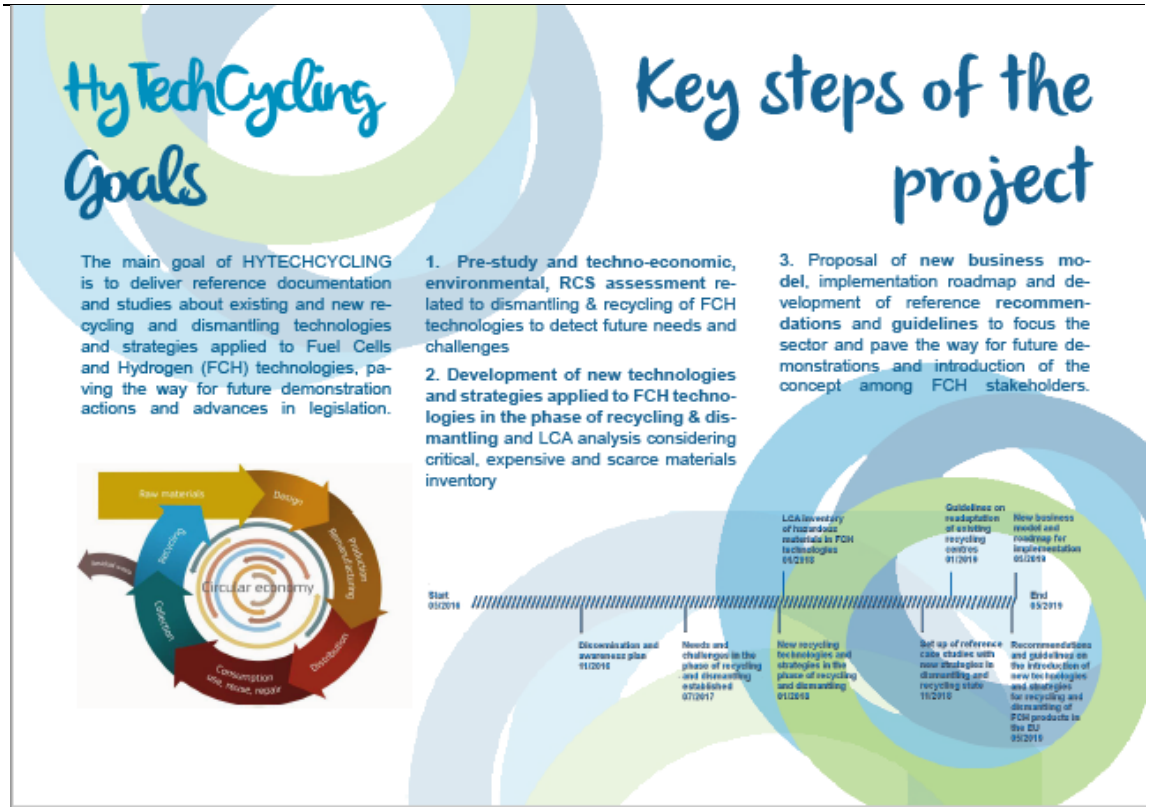

Figure 13. First leaflet version inside

Video

At the time of finalization of the project, a video is being edited to be released including the main public results and impact of the HyTechCycling project. This video will be shared through press release and it will be posted at the project's main website. The aim of the video will be to serve as the global final message of the project, and to provide a general view of the work performed.

3.3.3 Social and professional networks

The use of social media and social and professional networks will be also a key communication tool to disseminate information about the Project, events and Project results. Partners have been using their own accounts in the social/professional networks to contribute to the Project dissemination and to create open debates and detect future industrial investors from other cities in Europe. The main social networks considered for the dissemination of the Project communications and recommendations on how it's been used each of them according to their unique characteristics are detailed below:

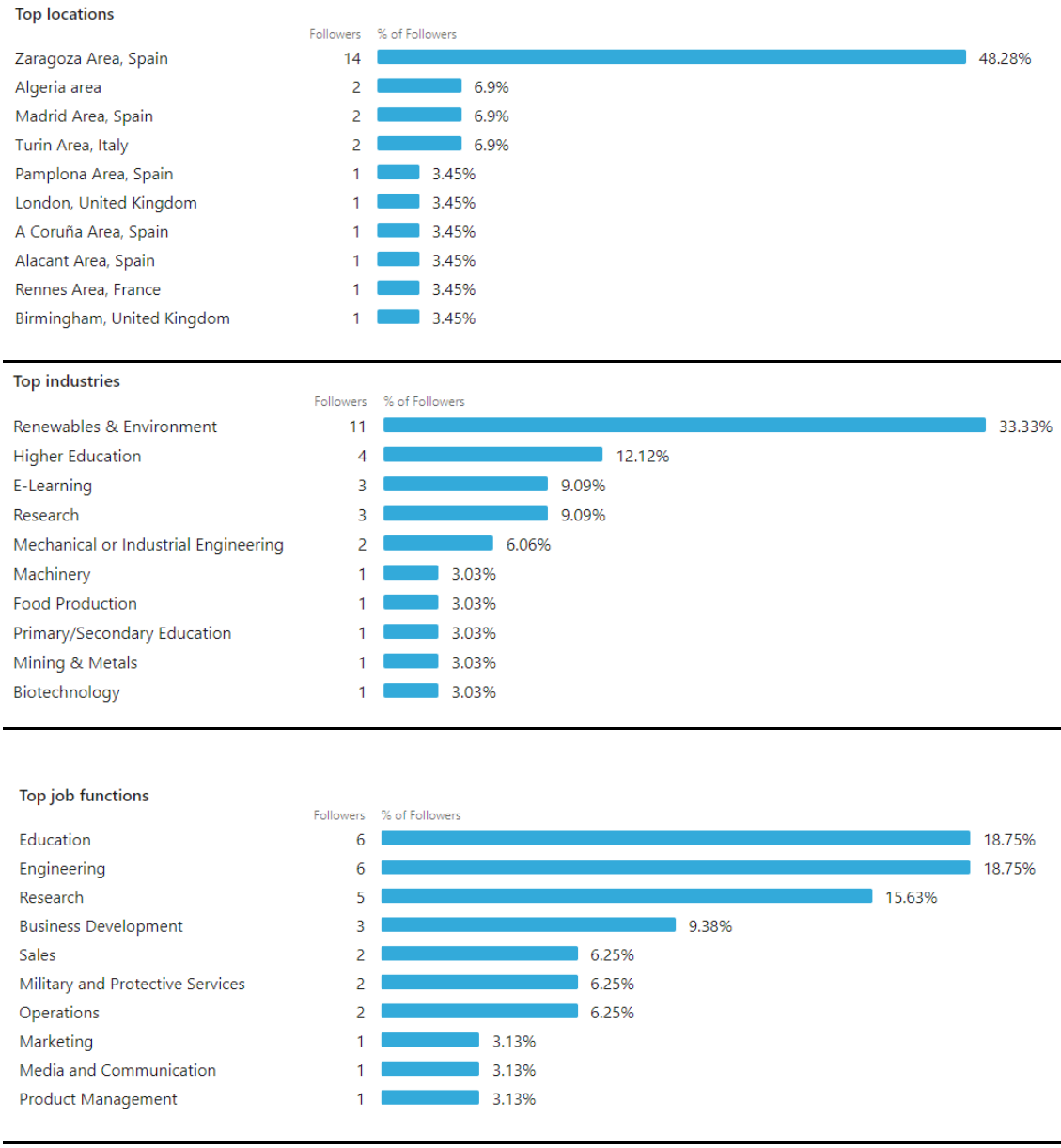

Figure 14. LinkedIn Followers Demographics

LinkedIn: A Project LinkedIn page has been created and shared with all the partners. Each participant on the Project of every partner has been able to post. The average visitor to the HyTechCycling project is a Spanish engineer from the renewable and environment sector.

Twitter: The partners must echo the Project events and press releases through a brief message or tweetable fact using the hash tag #HyTechCycling in the account holder language and also in English, redirecting to the main press release, linking to the new or event published in the Project website.

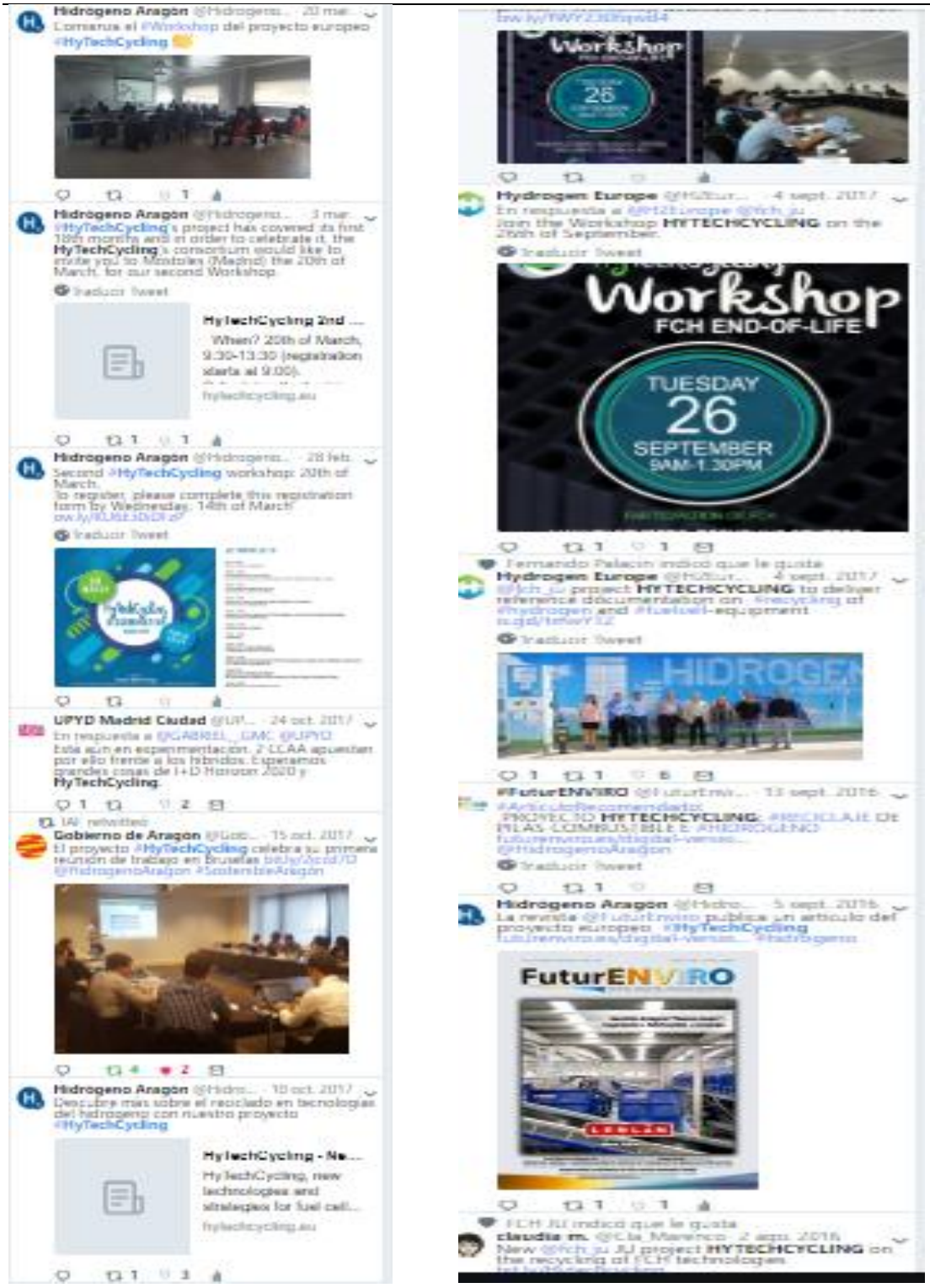

Figure 15. Twitter Captions

Facebook: The partners have echoed the Project achievements in the same way as in the twitter case, although the platform characteristics had allowed posting a more detailed message for each communication.

Figure 16. Facebook Captions

YouTube: The channels of the partners involved in the Project will be useful to make a better diffusion of the promotional videos made during the development of the Project (like the final video regarding the results obtained) as well as of any appearances of the partners on television.

3.4 Communication activities

3.4.1 Identification of ongoing projects for Project coordination

Possible paths of collaboration in public workshops and seminar will be explored by the Consortium when it is considered suitable and of interest for the Project and the partners. The assessment of the collaboration will be studied case by case taking into account the goals of the Project and partners

involved. Moreover, once the Project is concluded, the partners will be encouraged to show the results obtained at conferences, fairs and events related to the Project targets. The identification for Project coordination is challenging due to the almost non-existence of ongoing projects specifically focused on FCH recycling and dismantling. Therefore, the scope must widen till some of the main topics treated on HYTECHCYCLING such as FCH technologies life cycle and political framework analysis or metal and Waste Electronic and Electrical Equipment (WEEE) recycling. There is listed below some ongoing projects that could be related with HYTECHCYCLING in some of their aspects.

Fuel Cell Recovery project (funded by Innovate UK) the project aims to create knowledge on PEMFCs recovery from FCEVs at their EoL. The objectives of the project are: develop new design guidelines for FC recovery, new remanufacturing and recycling process design to facilitate recovery and new 'circular' business models.

CERTIFHY (funded by FCH 2 JU) the development of hydrogen as an energy carrier will be dependent upon the capacity of the market to offer low-carbon or carbon-free hydrogen to end-users and consumers. The objectives of the CertifHy project are to assess the necessary market and regulatory conditions, develop the complete design and initiate a unique European framework for green hydrogen guarantees of origin. It includes a Life Cycle Assessment (LCA) of hydrogen producing process from green energy sources, thus using electrolysers and including technological factors and regulatory framework in the assessment.

CRMRecovery project (funded by LIFE 2014) each year around 9.9 million tonnes of WEEE is generated in the EU. Due to poor collection and recycling rates and processes that can only recover a small number of materials, many critical and valuable materials are lost from the system.

The Critical Raw Material Recovery project is working to ensure that a wider range of mineral and metals are recovered during recycling of WEEE in Europe. The project will fund a series of WEEE collection and reprocessing trials, and deliver a European policy and infrastructure plan.

Projects developed by ElectroCat (funded by USA Department of Energy - DOE) The Electro catalysis Consortium (ElectroCat) are an initiative to accelerate the development of catalysts made without PGM for use in automotive fuel cell applications. It is co-led by Argonne National Laboratory and Los Alamos National Laboratory.

ElectroCat aims to bring together a network of enduring tools and expertise across the National Laboratory network (USA) under a streamlined, single point of contact interface that makes it easy for industry and academic partners to quickly gain access to the Consortium.

3.4.2 Publications and Dissemination activities

Conference, congress, etc.	Name of the publication	Date of issue	Place	Author(s)	Scope	Brief description
III Symposium of Spanish Life Cycle Assessment Network	Towards a robust life cycle assessment of end-of-life strategies for fuel cells and hydrogen technologies	04/11/2016	Escuela Técnica Superior de Ingeniería Agronómica y del Medio Natural, Universitat Politècnica de València (SPAIN)	IMDEA Energía. Antonio Valente, Mario Martín-Gamboa, Diego Iribarren, Javier Dufour	National (SPAIN)	Poster presentation
HYPOTHESIS XII	Revisting end-of-life technologies for fuel cells and hydrogen products	28-30/06/20174	Siracusa (Italy) 28-30 Junio 2017	IMDEA Energía. Antonio Valente, Mario Martín-Gamboa, Diego Iribarren, Javier Dufour	International (ITALY)	Oral Contribution
World Hydrogen Technology Convention 2017	Harmonised cumulative energy demand of renewable hydrogen	9-12/07/2017	Prague (Czech Republic) 9-12/07/2017	IMDEA Energía. Antonio Valente, Diego Iribarren, Javier Dufour	International (CZECH REPUBLIC)	Oral Contribution
SEEP 2017	Assessment of Critical Materiasl and Components in FCH Technologies to Improve LCIA in End of Life Strategy	27-30/06/2017	Bled (Slovenia)	UL - FHA. Andrej Lotrič, Rok Stropnik, Boštjan Drobnič, Boštjan Jurjevčič, Mihael Sekavčnik, Mitja Mori, Ana María Férriz Quílez	International (SLOVENIA)	Oral Contribution
IBERCONAPPICE 2017	Materiales críticos y estrategias de reciclado actuales en las tecnologías del hidrógeno y las pilas de combustible.	17-20/10/2017	Huesca (Spain)	FHA - IMDEA - UL - EP. A. M. Férriz, M. Zarzuela , J. Dufour , D. Iribarren, M. Mori, S. Fiorot	National (SPAIN)	Oral Contribution
International Conference on Sustainable Energy & Environmental	Life cycle assessment of EU critical raw materials in FCH technologies. Renewable and sustainable energy developments beyond 2030 : proceedings of the 8th	Tuesday 8 - Friday 11 May 2018,	University of the West of Scotland, Scotland.	STROPNIK, Rok, SEKAVČNIK, Mihael, LOTRIČ, Andrej, MORI, Mitja. V: OLABI, Abdul Ghan	International (SCOTLAND)	
FCHJU Programe Review Days 2018	HyTechCycling Poster	14-15 November 2018	European Comission, Brussels		International	Poster
WHEC2018	Critical materials and recycling strategies for fuel cells and hydrogen technologies.	16 june 2018	Rio de Janeiro Brasil	A. Bernad*(1),A. M. Férriz (1), M. Zarzuela (1), S. Fiorot (2), J. Dufour (3)(4), D. Iribarren (3), A. Valente (3)(4), R. Stropnik (5), M. Mori (5)	International	Oral Contribution

MedioTejo 21	HyTechCycling - New technologies and strategies for fuel cells and hydrogen technologies in the phase of recycling and dismantling	29-may-18	Portugal	FHA- Alfonso Bernad	International	Oral Contribution
EHEC2018	End-of-life of FCH products: a review of the current situation.	15 march 18	Málaga, Spain	Fha - Ana Férriz	International	Oral Contribution
HYPOTHESIS XIII,	Novel end-of-life technologies for fuel cells and hydrogen products	24-27 julio 2018.	Singapur (Singapur),	A. Valente, D. Iribarren, J. Dufour	International	Oral Contribution
HYPOTHESIS XIII,	End of life of fuel cells and hydrogen products: from technologies to strategies	24-27 julio 2018.	Singapur (Singapur),	A. Valente, D. Iribarren, J. Dufour	International	Oral Contribution

Figure 17. List of Dissemination Activities: Congress, events, etc.

Press Name	Date of issue	Author(s)	Target	Scope	Brief description	Link
Aragon hoy	08/05/2016	FHA	General Public	National (SPAIN)	KOM 160505	http://aragonhoy.aragon.es/index.php/mod.noticias/mem.detalle/area.1348/relmenu.4/id.180208
El periodico de la Energía	08/05/2016	FHA	General Public	National (SPAIN)	KOM 160506	http://elperiodicodelaenergia.com/tag/hytechcycling/
Exportar en Aragón	08/05/2016	FHA	General Public	National (SPAIN)	KOM 160510	http://exportarenaragon.es/la-fundacion-del-hidrogeno-coordinara-proyecto-europeo-hytechcycling/
Heraldo de Aragón	09/05/2016	FHA	General Public	National (SPAIN)	KOM 160504	http://www.heraldo.es/noticias/aragon/2016/05/08/la-fundacion-del-hidrogeno-coordinara-proyecto-europeo-hytechcycling-847363-300.html
Finanzas	09/05/2016	FHA	General Public	National (SPAIN)	KOM 160507	http://www.finanzas.com/noticias/empresas/20160508/aragon-coordinara-proyecto-europeo-3405128.html
El Periódico de Aragón	09/05/2016	FHA	General Public	National (SPAIN)	KOM 160508	http://www.elperiodicodearagon.com/noticias/economia/aragon-coordinara-proyecto-hidrogeno_1108987.html
Diario del Alto Aragón	09/05/2016	FHA	General Public	National (SPAIN)	KOM 160509	http://www.diariodelaltoaragon.es/Movil/Noticia.aspx?Id=994720
Diario aragonés	09/05/2016	FHA	General Public	National (SPAIN)	KOM 160511	http://www.diarioaragones.com/previo/mediodia/92329-la-fundacion-del-hidrogeno-coordinara-un-proyecto-europeo-sobre-reutilizacion-del-hidrogeno.html

Retema	09/05/2016	FHA	General Public	National (SPAIN)	KOM 160512	http://www.retema.es/noticia/arranca-el-proyecto-hytechcycling-sobre-reciclaje-y-reutilizacion-de-las-tecnologias--963f5
NoticiasHuesca	10/05/2016	FHA	General Public	National (SPAIN)	KOM 160513	http://noticiashuesca.com/la-fundacion-del-hidrogeno-coordinara-el-proyecto-europeo-hytechcycling/
FuturENVIRO	11/05/2016	FHA	Recycling centres (among others)	National (SPAIN)	KOM 160514	http://futurenviro.es/la-fundacion-del-hidrogeno-coordinara-proyecto-europeo-hytechcycling/
Diario del Alto Aragón	16/05/2016	FHA	General Public	National (SPAIN)	KOM	http://www.diariodelaltoaragon.es/Movil/Noticia.aspx?Id=994720
Prensa Unizar	18/05/2016	FHA	General Public	National (SPAIN)	KOM	http://www.diariodearagones.com/previo/mediodia/92329-la-fundacion-del-hidrogeno-coordinara-un-proyecto-europeo-sobre-reutilizacion-del-hidrogeno.html
Diario del Alto Aragón	20/06/2017	FHA	General Public	National (SPAIN)	Premio Empresa 2017	15006DA17062038 (Z:\16_01_HYTECHCYCLING\Proyecto\Difusión\Artículos)
Aragón Hoy	15/10/2017	FHA	General Public	National (SPAIN)	FIRST WORKSHOP 170926	http://www.aragonhoy.net/index.php/mod.noticias/mem.detalle/id.206536
Aragón digital	15/10/2017	FHA	General Public	National (SPAIN)	FIRST WORKSHOP 170926	12023AD17101616 (Z:\16_01_HYTECHCYCLING\Proyecto\Difusión\Artículos)
El Periodico de Aragón	16/10/2017	FHA	General Public	National (SPAIN)	FIRST WORKSHOP 170926	12024PA17101623 (Z:\16_01_HYTECHCYCLING\Proyecto\Difusión\Artículos)

Diario del Alto Aragón	17/10/2017	FHA	General Public	National (SPAIN)	FIRST WORKSHOP 170926	12004DA17112707 (Z:\16_01_HYTECHCYCLING\Proyecto\Difusión\Artículos)
Aragón digital	17/11/2017	FHA	General Public	National (SPAIN)	PRD 2017	12002AD17112712 (Z:\16_01_HYTECHCYCLING\Proyecto\Difusión\Artículos)
El Periódico de Aragón	17/11/2017	FHA	General Public	National (SPAIN)	PRD 2017	12003PA17112730 (Z:\16_01_HYTECHCYCLING\Proyecto\Difusión\Artículos)
Diario del Alto Aragón	17/11/2017	FHA	General Public	National (SPAIN)	PRD 2017	12006DT17112711 (Z:\16_01_HYTECHCYCLING\Proyecto\Difusión\Artículos)

Figure 18. List of Dissemination Activities: Press Release

Magazine Name	Date of issue	Author(s)	Target	Scope	Brief description	Link
FuturENVIRO	07/07/2016	FHA	Recycling centres (among others)	International	Introduction of the Project	http://futurenviro.es/digital-versions/2016-07/index.html#70
Fuel Cells Bulletin	01/08/2016		FCH stakeholders	International	Introduction of the Project	http://www.sciencedirect.com/science/article/pii/S1464285916302218
EU Innovations	21/12/2018	DCHT, UL	Expert, Public	International	Hydrogen technologies in Slovenia: a question of space and time	http://www.europeanenergyinnovation.eu/OnlinePublication/Winter2018/mobile/index.html#p=57

Figure 19. List of Dissemination Activities: Magazine Publications

Name	Topic	Date of issue	Author(s)	Brief description	Link
INTERNATIONAL JOURNAL OF HYDROGEN ENERGY	Critical materials and recycling strategies for fuel cells and hydrogen technologies		A. Bernad*(1),A. M. Férriz (1), M. Zarzuela (1), S. Fiorot (2), J. Dufour (3)(4), D. Iribarren (3), A. Valente (3)(4), R. Stropnik (5), M. Mori (5)	Fuel Cells and Hydrogen (FCH) technologies are expected to play a key role in decarbonising the energy system. A key requirement for complete FCH commercialisation is the development of the recycling and dismantling stage. In order to deliver reference documentation and studies about existing and new recycling and dismantling technologies, the first step is to identify, describe and classify the materials used in FCH technologies.	https://www.sciencedirect.com/science/article/pii/S0360319918330969
INTERNATIONAL JOURNAL OF HYDROGEN ENERGY	End-of-life of Fuel Cell and Hydrogen products: from technologies to strategies		A. Valente, D. Iribarren, J. Dufour	End-of-Life (EoL) technologies and strategies are needed to support the deployment of fuel cells and hydrogen (FCH) products. This article explores current and novel EoL technologies to recover valuable materials from the stacks of proton exchange membrane fuel cells and water electrolysers, alkaline water electrolysers, and solid oxide fuel cells. Current EoL technologies are mainly based on hydrometallurgical and pyro-hydrometallurgical methods for the recovery of noble metals, while novel methods attempt to recover additional materials through efficient, safe and cost-competitive pathways. Strengths, weaknesses, opportunities and threats of the reviewed EoL technologies are identified under techno-economic, environmental and regulatory aspects. Beyond technologies, strategies for the EoL of FCH stacks are defined mainly based on the role of manufacturers and recovery centres in the short-, mid- and long-term. In this regard, a dual role manufacturer/recovery centre would characterise long-term scenarios within a potential context of a well-established hydrogen economy	https://www.sciencedirect.com/science/article/pii/S0360319919302423?via%3Dihub

Figure 20 Scientific Project Publications

Date of issue	Author(s)	Brief description	Link
08/05/2016	FHA	KOM 160504	http://hidrogenoaragon.org/es/la-fundacion-del-hidrogeno-coordinara-el-proyecto-europeo-hytechcycling/
30/05/2017	FHA	1st PM 170609	http://hidrogenoaragon.org/es/hytechcycling-celebra-un-ano-de-trabajo/
30/05/2017	EP	1st PM 170609	http://www.envipark.com/2017/06/08/hytechcycling-procedono-gli-studi-sui-sistemi-smaltimento-delle-tecnologie-allidrogeno/
	FHA	EL PROYECTO HYTECHCYCLING CELEBRA SU SEGUNDO WORKSHOP	http://hidrogenoaragon.org/es/el-proyecto-hytechcycling-celebra-su-segundo-workshop/
	FHA	LA FUNDACIÓN HIDRÓGENO ARAGÓN PARTICIPA EN EL EUROPEAN HYDROGEN ENERGY CONFERENCE – EHEC2018	http://hidrogenoaragon.org/es/la-fundacion-hidrogeno-aragon-participa-ehec2018/
29/11/2017	FHA	LA COMISIÓN EUROPEA PONE COMO MODELO A CINCO PROYECTOS DE LA FUNDACIÓN HIDRÓGENO EN EL PRINCIPAL ENCUENTRO DEL SECTOR	http://hidrogenoaragon.org/es/comision-europea-pone-como-modelo-a-cinco-proyectos-de-la-fundacion-hidrogeno/
28/09/2017	FHA	EL PROYECTO HYTECHCYCLING CELEBRA SU PRIMER WORKSHOP	http://hidrogenoaragon.org/es/hytechcycling-celebra-su-primer-workshop/

09/06/2017	FHA	EL PROYECTO HYTECHCYCLING CELEBRA SU PRIMER AÑO DE TRABAJO	http://hidrogenoaragon.org/es/hytechcycling-celebra-un-ano-de-trabajo/

Figure 21. List of Dissemination Activities: Partner Media

3.4.3 Workshops

Two workshops have been carried out. The first workshop It was dedicated mainly to the potential agents involved in the recycling of hydrogen technologies as manufacturers of batteries and electrolysers, end users and recycling centers. That is the main objective of HyTechCycling, anticipating the deployment of hydrogen technology addressing existing and future actions of recycling and its necessary legislative accompaniment. In this first meeting the members of the consortium presented the results achieved so far in the study of the components of hydrogen batteries and the various existing recycling technologies, but also proposals to facilitate their implementation in companies and recycling centers which will be responsible for the classification and treatment of materials.

During the workshop, advances were made in the study of the Life Cycle Analysis (LCA) of fuel cells and electrolysers and of the various auxiliary elements that are necessary for their optimum operation. This identification is the key both to characterize how clean these technologies are and to understand more clearly which the most harmful components for the environment are.

The second workshop was dedicated to the communication and dissemination of the project. It was held in Móstoles (Madrid) on March 20. The main objective of this workshop was to present the new technologies in the recycling phase of fuel cells and hydrogen technologies. In addition, the results of the LCA, the information obtained from different members of the life cycle of the FCH and the general information on the project will be presented. The contributions and feedback of those attending the event will be the basis for the development of a business model, seeking an adaptation to all the needs and knowledge of FCH.

3.4.4 Demo-events and showcases

ILSSA facilities have held a showcase for the final four months of the project.

One of the showcases focused for the students, was organized for January 31. The contact with the centers of the students could interest to know the change of the model of power that is producing to world-wide level with the inclusion of clean technologies in the power generation and the recycling. Within this framework, we would like to know the benefits of hydrogen technologies and present fuel cells, bringing

them closer to this public. Considering that they were very bad dates for the students. For these shop windows we have a group of about forty students.

The last demo event of the HyTechCycling Project took place at ILSSA facilities the 9th of April, with attendants with a diverse background. During the event, the project partners presented results from the project and with the collaboration of all the attendants, interesting remarks and considerations about the FCH technologies and its whole life were discussed. Additionally, all the attendants had the chance to visit a recycling centre and to realize how the End of Life is managed in a real plant.

Figure 22 Demo events Leaflet

Figure 23 Demo event April 9th

4. Conclusions

The present document constitutes the main of the work done by the HyTechCycling in terms of communication activity. It contains all the necessary information in relation to the target groups, how we have reach them and which are the tools that the consortium have used to perform these tasks, as well as a selection of potential partners within Europe and conferences, congress and fairs that the partners of the project had attended for the dissemination of the results of the Project.

The main target groups identified are the public regulator bodies, the hydrogen technology actors: manufacturers, distributors and end user; the recycling centers and, of course, the general public too. The ways of reaching these audiences have been different for each of them, but in any case, the website of the Project has been meant to be the central point of information related to the project, as it contains all the public documents generated during the Project, as well as a 'News' section to gather all the important updates on the Project. During the time of execution of the Project, the partners have used their institutional accounts in social networks (Twitter, Facebook, LinkedIn, etc.) to promote the work performed in the Project.

A set of graphic materials has been prepared to unify the corporate image of any work performed under HYTECHCYLING and to help the diffusion of the Project and its presence in fairs, congress, etc. These include the logo and a press kit, between other materials. Overall, it serves as the main support material to introduce the Project to both technical and non-technical audiences.

At the same time, a search between other European projects has resulted in a selection of ongoing projects approaching any of the main topics addressed by HYTECHCYCLING, in a more or less detailed level.

The report also includes an extensive list of many congresses and fairs that have been celebrated in Europe during the time of execution of the Project and have served as scenarios for the showcasing of the Project, as well as very good networking opportunities.

Finally, the workshops and demo-events carried out have target both the general public and more specific audiences interested in the Project result

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Annex

Presentations Demo Demo-events and showcases

HyTechCycling

Beneficios de las tecnologías del hidrógeno y su potencial

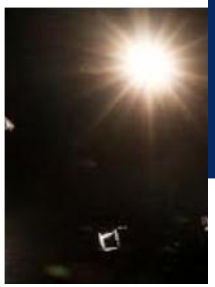
¿Qué pasa con el cambio climático?

euronews. Europe World Business Sport Culture Style Sci-tech Travel Video Programmes

GOOD MORNING EUROPE

COP24 agreement: Does it go far enough? 4 COMMENTS

By Euronews • last updated: 17/12/2018



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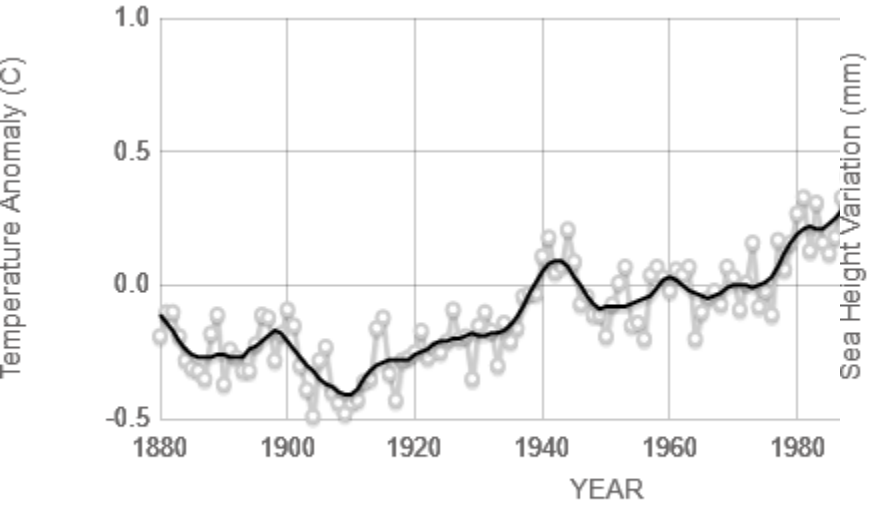
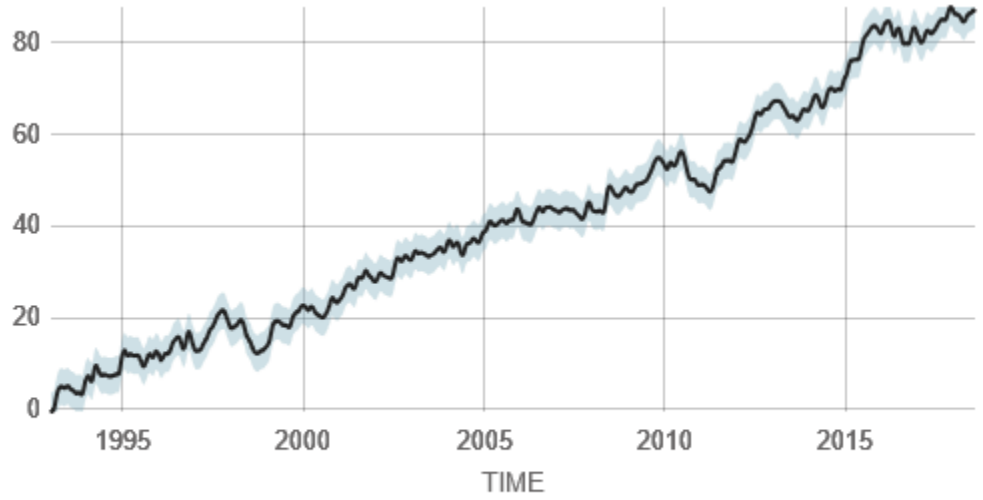


Source: climate.nasa.gov



Source: climate.nasa.gov

FCH FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

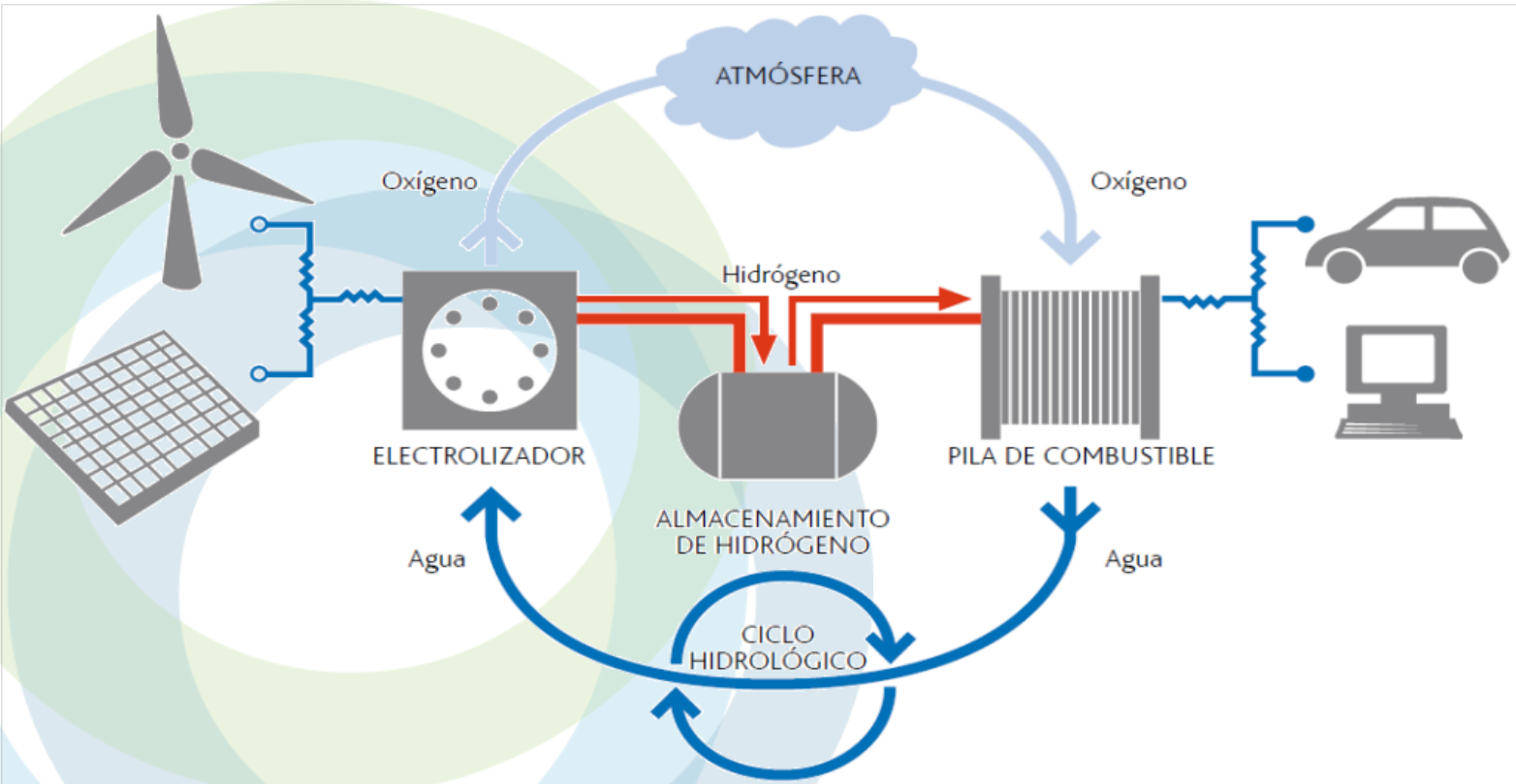
FOUNDATION FOR THE DEVELOPMENT OF NEW HYDROGEN TECHNOLOGIES IN ARAGON

institute iMdea energy

GRUPO LÓPEZ SORIANO

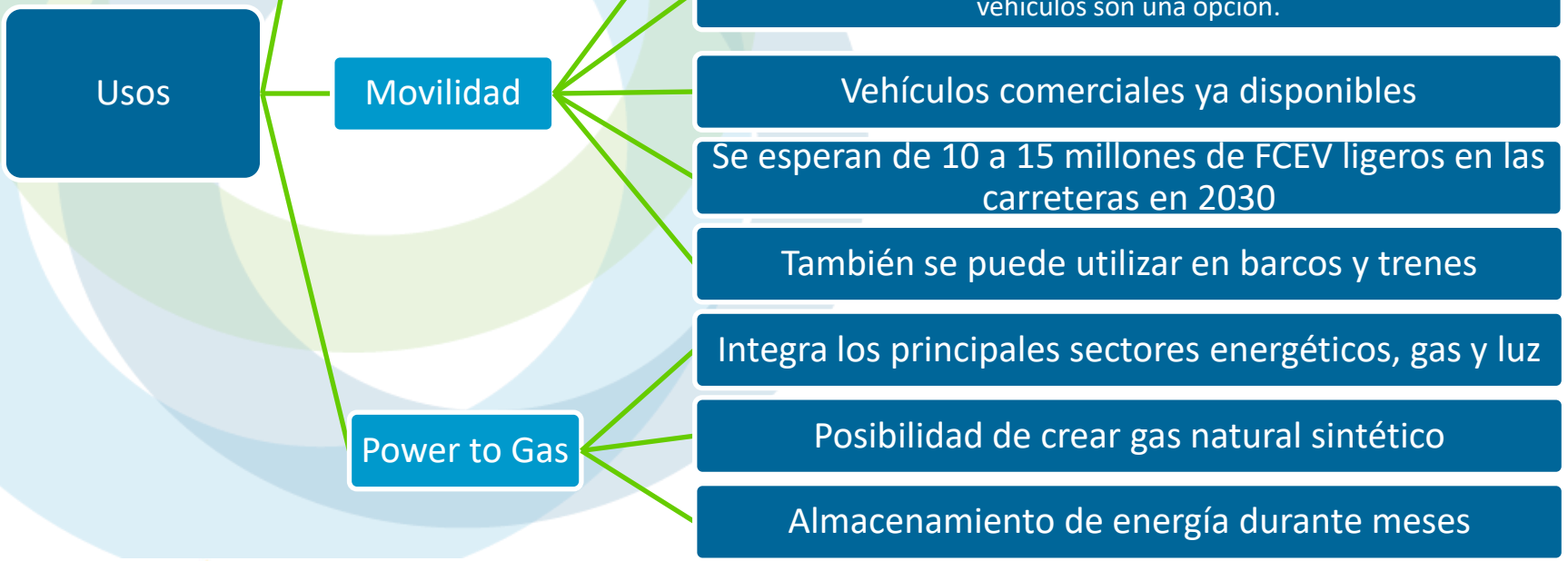
ENVIRONMENT PARK Parco Scientifico Tecnologico per l'Ambiente

¿Por qué hidrógeno?

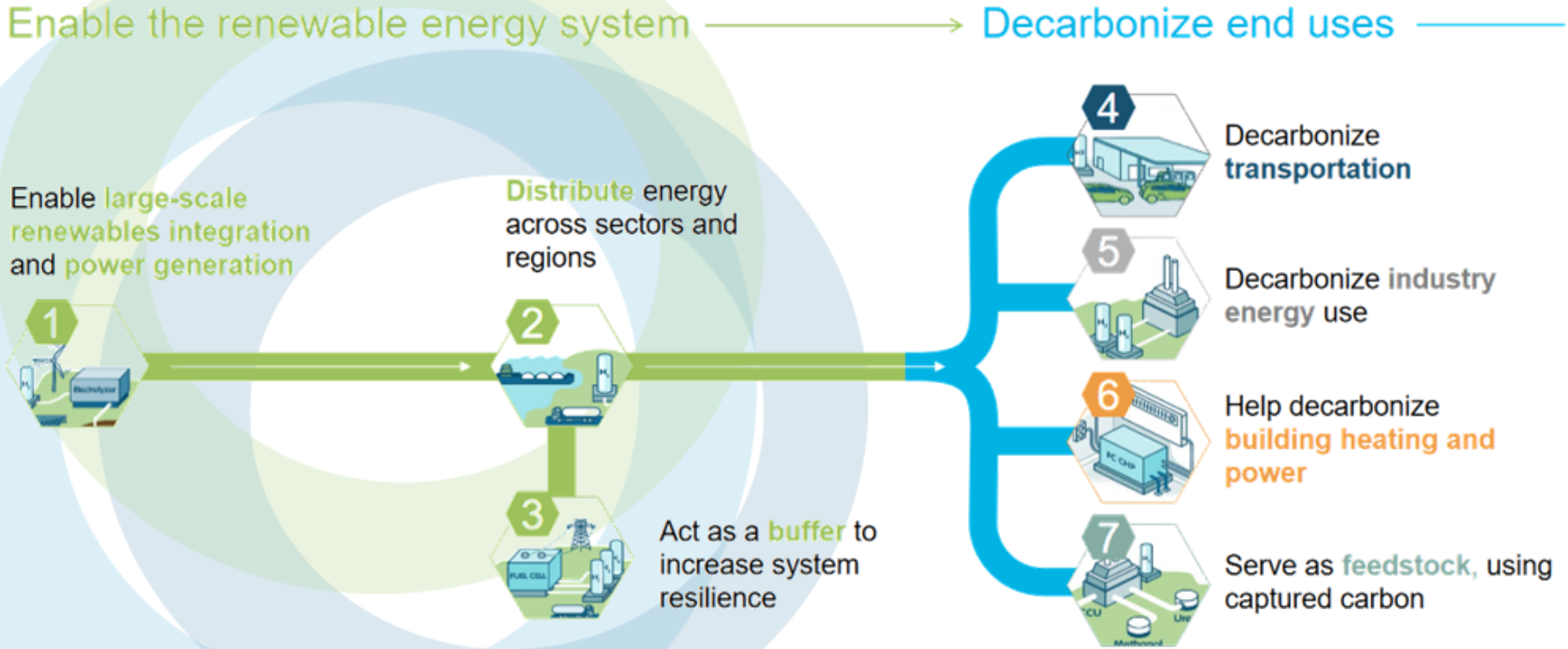


Source: Fundación Hidrógeno Aragón

El hidrógeno a día de hoy

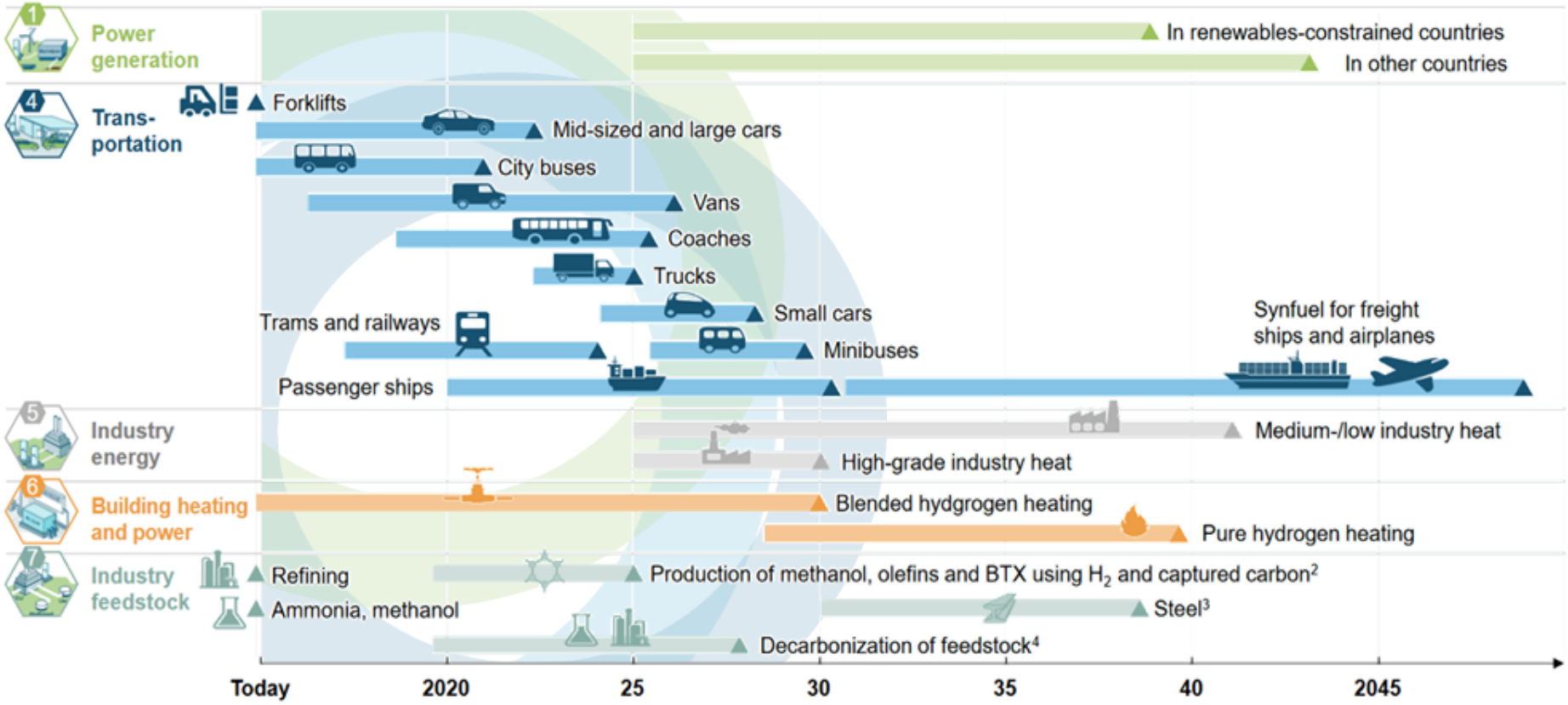


¿Qué se hará con hidrógeno en el futuro?



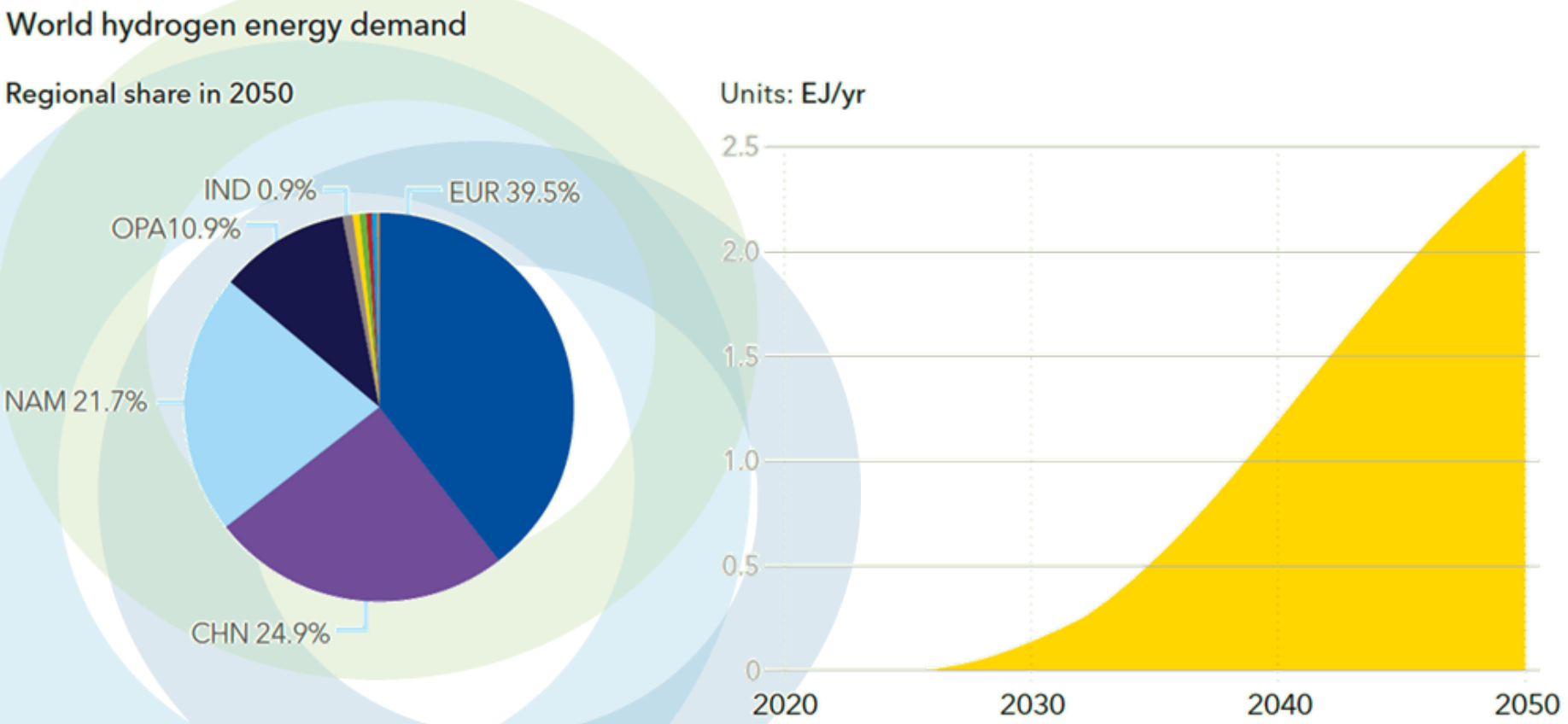
Source: Hydrogen Council

¿Qué se hará con hidrógeno en el futuro?



Source: Hydrogen Council

Perspectivas de futuro



Source: DNV GL Energy Transition Outlook 2018

Visión del futuro de la industria

En 2050

SOURCE: Hydrogen Council; IEA ETP Hydrogen and Fuel Cells CBS; National Energy Outlook 2016

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.

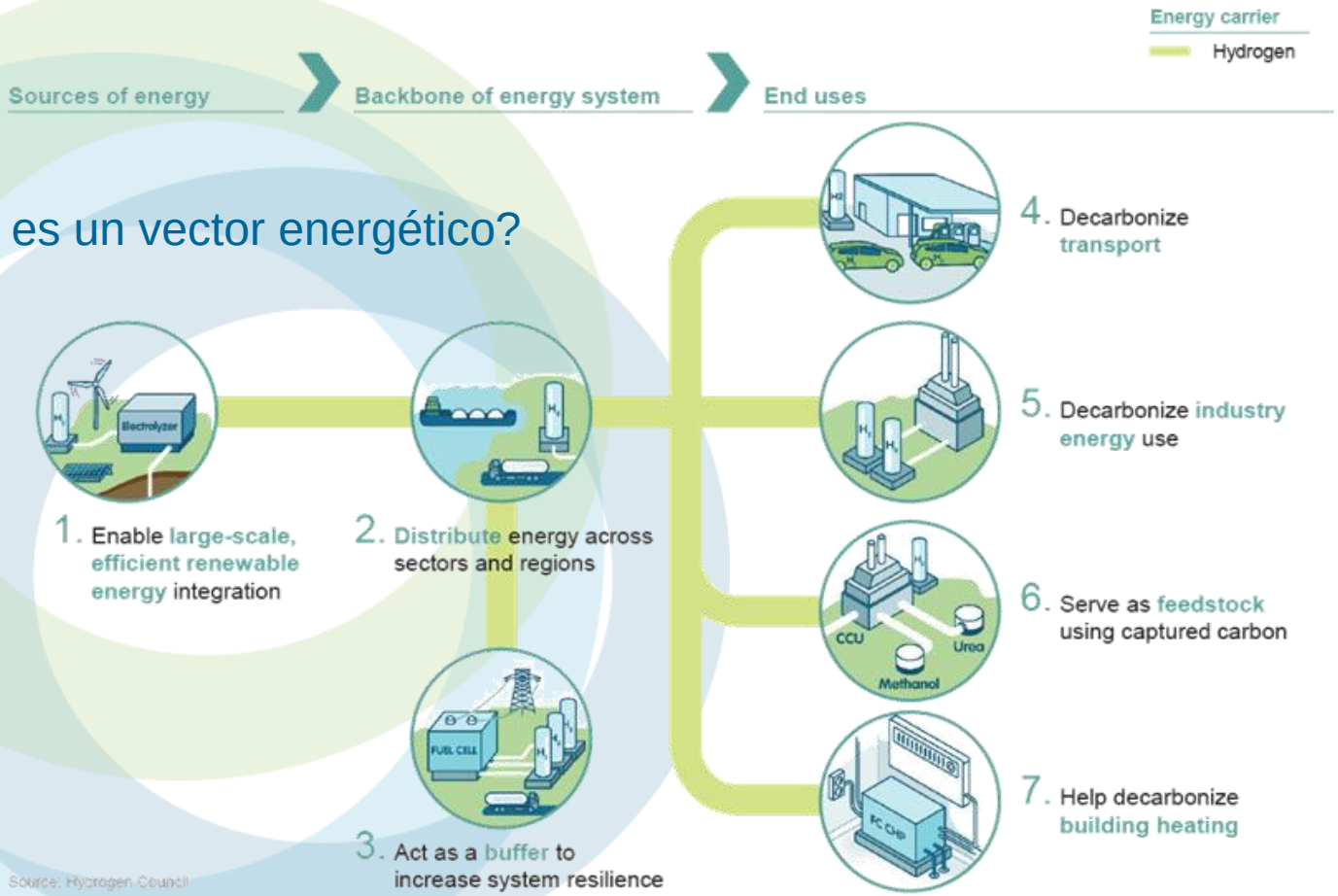
HyTechCycling

HyTechCycling

Introducción a las tecnologías del hidrógeno

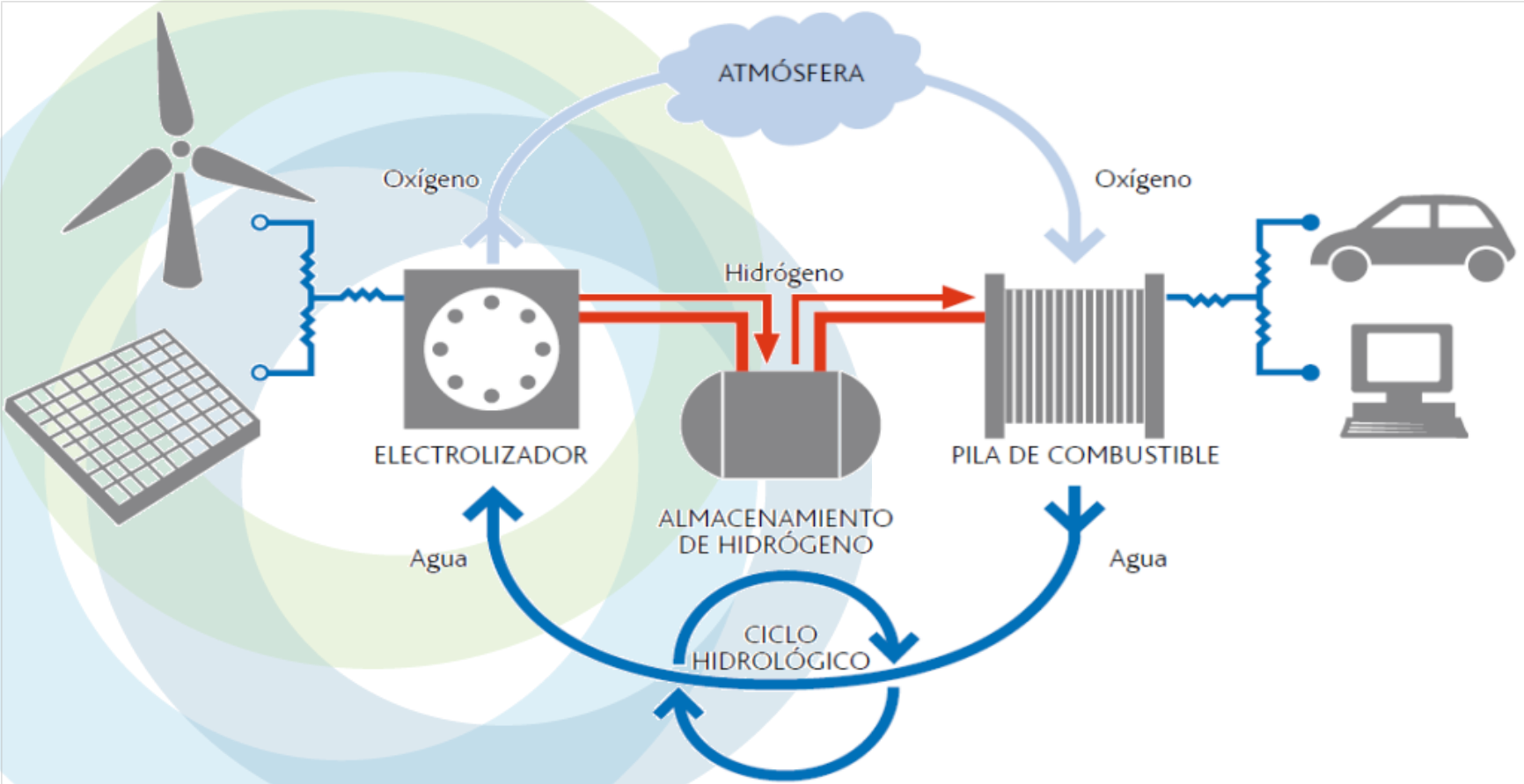
Hidrógeno: Parte de la solución

¿Qué es un vector energético?



Source: Hydrogen Council

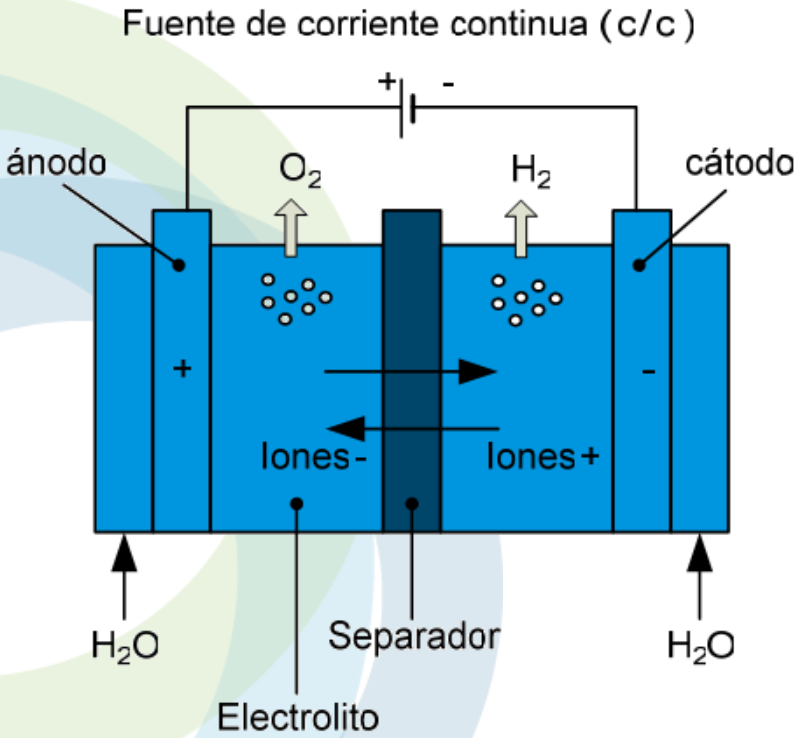
Ciclo del hidrógeno



Source: Fundación Hidrógeno Aragón

Electrolizadores

Ánodo
Se da la oxidación.
Polo positivo.
Se produce oxígeno.



Cátodo
Se da la reducción.
Polo negativo.
Se produce hidrógeno.

Consiste en la ruptura de la molécula de agua por acción de una corriente eléctrica.

$$H_2O + \text{electricidad} \rightarrow H_2 + \tfrac{1}{2} O_2$$

AWE

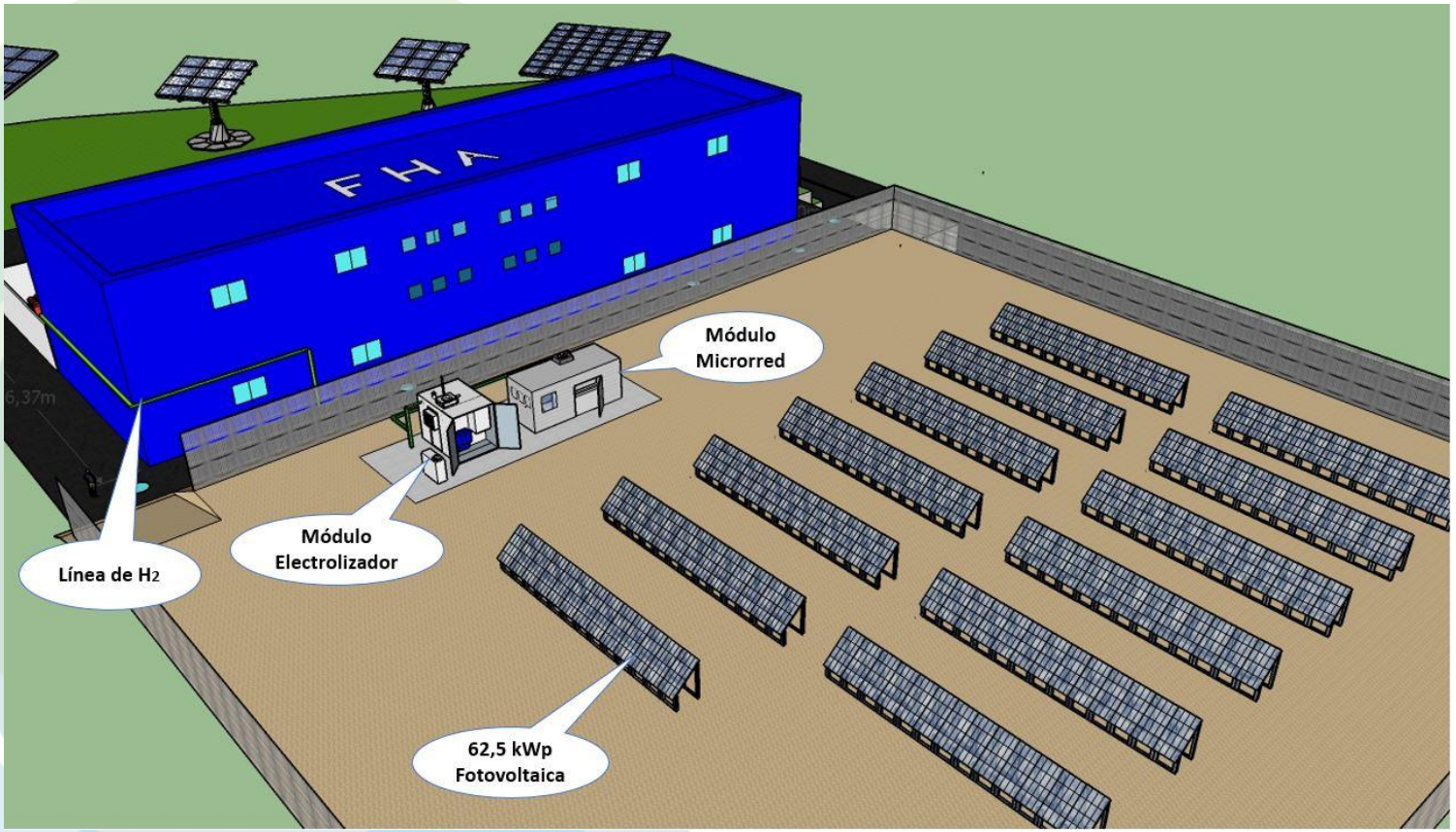
Source: Fundación Hidrógeno Aragón

AWE

Materiales

Componente	Material	Clasificación del material	Valor del material	Criticalidad del material
Electrolito	Potasa	Peligroso (corrosivo)	Medio	Bajo
Ánodo	Metales preciosos	No Peligroso	Alto	Alto
	Plástico	No Peligroso	Bajo	Bajo
Cátodo	Níquel Raney	Peligroso (cancerígeno)	Medio	Alto
	Plástico	No Peligroso	Bajo	Bajo
Interconexión	Plástico	No Peligroso	Bajo	Bajo
Aislante	Termoplástico	No Peligroso	Bajo	Bajo
	Elastómero	No Peligroso	Bajo	Bajo
Diafragma	Asbestos	Peligroso (cancerígeno)	Bajo	Bajo
Membrana	Polímeros	No Peligroso	Medio	Bajo

PEMWE



Source: Fundación Hidrógeno Aragón

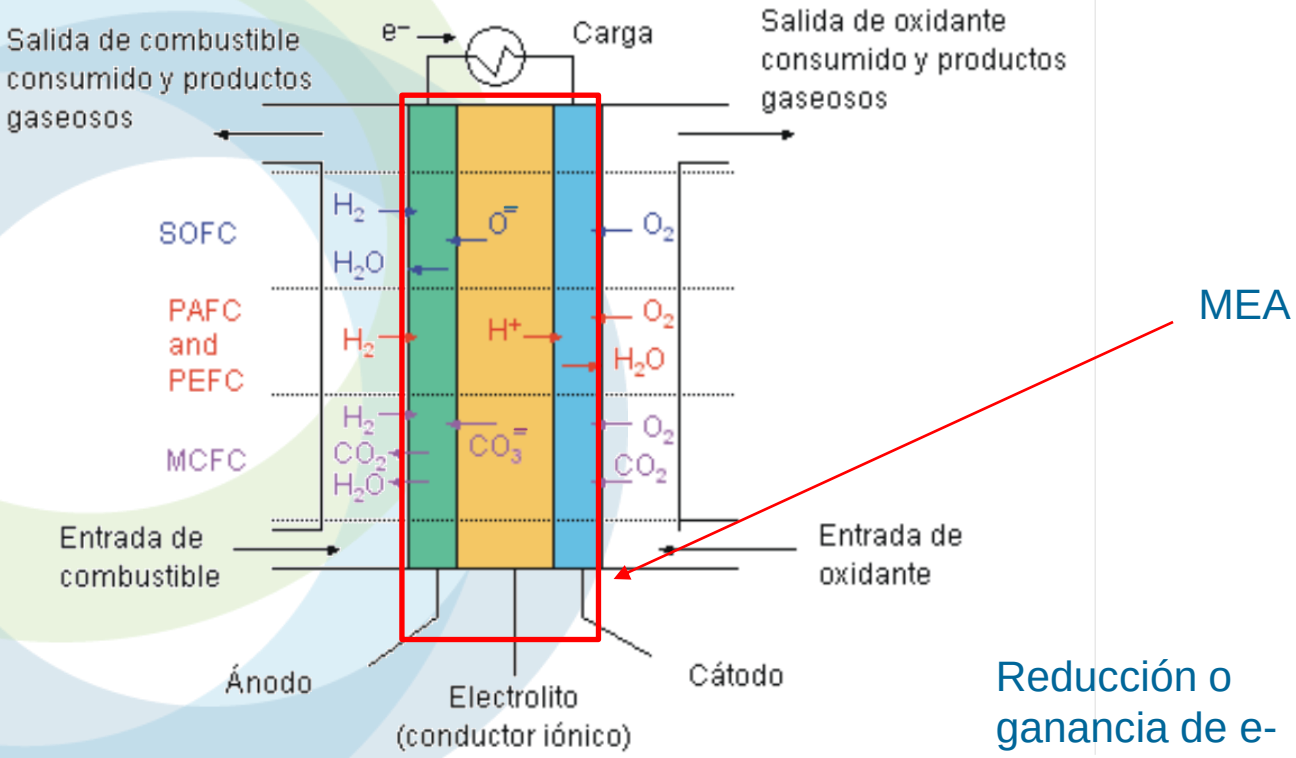
PEMWE

Materiales

Componente	Material	Clasificación del material	Valor del material	Criticalidad del material
Electrolito	Ácido Perfluorosulfónico (PFSA)	No Peligroso	Medio	Medio
	Polietercetona sulfonatada (s-PEEK)	No Peligroso	Medio	Bajo
Capa catalizador –Cátodo	Pt o aleaciones	No Peligroso	Alto	Alto
Capa catalizador – Ánodo	Iridio o aleaciones	Peligroso (irritante, nocivo)	Alto	Alto
	Rutenio o aleaciones	Peligroso (tóxico, cancerígeno)	Medio	Alto
Ánodo y Cátodo – GDL	Ti sinterizado térmicamente	No Peligroso	Bajo	Medio
	Titanio o malla de acero inoxidable	No Peligroso	Bajo	Medio
	Grafito (solo posible en el Cátodo)	No Peligroso	Bajo	Alto
Interconexión	Aleaciones de titanio	No Peligroso	Bajo	Medio
Aislante	Termoplástico	No Peligroso	Bajo	Bajo
	Elastómero	No Peligroso	Bajo	Bajo

Pilas de combustible

Las pilas de combustible son dispositivos electroquímicos que convierten directamente la energía química de un combustible en energía eléctrica

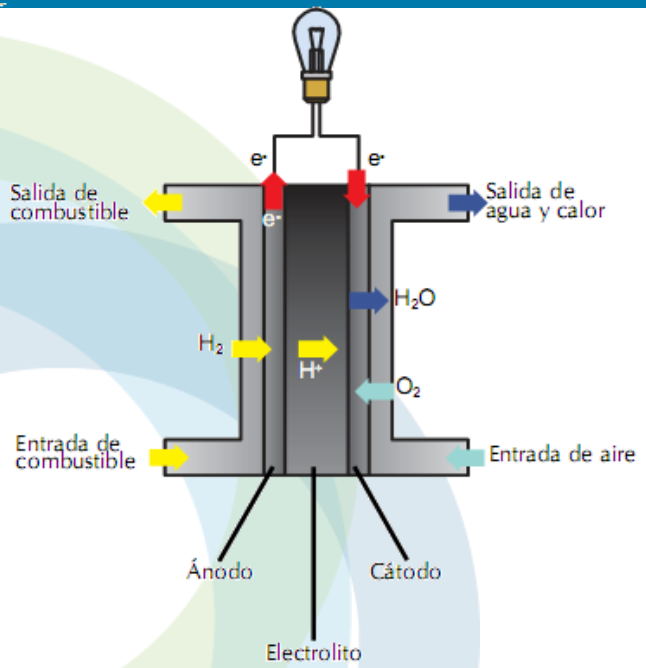


Oxidación o pérdida de e-

Reducción o ganancia de e-

$$H_2 + \frac{1}{2} O_2 \rightarrow H_2O + \text{electricidad}$$

PEMFC



Hidrógeno + **Oxígeno** → **E.Eléctrica** + **Agua** + **Calor**

→Temperatura

Este tipo de celdas operan a 20 ºC – 100 ºC, donde tiene lugar la conducción iónica por iones oxígeno.

PEMFC

Materiales

Componente	Material	Clasificación del material	Valor del material	Criticaliad del material
Electrolito	Ácido perfluorosulfónico (PFSA)	No Peligroso	Medio	Medio
	Polietercetona sulfonatada (s-PEEK)	No Peligroso	Medio	Bajo
	Poliestireno de ácido sulfónico(PSSA)	No Peligroso	Bajo	Medio
	polibenzilimidazol (PBI) dopado conH_3PO_4 *	Peligroso (corrosivo)	Medio	Bajo
Ánodo y Cátodo - GDL	Componente hidrofóbico	No Peligroso	Bajo	Bajo
	Malla metálica	No Peligroso	Bajo	Bajo
Ánodo y Cátodo – Capa de catalizador	Platino o aleaciones	No Peligroso	Alto	Alto
	Soporte del catalizador (carbono entre otros)	No Peligroso	Medio	Bajo
Interconexión	Grafito	No Peligroso	Bajo	Alto
	Acero inoxidable	No Peligroso	Bajo	Bajo
Aislante	Termoplástico	No Peligroso	Bajo	Bajo
	Elastómero	No Peligroso	Bajo	Bajo

PEMFC

Aplicaciones

Fuente: Toyota

Fuente: Horizon

Fuente: Fundación Hidrógeno Aragón

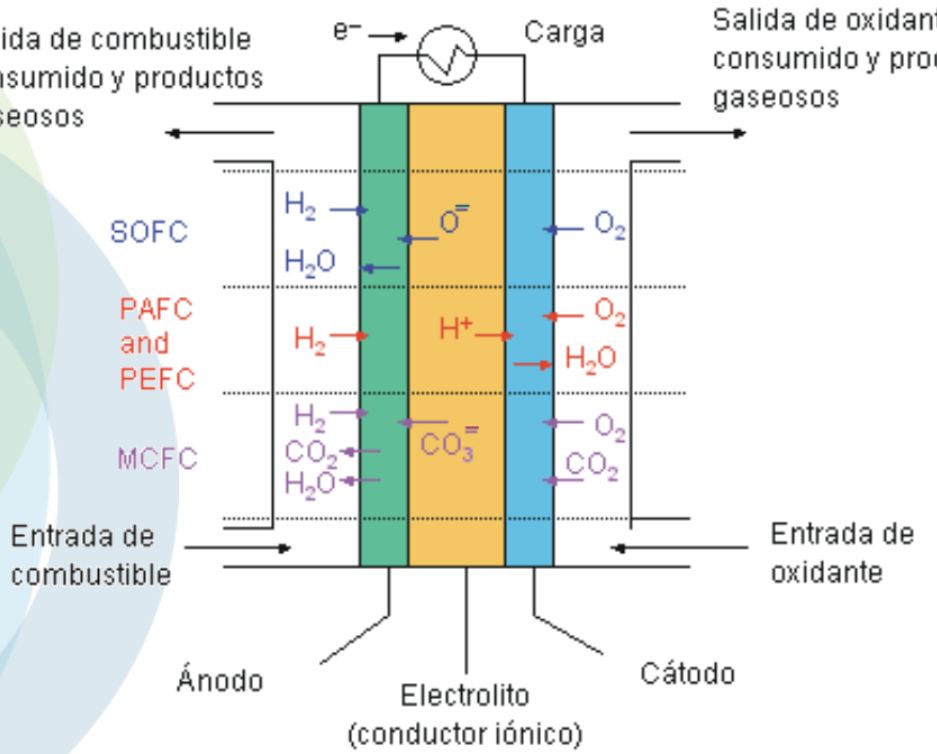
SOFC

→Funcionamiento

Hidrógeno o Gas natural + Oxígeno

E.Eléctrica + Agua + Calor

→Temperatura



Este tipo de celdas operan a 650 ºC – 1 000 ºC, donde tiene lugar la conducción iónica por iones oxígeno.

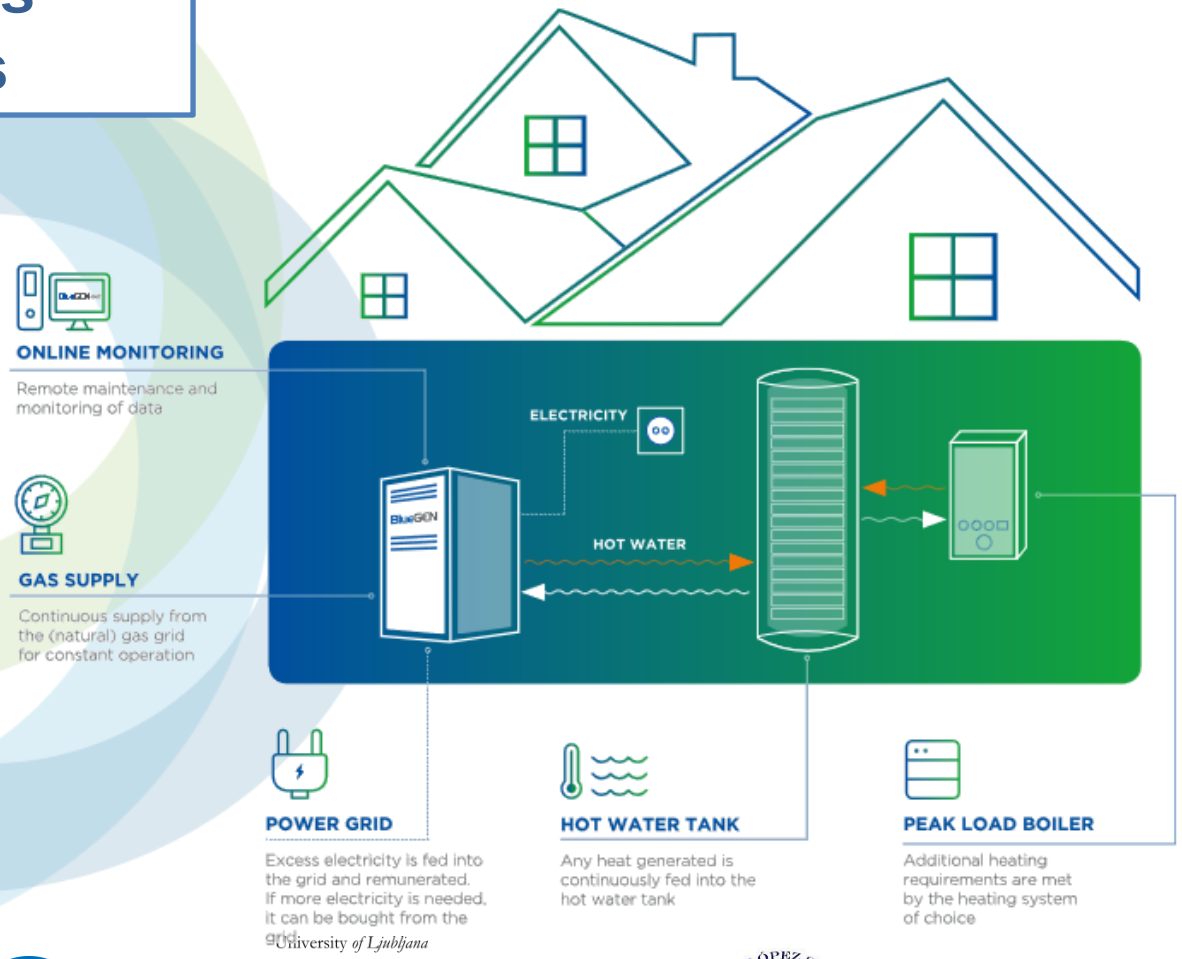
SOFC

Materiales

Componente	Material	Peligrosidad del material	Valor del material	Criticaliad del material
Electrolito	YSZ	No Peligroso	Medio	Alto
Ánodo	Óxido de níquel dopado con YSZ	Peligroso (cancerígeno)	Medio	Alto
	Níquel	Peligroso (cancerígeno)	Medio	Alto
Cátodo	Estroncio dopado	Peligroso (Irritante)	Medio	Alto
Interconexión	Cromato dopado	Peligroso (Irritante, nocivo)	Medio	Medio-Alto
	Metales inertes	No Peligroso	Alto	Medio-Alto
Aislante	Vidrio/fibra de vidrio	No Peligroso	Bajo	Bajo
	Mineral	No Peligroso	Bajo	Bajo
	Metales preciosos	No Peligroso	Alto	Alto
Sustrato	Cerámica	No Peligroso	Bajo	Bajo

SOFC

Aplicaciones Principales



Source: SolidPower

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.

HyTechCycling

HyTechCycling

Desmontaje y reciclaje de las tecnologías del hidrógeno según el proyecto HyTechCycling

¿Por qué necesitamos reciclar?

Gestión de residuos

Reducción de la basura

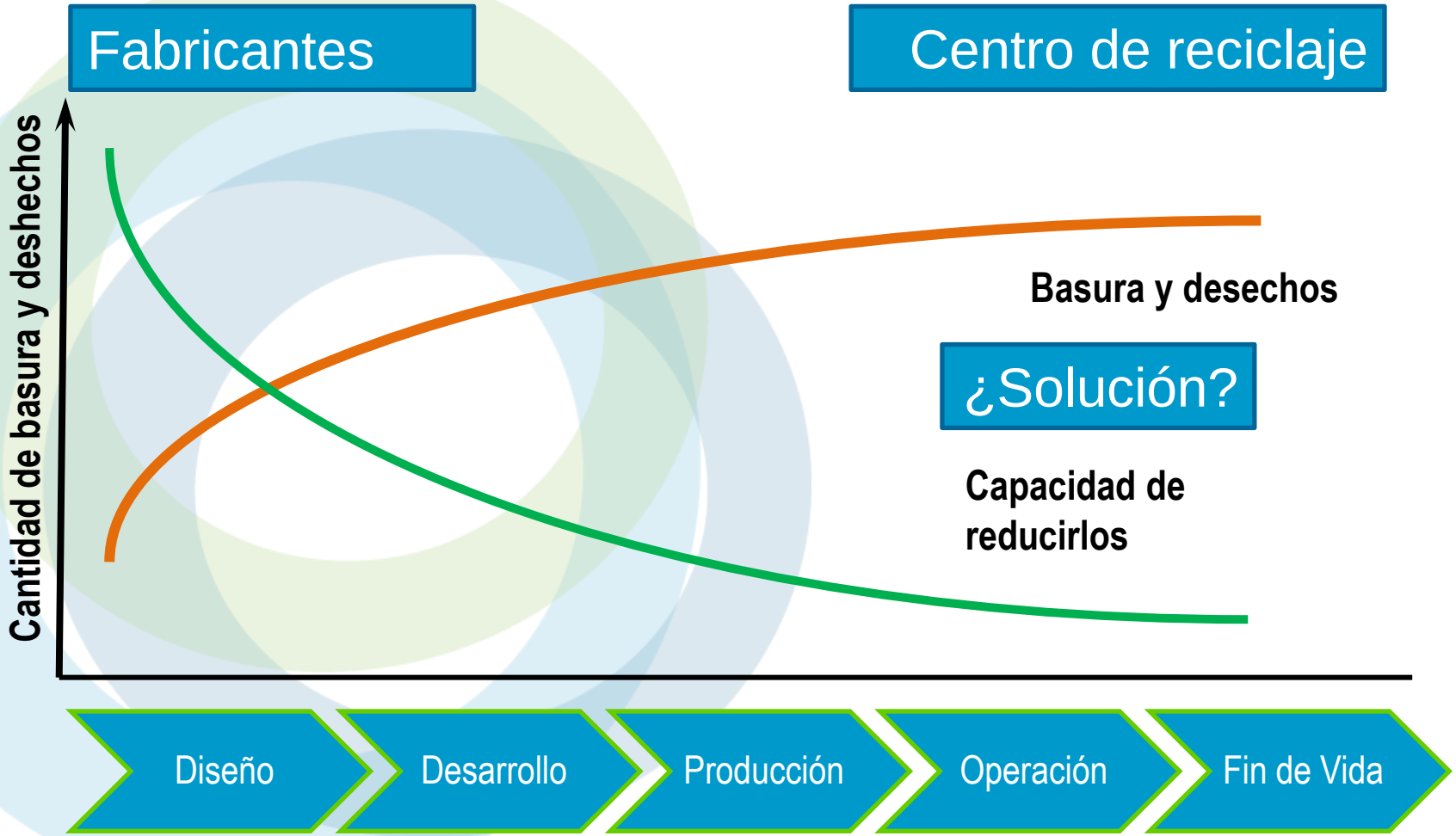
Reutilización de partes tras:
Reparar
Reacondicionar

Recuperación de materiales para su reutilización.

Valorización energética

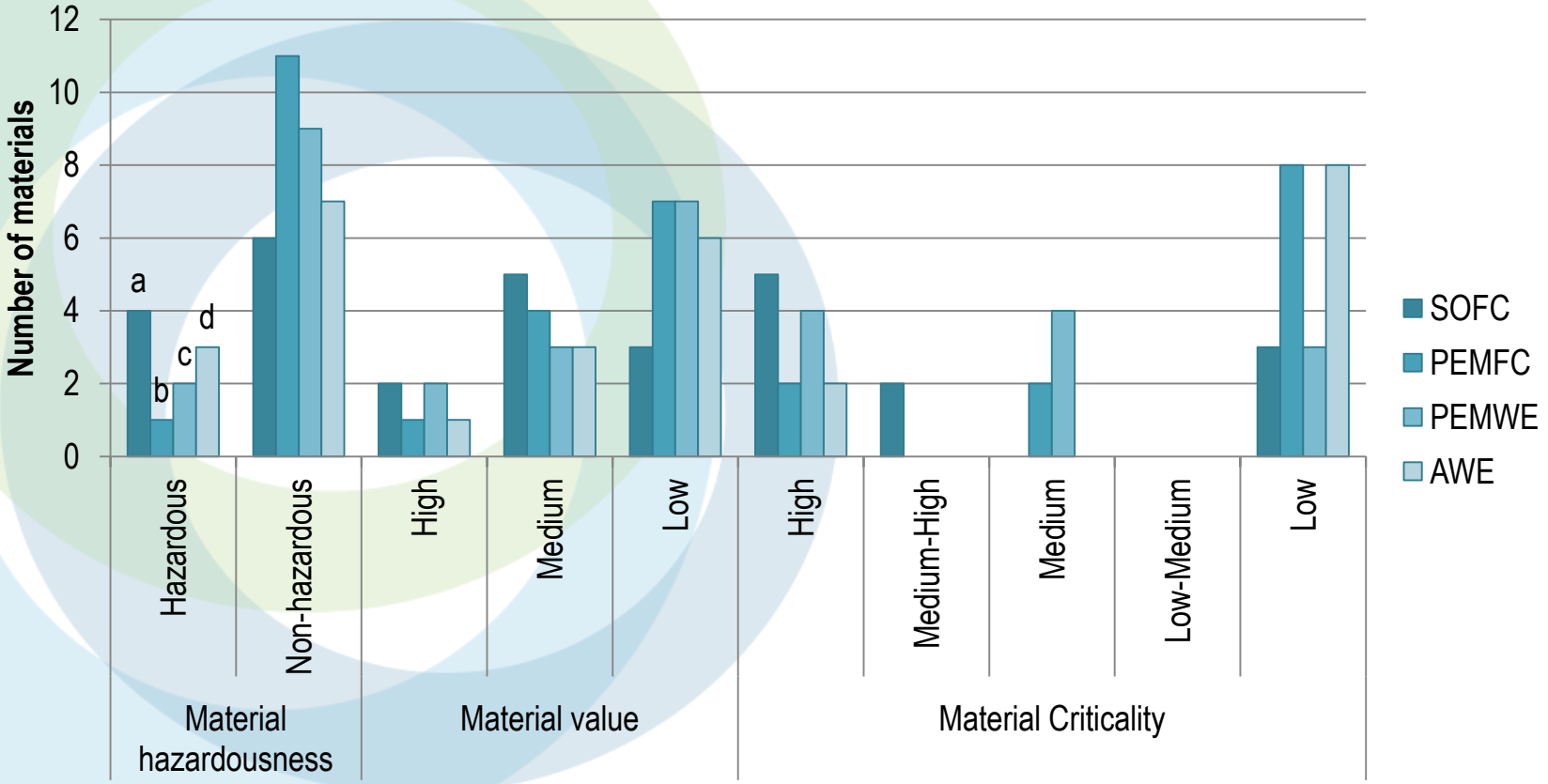
Vertido e incineración del residuo

Reducción de la basura



Reemplazo de materiales críticos

Selección de materiales



EcoDiseño

¿Ideas?

- Reducción de tamaño
- Reducción del consumo de electricidad, energía y agua en la fabricación
- Reutilización de componentes
- Diseño de partes con vida útil muy larga.
- Estandarización

Pasos en el proceso de reciclaje

Desmontaje

Manual

Separación

Selección de cables, electrolitos, electrodos y otros elementos.

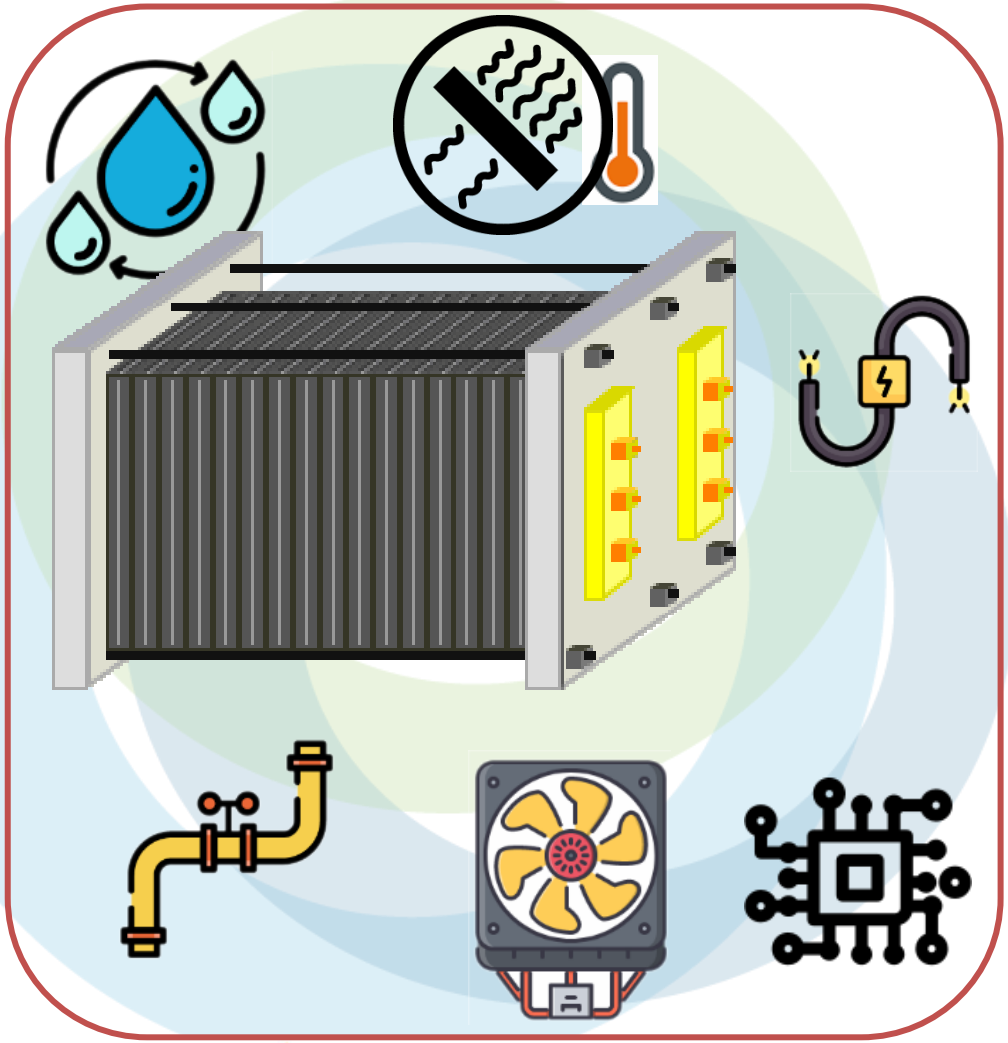
Reducción de tamaño

Por procesos de molienda o pulverización

Tratamientos de recuperación

Procesos más específicos para obtener materiales separados

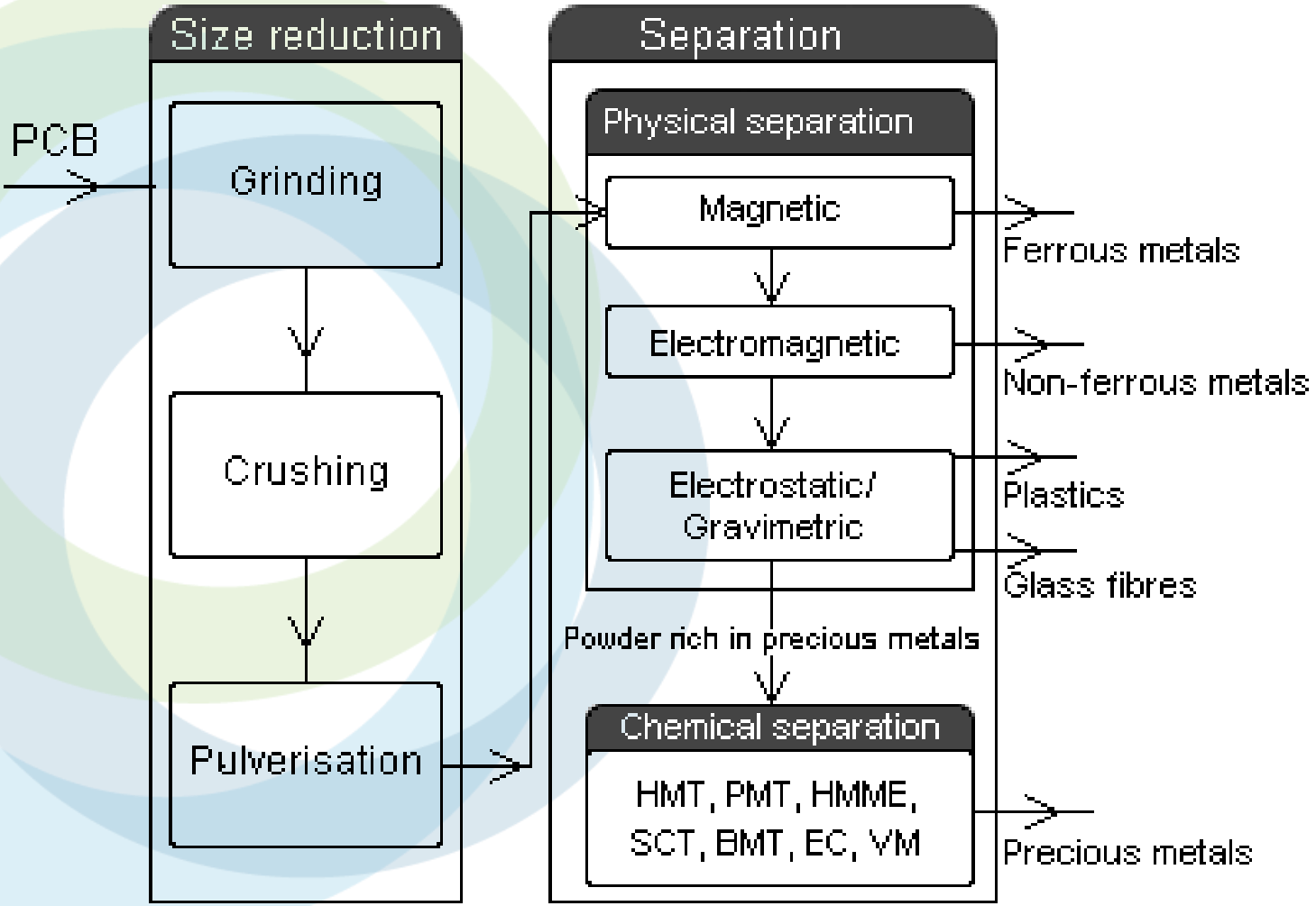
Separación



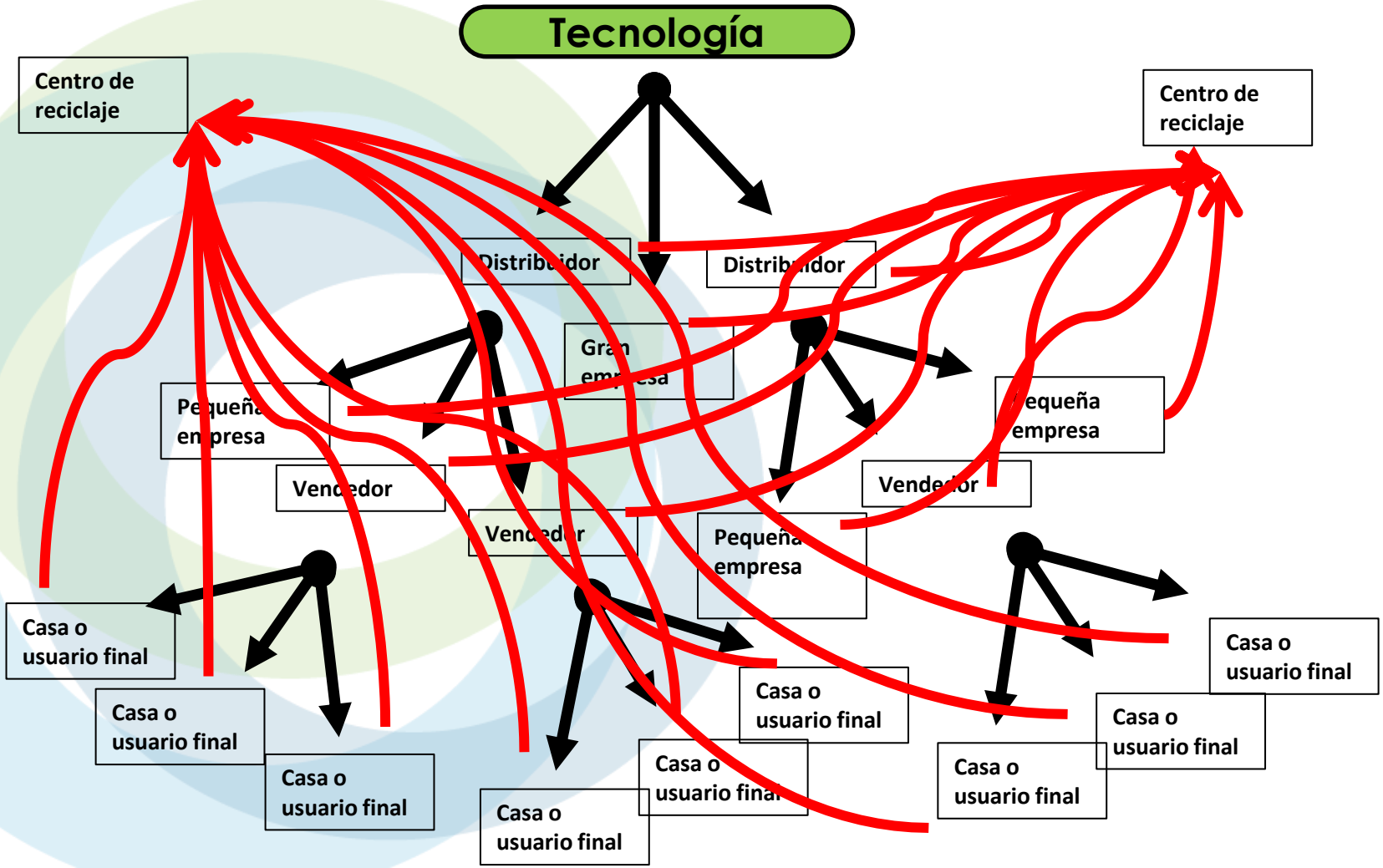
Componentes del stack

Componentes auxiliares

Reducción de tamaño y recuperación



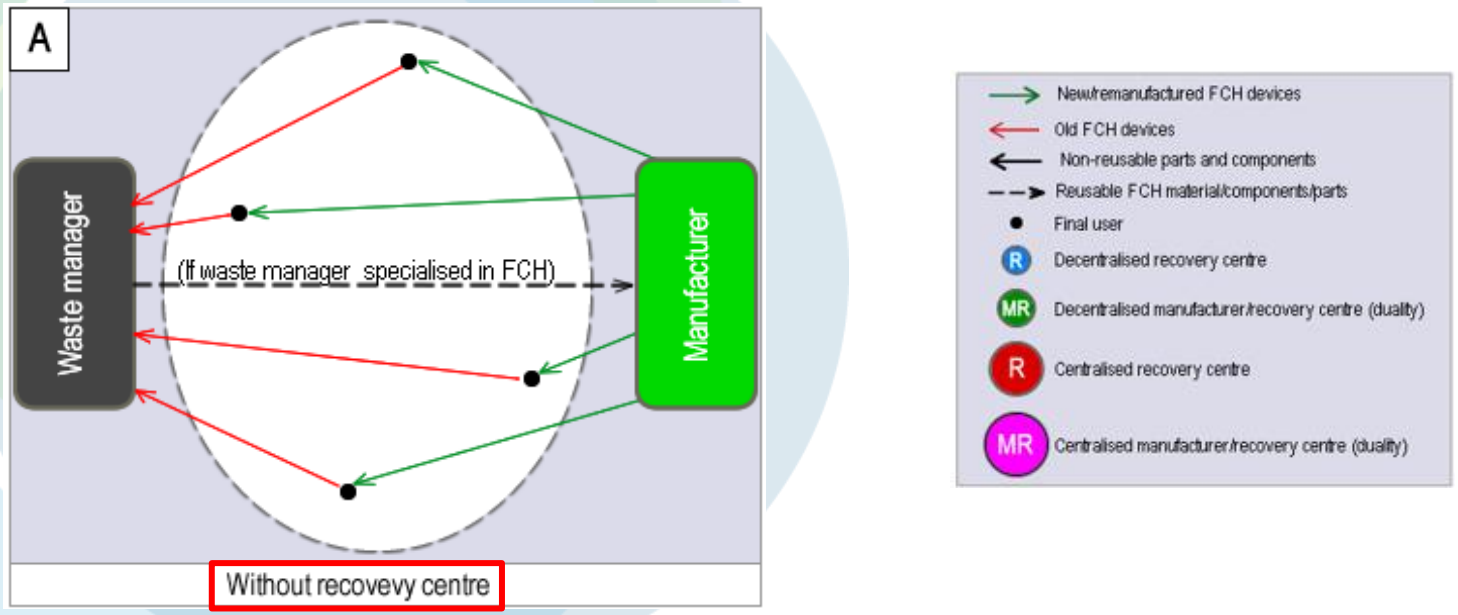
¿Cómo hacer que lleguen los residuos?



Escenarios

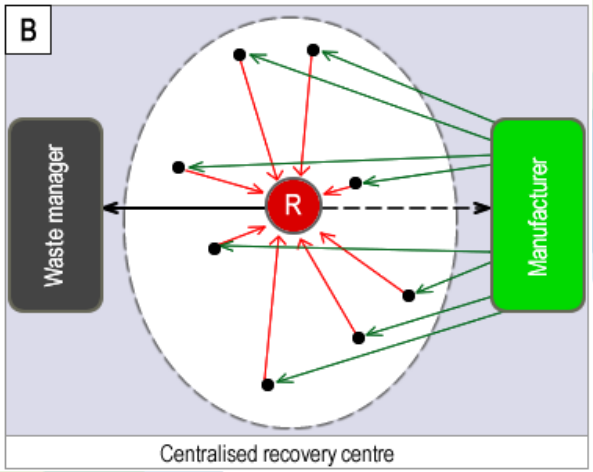
- ✓ Hay distintos roles definidos para los fabricantes de materia prima, los fabricantes de componentes y tecnologías del hidrógeno, los usuarios y los gestores de residuos. También aparece una figura interesante, **el centro de recuperación de componentes**.

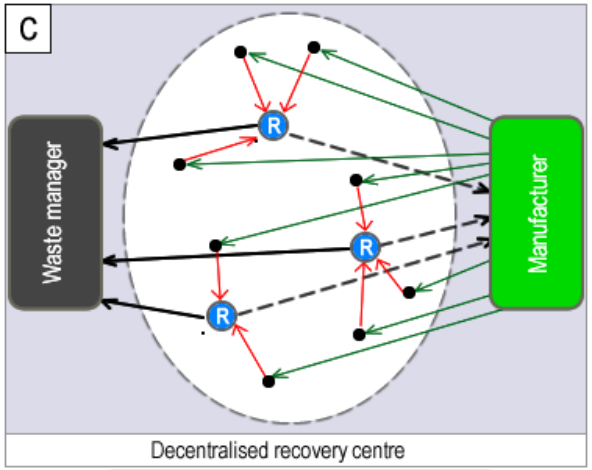
Corto plazo

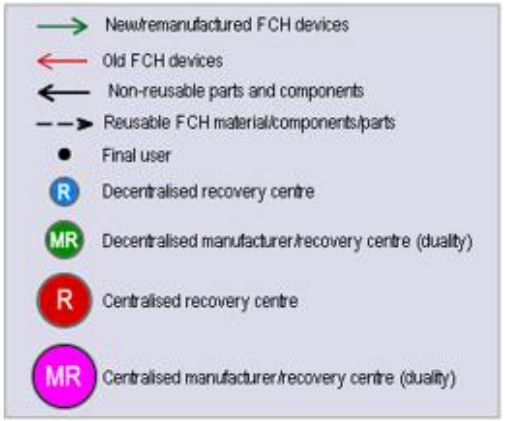


Escenarios

Medio plazo







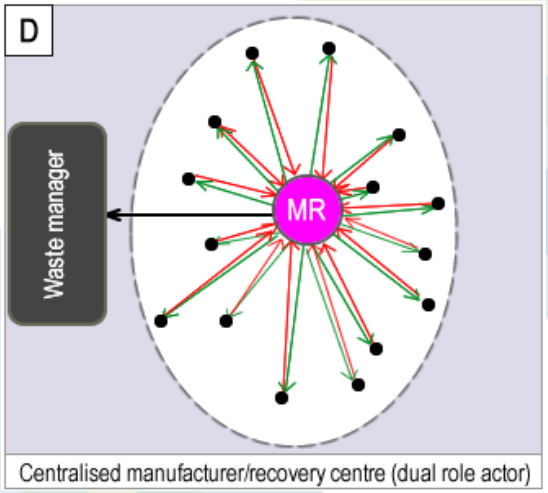
A los centros les llega basura de forma más regular

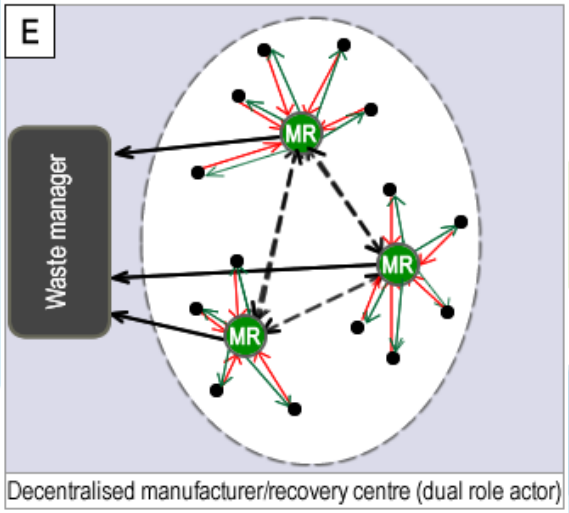
Se promueve la reutilización de componentes

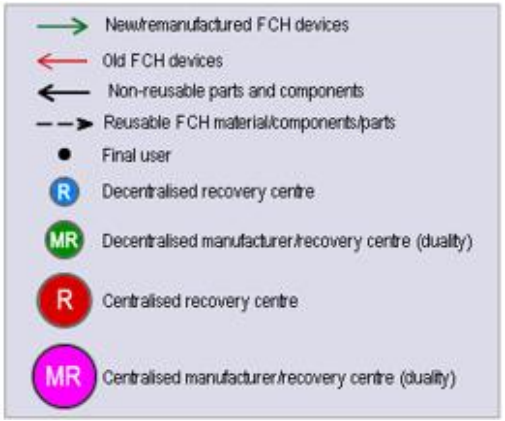
Nuevas tecnologías se implementan a menor coste

Escenarios

Largo plazo







Se mejora el fin de vida y se reducen los costes

Se necesita optimizar la logística

FIN DE CONDICIÓN DE RESIDUO

ANTECEDENTES

- Sexto programa de acción comunitario en materia de Medio ambiente

- Directiva 2008/98/CE de 19 de noviembre de 2008 sobre residuos

Artículo 6

Fin de la condición de residuo

1. Determinados residuos específicos dejarán de ser residuos, en el sentido en que se definen en el artículo 3, punto 1, cuando hayan sido sometidos a una operación, incluido el reciclado, de valorización y cumplan los criterios específicos que se elaboren, con arreglo a las condiciones siguientes:

a) la sustancia u objeto **se usa normalmente** para finalidades específicas

b) **existe un mercado** o una demanda para dicha sustancia u objeto

c) la sustancia u objeto **satisface los requisitos técnicos** para las finalidades específicas, y cumple la legislación existente y las normas aplicables a los productos; y

d)el uso de la sustancia u objeto **no generará impactos adversos** globales para el medio ambiente o la salud.

FIN DE CONDICIÓN DE RESIDUO

REGLAMENTOS EoW EUROPEOS

- Reglamento (UE) nº333/2011 Chatarra de hierro, acero y aluminio
- Reglamento (UE) nº1179/2012 Vidrio recuperado
- Reglamento (UE) nº715/2013 Chatarra de cobre

FIN DE CONDICIÓN DE RESIDUO

Cumplir Criterios Reglamentos EoW

+

Certificar Sistema de Gestión de Calidad conforme Reglamento de aplicación

+

Declaración de Conformidad con reglamento

PRODUCTO

FIN DE CONDICIÓN DE RESIDUO

REGLAMENTO REACH

Los residuos no son materiales a registrar, verificar o autorizar

Las sustancias recuperadas dentro de la UE tienen mismas obligaciones que sustancias originales

Pueden quedar exentas de registro en el REACH si:

- Son sustancia que ya han sido registradas (en origen)
- La sustancias recuperadas ha de ser la misma que la registrada
- Ficha de seguridad o de información

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.

HyTechCycling

HyTechCycling

Environmental and Economical Benefits of FCH technologies and potential penetration

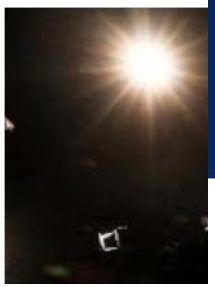
What's up with the Climate Change?

euronews. Europe World Business Sport Culture Style Sci-tech Travel Video Programmes

GOOD MORNING EUROPE

COP24 agreement: Does it go far enough? 4 COMMENTS

By Euronews • last updated: 17/12/2018



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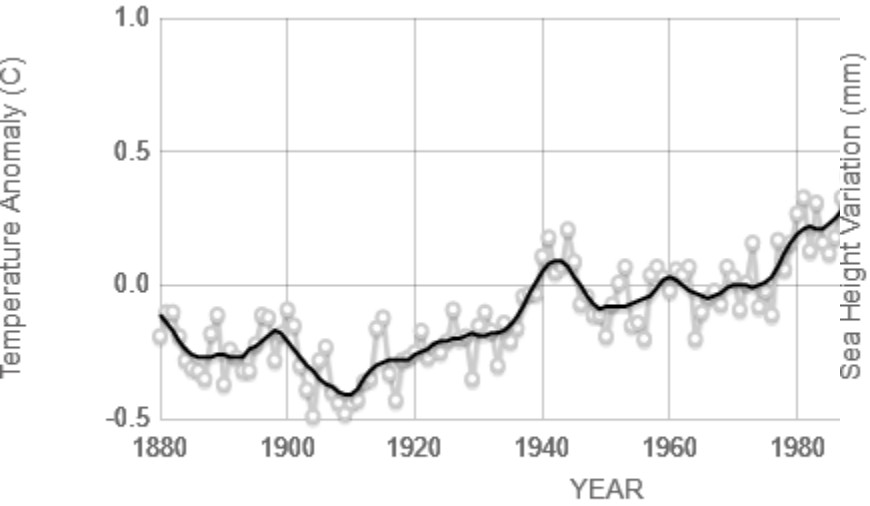
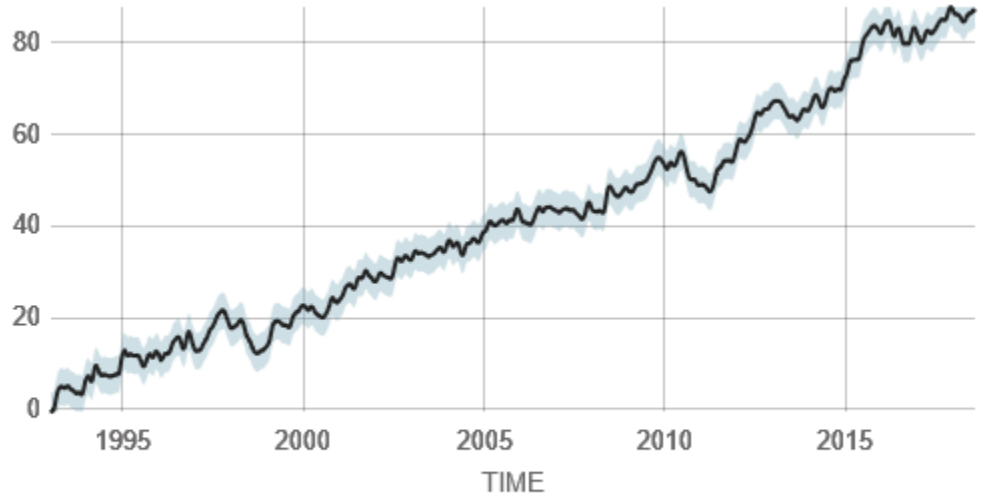
The Upside How Cape Town was saved from



Source: climate.nasa.gov



Source: climate.nasa.gov

FCH FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

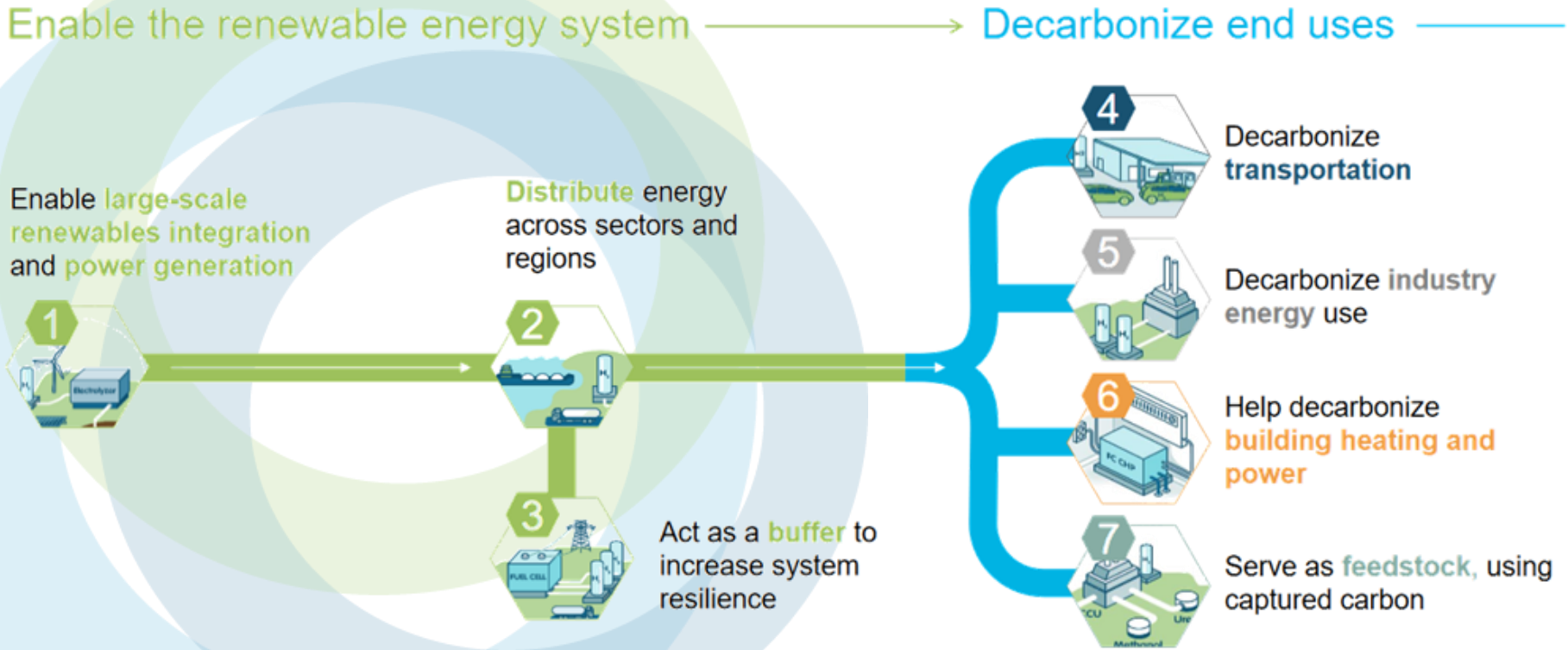
Ha FOUNDATION FOR THE DEVELOPMENT OF NEW HYDROGEN TECHNOLOGIES IN ARAGON

institute iMdea energy

GRUPO LÓPEZ SORIANO LS

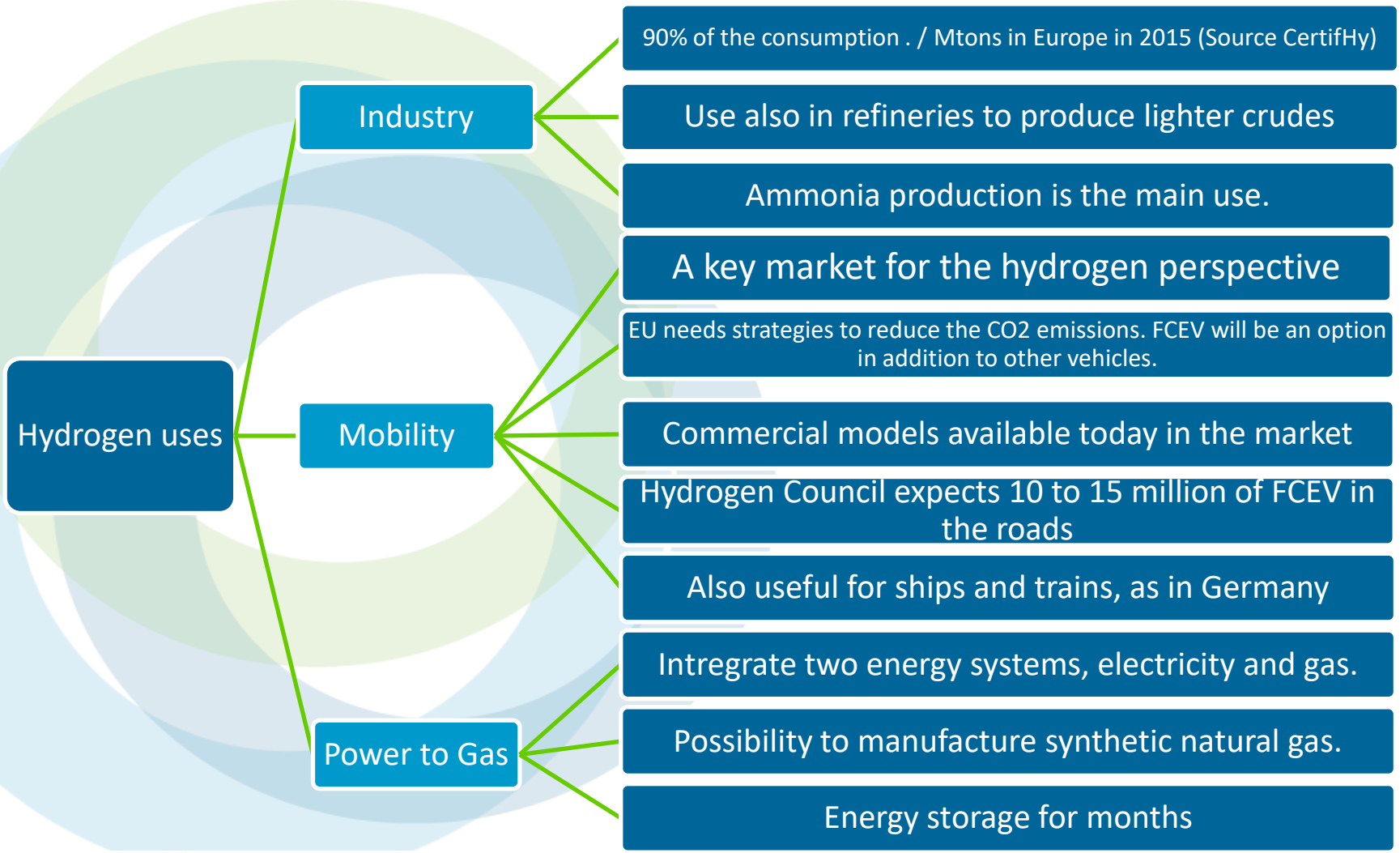
ENVIRONMENT PARK Parco Scientifico Tecnologico per l'Ambiente

Why Hydrogen?

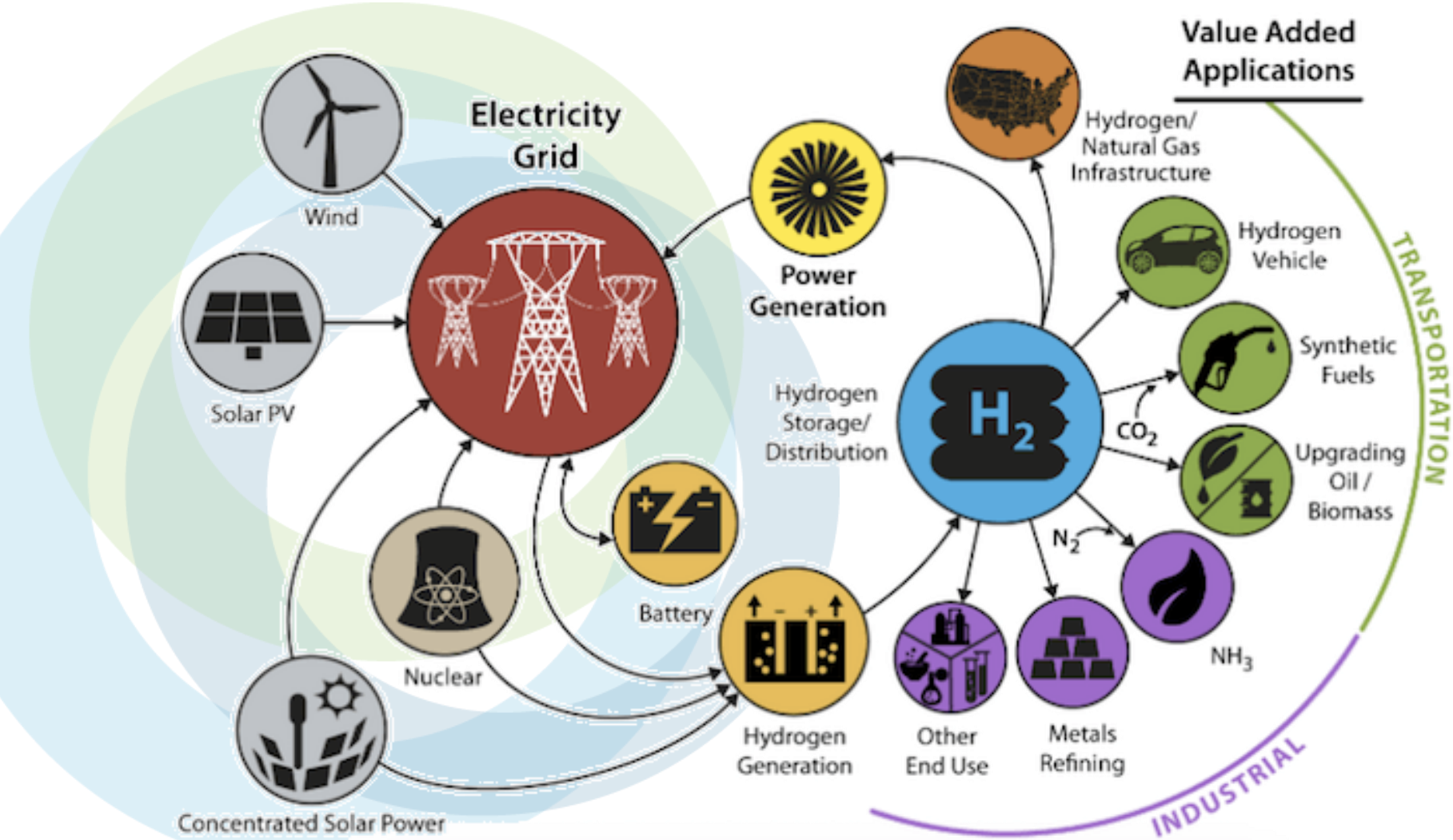


Source: Hydrogen Council

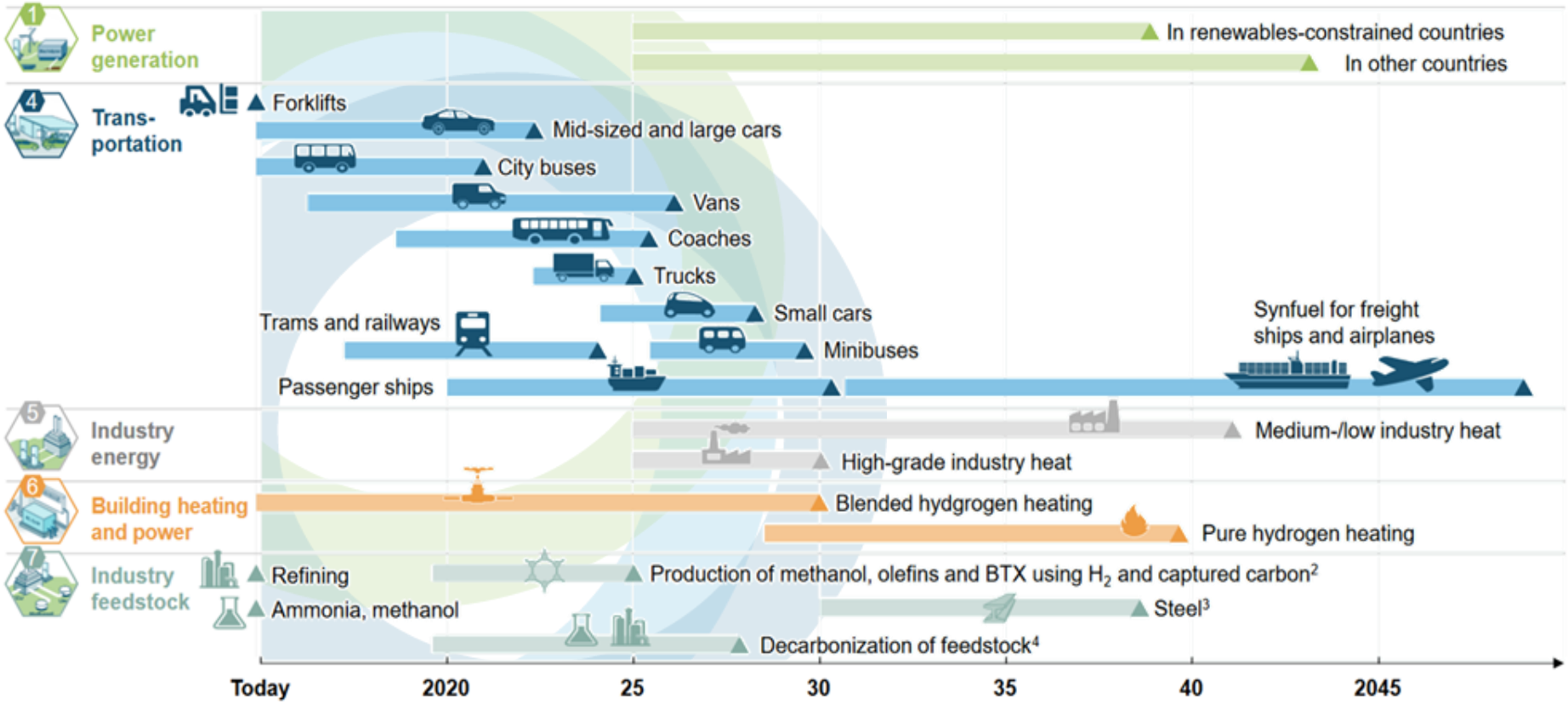
Current hydrogen uses



Hydrogen uses



What will be done with H2 in the future



Source: Hydrogen Council

Environmental benefits

World Health Organization

Health Topics | Countries | News | Emergencies | About Us

Air pollution

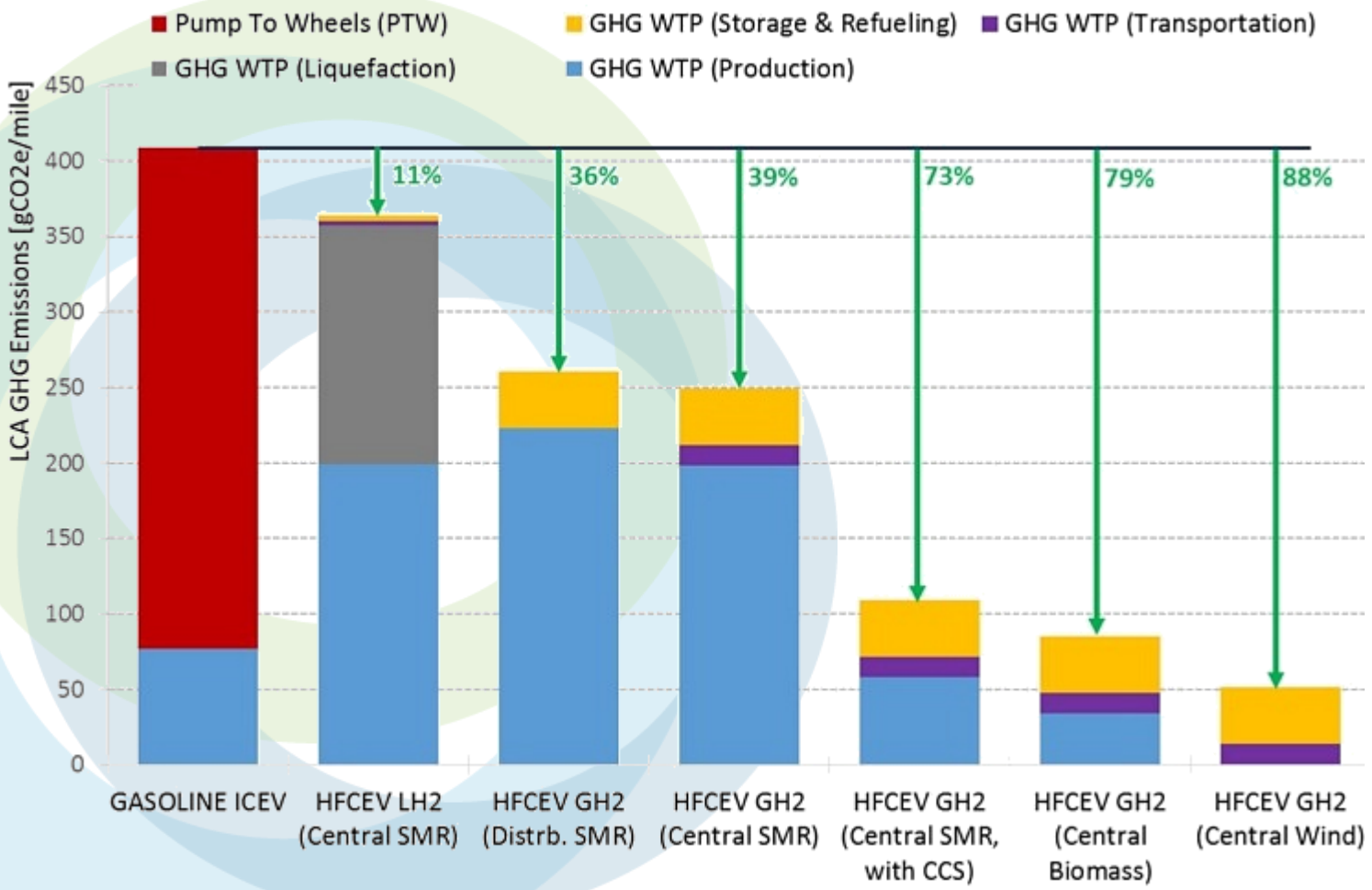
- Air pollution
- Ambient air pollution
  - Health impacts
  - Pollutants
  - Interventions and tools
  - Policy and progress
  - Outreach and advocacy
- Household air pollution

Ambient air pollution - a major threat to health and climate

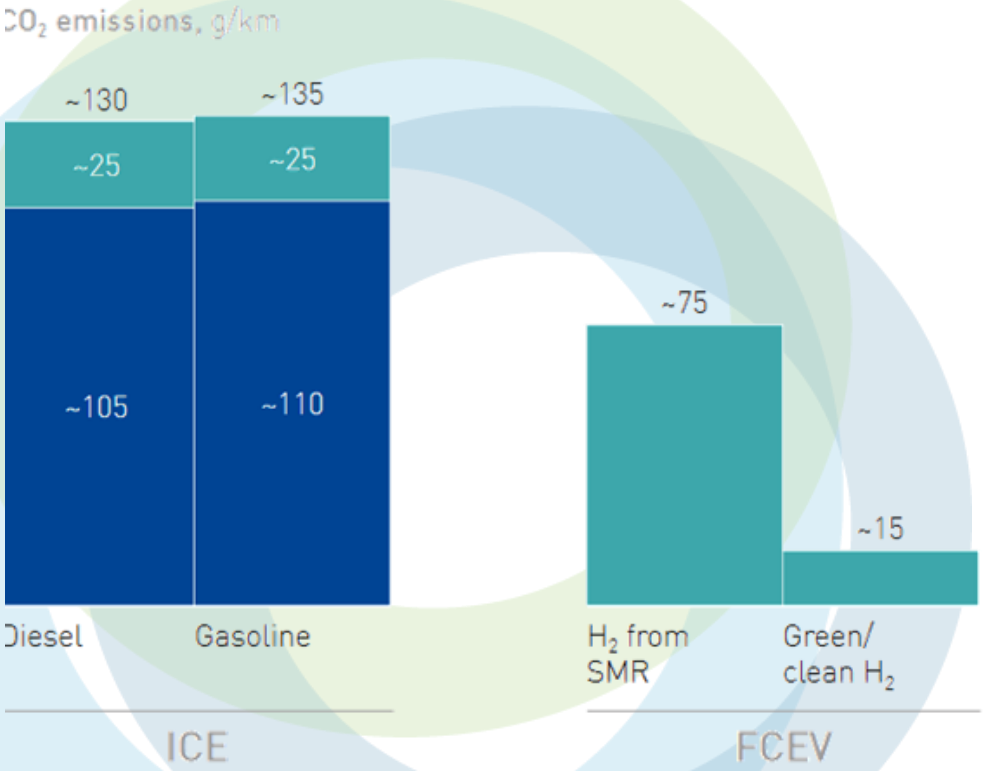
Ambient air pollution accounts for an estimated 4.2 million deaths per year due to stroke, heart disease, lung cancer and chronic respiratory diseases. Around 91% of the world's population lives in places where air quality levels exceed WHO limits. While ambient air pollution affects developed and developing countries alike, low- and middle-income countries experience the highest burden, with the greatest toll in the WHO Western Pacific and South-East Asia regions.

Policies and investments supporting cleaner transport, energy-efficient housing, power generation, industry and better municipal waste management can effectively reduce key sources of ambient air pollution.

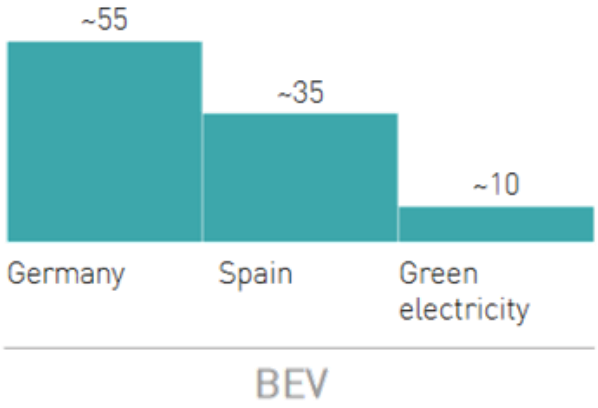
Environmental benefits



Source: https://greet.es.anl.gov/publication-c2g-2016-report

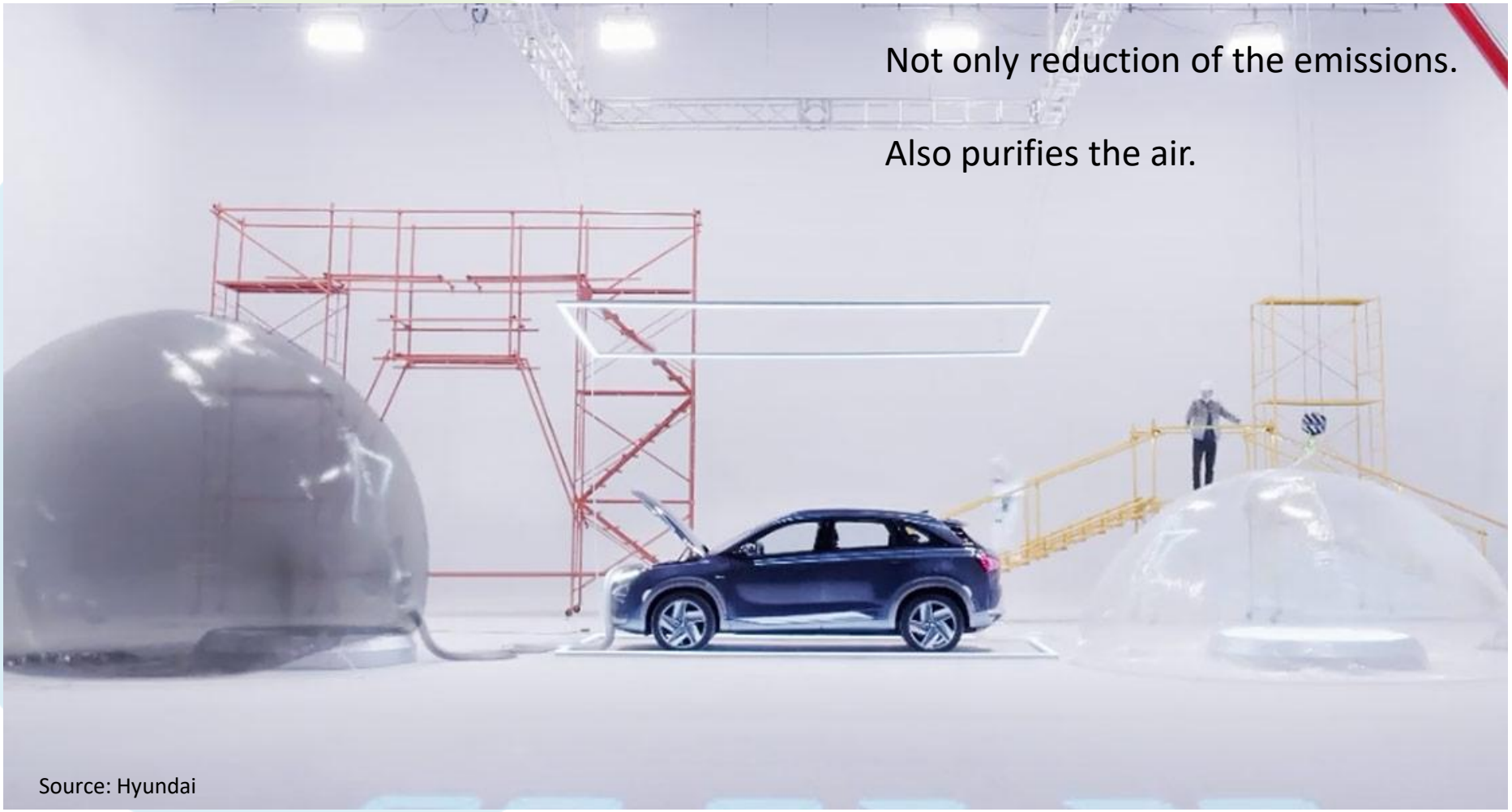


The cleaner the electricity source is, the smaller the emissions are.



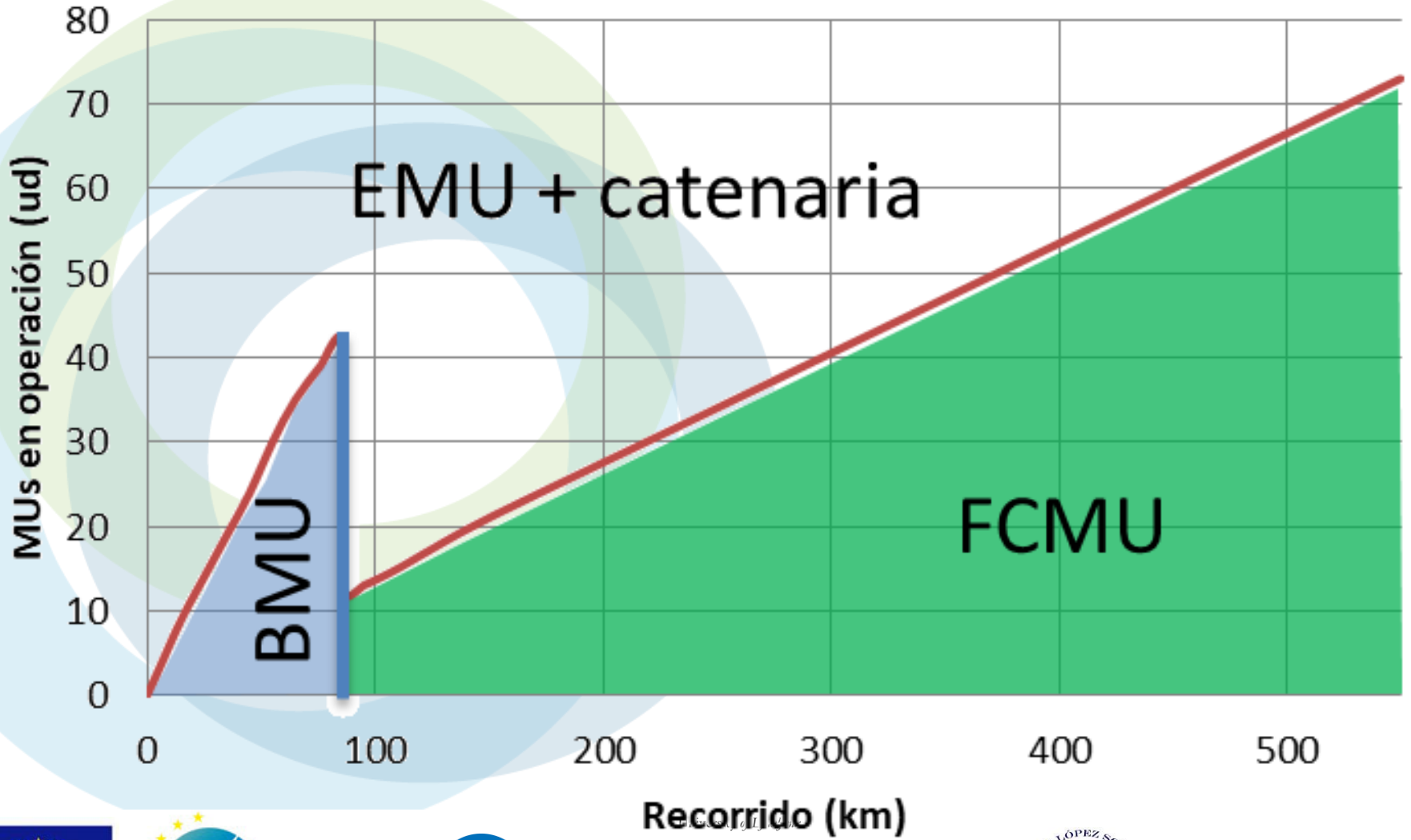
Source: Hydrogen Roadmap Europe (FCH JU)

Environmental benefits

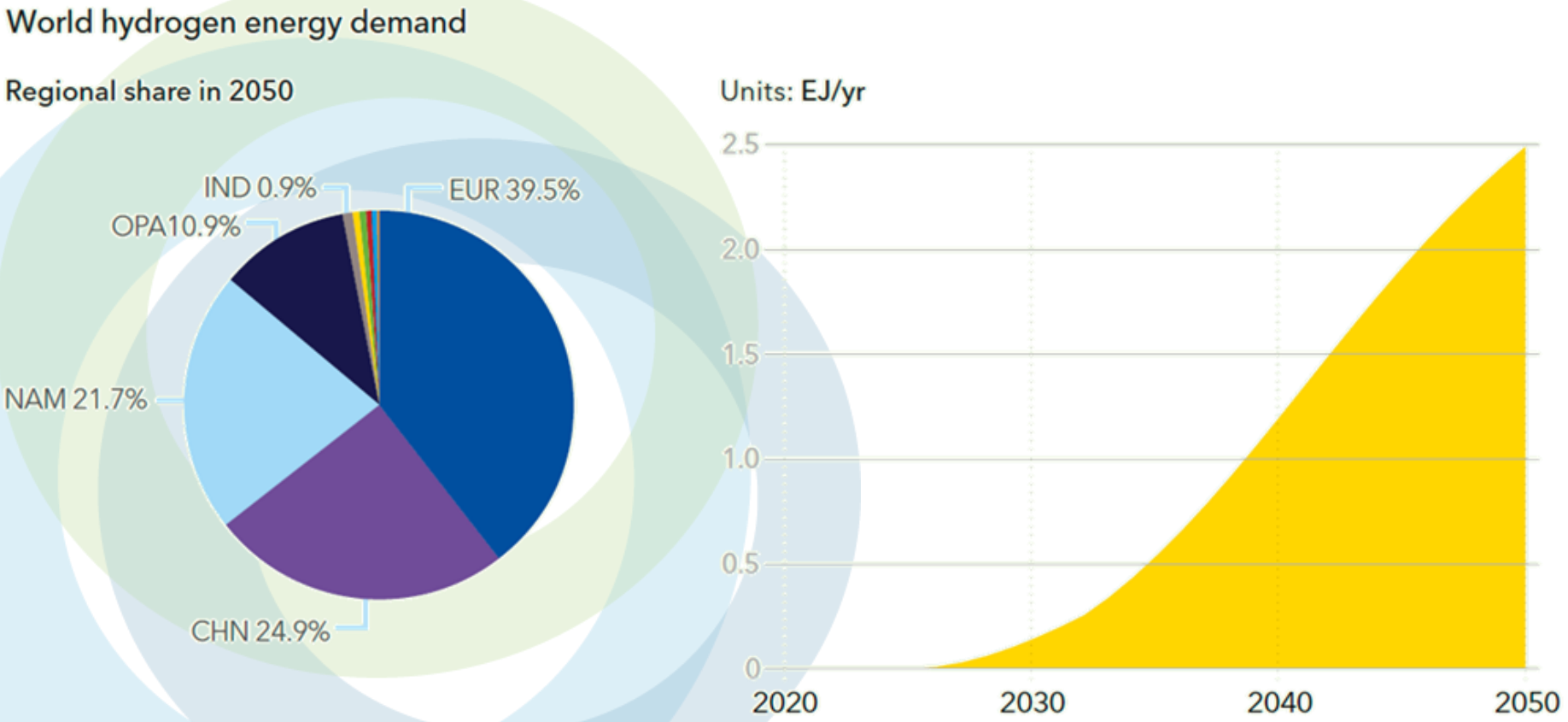


Source: Hyundai

Economical benefits



Perspectives



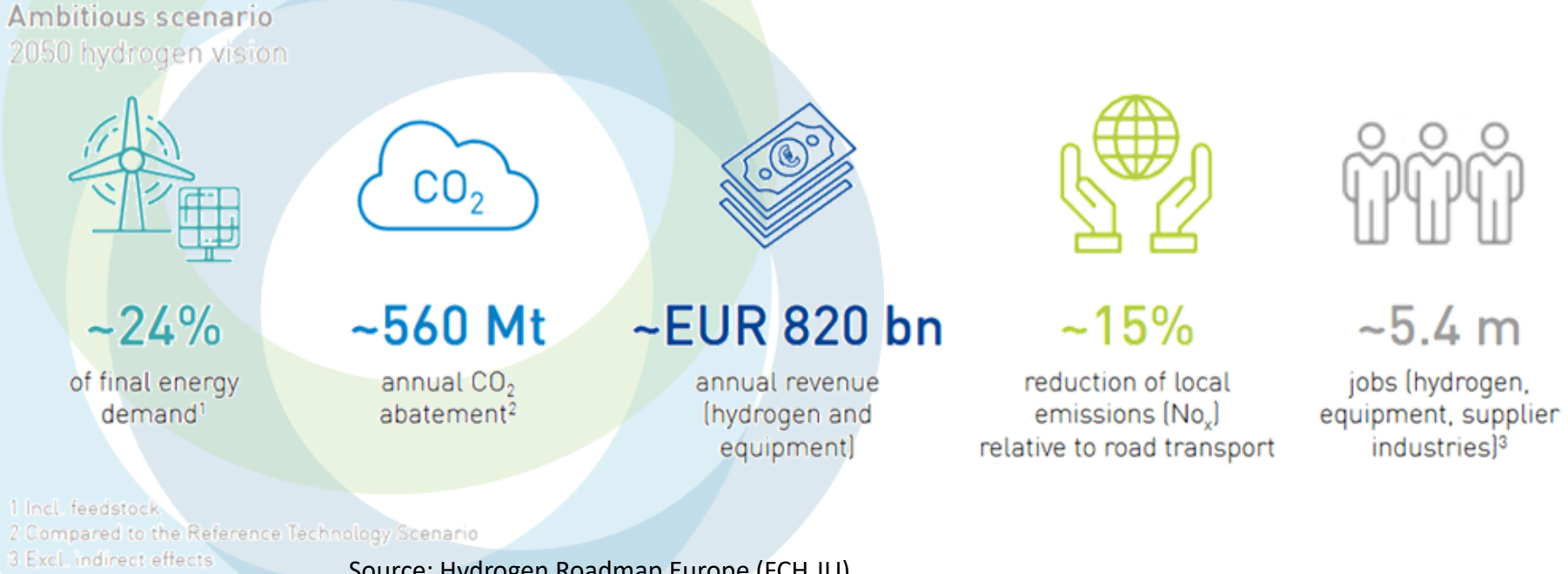
Source: DNV GL Energy Transition Outlook 2018

Future worldwide vision

In 2050

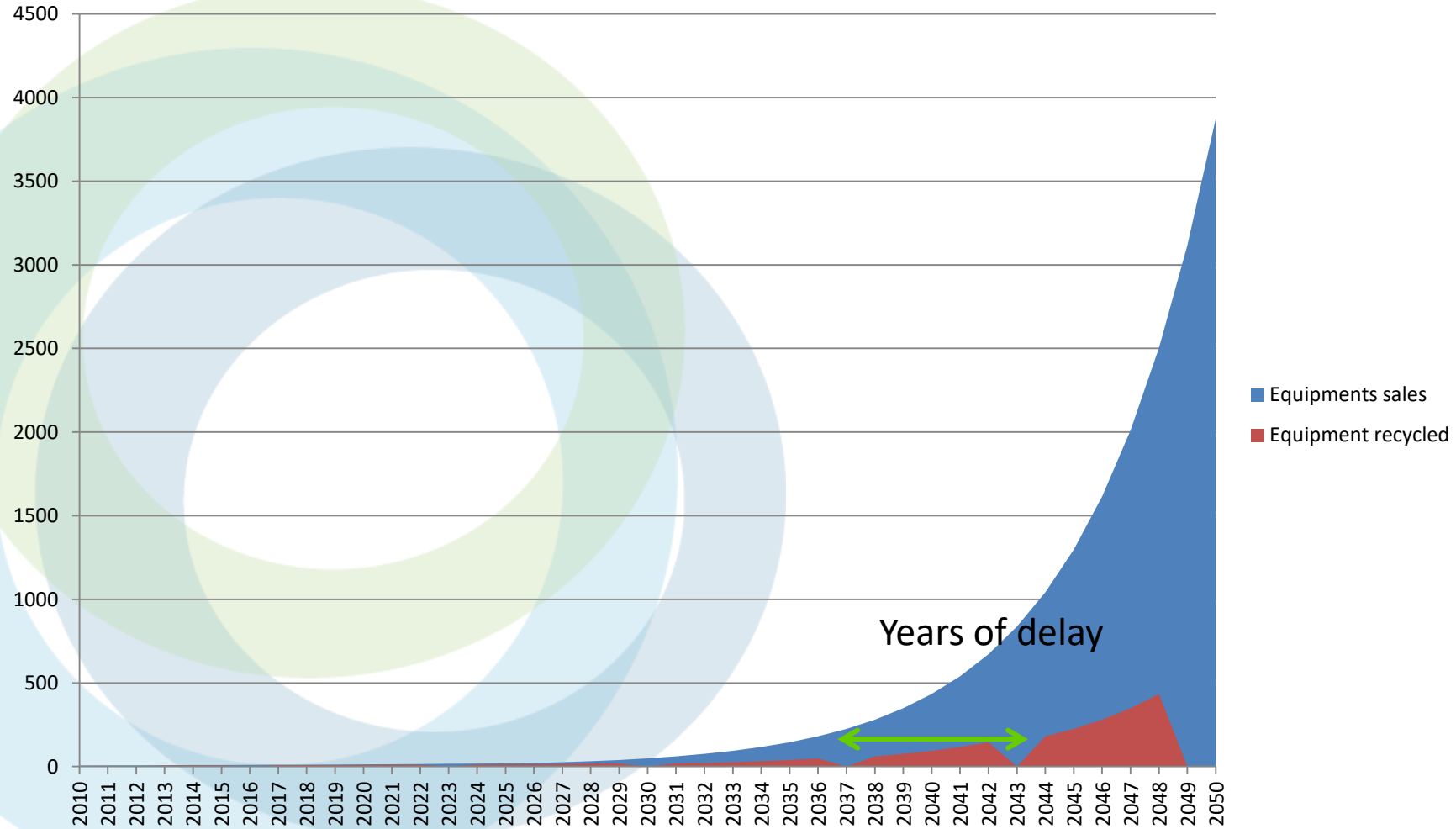
SOURCE: Hydrogen Council; IEA ETP Hydrogen and Fuel Cells CBS; National Energy Outlook 2016

Future European vision



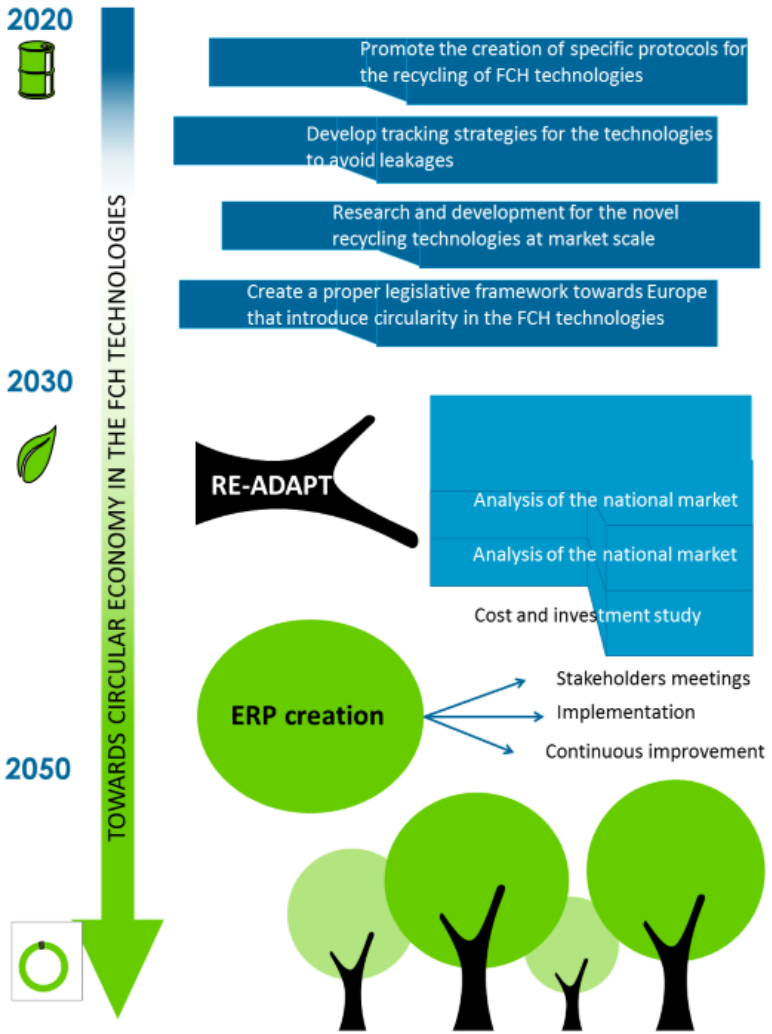
Source: Hydrogen Roadmap Europe (FCH JU)

Nevertheless, the recycling will come later



Towards circular economy in the FCH technologies roadmap

The future must become greener and greener if the society expects to leave a better world for the future generations. This movement should be promoted with technologies as hydrogen, which is a key component for the future playing a role in the balance of the grids, as industrial feedstock and being a way to promote a real and efficient decarbonisation of the transport sector.



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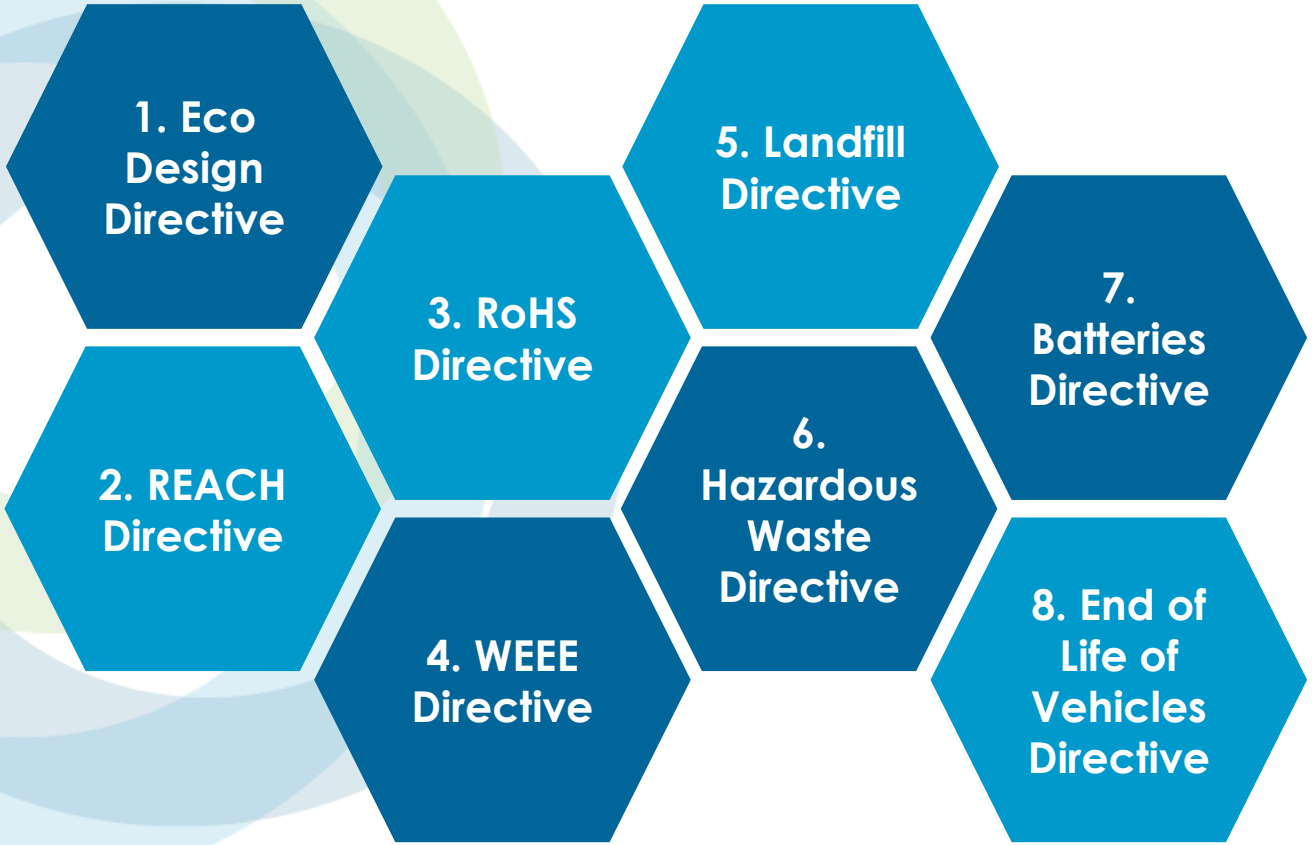
HyTechCycling

HyTechCycling

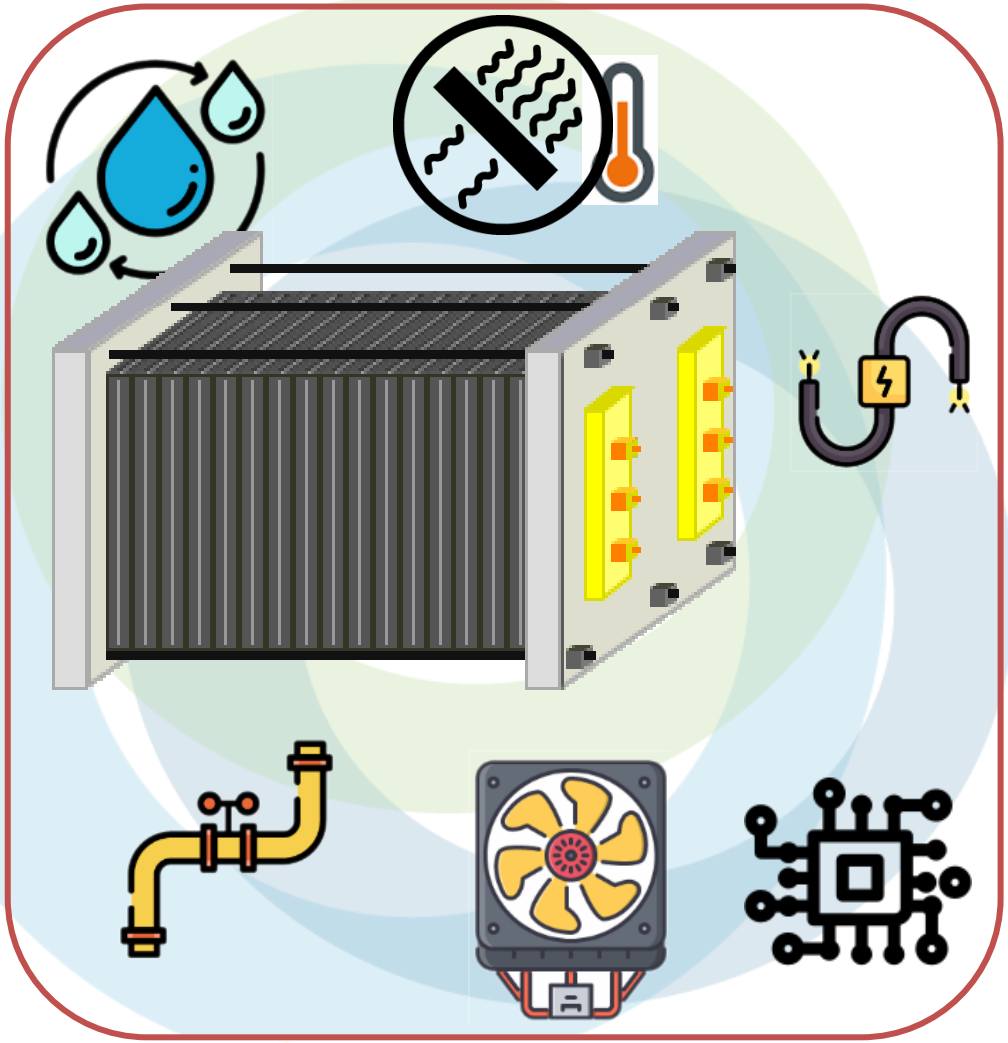
RCS regarding recycling and dismantling of FCH technologies

Regulations that applies to FCH technologies

There is no proper legislation around the FCH technologies. Which directives could affect FCH technologies?



Separation



Stack components

BoP components

Legislation reference to life cycle of a FCH system

Life cycle of FCH	DIRECTIVES	FCH stack	BoP components	power conditioning	Batteries	Cabinet	FCH product	FCEV	CHP
Design	Eco Design Directive	X	X				X	X	X
Material selection	REACH Regulation	X	X				X		
	RoHS Directive			X			X		
End of life management	WEEE Directive	X	X	X			X		
	Landfill directive	X	X	X	X	X	X	X	X
	Hazardous waste Directive	X	X						
	Batteries Directive				X			X	X
	ELV Directive							X	

Regulatory barriers analysis

Hazardous materials in FCHs and barriers on REACH Regulation

Affect the deployment mainly in relation to future restriction on use of hazardous materials

Critical raw materials

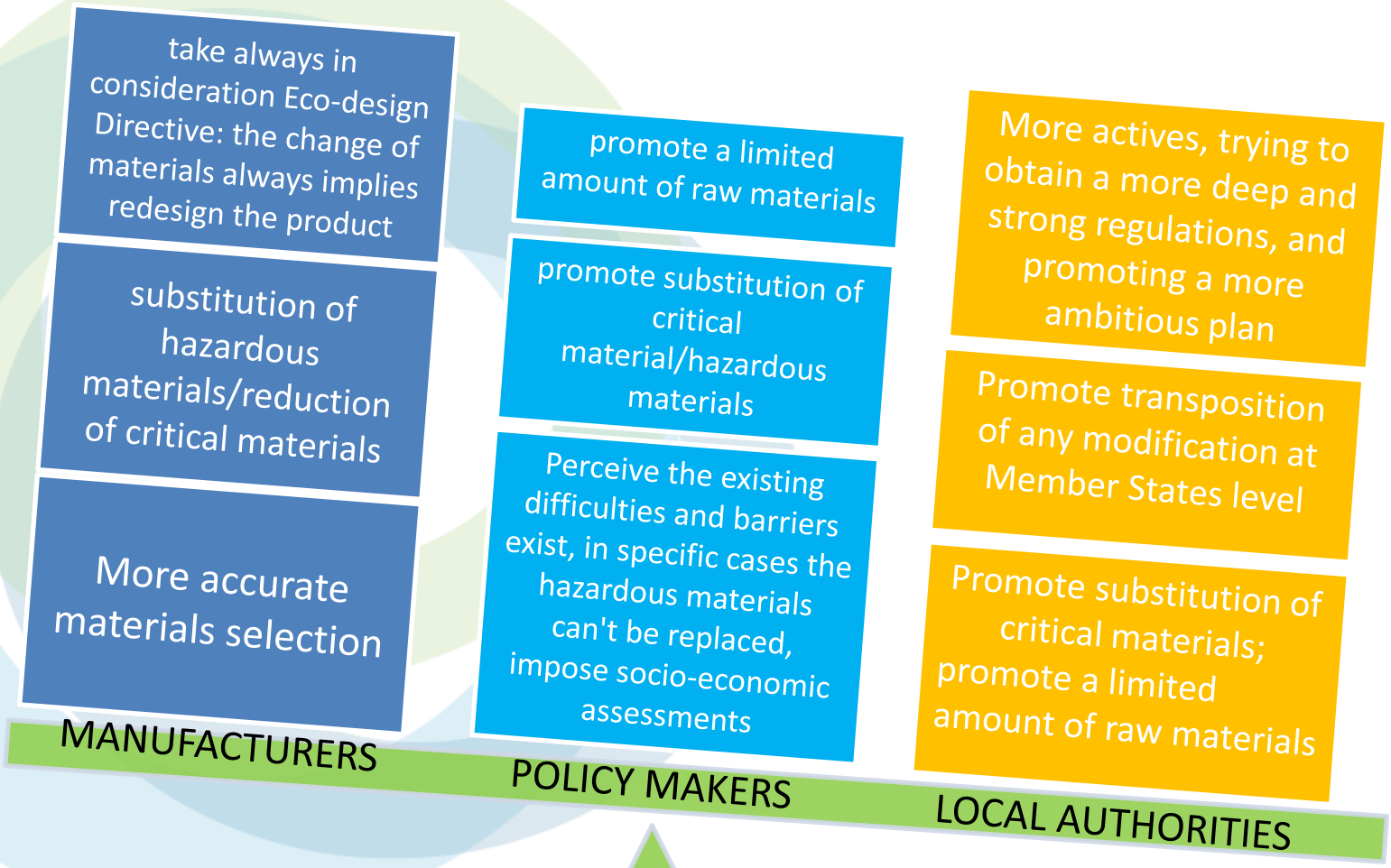
- Pt based & REE

problems mainly due to an increasing cost of materials and a decreasing availability, impact in the production system and limit its commercialization.
→Manufacturers must consider during design-phase.

Presence of specific hazardous materials

(Pb, Hg, ….) could limit commercialization or impose substitution (RoHS Directive)

Recommendations for stakeholders/target gruops



Regulatory barriers analysis

interests of producers, users and recyclers not aligned

Eco-design Directive does not mention FCH technologies explicitly, but it applies to all energy products

Reduced number of recycled materials

Eco-Design

Re-use of components?

this imply a new design of the products in order to optimized the recycling and disassembling phases:

- ✓ all agree it can be sustainable as far as the reliability of the FCSs are guaranteed if compared with FCHs mounting new components
- ✓ all think it is easier for the BoP components
- ✓ 80% of FCHs manufacturers already implement used materials in the design
- ✓ some of them are developing but mainly with the bipolar plates, but not yet developed it in the stacks
- ✓ 40% of them think as many components as possible are recycled or refurbished
- ✓ all agree the most important step is to find a suitable procedure to recycle the different components.

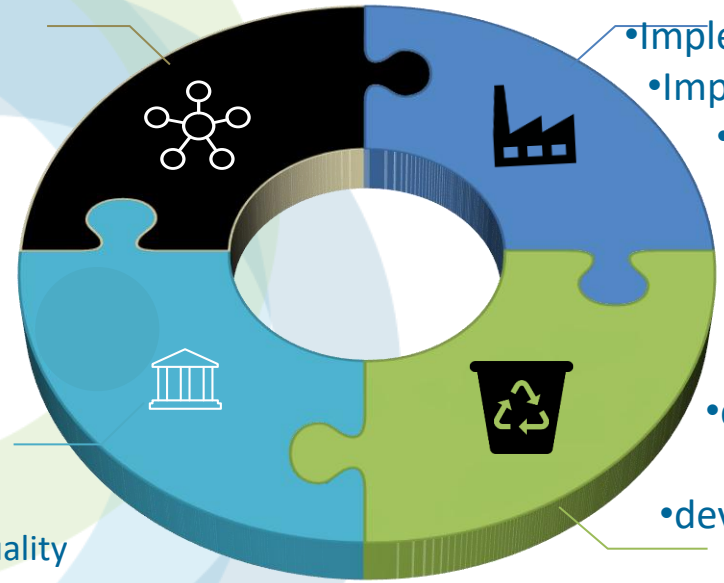
Use of recycled raw materials?

What emerged from the surveys is that the manufacturers agreed that recycled material could be used. In terms of the PGM it is a closed cycle already, cell plates and platinum are already being recycled in some cases and also some mechanical components from bipolar plates, can be recycled after an intermittent cleaning step.

Recommendations for stakeholders/target groups

•Specific agreeements between manufacturers&RCs: assure recycling centers to profit from recycling FCH technologies

• **working group** creation with the main actors involvement



MANUFACTURERS

•Harmonization of the design process in order to facilitate the dismantling stage.
•Reduction in weight and volume of the product
•Implementation a modular concept
•Improve the quality and durability
•creation of recyclability charts
•increase the rate of reused components/material

EU Policy makers& local authorities:

•promote agreements , working groups and innovation deals;
•promote eco-design;
•impose of a minimum standard of quality and durability;
•impose a rate of recycled materials used
•promote recycling
•look for new ways to promote recycling ratios, also involving society;
•reduce number of recycled materials

RCs

•develop a more environmental friendly method of recycling
•develop a more detailed research recycling methods
•guarantee the highest recycling ratio possible
•guarantee the origin of the material

Barriers and recommendation in EoL regulations

REGULATIONS	BARRIERS	MANUFACTURERS	POLICY MAKERS	LOCAL AUTHORITIES
Waste Framework	Market delay-entry: differences in national legislations as regards the definition of waste	cooperation in the definition of waste	☐ Harmonization of transboundary waste movements; ☐ Harmonisation of waste regulation in EU countries. Clarification of the "waste" and "end of waste" status and its harmonisation within different countries it is necessary to develop the market. Once a material, device, etc is classified as waste, before being use as "raw material" again, it has to be declassified as a waste. Depending on the country, this step could be not possible	more actives, trying to obtain a more deep and strong regulations, and promoting a more ambitious plan
WEEE Directive	large stationary systems out of scope	collect the main information on the product and to propose the inclusion of "large stationary power generation systems" in the WEEE Directive product list	change the scope of the Directives including also LARGE STATIONARY systems	☐ influence the change of Directive and promote transposition □ more actives, trying to obtain a more deep and strong regulations, and promoting a more ambitious plan
Landfill Directive	need of a pre-treatment prior to the disposal to landfill	find a solution for the main parts of the FCHs system and mainly the stack in order to comply with the law and enter in the market with large volumes	perceive the existing difficulties and barriers exist and to incorporate changes of regulation	□ promote transposition of any modification at Member States level □ also being more actives, trying to obtain a more deep and strong regulations, and promoting a more ambitious plan □ involvement of the society

Barriers and recommendation in EoL regulations

REGULATIONS	BARRIERS	MANUFACTURERS	POLICY MAKERS	LOCAL AUTHORITIES
Hazardous waste Directive	☐ damage the environmental beneficial image promoted by FCH manufacturers and developers ☐ delay the market entry	☐ provide a detailed life cycle assessment in order to stay below the limits in final waste and prevent damage to the technology image ☐ perform a correct choice of materials in the design phase of technology	impose a LCA analysis ijn order to guarantee the limit respect	□ promote transposition of any modification at Member States level □ also being more actives, trying to obtain a more deep and strong regulations, and promoting a more ambitious plan
ELV Directive	restrictive targets for reuse&recovery and reuse&recycle, respectively of 95% and 85% of the vehicle by weight	☐ FCH manufacturers have to consider the target and transpose it mainly to the Fuel cell stack ☐ Look for a progressive reuse and recycle ratio in FCEV vehicles, as far as the technology is not widely implemented yet.	impose ratio of reused and recycled materials	promote transposition of any modification at Member States level

Codes and Standards in RCs

Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products **ECO-design directive**

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives referred to as **Waste Framework Directive** or **WFD**

Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste last amended by Council Directive 2011/97/EU of 5 December 2011 referred to as **Landfill Directive** complemented by 2003/33/EC: Council Decision of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC

Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) **IPPC Directive**

Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment **RoHS Directive**

Codes and Standards in RCs

Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) **WEEE Directive**
Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles - Commission Statements **ELV Directive**
Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC **Batteries Directive**
Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC **REACH**
REGIONAL OR LOCAL LICENCES, FACILITY OR MANAGEMENT PERMIT, REGISTRATION OR PRIOR NOTICE OR OTHER ADDITIONAL

Similarities

DIRECTIVES	MANUFACTURERS	RECYCLING CENTERS
Eco Design Directive	X	X
REACH Regulation	X	X
RoHS Directive	X	X
WEEE Directive	X	X
Landfill directive		X
Hazardous materials Directive	X	
Batteries Directive	X	X
ELV Directive	X	X
Waste Framework Directive		X
Integrated Prevention Pollution and control		X

Disassembly differences

Manufacturers estimation of time (hours) for the disassembly time by their operator in their facilities:

PEMFC	2
PEMWE	28
AWE	16
SOFC	3

Nevertheless, the general purpose recycling centre expect higher times due to their operators, what increase the recycling costs.

¿How to solve this?

The idea is here to raise modularity and to help in the disassembly stages.

Conclusion


Propose specific FCH Directives
provide evidence of Eco-design improve the choice of materials
Organize Working group and settle agreements
Reduce the use of hazardous materials
focus on strategies for end-of-life management

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.

HyTechCycling

HyTechCycling

New strategies according the End of Life

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

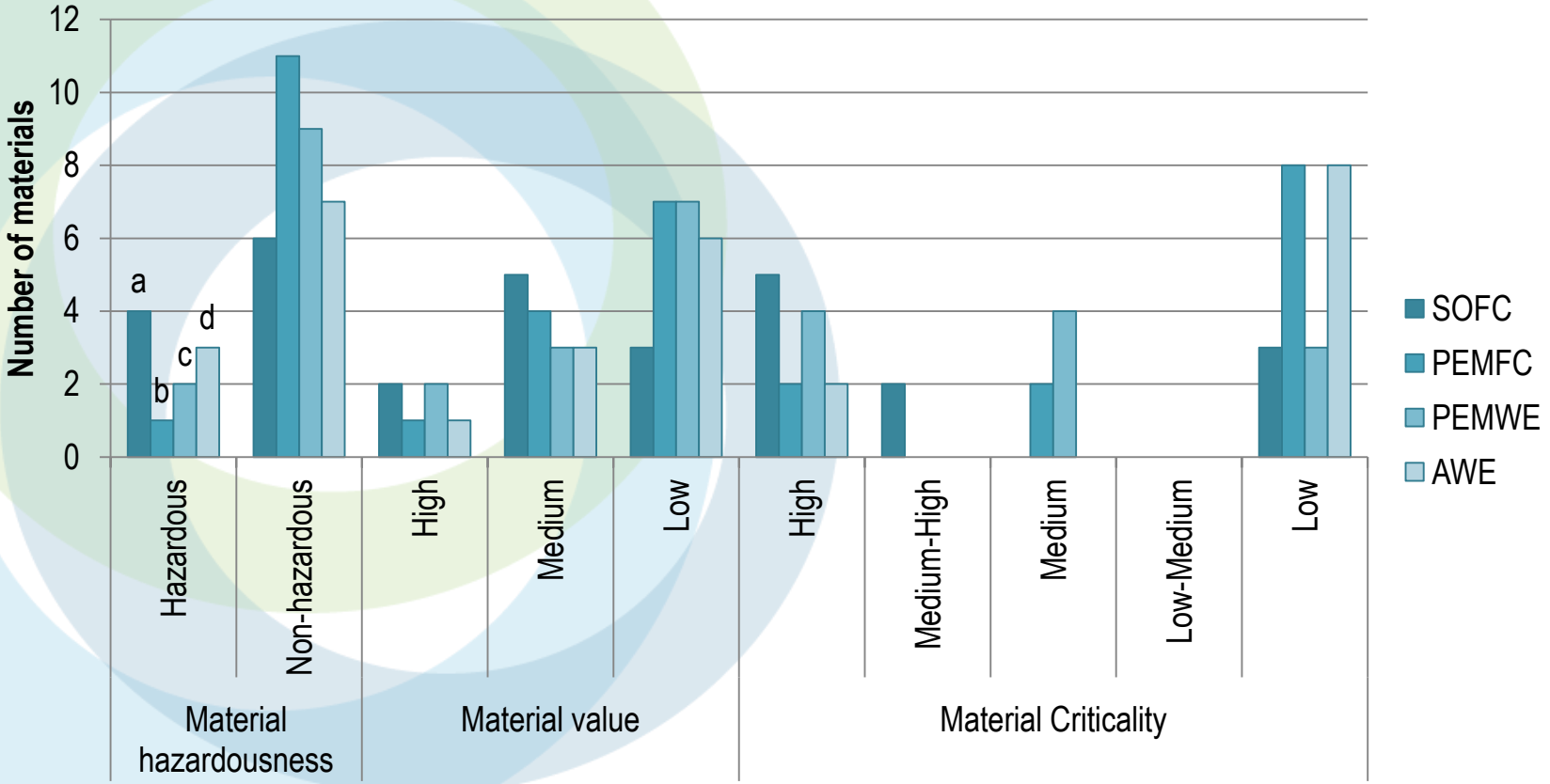
SOFC

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

HyTechCycling 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

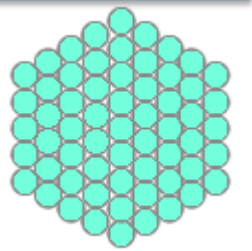
In AWE stacks

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

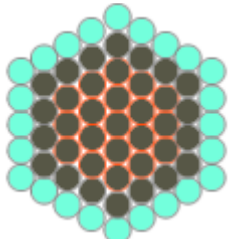
In PEMFC and PEMWE stacks

Core-shell catalyst structure

Conventional structure



Core-shell structure

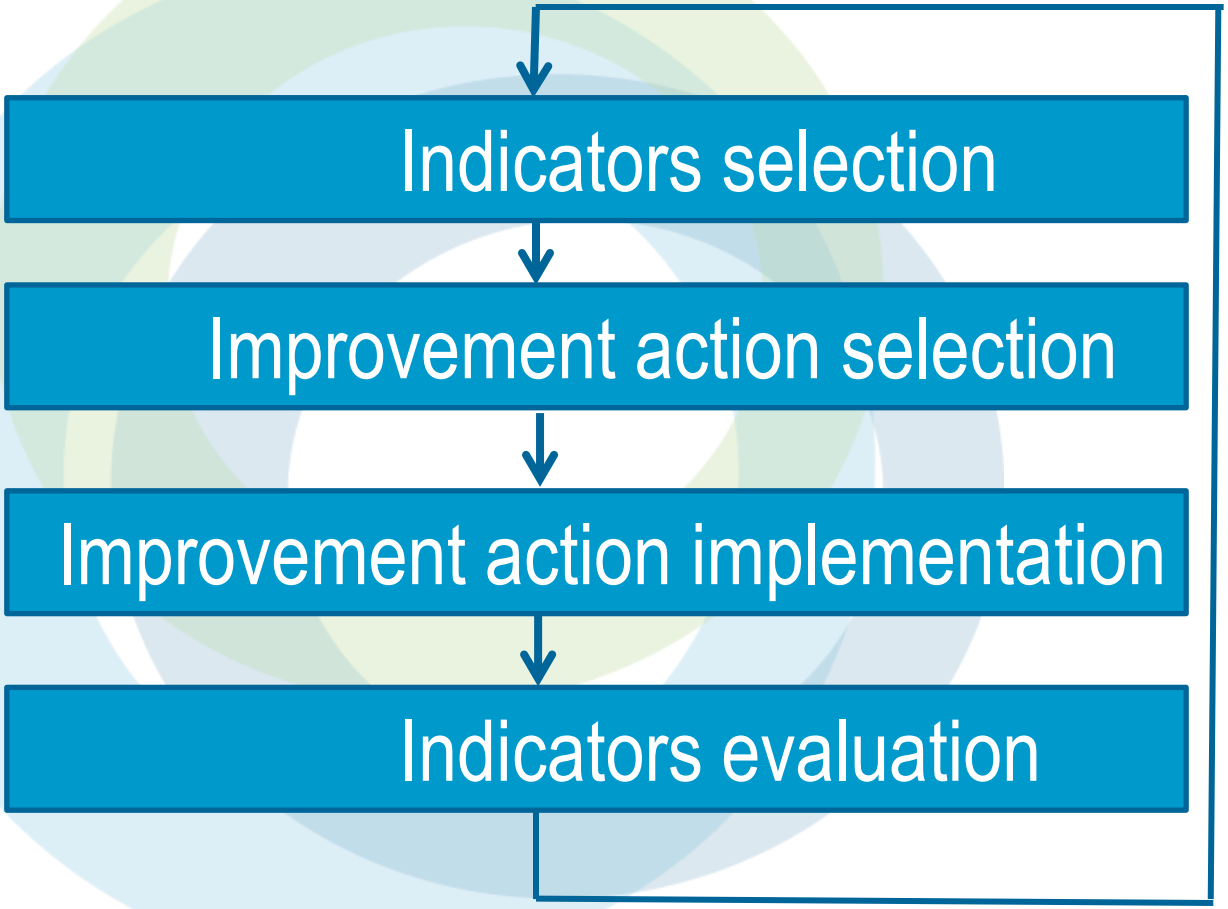


Pt particles

non-Pt particles

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

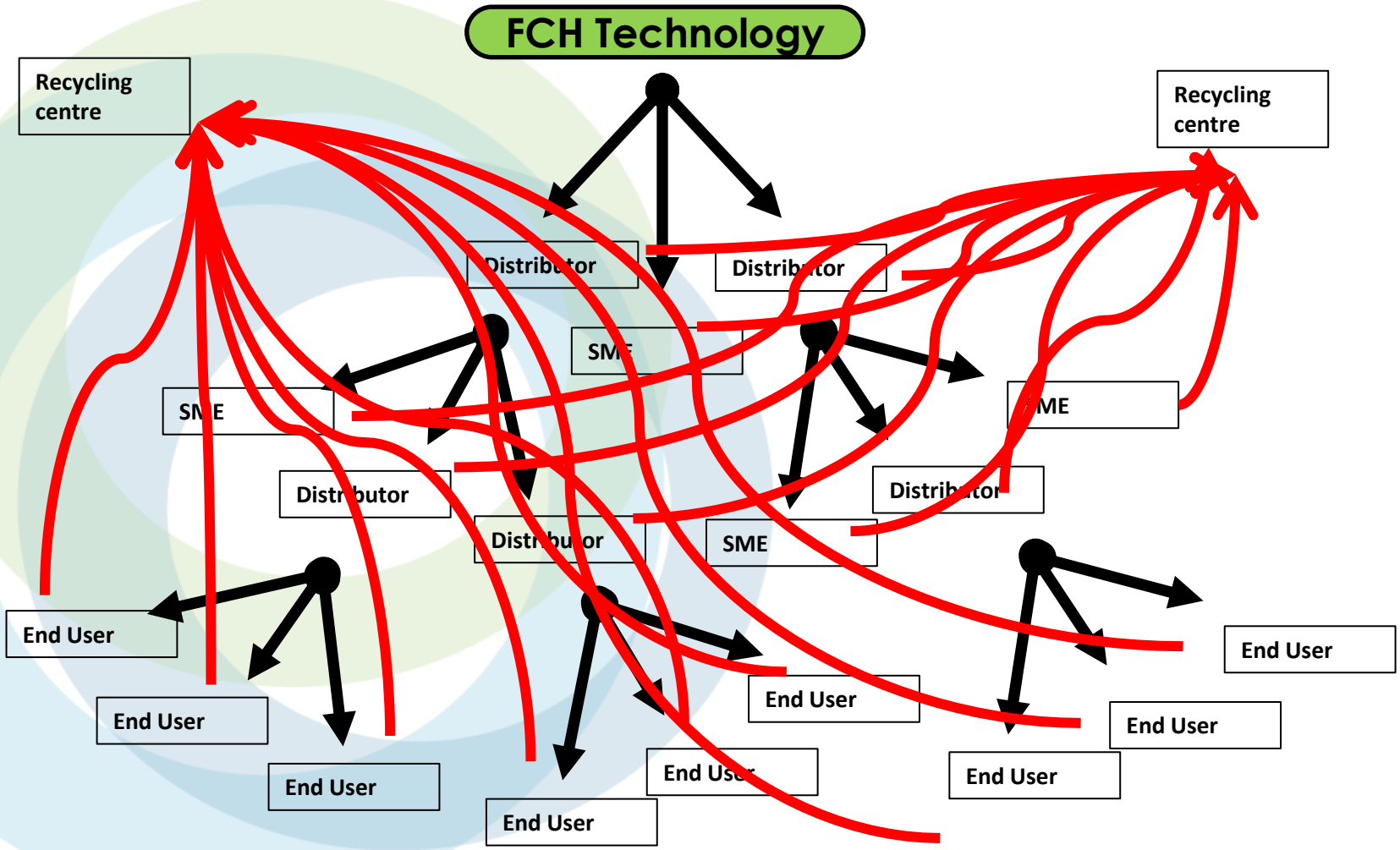
EcoDesign



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.

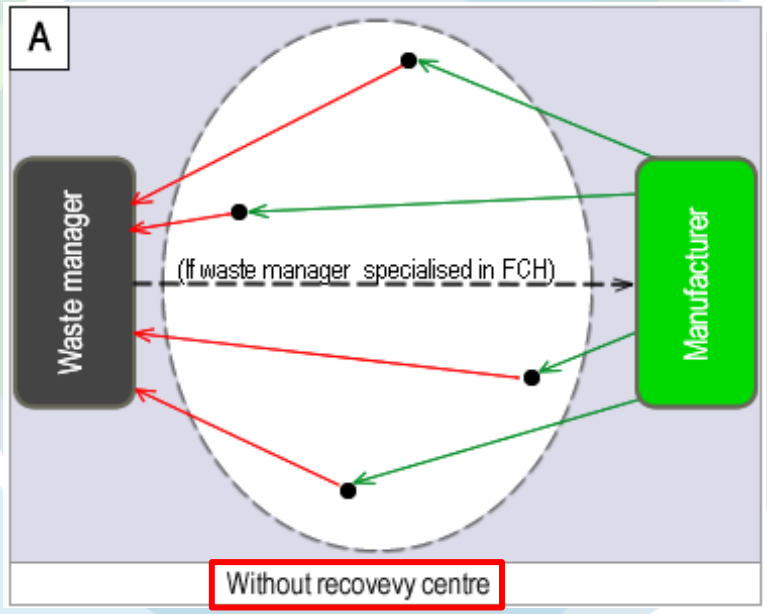
Reverse Logistics

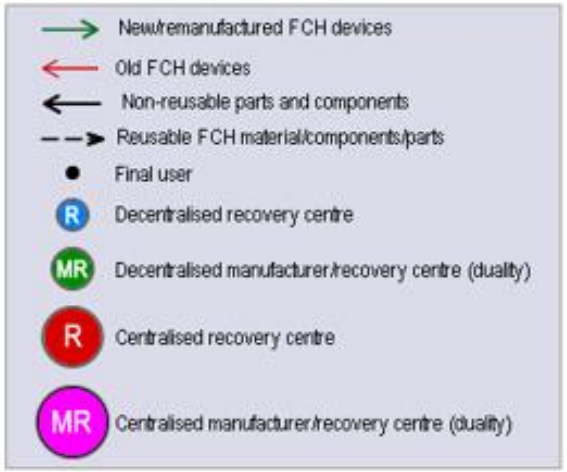


Scenarios

- ✓ 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.

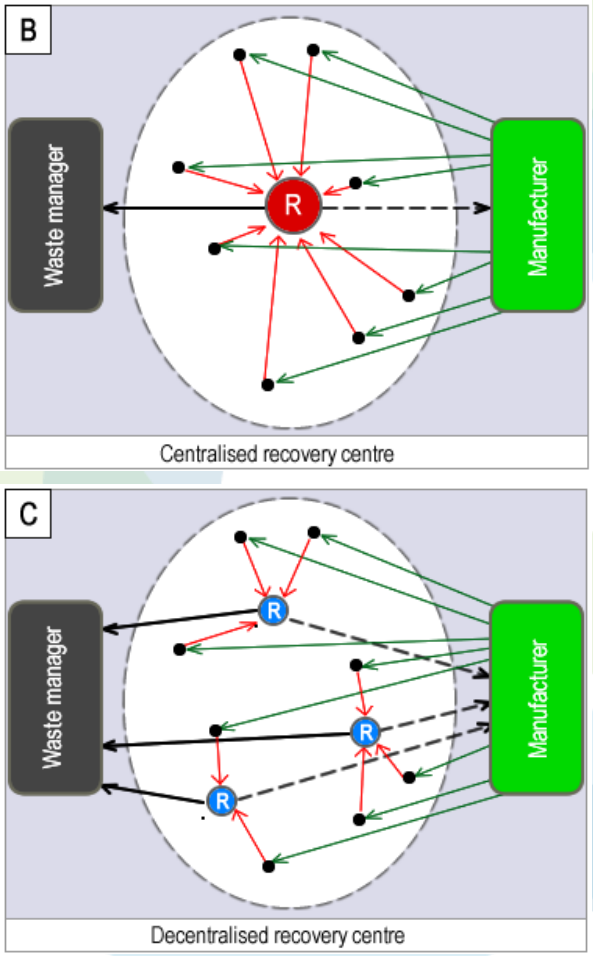
Short-term scenario

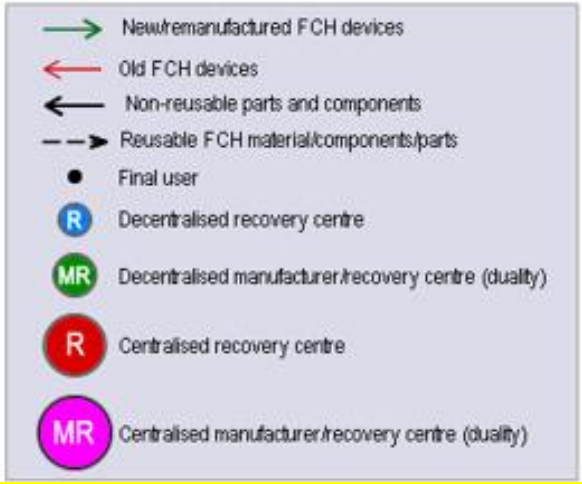




Scenarios

Mid-term scenario





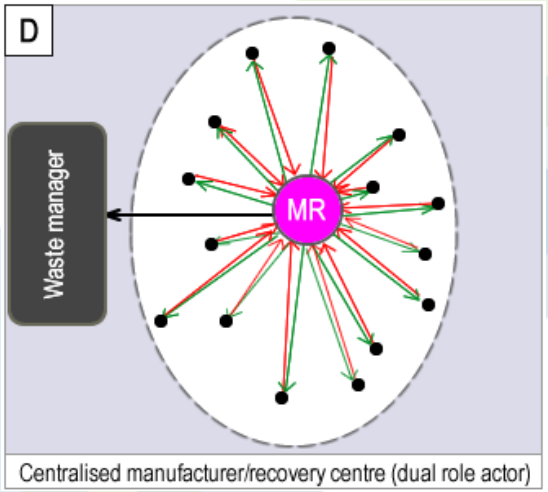
-RCs reduce the need for regular waste management

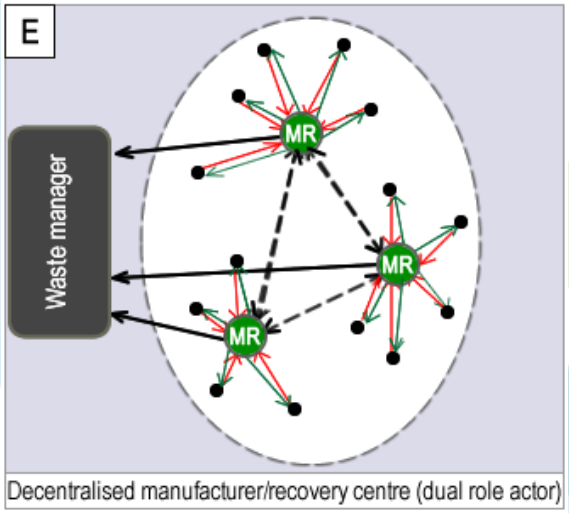
-Promote the reuse of components and materials → reducing costs of FCH products

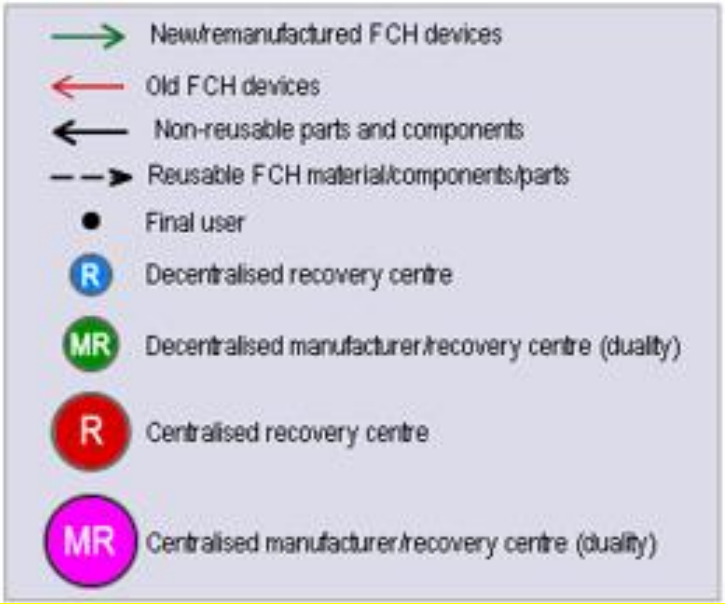
-Novel EoL technologies may start to be used together with existing ones

Scenarios

Long-term scenario



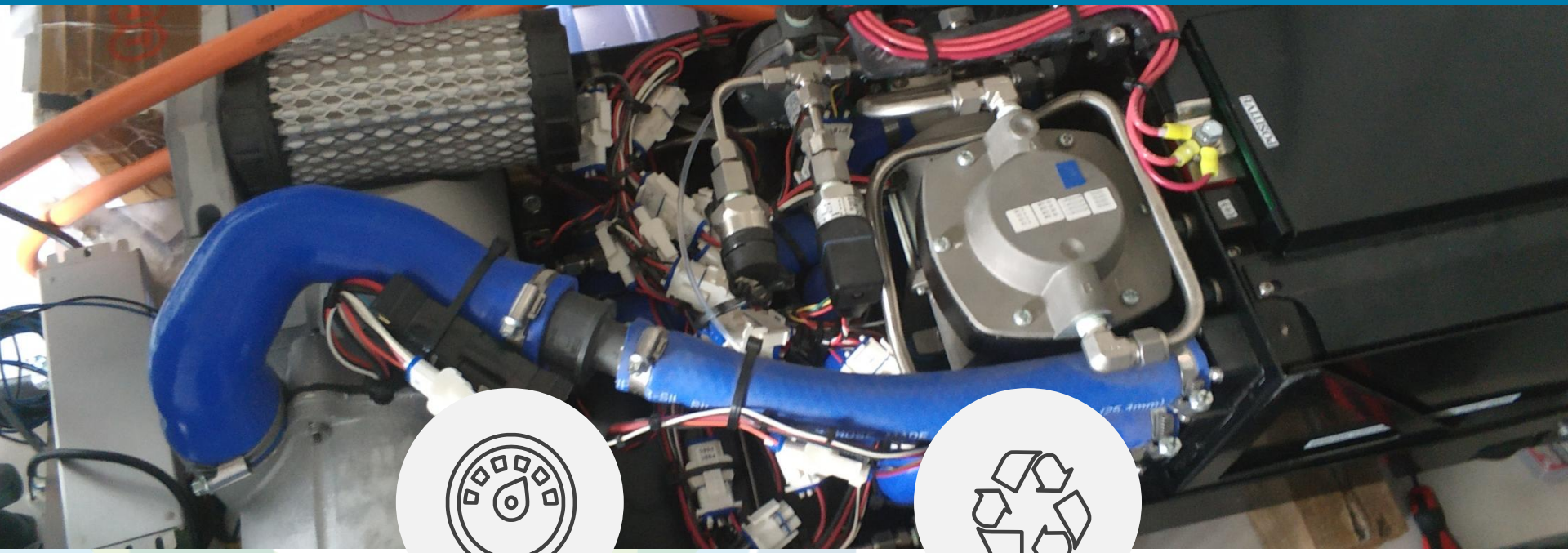




Dual role ->higher control on the life-cycle-> optimisation of the supply chain

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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University of Ljubljana
institute IMDEA energy
GRUPO LÓPEZ SORIANO
ENVIRONMENT PARK Parco Scientifico Tecnologico per l'Ambiente

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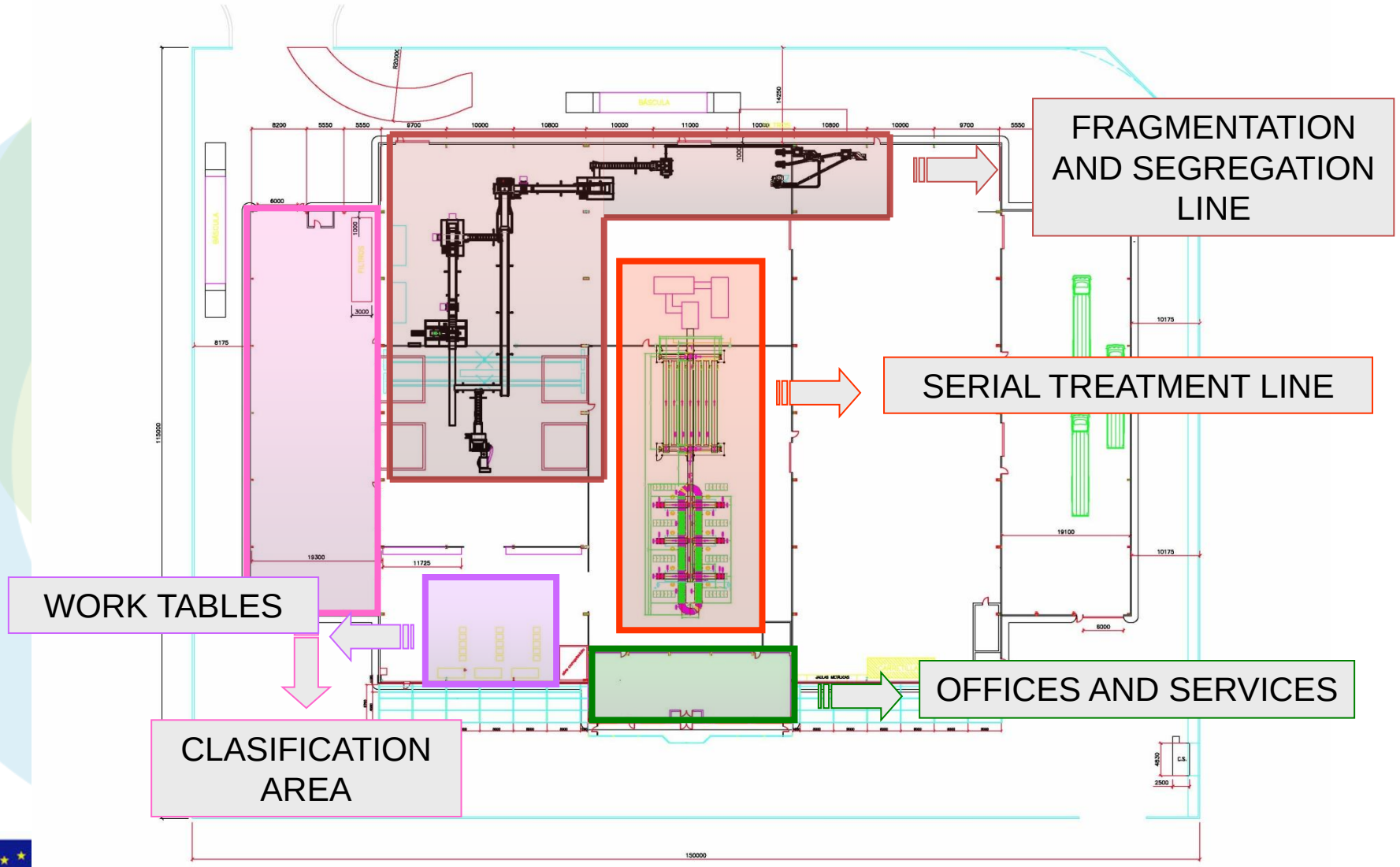
HyTechCycling

HyTechCycling

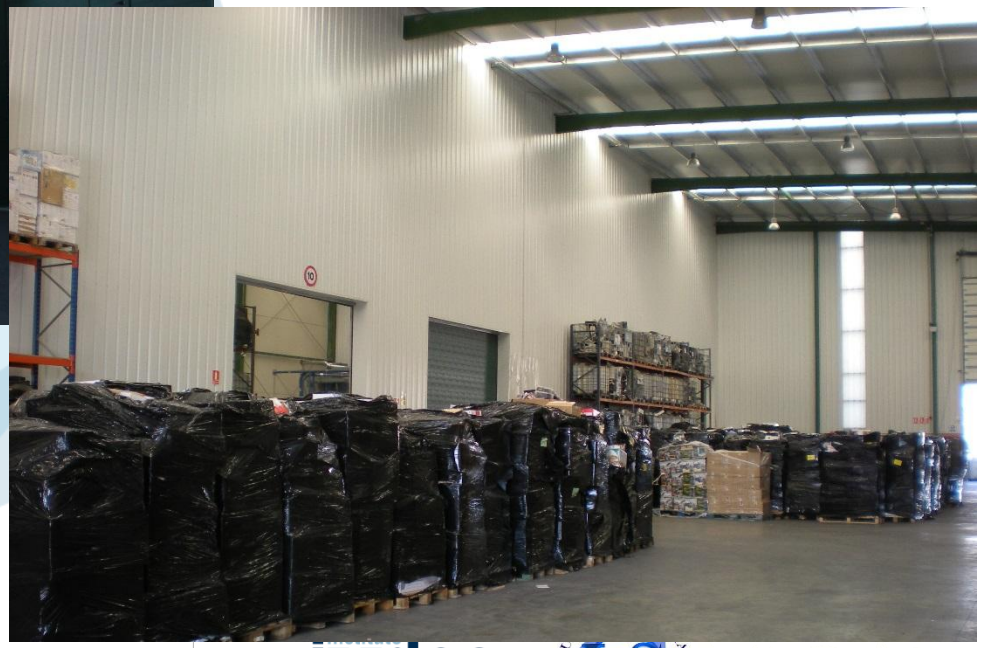
New technologies for the phase of recycling and dismantling: Detail on the specific processes followed at recycling center

Global scheme of current plant



Global scheme of current plant

SEGREGATION AND WEIGHING

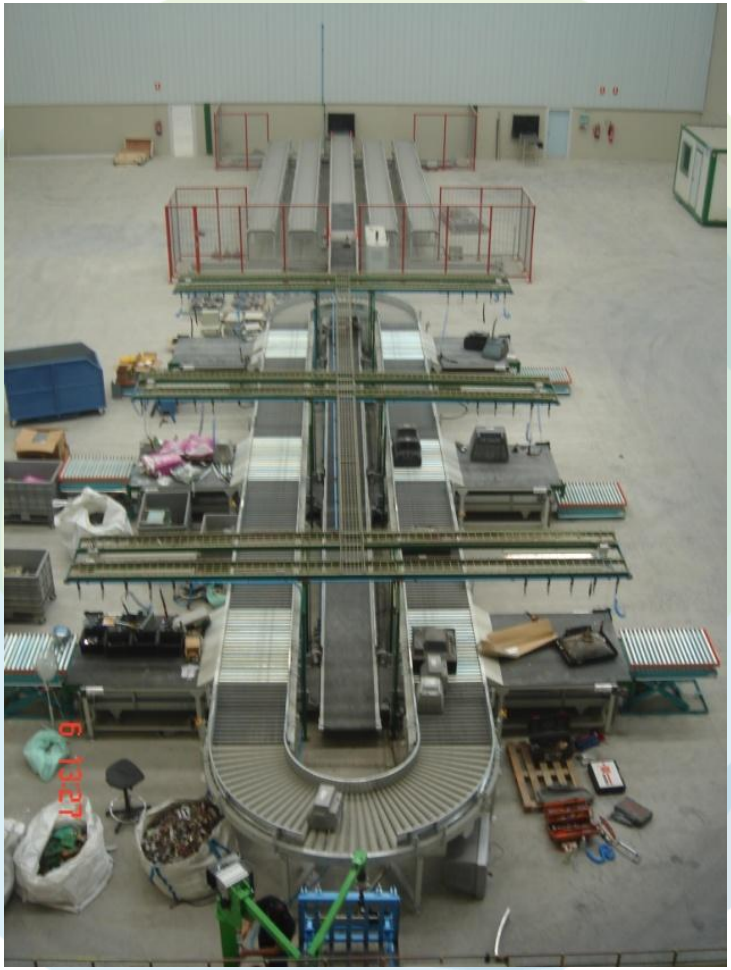


Global scheme of current plant

SEPARATION WORK TABLES

Global scheme of current plant

SERIAL TREATMENT LINE



Global scheme of current plant

FRAGMENTATION AND SEGREGATION LINE

FCH FUEL CELLS AND HYDROGEN JOINT UNDERTAKING
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Global scheme of current plant

Super Chopper

Global scheme of current plant

Shredder

Global scheme of current plant

FOUCAULT

Global scheme of current plant

GRANULATORS

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Global scheme of current plant

DENSIMETRY

University of Ljubljana

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New technologies in recycling phase

CHEMICAL PROCESS

Device	Component	Material	Critical aspect	Recovery technologies	
				Existing [a]	Novel [b]
SOFC	Anode	YZS	Cost; supply risk	HDT	N/A
		Ni; NiO	Hazard	HDT; HMT	N/A
	Cathode	LSM	Hazard; supply risk	N/A	N/A
	Electrolyte	YZS	Cost; supply risk	HDT	N/A
	Interconnects	Ni; NiO	Hazard	HDT; HMT	N/A
		LSC	Hazard; supply risk	N/A	N/A
PEMFC	Anode	Pt	Cost	HMT; PMT	SED; TD; AP
	Cathode	Pt	Cost	HMT; PMT	SED; TD; AP
	Electrolyte	Ionomer	Cost; hazard [c]	N/A	AD; AP
PEMWE	Anode	Ir; Ru	Cost; hazard	HMT; PMT	TD
	Cathode	Pt	Cost	HMT; PMT	SED; TD; AP
	Electrolyte	Ionomer	Cost; hazard [c]	N/A	AD; AP
	Bipolar plates	Ti	Cost	HMT	N/A
AWE	Anode	Ag	Cost	HMT	N/A
	Cathode	Ni; NiO	Hazard	HDT; HMT	N/A

Device Abbreviations	
SOFC	Solid Oxide Fuel Cell
PEMFC	Polymer Electrolyte Membrane Fuel Cell
PEMWE	Polymer Electrolyte Membrane Water Electrolyser
AWE	Alkaline Water Electrolyser

Recovery Abbreviations	
AD	Alcohol Dissolution
AP	Acid Process
HDT	Hydro Treatment
HMT	Hydro Metallurgical Technology
PMT	Pyro Metallurgical Technology
SED	Selective Electrochemical Dissolution
TD	Transient Dissolution

Table above summarizes the existing and novel recovery technologies applicable to critical materials of FCH stacks: the existing technologies for PEMFCs, PEMWEs, AWEs and SOFCs are focused mainly on hydrometallurgical and pyrometallurgical recovery of precious metals used in the stacks as catalysts for the conversion process.

New technologies in recycling phase

CHEMICAL PROCESS

Existing ones

- **hydrometallurgical,**
- **pyro-hydrometallurgical**

Novel processes

- **Alcohol dissolution (AD)**
- **Acid process (AP)**
- **Selective electromechanical dissolution (SED)**
- **Transient dissolution (TD)**

New technologies implementation in current plants

Permissions and authorizations for new implementations (permissions differs from Country to Country)

- **procedure which requires lot of time**
- **identification unified in all member states**
- **efficient and productive (how much can be recovered by a product)**
- **Knowledge of the process- Design Staff**
- **Civil Works and installation**
- **Insurance**
- **Operation Staff**

New technologies implementation in current plants

Economic and financial evaluation

- **Investment costs - sustain for the new installation**
- **Financing**
- **Revenues**

MATERIAL OUTPUTS

Find opportunities to use recycled material

- **Traditional output**
- **New AUTHORIZED ways**
- **End of Waste**

END OF WASTE

Meet Criteria of EoW Regulations

+

Certify Quality Management System according to the Application Regulation

+

Statement of Conformity with Regulation

PRODUCT

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HyTechCycling