



FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

***Clean Hydrogen
Joint Undertaking
CH₂ - JU***

**Bart Biebuyck
28 / 06 / 2021 Virtual**



Strong public-private partnership with a focused objective

A combined private-public of more than 2 billion Euro has been invested since 2008



FUEL CELLS AND HYDROGEN JOINT UNDERTAKING



Industry grouping
>270 members
50% SME



Research grouping
83 members



Energy

H₂ production and distribution
H₂ storage
F/C for CHP



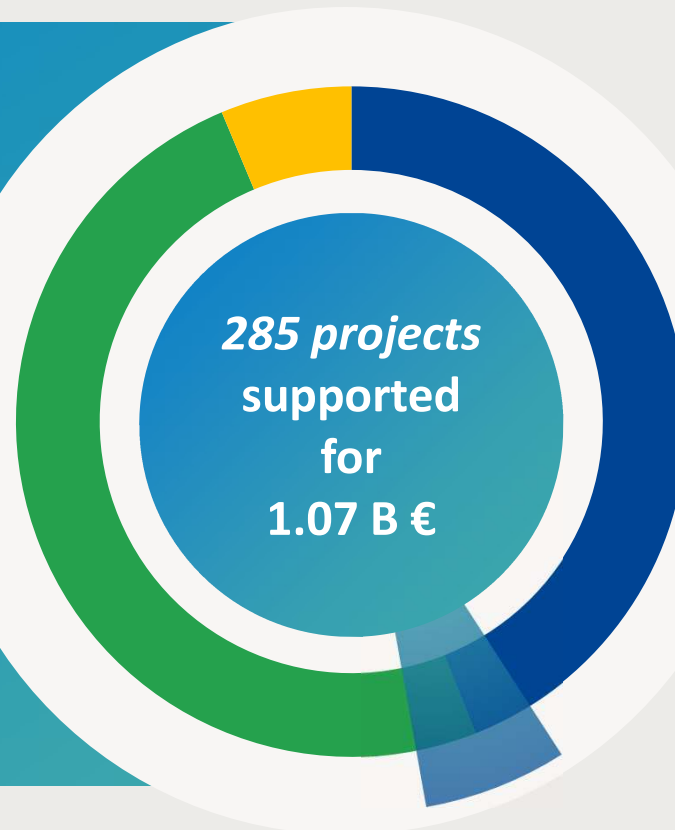
Transport

Road vehicles
Non-road vehicles
Refueling infra
Maritime, rail and aviation applications



Cross-cutting

standards, safety, education, consumer awareness, ...



45 %



481 million euros
153 projects

41.4 %



443 million euros
77 projects

6.3 %



67 million euros
48 projects

7.3 %



79 million euros
7 projects



Similar leverage of other sources of funding: 1.08 B €

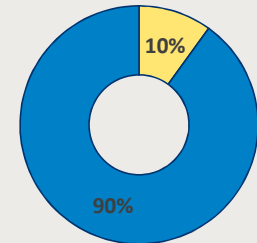
Overview of FCH JU activities in Poland



Poland

PACE: 10 planned m-CHP

FCH JU Budget Allocation Calls 2008-2020



■ DEMO ■ Research

- FCH JU Contribution: 3.6 M€

- 16 Beneficiaries

- 27 Projects

FCH JU Projects

LOTOS

GRUPA AZOTY

Other Projects*
Pure H2
Hestor

Intentions*

By 2034 to have 2GW H2 capacity
By 2025 to have 500 hydrogen FC buses

Plans*

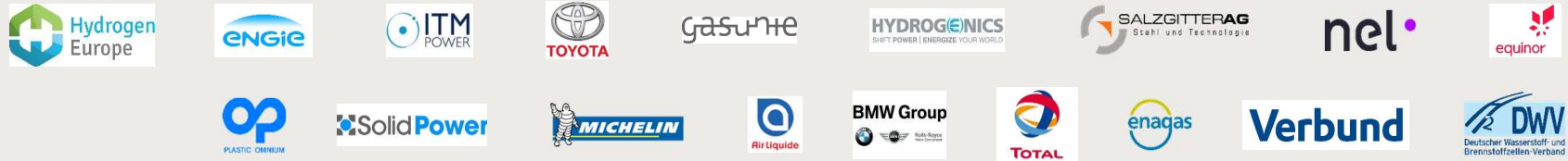
- 2 HRS planned (in Poznań & Katowice)
- 1 PEM electrolyser (2.5 MW)* (by Zespół Elektrowni Pątnów-Adamów-Konin S.A.)

- | | | |
|---------------|-----------|---------------|
| • COPERNIC | • HyTime | • SO-FREE |
| • FC-EuroGrid | • IRAFC | • StackTest |
| • FCHgo | • IRMFC | • STAGE-SOFC |
| • HAWL | • LOLIPEM | • StaSHH |
| • HyCOMP | • NewSOC | • SUAV |
| • HyLAW | • ONSITE | • SWITCH |
| • HYPACTOR | • SAFARI | • Temonas |
| • HYPER | • SAPIENS | • TriSOFC |
| • HyStorIES | • SOFCOM | • VIRTUAL-FCS |

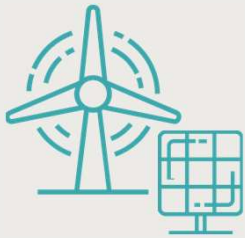


*Not related to FCH JU activities

Besides CO₂ abatement, deployment of the hydrogen roadmap also cuts local emissions, creates new markets and secures sustainable employment in EU

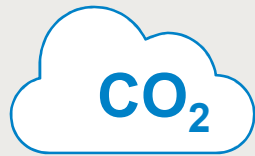


2050 hydrogen vision



~24%

of final energy demand¹



~560 Mt

annual CO₂ abatement²



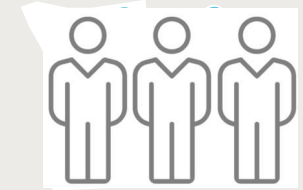
~EUR 820bn

annual revenue (hydrogen and equipment)



~15%

reduction of local emissions (NO_x) relative to road transport



~5.4m

jobs (hydrogen, equipment, supplier industries)³



1 Including feedstock 2 Compared to the reference technology scenario 3 Excluding indirect effects

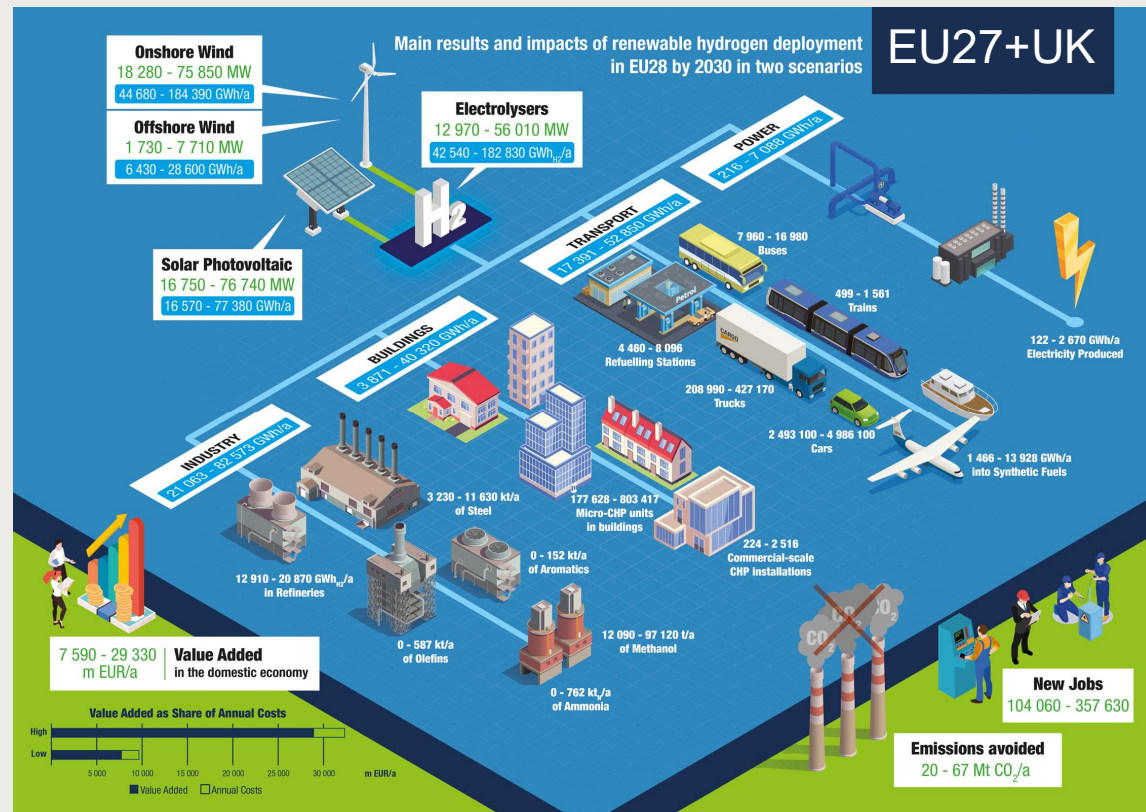
SOURCE: Hydrogen Roadmap Europe team

Opportunities from the inclusion of Hydrogen in NECPs

EU27+UK NECPs were analyzed on the national opportunities for hydrogen deployment by 2030.



<https://www.fch.europa.eu/publications/opportunities-hydrogen-energy-technologies-considering-national-energy-climate-plans>



In EU27+UK by 2030 depending on the scenario, 13-56 GW of electrolysers (4800Hrs full load) are needed reducing 20-67MtCO₂/a, creating 7.5-29 bn € added value and 104k-358k jobs.

EU Hydrogen Strategy of 8th July 2020

Objectives in 3 phases with the Hydrogen Alliance to support the investment agenda



Phase 1: 2020-2024

- **6GW** of renewable H₂ electrolyzers
- 1 million tonnes renewable H₂
- Replace **existing** H₂ **production**
- Regulation for liquid H₂ markets
- Planning H₂ infrastructure

Phase 2: 2025-2030

- **40GW** renewable H₂ electrolyser
- 10 million tonnes renewable H₂
- New applications in steel & transport
- H₂ for electricity balancing purposes
- Creation of "Hydrogen Valleys"
- Cross-border logistical infrastructure

Phase 3: 2030-2050

- H₂ technologies matured and deployed at large scale in hard to abate sectors.
- Expansion of hydrogen-derived synthetic fuels
- EU-wide infrastructure network
- An open international market

Clean Hydrogen Alliance to support the EU investment agenda





What is it?



- Launch on 8th July 2020
- Mission to create a project pipeline for a massive role-out of EU Clean Hydrogen technology
- Involving all active stakeholders in the clean hydrogen ecosystem, bringing together supply and demand

The blueprint estimates investments of
€430 billion by 2030

Hydrogen Production

Transmission & Distribution

Mobility Applications

Industrial Applications

Energy Applications

Residential Applications

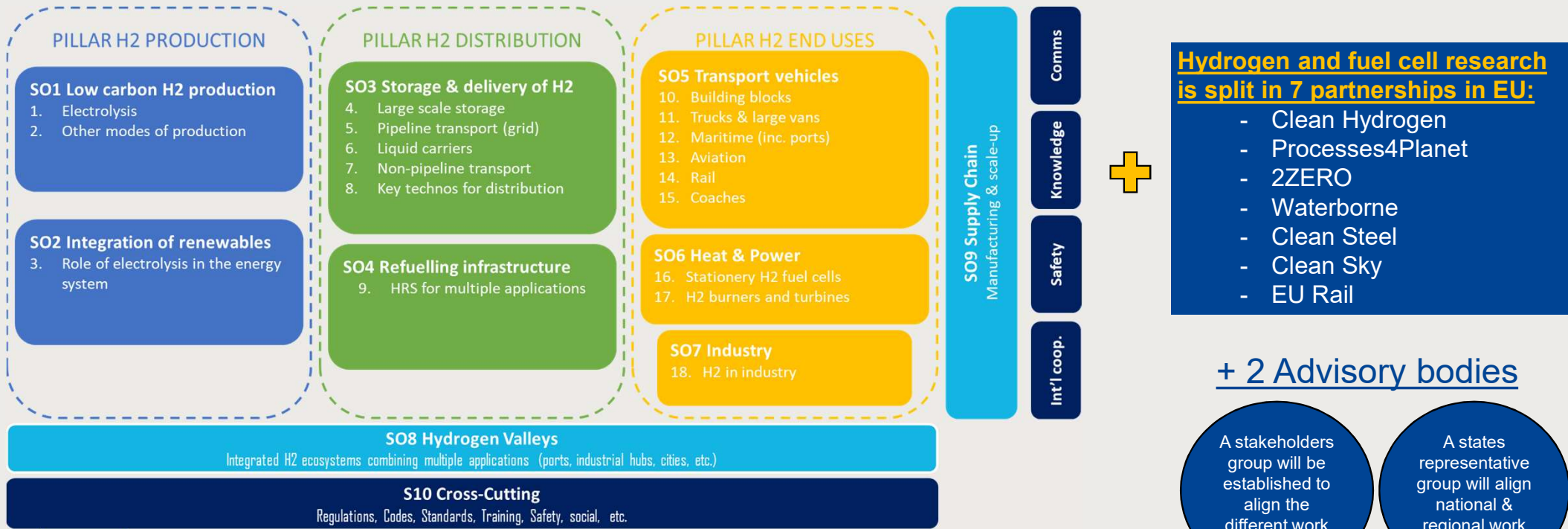


Hydrogen – Research and innovation

Partnership under Horizon Europe Programme
with a stronger focus on Hydrogen and hard to decarbonizing sectors.



Maintain and strengthen **EU's global leadership role**
Clean Hydrogen Partnership start in Q4 2021 with a budget of **1 billion EUR**
(Indicative: Dec '21:150m € + Jul '22:150€ + Jan '23:150m € + Jan '24:130m € +Jan '25:130m € +Jan '26:130m € +Jan '27: 130m €)



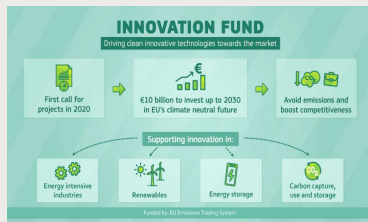
SYNERGIES: Strong cooperation is Key to deal with bigger yet fragmented EU Funds



H2 evolving and growing: from R&D&I to large Demos and full Market Deployment



International Cooperation



FCH-JU region initiative was key to boost the hydrogen awareness in EU

The regions initiative led to the H2 Valley partnership, PDA and a call topic on H2 Valleys



<https://www.fch.europa.eu/page/about-initiative>

European Hydrogen Valleys Partnership

launched May '19 at EVS 32 in Lyon

Partnership led by:
North of Netherlands (NL)
Auvergne-Rhône Alpes (FR)
Le Normandy (FR)
Aragon (ES)

40 regions joined

<http://s3platform.jrc.ec.europa.eu/hydrogen-valleys>

Supporting regions and cities in assessing various FCH applications

- Belgium:** Flanders, Wallonia, Brussels, Liège
- United Kingdom:** London (Greater London Authority), Yorkshire, Midlands, North East, North West, Yorkshire and the Humber, Yorkshire and the Humber, Yorkshire and the Humber
- Norway:** Akershus, Oslo, Vestfold, Hedmark, Oppland, South Norway, North Norway, Central Norway
- Sweden:** Skåne, East Coast, West Coast, North
- Finland:** Helsinki, Tampere, Oulu, Rovaniemi
- Denmark:** South Denmark, North Denmark
- Germany:** Baden-Württemberg, North Rhine-Westphalia, Bavaria, Saxony, Saxony-Anhalt, Lower Saxony, Hesse, Rhineland-Palatinate, Schleswig-Holstein
- France:** Bourgogne-Franche-Comté, Auvergne-Rhône-Alpes, Île-de-France, Normandy, Occitanie, Provence-Alpes-Côte d'Azur
- Spain:** Madrid, Catalonia, Basque Country, Castile and León, Castile-La Mancha, Castile and León, Canary Islands, Galicia, Asturias, Cantabria, Rioja, Navarre, Aragon, Balearic Islands, Valencian Community, Balearic Islands
- Italy:** Emilia-Romagna, Lombardy, Veneto, Trentino-Alto Adige, Sicily, Sardinia, Puglia, Basilicata, Campania, Apulia, Marche, Umbria, Lazio, Abruzzo, Molise, Campania, Basilicata, Puglia, Basilicata
- Portugal:** Madeira, Azores, Continental Portugal
- Netherlands:** North of Netherlands, Friesland, Drenthe, Groningen, Overijssel, Gelderland, Utrecht, North Brabant, Zeeland
- Austria:** Vienna, Lower Austria, Upper Austria, Tyrol, Carinthia, Styria, Salzburg, Vorarlberg
- Greece:** Macedonia, Central Macedonia, Thessaly, Western Macedonia, Eastern Macedonia and Thrace, Crete
- Czech Republic:** Prague, Brno, Olomouc, Hradec Králové, Pardubice, Středočeský územní svaz, South Moravia, South Bohemia, North Bohemia, Vysočina
- Slovenia:** Ljubljana
- Croatia:** Zagreb
- Romania:** Bucharest, Cluj-Napoca, Iași, Timișoara, Brașov
- Bulgaria:** Sofia, Plovdiv, Varna, Burgas



Project Development Assistance (PDA)

launched Jan '20 (38 applications / 19 countries)

- Limburg, Belgium
- Bourgogne-Franche-Comté, France
- Asturias, Spain
- Medio Téjo, Portugal
- Texel, Netherlands
- Mariestad, Sweden
- Gdynia, Poland
- Mocenk, Slovakia
- Ruse, Bulgaria
- Sofia, Bulgaria
- Zagreb, Croatia

Great opportunity to bring on-board and share learnings with 'less FCH ready' but highly interested EU13 regions

<https://www.fch-regions.eu/>

"I want NextGenerationEU to create new European Hydrogen Valleys to modernise our industries, power our vehicles and bring new life to rural areas."

End of 2021 another PDA will be launched focus on EU13!



Examples of Hydrogen valleys in Europe today



Its scope is system integration: Production of renewable H₂, storage, distribution and end use (transport, stationary & industry)



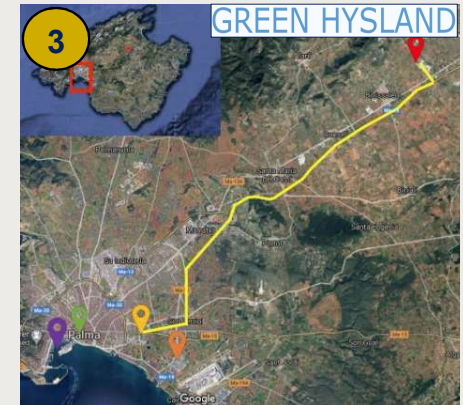
Orkney's Island (Scotland):

- H₂ production by wind on Islands
- Storage and transportation by truck
- Use: heat (school), power (ferries) & mobility (municipality cars)



North Netherlands (Groningen):

- 31 partners (public + private)
- Electrolysis for green H₂ production,
- H₂ Mobility: buses, passenger cars and trucks
- H₂ Refueling stations
- E-Kerosene for aviation
- H₂ for an inland water transport barge
- Domestic Heat applications
- Underground H₂ storage (Hystock)



Hydrogen Island (Spain)

- H₂ production from solar
- H₂ injection in gas-grid
- Use: heat (hotel, municipality buildings), power (port of Palma), mobility (buses)



Future Possible (cross border) H₂ valleys: Ports, Airports, Industrial hubs, Logistical hubs, A H₂ city (or area)

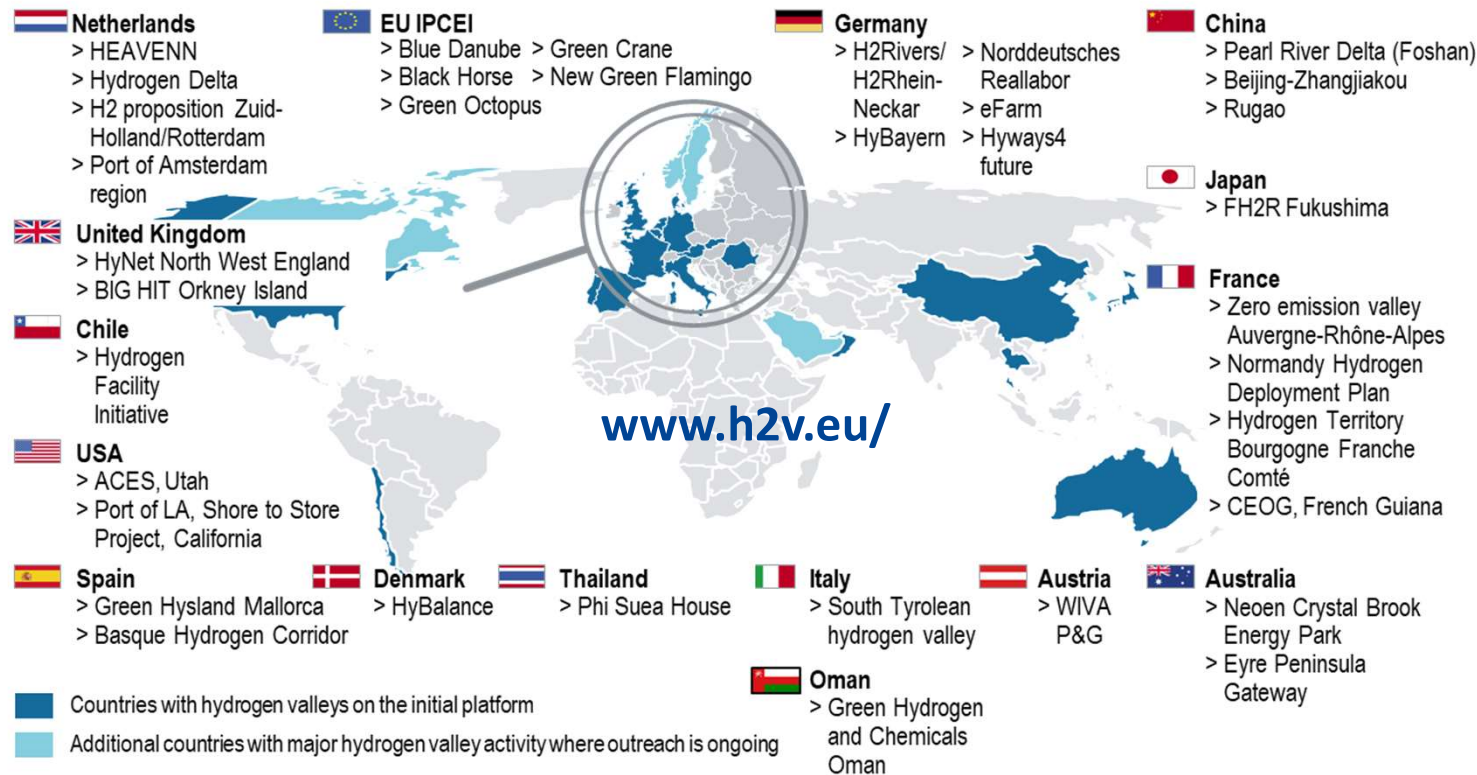
Hydrogen Valleys have become a global phenomenon

Integrated projects are emerging all around the world

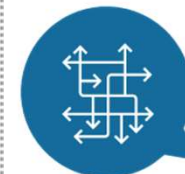


The Hydrogen Valley Platform offers a variety of insights into projects globally and also provides a way to connect

A fast-growing landscape of globally leading projects ...



... featured on the new platform



> 34 valleys from 19 countries



> 3,500 data points



10 in-depth best-practice profiles

Electrolysis projects: increase capacity & lowering cost

Europe is world-leader in electrolysis systems (EU has the most patents and publications vs other parts of the world)



Next: building standard modules (10~20MW), replacing materials, cost reduction



Developing an EU wide Guarantees of Origin (GO) Scheme for Hydrogen

Two definitions: one for Green and one for Low-Carbon Hydrogen – more than 70,000 GOs issued already



Four production plants included in the pilot scheme which have been already audited

Air Liquide, Port Jerome (SMR +CCS)



Colruyt Group, Halle (Electrolysis +RE)



Air Products, Rotterdam (by product H2 from Chlor-alkali process)



Uniper, Flakenhagen (Electrolysis + RE and methanation)



On-going actions:

(1) Certifhy3: Setup of a platform for piloting a GO scheme for hydrogen across Europe. <https://www.certifhy.eu/>

(2) IPHE* taskforce on Hydrogen Production Analysis methodology.

=> important to unlock future cross border trading.



(*) IPHE: International Partnership on hydrogen and fuel cells in the economy www.iphe.net

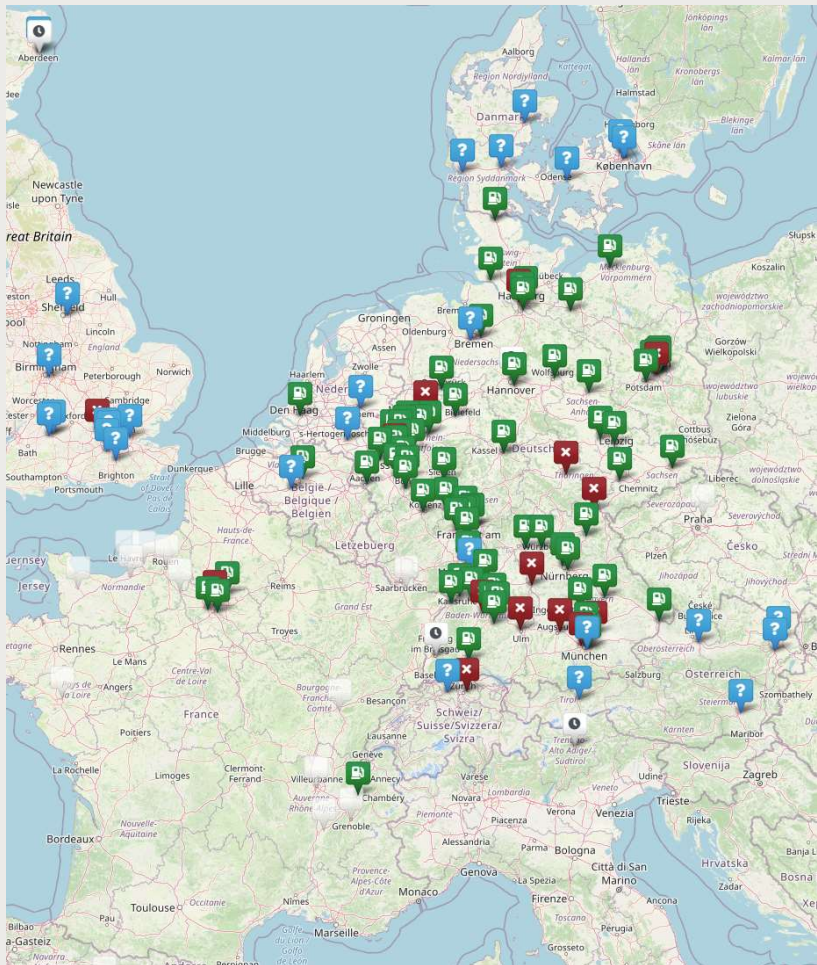
FCH-JU has projects related to many different modes of transport

Heavy duty transportation is looking seriously to hydrogen due to the huge performance improvements of fuel cells



Visualization of the data: Real-time availability information

<https://h2-map.eu/>



Next: continue to update the database with new stations and include heavy duty refueling stations.

HRS Availability Map with availability data from the E-HRS-AS

Choose H₂ fuelling option

- 700 bar
- 700 bar**
- 350 bar
- 350 bar

HRS statistics

Σ total	145
700 bar	127
350 bar	46
350 bar	17

FCH JU - European Commission

Map legend

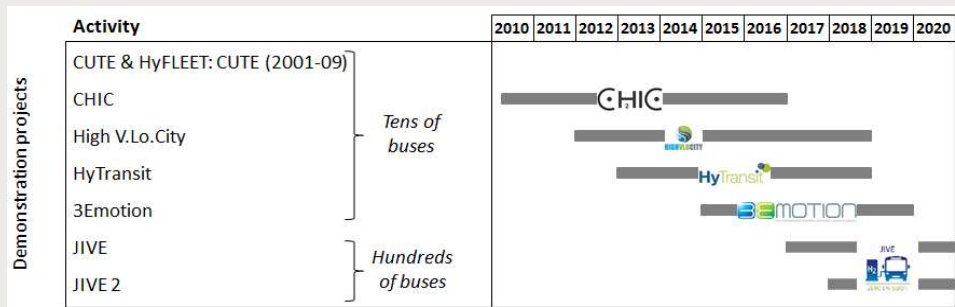
HRS status

- Available
- Limited availability
- Unavailable
- No live status
- Outside opening hours
- 700 bar H₂ for cars not provided

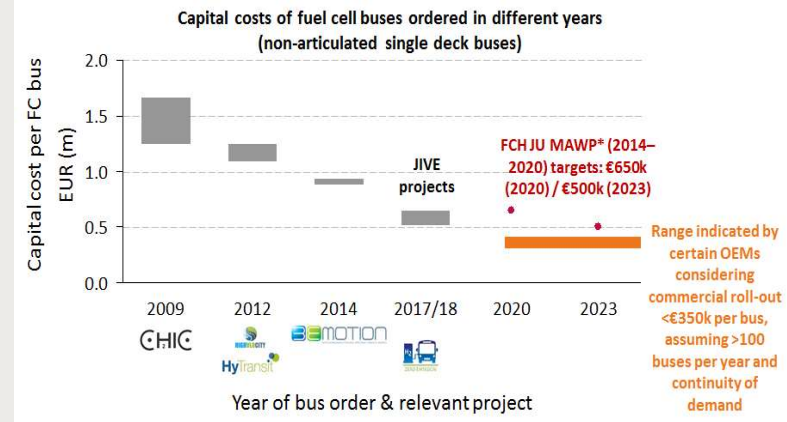
Availability refers to the selected fuelling option only.

FCH-JU funded FCB projects and studies since 2009

7 projects will put in total about 360 FCB's on the road



Van Hool hydrogen bus for PAU (France) crowned as best bus of the world 2019!



JIVE/JIVE2

- Orders placed for 230/295 buses (78%) with 5 suppliers Van Hool (80), Solaris (57), Wrightbus (65), SAFRA (10), and Caetano (18).
- Delivery of the first 50 buses in Cologne (35), Wuppertal (10), and Pau (5) and start of full route operation. All buses on the road by end 2021
- Increased interest from other European OEMs, with JIVE-compliant offers received from: Optare, Rampini, and SOL and continued interest from ADL, Daimler, VDL, and interest from 2 other major European OEMs.



NEXT:

City buses have advanced a lot, next is to work on coaches. The project CoachHyfied will demonstrate 6 Fuel Cell Coaches in the two coach segments (inter-city and long-distance passenger transport)



Heavy duty trucks demonstration projects to validate the technology

Long haul and urban applications



15 Long haul trucks



- At least 400 km autonomy;
- Tractor and rigid configurations;
- Integration in the daily operations of end users with different operations (Air Liquide, BMW, Carrefour, Colruyt)
- 2021/2022 deployment of the trucks;



30 trucks
13 demonstration sites
7 countries

15 Refuse trucks



- Daily back-to-base missions;
- Standardization of the design towards mass production;
- Fleet operation: 120.000 hours;
- First truck already deployed in Breda;



23/11/2020: Industry commitment for 100.000 trucks and 1500 HRS by 2030 in the EU



Components & infrastructure

Targeted development for Heavy Duty applications



Durability-Lifetime of stacks for Heavy Duty trucks



- Understanding of degradation mechanisms;
- Aim 30.000 hours durability;

Scale-up and demonstration of innovative hydrogen compressor technology for full-scale hydrogen refueling station



- Upscale and integrate innovative compressor technology in a HRS;
- Demonstration in HRS $\geq 200\text{kg/d H}_2$;

Standard Sized FC module for Heavy Duty applications



- Joint effort between FC suppliers and OEMs;
- Fostering economies of scale, “plug & play concepts” and competition;

Feasibility of liquid H2 on-board storage for heavy-duty vehicles



- Evaluate feasibility through a design study and demonstration test bench;



Refueling protocols and Business models

Business models, safe and rapid refuelling operations completing the picture



Safe & rapid refueling operations

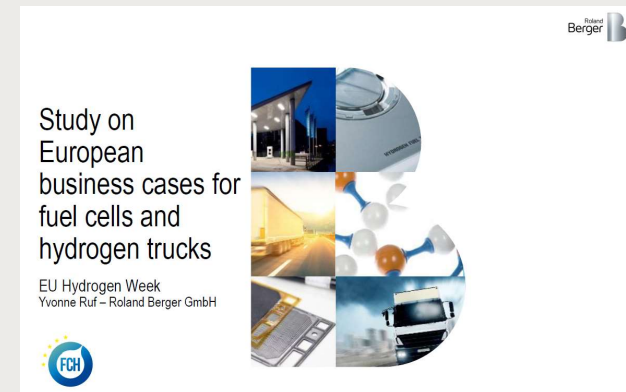


Protocol for heavy-duty refueling using hydrogen

- Develop refueling protocol(s) for vehicles with Compressed Hydrogen Storage System >250L & >10kg;
- Identify factors limiting the refueling rate (120g/s) and propose solutions for larger flow rates;
- Findings and recommendations should be shared with relevant sectors and standardization committees;
- International cooperation;



Business models

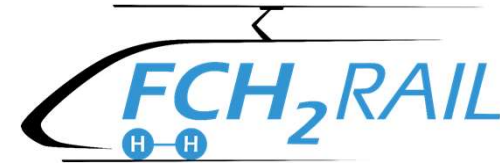


- 1.State of the art;
- 2.Business cases and market potential;
- 3.Case studies;
- 4.Recommendations;

<https://www.fch.europa.eu/publications/study-fuel-cells-hydrogen-trucks>

Fuel Cell Hybrid PowerPack for Rail Applications

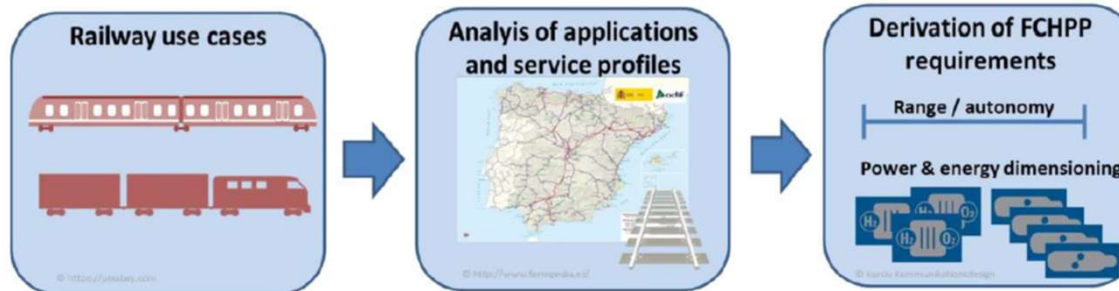
Demonstrate the system in a bi-mode train to be homologated in three MS



- Start date: 01/01/2021
- Total cost: 13,341,609.93 €
- Grant amount: 10,000,000.00 €
- Main objective:
 - Develop, build, test, demonstrate and homologate a scalable, modular and multi-purpose Fuel Cell Hybrid PowerPack (FCHPP) applicable for different rail applications (multiple unit, mainline and shunting locomotives) also suitable to retrofit existing electric and diesel trains, to reach TRL7.
 - The train demonstrator tests to be carried out cross-border in Portugal and Spain and homologation to be sought for three EU countries.



Methodology

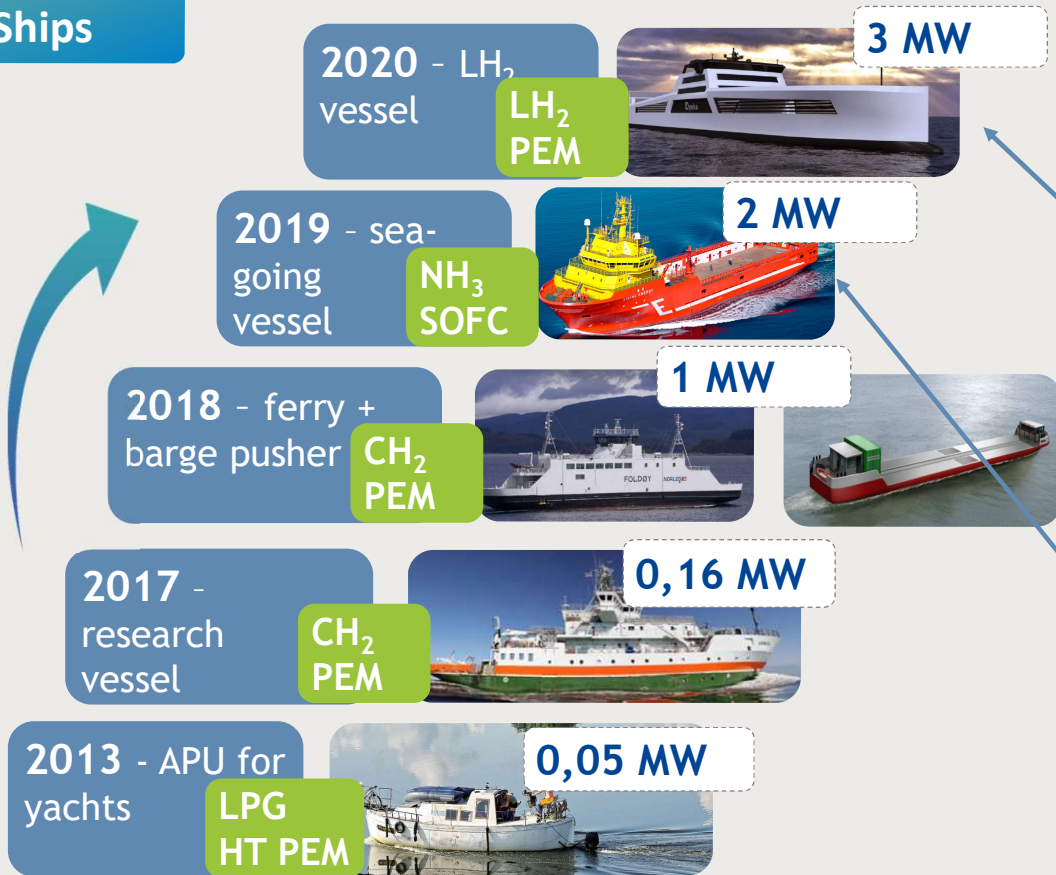


FCH 2 JU support for FC and H2 in maritime applications

Moving towards larger sizes of vessels, no « size fits all »



Ships



HySHIP

- RoRo vessel, for coastal goods transport
- 3MW fuel cell system using LH₂ (>5t storage)
- Conceptual designs for a 20MW ship
- Develop a standardised bunkering system
- LH₂ distributed to a series of maritime bases in a containerized system

ShipFC

- Platform support vessel in North Sea (Norway)
- Length: 95m, Gross tonnage: 5073MT
- Operation: 2024
- Zero emission ammonia

Global Ports Hydrogen Coalition launched under the CEM.

H2Port project Valencia: First application of hydrogen technologies in port handling equipment in Europe.



CEM H2 Initiative:



Global Ports Hydrogen Coalition

Launched on 1st of June

Co-Led by IEA H2I & DG ENER – Support by FCH-JU

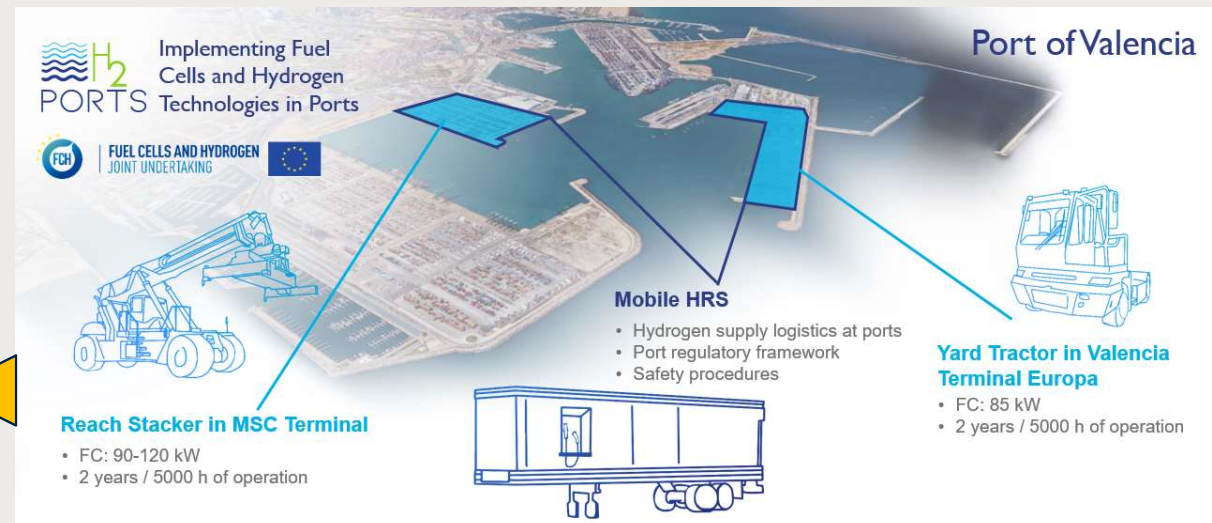
12 European Ports

(Norway:4, Germany:3, Spain:1, Sweden:1, The Netherlands:1, Belgium 1, Portugal)

Brunsbüttel Ports (Germany)
Flam Port (Norway)
North Queensland Bulk Ports (Australia)
Pecém Port Complex (Brazil)
Port of Auckland (New Zealand)
Port of Bahia Blanca (Argentina)
Port of Berlevåg (Norway)
Port of Brisbane (Australia)
Port of Duqm (Oman)

Port of Farsund (Norway)
Port of Grenland (Norway)
Port of Gothenburg (Sweden)
Port of Hamburg (Germany)
Port of Houston (USA)
Port of Mejillones (Chile)
Port of Rotterdam (The Netherlands)
Port of Valencia (Spain)
Port of Vancouver (Canada)

Portuguese Ports Association
Southern Ports (Australia)
Lehmann GmbH
Neltume Ports (Chile)
Woodside (Australia)
Free Hanseatic City of Bremen (Germany)
Hydrogen Council
International Association of Ports and Harbours
Port of Antwerp



H2PORTS project in the port of Valencia

- Reach stackers and yard tractors will be demonstrated in the port
 - A mobile hydrogen refueling station will be operated inside the port
- DURATION: 2019-2022; project 4.1 M€ (4 M€ by FCH-JU)**



Hydrogen powered Aviation study (joint study with Clean Sky2 JU)

Hydrogen propulsion has significant potential



Hydrogen-powered aviation
A fact-based study of hydrogen technology, economics, and climate impact by 2050

May 2020

LIQUID HYDROGEN

HYDROGEN-POWERED

Key takeaway: Hydrogen propulsion has significant potential



Technology

Hydrogen is feasible

to power aircraft with entry into service as early as 2030-2035 for short-range segments

Economics

Less than 20 USD per PAX

additional costs on a H2-powered short-range flight – 20% cheaper on medium-range to generate same climate impact than synfuels by 2040

Climate impact

Zero CO₂ and 70% reduction

of climate impact by converting 40% of the fleet to H₂ with 15% less global renewable energy needs for the sector in 2050

Research & Innovation

First prototype by 2028

required for short-range – significant investments for R&I needed now to meet 2050 target

23

Example: Short-range aircraft with hybrid H2 propulsion

Exemplary pictures

Evolutionary aircraft design for short range

Reference aircraft: Airbus A320 neo



-4% **Decrease of block energy** due to higher energy efficiency of fuel cell system

Source: DLR design study, expert input, project team

<https://www.fch.europa.eu/news/new-study-hydrogen-powered-aviation-preparing-take>



La France veut lancer un avion « zéro émission de CO₂ » dès 2035

Au-delà des mesures d'urgence, le plan de soutien à l'aéronautique française du gouvernement, chiffré à 15 milliards d'euros par Bruno Le Maire, vise à placer l'aéronautique française en pointe dans la transition énergétique. Avec un objectif ambitieux : lancer un avion vert à l'hydrogène dès 2035.

European Hydrogen Safety Panel (EHSP) initiative

Expert group on hydrogen safety assisting the FCH 2 JU at project and programme level



EHSP Launched and running!



Home > Initiatives

STUDIES

EUROPEAN HYDROGEN SAFETY PANEL

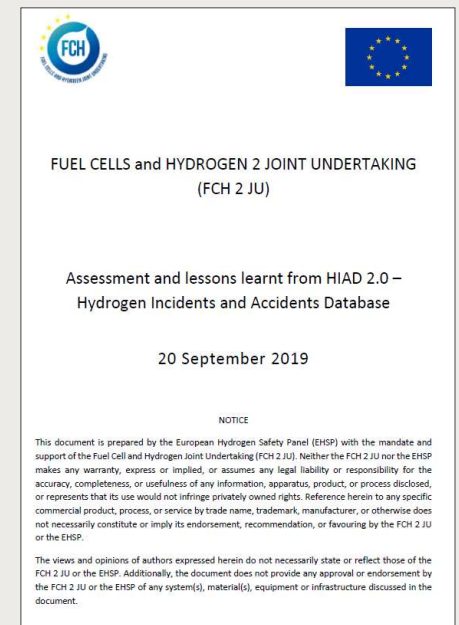
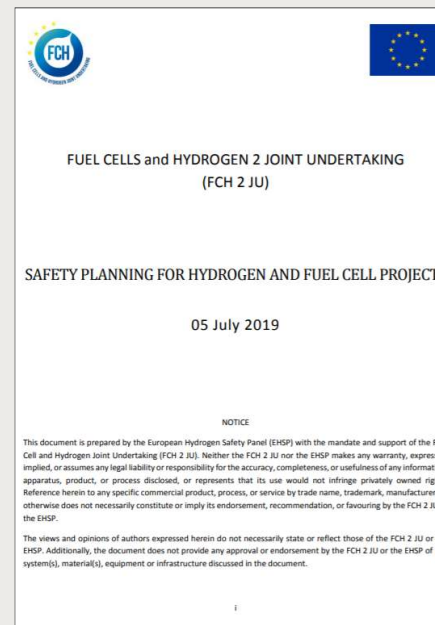


16 experts from industry & research

**Assuring that H2 safety is adequately handled
Promoting and disseminating H2 safety culture**



The EHSP released the first 2 reports on:
- Safety planning in FCH projects
- Lessons learnt from HIAD



Educational Activities – Overview

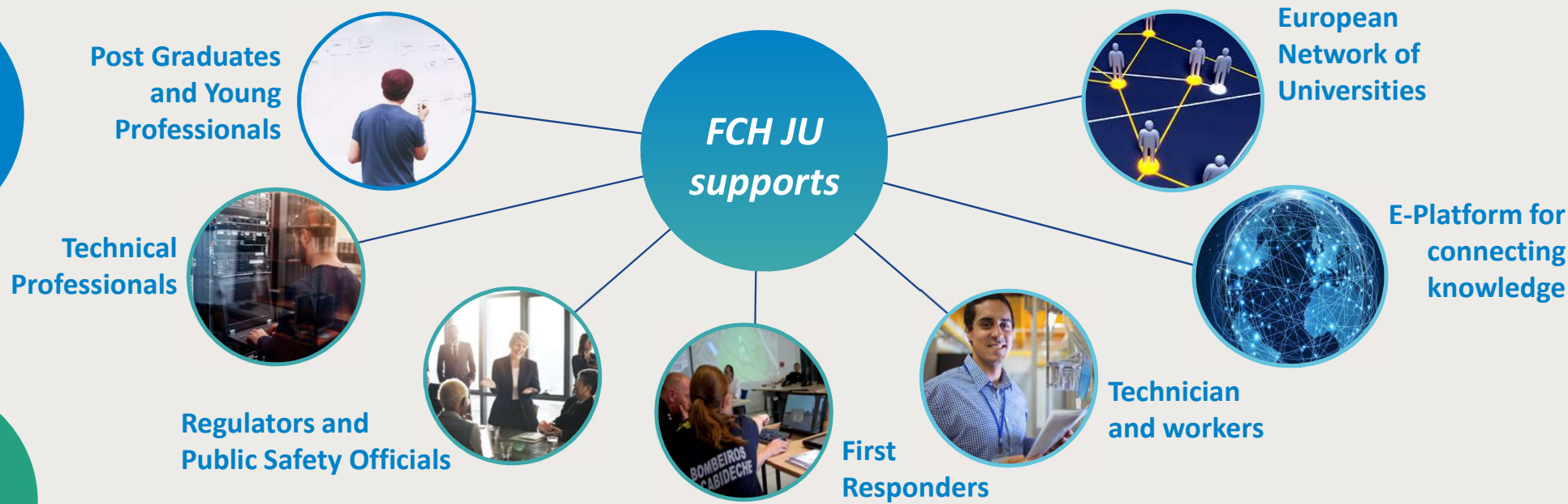
Preparing the European workforce is crucial for scaling up the industry.



Educational and training programs tailored to multiple target groups

15 projects
 10 – FP7
 5 – H2020
 + complementary initiatives & studies

Budget
 Overall 18,6 M€
 FCH 2 JU Funding 14,7 M€



Multiple levels and types of education, learning formats, features...

*Graduate Undergraduate ... In person training ... Serious games Mock-up installations
 Vocational Compulsory ... e-learning blended ... Virtual reality*

Happy to share best practices, learnings and material.

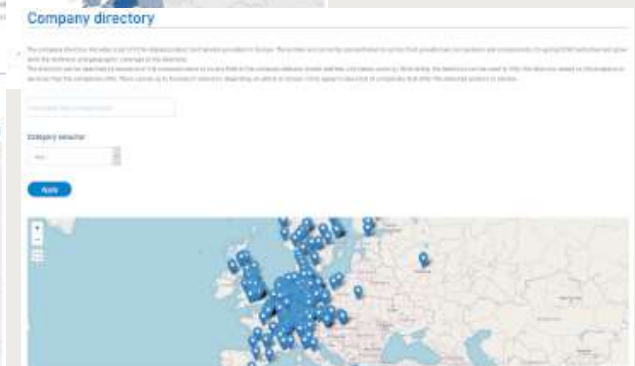
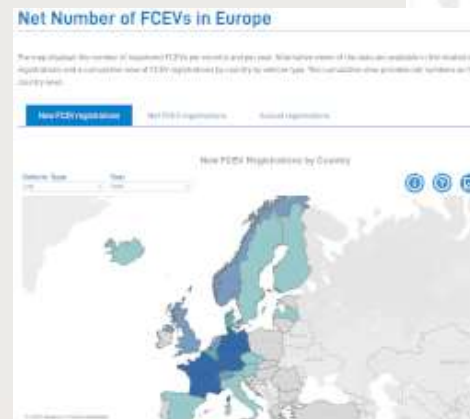
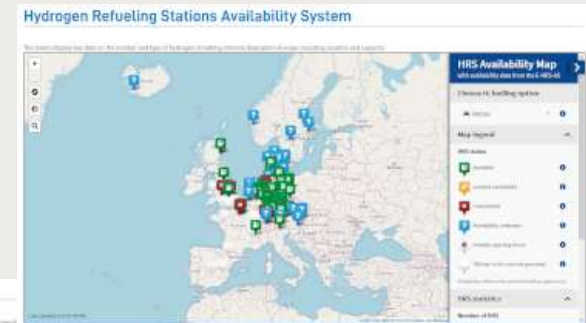


Fuel Cells and Hydrogen Observatory (Launched 15 Sept '20)



One stop shop to understand where the FCH sector is at and how it is evolving

- **Go to resource for all things on fuel cells and hydrogen**
- **User friendly and reliable output**
 - charts, graphs and data downloads
 - reports
- **It covers**
 - Technology & Market
 - Policies & regulation
 - Codes & Standards
 - Patents & Publications
 - Funding
 - Education & Training
- **Global resource**
- **www.fchobservatory.eu**
info@fchobservatory.eu



@FCHObservatory



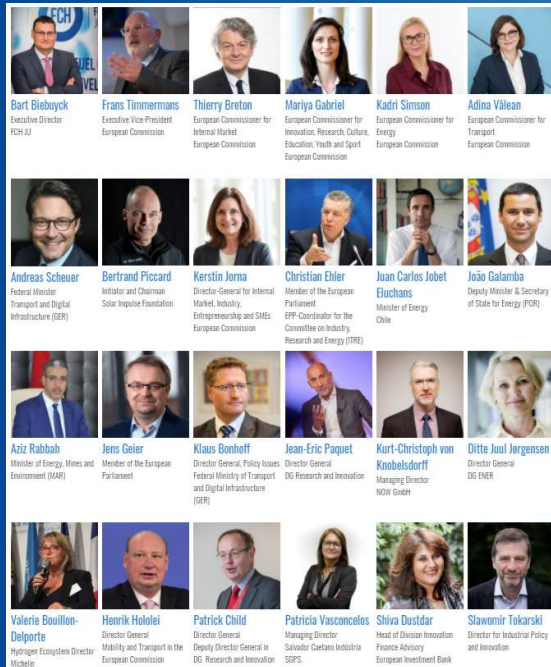
The Fuel Cells and Hydrogen Observatory has been prepared for the FCH 2 JU under a public procurement contract

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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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