



FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

***EU hydrogen
strategy and
highlights of
international
cooperation***

Bart Biebuyck
15 / 04 / 2021 Virtual

Strong public-private partnership with a focused objective

A combined private-public of more than 2 billion Euro has been invested to bring products to market readiness



FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Hydrogen Europe
Industry grouping
 >185 members
 50% SME

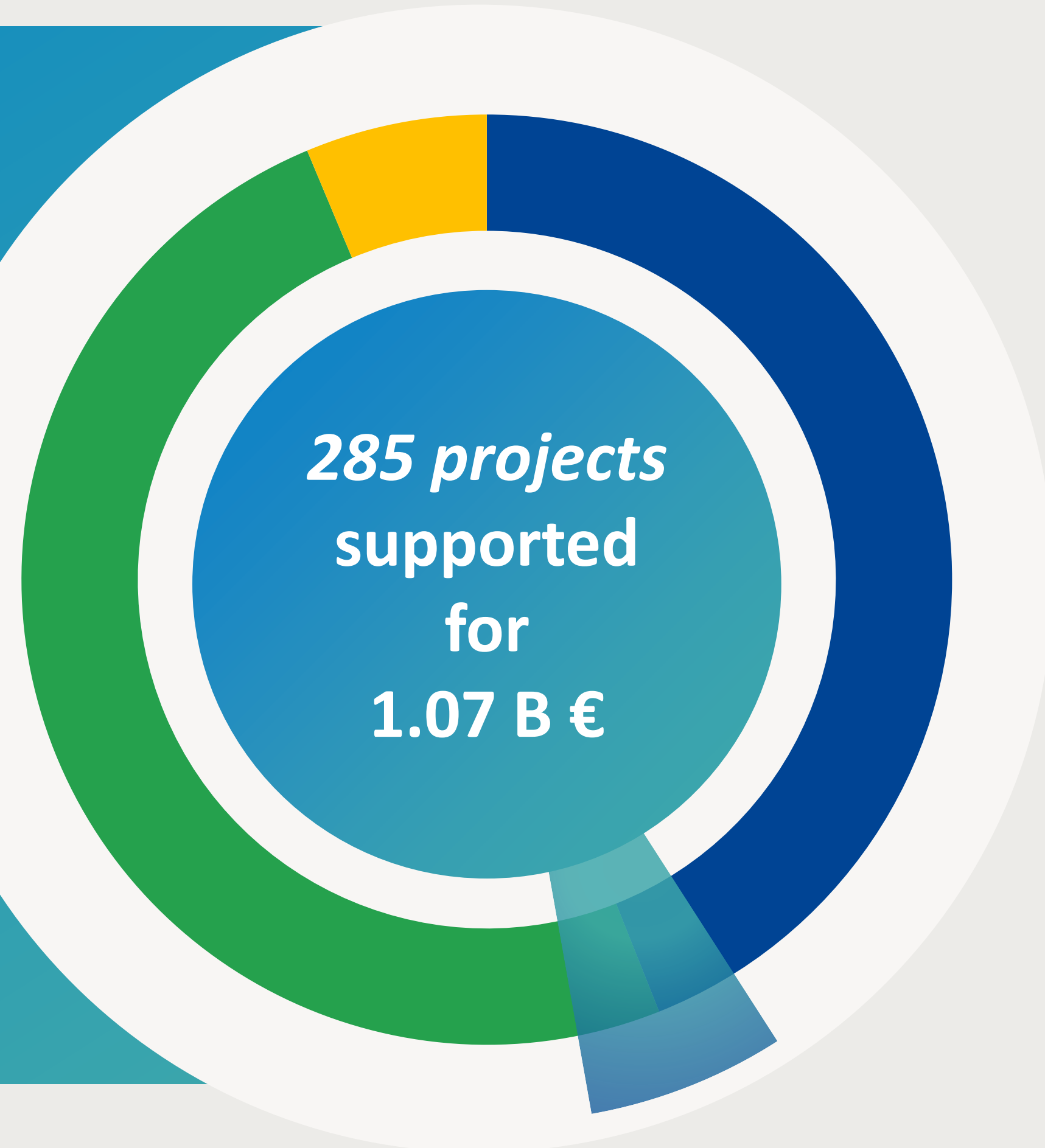
European Commission

Hydrogen Europe Research
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 Finland



FINLAND



- 20 Finnish beneficiaries
- Participating in 46 projects
- Total FCH JU contribution: 28,7 Mil € (approx. 2.67 % of Total FCH JU contribution)
- National Policy Framework: Target to reach 21 Public H2 refuelling stations by 2030

VTT / FCH JU contribution 15,4 Mil€

Various:
1 planned boat (MARANDA)



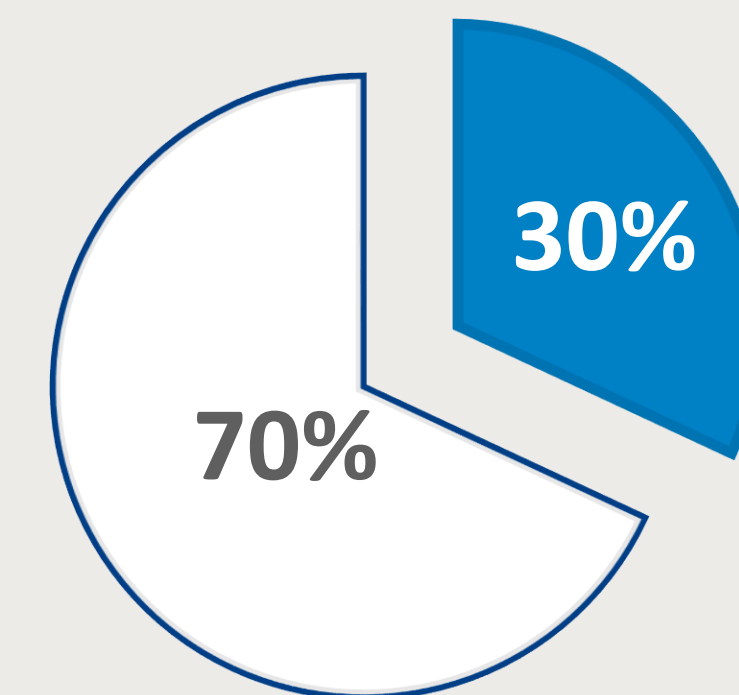
Finnish Company: **Convion** is a member of World Alliance for Efficient Solutions / FCH JU contribution 5.6 Mil€

REGIONS INITIATIVE:
Kokkola

- Helsinki:
- 1 CHP 50 kW deployed (INNOSOFC)
 - 1 CHP deployed (SOFCOM)
 - 1 Back-up power System deployed (PEMBeyond)

BUDGET ALLOCATION

■ Demonstration □ Research



Facts:

- 1 electrolyser deployed in Kokkala*
- 1 planned HRS in Rovaniemi*
- 20 planned Buses in Kerava*
- In 2013 Finland unveiled its Hydrogen Roadmap

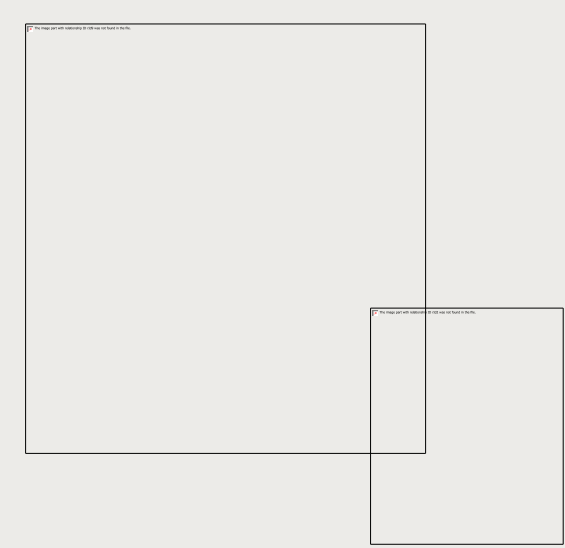
*non FCH JU demonstrations



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

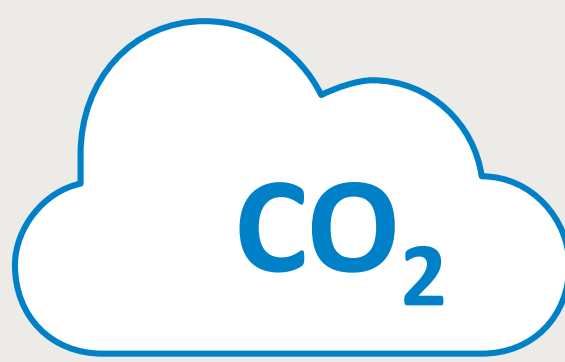


2050 hydrogen vision



~24%

of final energy demand¹



~560 Mt

annual CO₂ abatement²



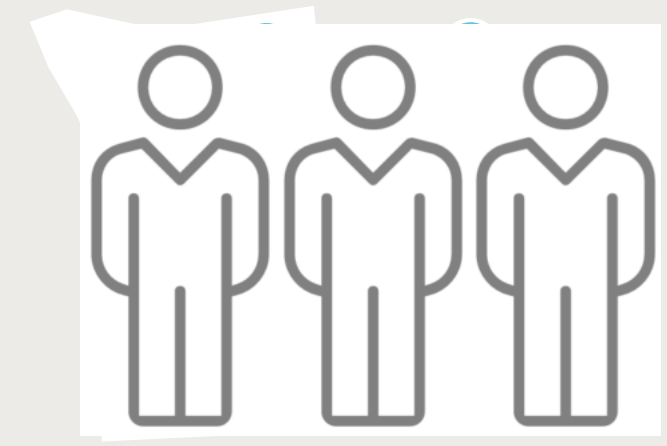
~EUR 820bn

annual revenue (hydrogen and equipment)



~15%

reduction of local emissions (NO_x) relative to road transport



~5.4m

jobs (hydrogen, equipment, supplier industries)³



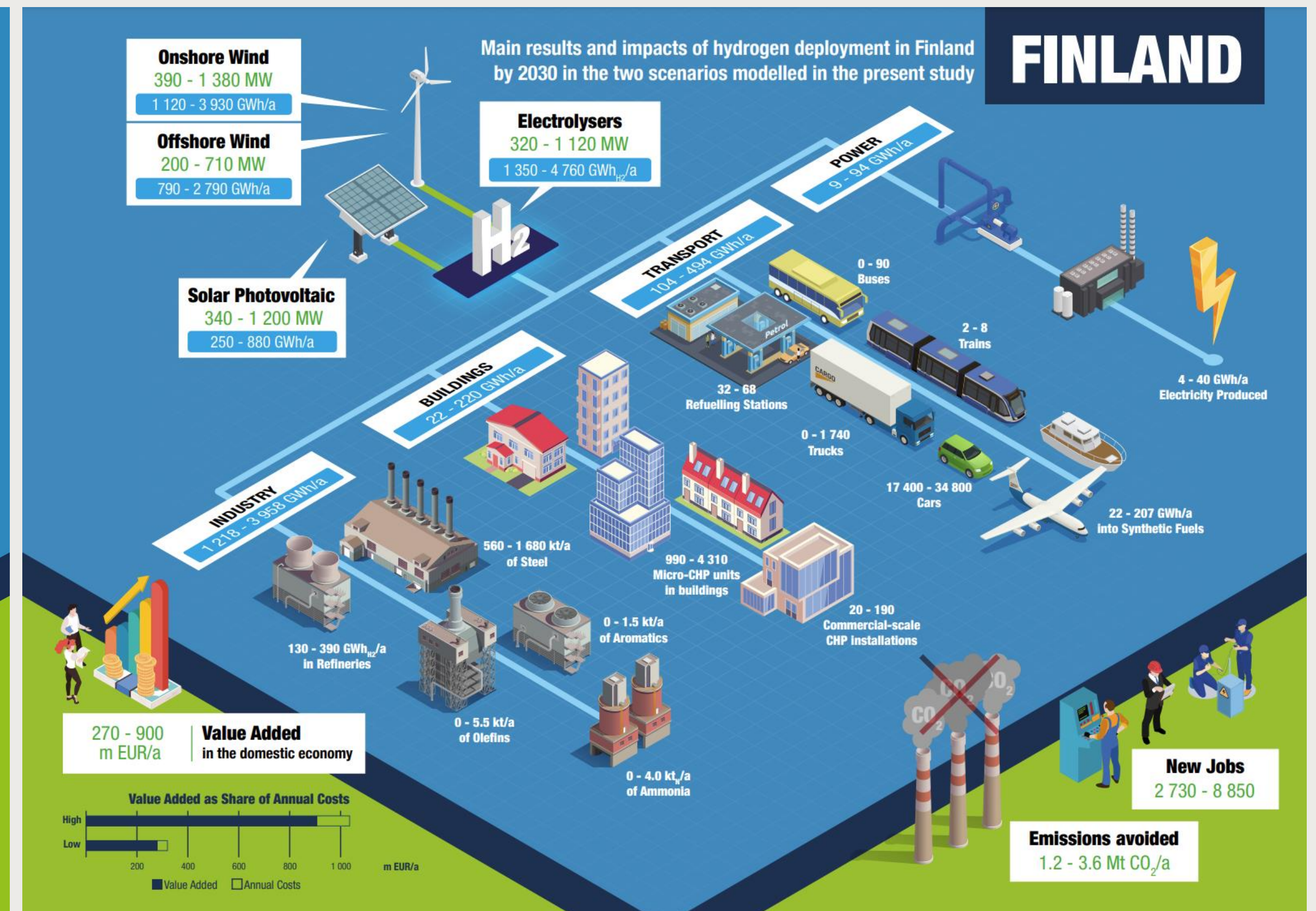
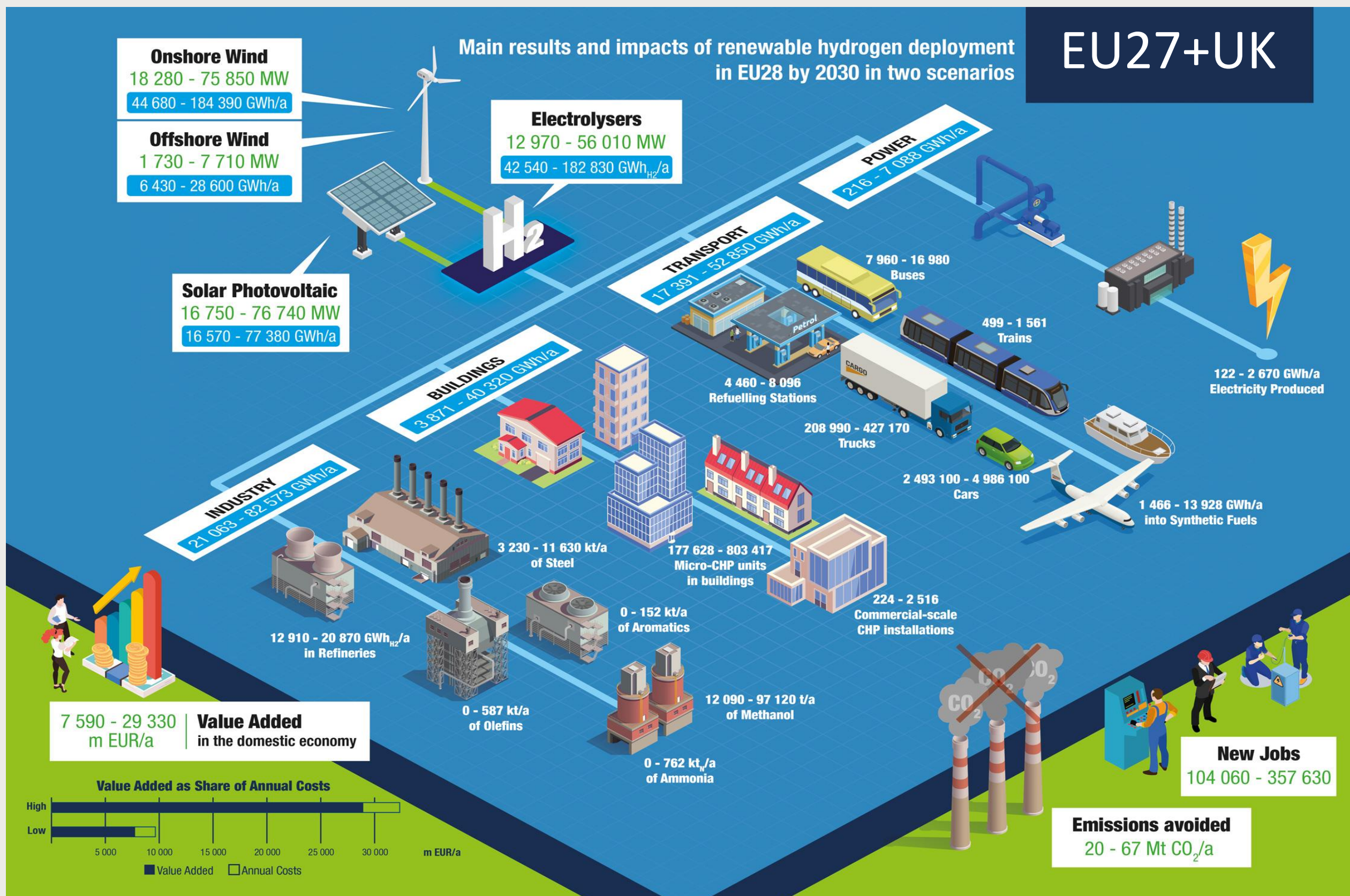
1 Including feedstock 2 Compared to the reference technology scenario 3 Excluding indirect effects

SOURCE: Hydrogen Roadmap Europe team

Opportunities from the inclusion of Hydrogen in NECPs by 2030

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

<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.

Finland can contribute (high scenario): 1.12 GW electrolysers, 900 m€ added value and nearly 9000 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




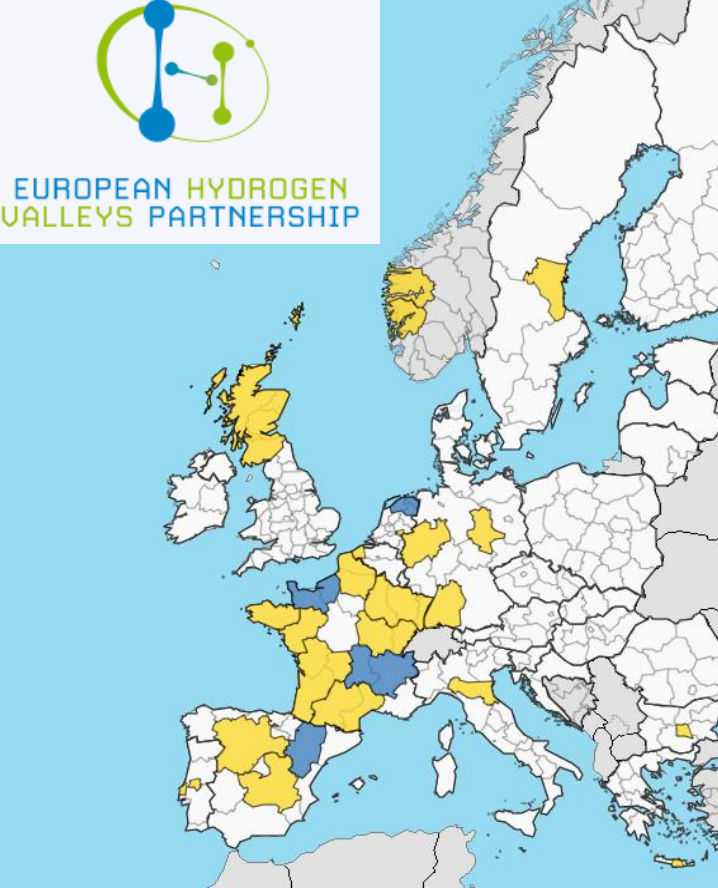

FCH-JU region initiative was key to boost the hydrogen awareness in EU



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, Pom West-Vlaanderen
- United Kingdom:** Swindon and Wiltshire, Aberdeen, Birmingham, Cornwall, Dundee, Fife, Leeds
- France:** Auvergne Rhone-Alpes, Bourgogne-Franche-Comté, Centre-Val de Loire, Grenoble, Grand Dole, La Roche sur Yon, Normandie, Occitanie-Pyrenees, Orléans, Pays de la Loire, Pays de St Gilles
- Spain:** Aragón, Barcelona, Cantabria, Castilla-La Mancha, Murcia, País Vasco, Port of Valencia, Puertollano, Valladolid
- Italy:** Lazio, South Tyrol, Faenza
- Portugal:** Torres Vedras, Médio Tejo
- Netherlands:** Assen, Drenthe, Emmen, Groningen, Helmond
- Austria:** Tirol
- Sweden:** Gävleborg, Mälardalen
- Norway:** Akershus, Møre og Romsdal, Oppland County Municipality, Sogn og Fjordane
- Iceland:** Reykjavik
- Finland:** Kokkola
- Denmark:** Guldborgsund, Lolland
- Estonia:** Tallinn
- Latvia:** Riga
- Czech Republic:** Trutnov
- Germany:** Baden-Württemberg, Bremerhaven, Hamburg, HyCologne, Hydrogen Region Rhineland, Kreis Steinfurt
- North Rhine-Westphalia:** Heide region, HYPOS (East Germany), Recklinghausen, Saxony-Anhalt
- Slovenia:** Velenje
- Croatia:** Split, Split-Dalmatia County
- Romania:** Constanta
- Bulgaria:** Bulgarian Ports, Sofia
- Greece:** Alimos, Kalymnos, Agia Paraskevi, Heraklion, Herapetra, Western Macedonia, Kozani, Papagou-Halargos, Milos, Region of Crete, Wilisissa



Project Development Assistance (PDA)
launched Jan '20 (38 applications / 19 countries)

- Texel, Netherlands
- Mariestad, Sweden
- Gdynia, Poland
- Limburg, Belgium
- Bourgogne-Franche-Comté, France
- Asturias, Spain
- Medio Têjo, Portugal
- 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/>

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



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



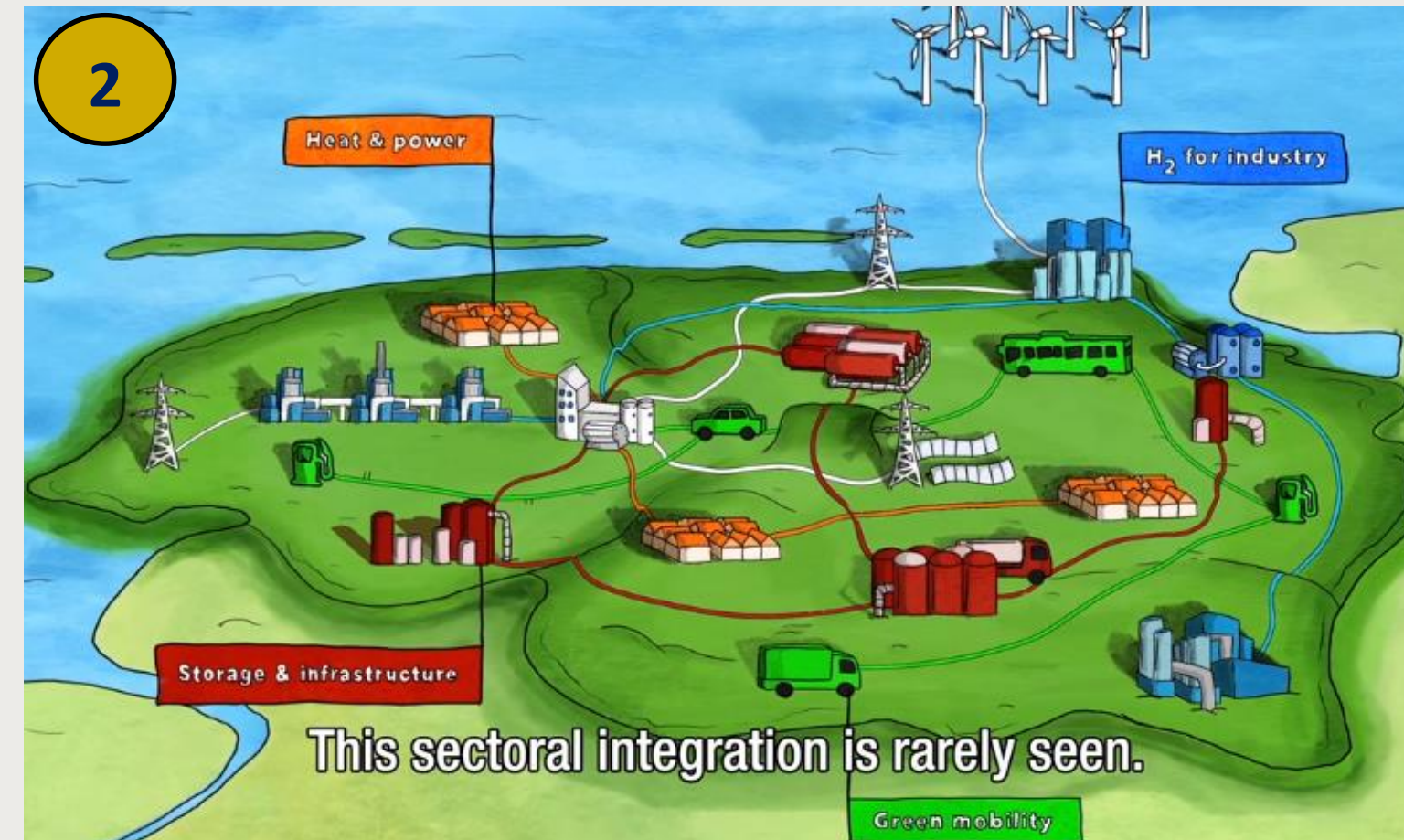
Examples of Hydrogen valleys in Europe today

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



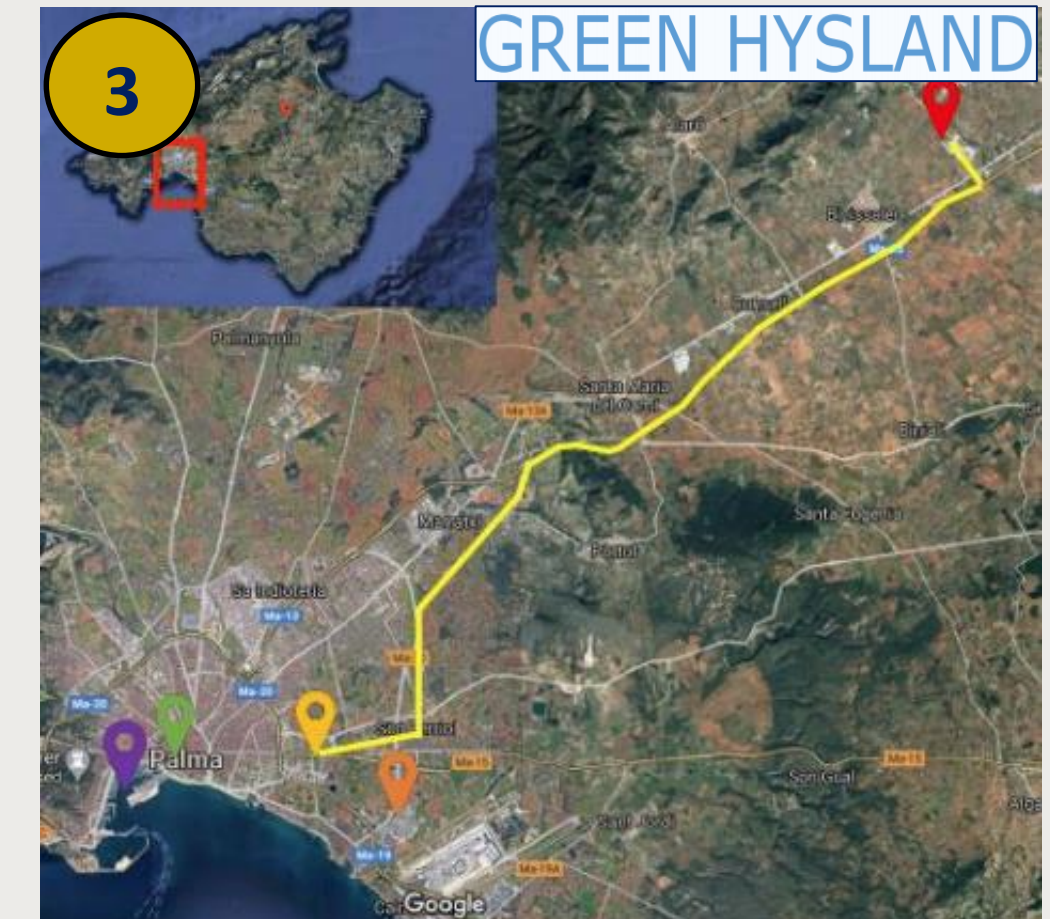
Orkney's Island (Scotland):

- 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)

(*) Subject of successful signing the grant by Dec 2020



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

Hydrogen Valleys to accelerate the energy transition

Renewable and Clean Hydrogen Challenge (IC8) under  MISSION INNOVATION



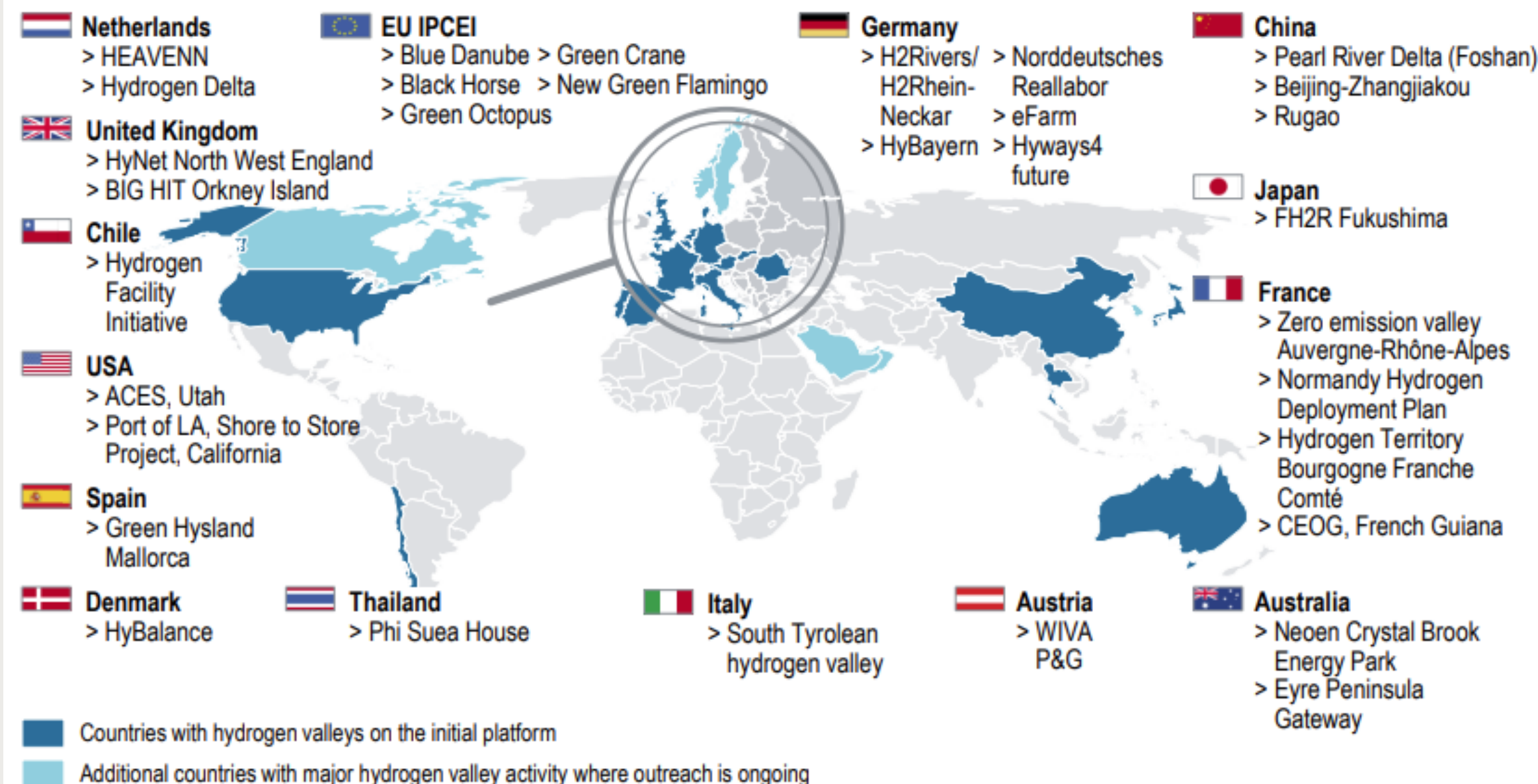
Mission Innovation






Hydrogen Valleys have become a global phenomenon, with integrated projects emerging all around the world

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

» ... featured on a new platform



-  > 30 valleys from 18 countries
-  > 3,000 data points
-  10 in-depth best-practice profiles

- ✓ Peer-to-peer exchange among H2 valleys
- ✓ Raise awareness among policy makers
- ✓ Advance clean energy transition
- ✓ EU (EC+FCH JU) in the lead also in terms of gathering and sharing lessons learnt

<https://www.h2v.eu/>



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)



Project: Don Quichot
Place: Belgium
Date: 2011
Electrolyser: Hydrogenics (PEM)
Funding: 5.0 m€

Project: Haeolus
Place: Norway
Date: 2017
Electrolyser: Hydrogenics (PEM)
Funding: 5.0 m€

Project: H2future
Place: Austria
Date: 2016
Electrolyser: Siemens (PEM)
Funding: 12 m€

Project: Djewels
Place: The Netherlands
Date: 2018
Electrolyser: McPhy (ALK)
Funding: 11 m€

NEXT:
~2025:
several 100 MW's
~2030: GW scale



Project: Hybalance
Place: Denmark
Date: 2014
Electrolyser: Hydrogenics (PEM)
Funding: 8.0 m€

Project: Demo4grid
Place: Austria
Date: 2016
Electrolyser: IHT (ALK)
Funding: 2.9 m€

Project: Refhyne
Place: Germany
Date: 2017
Electrolyser: ITM (PEM)
Funding: 10 m€

The European Green Deal call for proposals includes a topic to install a 100MW Electrolyser.

Call closed:
16 proposals received



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)



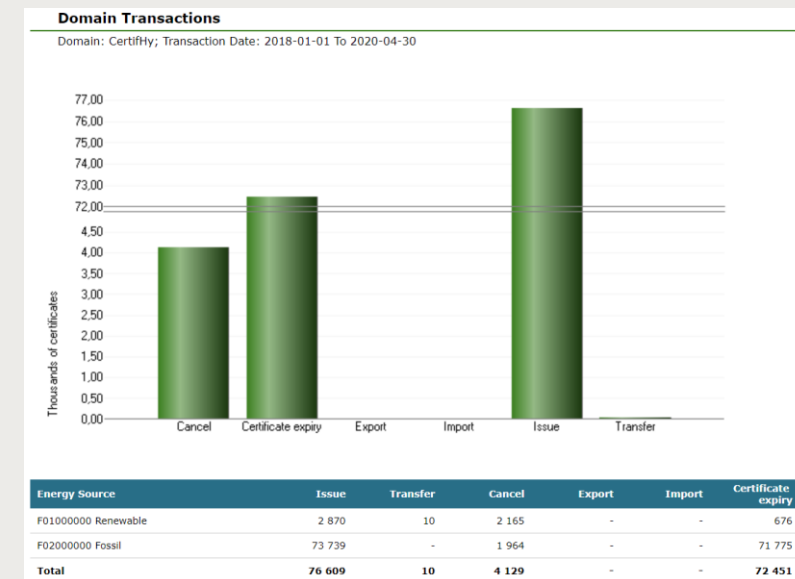
Colruyt Group, Halle (Electrolysis +RE)



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



Uniper, Flakenhagen (Electrolysis + RE and methanation)



<https://cmo.grexel.com/Lists/PublicPages/Statistics.aspx>

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.



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



Bringing H2 mobility initiatives into one framework

H2ME Project overview (2015 – 2022)

HRS: Hydrogen Refuelling Station

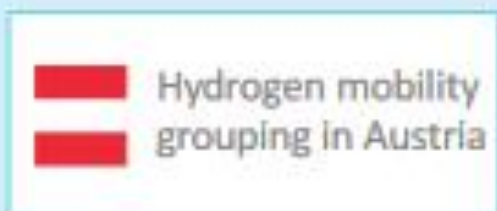
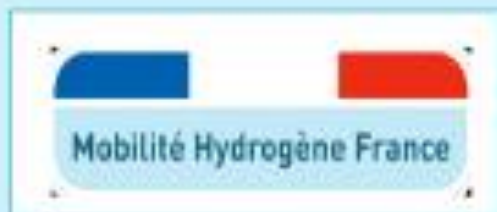
FCEV: Fuel Cell Electric Vehicle

RE-EV : Range-Extended Electric Vehicle

OEM: Original Equipment Manufacturer



Endorsers:



Concept:

- ❖ Joint initiative from the **most ambitious European hydrogen mobility initiatives**
- ❖ **One 'working framework'** linking these initiatives, which provide the opportunity to:
 - 1) identify **optimal commercialisation strategies and synergies between countries**
 - 2) develop **European strategies for commercialisation**

New hydrogen refuelling stations:

- ❖ **20** - 700bar HRS in Germany
- ❖ **12** - 700bar HRS in Scandinavia
- ❖ **11** - 350bar and 700bar HRS in France
- ❖ **6** – 350bar and 700bar HRS in the UK
- ❖ **1** - 700bar HRS in NL

Fuel cell vehicles:

- ❖ **500** OEM FCEVs
- ❖ **900** fuel cell RE-EV vans



Visualization of the data: Real-time availability information

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



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

Number of HRS

Σ total	139
700 bar	121
350 bar	45
350 bar	16



Map legend

HRS status

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

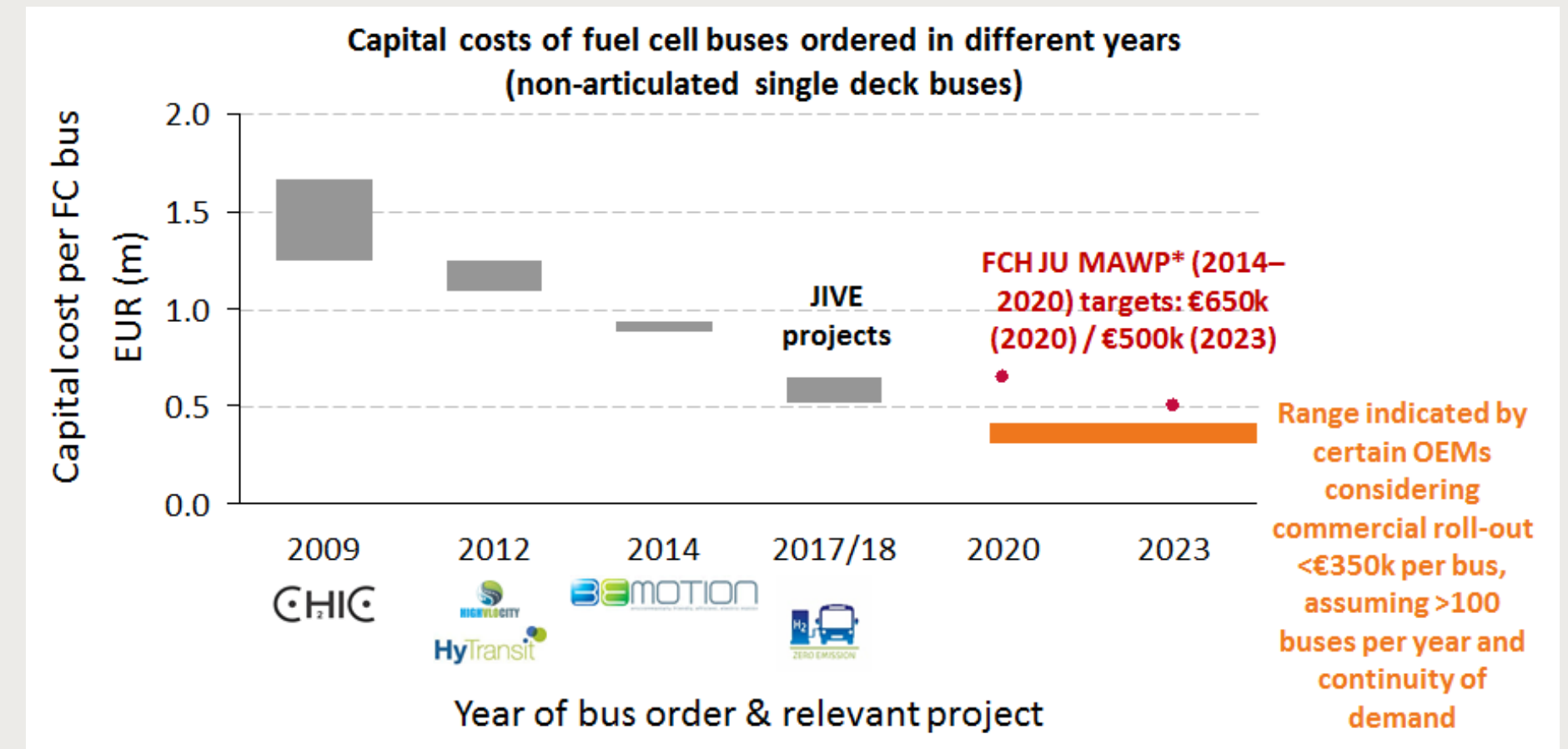
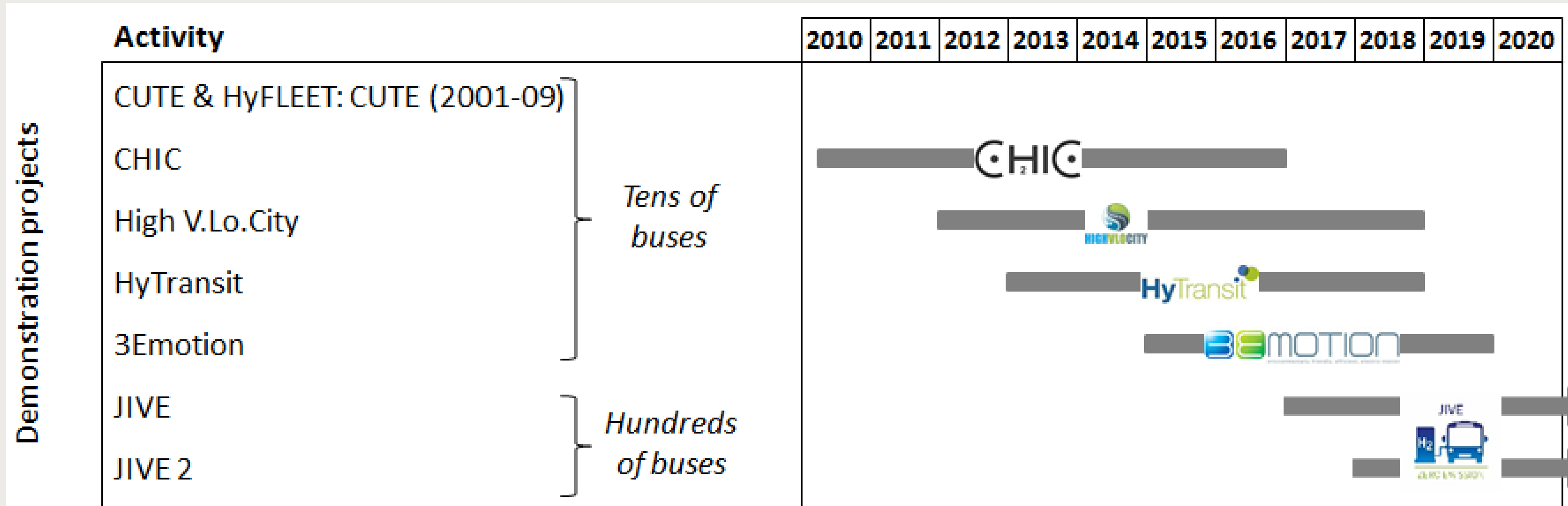
Availability refers to the selected fuelling option only.



FCH-JU funded FCB projects and studies since 2009



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



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: Coaches



Project Information	
CoachHyfied	Funded under H2020-EU.3.4.6.
Grant agreement ID: 101006774	
Status	Overall budget € 7 329 180,25
Ongoing project	EU contribution € 4 999 441,75
Start date	End date
1 January 2021	31 December 2025
Coordinated by FEV EUROPE GMBH Germany	

Heavy duty trucks demonstration projects to validate the technology

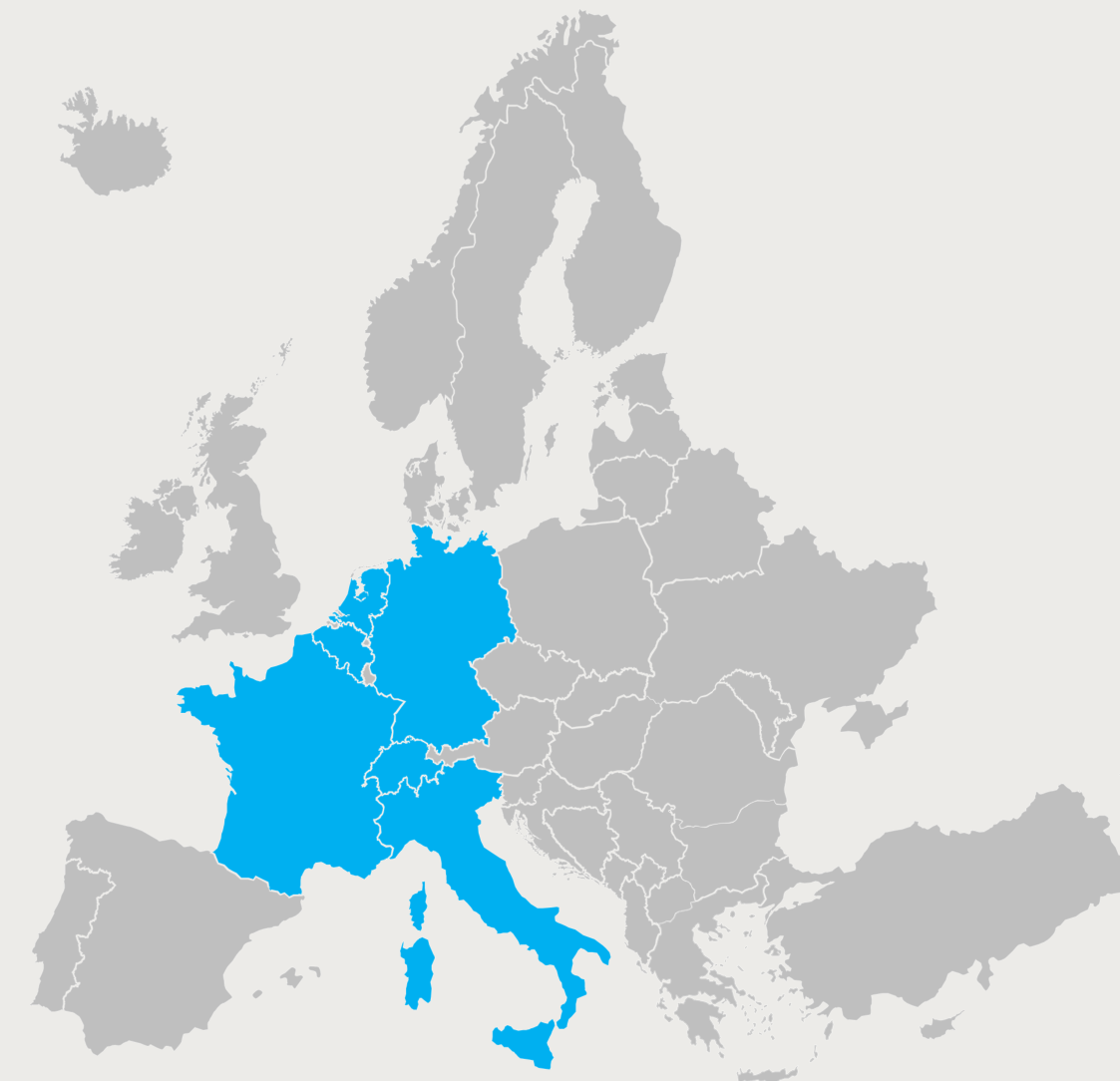
Long haul and urban applications



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;

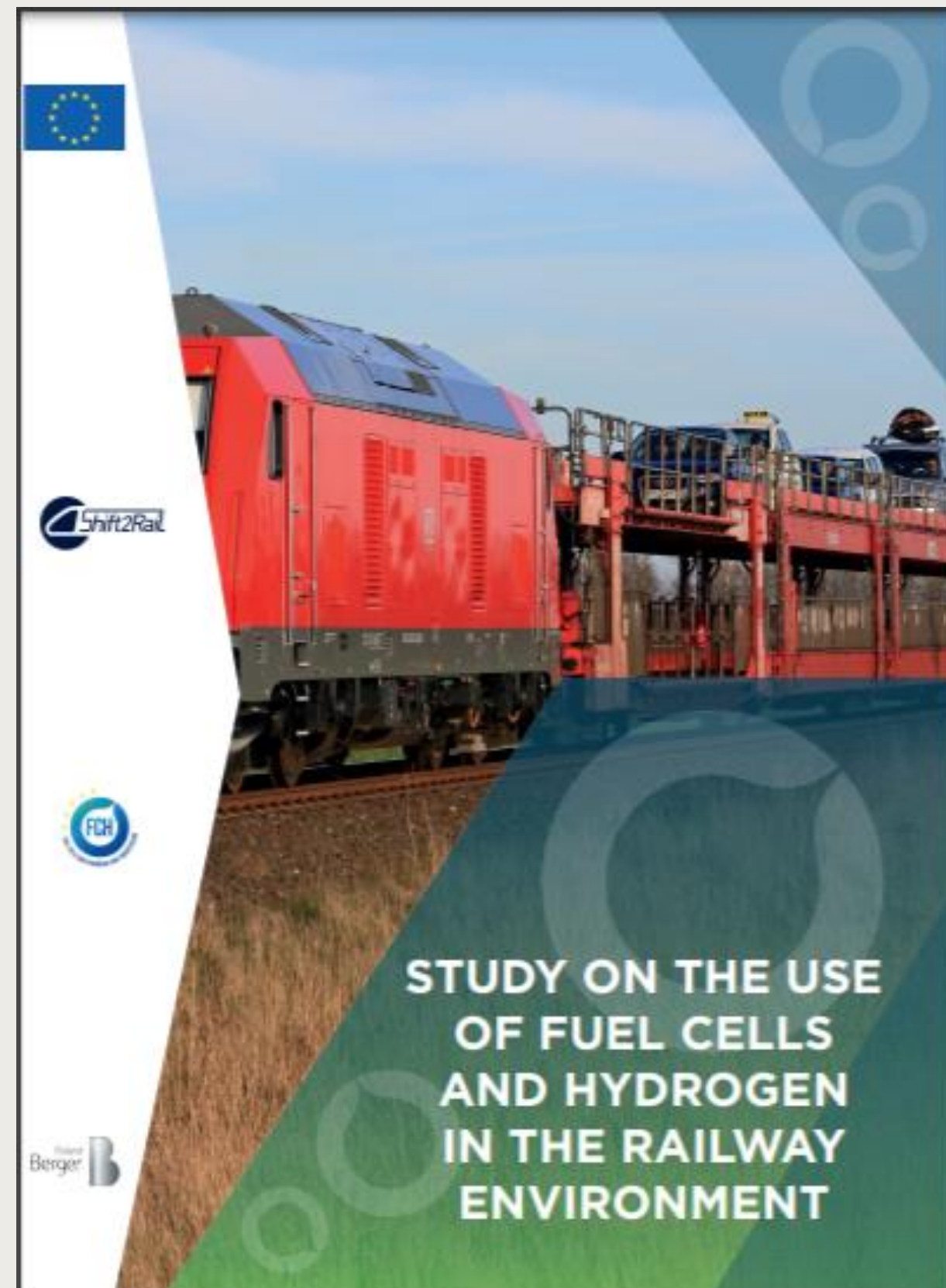


23/11/2020: Industry commitment for 100.000 trucks and 1500 HRS by 2030 in the EU

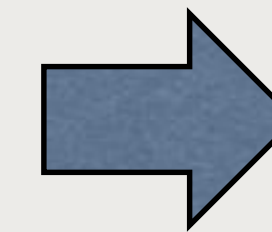


Rail accelerates Hydrogen and Fuel Cells technology

The first business models are appearing



- FCH trains make economic sense above all on longer non-electrified routes >100 km
- FCH trains esp. for last mile delivery & main routes with very low utilisation (<10 trains/day)
- Low electricity costs (<EUR 50 /MWh) & high infra utilisation (HRS...) favour FCH technology;
- FCH trains has downtimes <20 minutes (due to fast refuelling) and withstand long operating hours >18 hours w/o refuelling;
- FCH trains are economically feasible clean alternative to diesel trains in many cases;
- In some cases, battery trains may appear as more cost-effective option but come with operational constraints resulting from highly route-specific tailored battery configurations.



FCH2RAIL



The European Commission's Fuel Cells and Hydrogen Joint Undertaking (FCH JU) has selected a CAF-led project for a €10m grant to support the development of a hydrogen-powered train prototype.

The €14m FCH2RAIL project seeks to design and develop a zero-emission vehicle with competitive operating performance compared with diesel engine-powered trains.

The European Union (EU) funding was awarded under the Horizon 2020 programme.

Besides CAF, the FCH2RAIL project involves DLR, Renfe, Toyota Motor Europe, Adif, IP, CNH2 and Faiveley Stemmann Technik.

<https://fch.europa.eu/publications/use-fuel-cells-and-hydrogen-railway-environment>



FCH2 JU is supporting the growing sector of maritime

Continuum of funding in the best fit for business case



2020 – LH2 vessel



2019 – sea-going vessel



2018 – ferry + barge pusher



2017 – research vessel



2013 - APU for yachts



No « one size fits all »

- Different vessels segments
- Different power and autonomy
- Various fuels (H₂, NH₃, LOHC)
- FC technologies (PEM, SOFC)

Key considerations

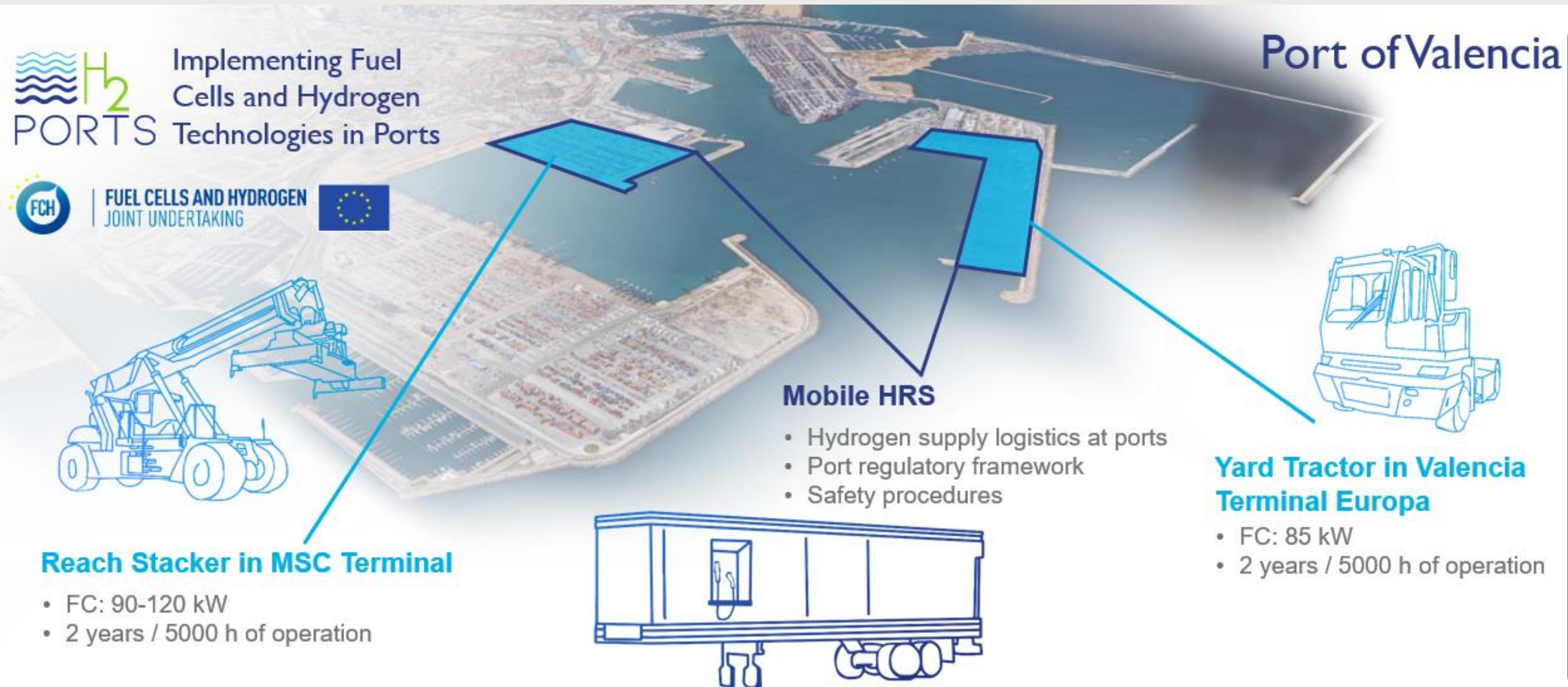
- Crucial need for international cooperation
- Importance of regulatory aspects (IMO and CESNI)
- Ports as hydrogen « coastal hubs »
- FC for hotel load at port or propulsion at sea

Challenges: R&D in the area's of LH₂ storage (bunkering), MW scale Fuel Cells, carriers,...



H2Ports project aims to implement Fuel Cells and Hydrogen in Ports

First application of hydrogen technologies in port handling equipment in Europe



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)



Next: Building a worldwide hydrogen ports coalition under CEM

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

Hydrogen propulsion has significant potential



Key takeaway: Hydrogen propulsion has significant potential

Technology	Economics	Climate impact	Research & Innovation
Hydrogen is feasible to power aircraft with entry into service as early as 2030-2035 for short-range segments	Less than 20 USD per PAX additional costs on a H ₂ -powered short-range flight – 20% cheaper on medium-range to generate same climate impact than synfuels by 2040	Zero CO₂ and 70% reduction of climate impact by converting 40% of the fleet to H ₂ with 15% less global renewable energy needs for the sector in 2050	First prototype by 2028 required for short-range – significant investments for R&I needed now to meet 2050 target

Example: Short-range aircraft with hybrid H₂ propulsion

Exemplary pictures

Evolutionary aircraft design for short range

Reference aircraft: Airbus A320 neo

- 2 LH₂ tanks in 5 m extended back of fuselage behind PAX cabin
- Fuel cell system (11 MW) generating electricity for electric motors
- Electric motor mounted on the main turbine fan shaft – providing full power for cruise, while H₂ direct burning turbine is turned off
- Balanced center of gravity – wing shifted to back and increased wing loading

-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>

Next: Close collaboration with all stakeholders to realize the demonstrator by 2028!

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.



Educational Activities – Overview

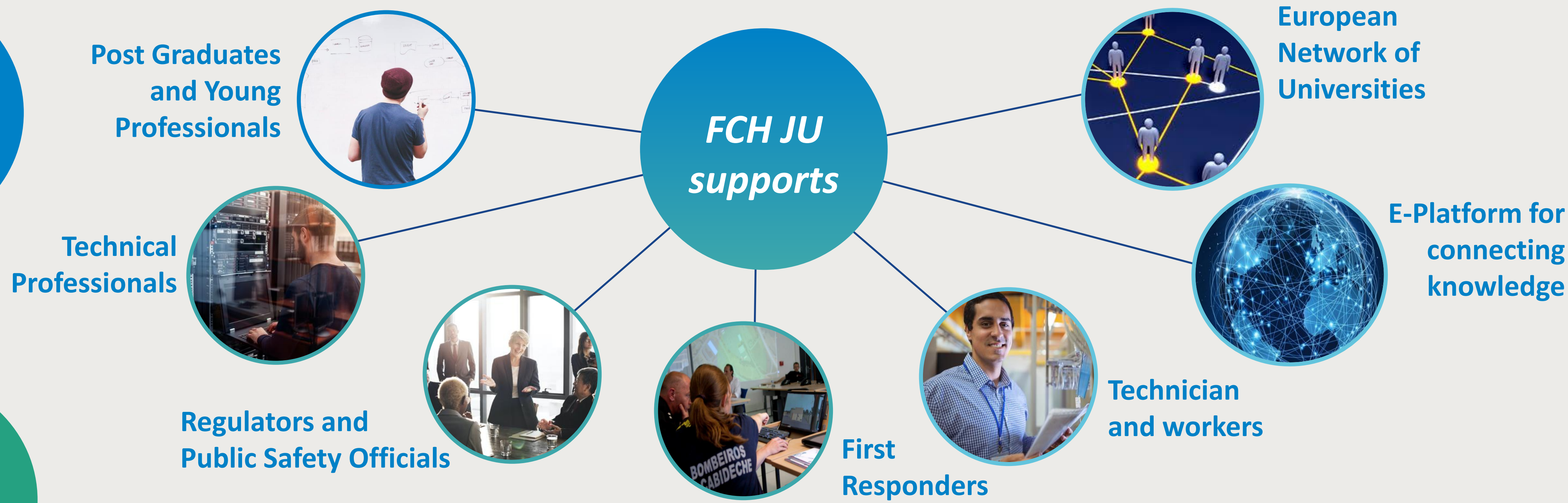
Preparing the European workforce is crucial for scaling up the industry.



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.



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!

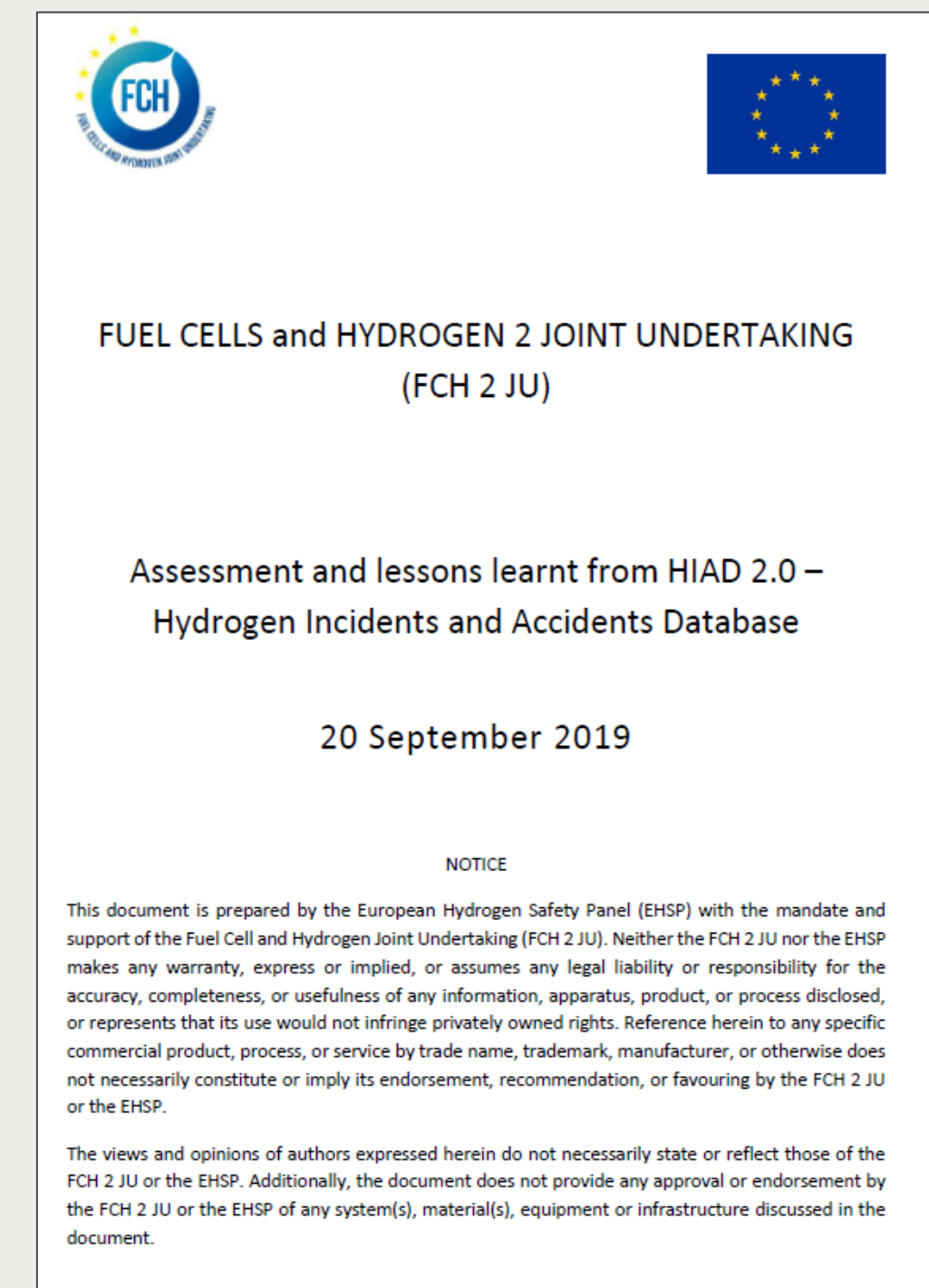
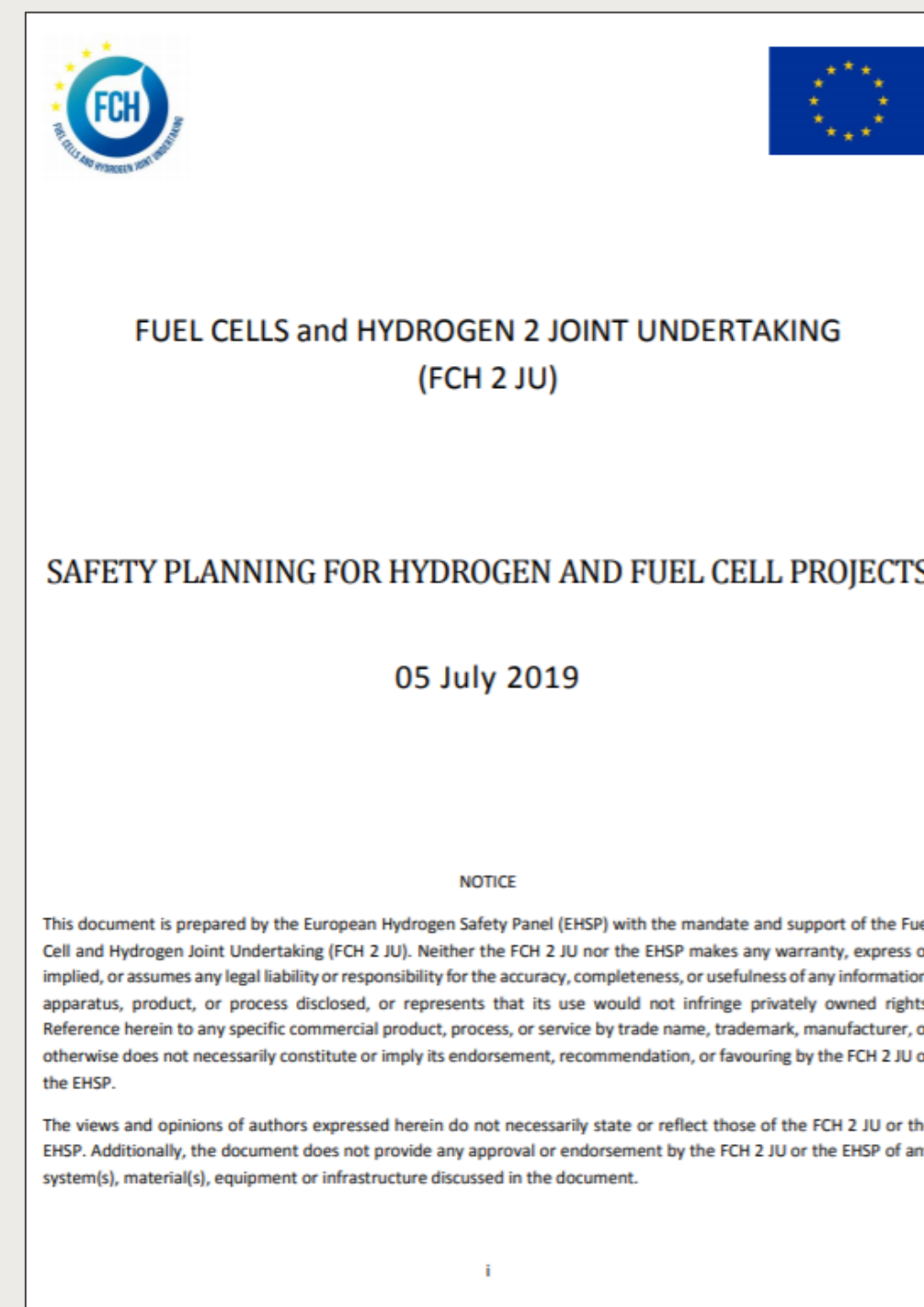


16 experts from industry & research

**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



Funding instruments at EU level

Future European Funding opportunities for hydrogen

Depending on the project seize and goal, the right funding instrument should be chosen, FCH can help you





Horizon Europe

THE NEXT EU RESEARCH & INNOVATION PROGRAMME (2021 – 2027)

New partnership: CLEAN HYDROGEN

PILLAR H2 PRODUCTION

SO1 Low carbon H2 production

1. Electrolysis
2. Other modes of production

SO2 Integration of renewables

3. Role of electrolysis in the energy system

PILLAR H2 DISTRIBUTION

SO3 Storage & delivery of H2

4. Large scale storage
5. Pipeline transport (grid)
6. Liquid carriers
7. Non-pipeline transport
8. Key technos for distribution

SO4 Refuelling infrastructure

9. HRS for multiple applications

PILLAR H2 END USES

SO5 Transport vehicles

10. Building blocks
11. Trucks & large vans
12. Maritime (inc. ports)
13. Aviation
14. Rail
15. Coaches

SO6 Heat & Power

16. Stationery H2 fuel cells
17. H2 burners and turbines

SO7 Industry

18. H2 in industry

SO8 Hydrogen Valleys
Integrated H2 ecosystems combining multiple applications (ports, industrial hubs, cities, etc.)

S10 Cross-Cutting
Regulations, Codes, Standards, Training, Safety, social, etc.

SO9 Supply Chain
Manufacturing & scale-up

Int'l coop.

Safety

Knowledge

Comms

Start expected by end 2021 with an increased budget

Connecting Europe Facility

Investing in Europe's growth

INNOVATION FUND

Driving clean innovative technologies towards the market

First call for projects in 2020

€10 billion to invest up to 2030 in EU's climate neutral future

Avoid emissions and boost competitiveness

Supporting innovation in:

Energy intensive industries

Renewables

Energy storage

Carbon capture, use and storage

Funded by: EU Emissions Trading System

IPCEI

Hydrogen for Climate Action



Important Project for Common European Interest

Next Generation EU

#NextGenerationEU #EUBudget





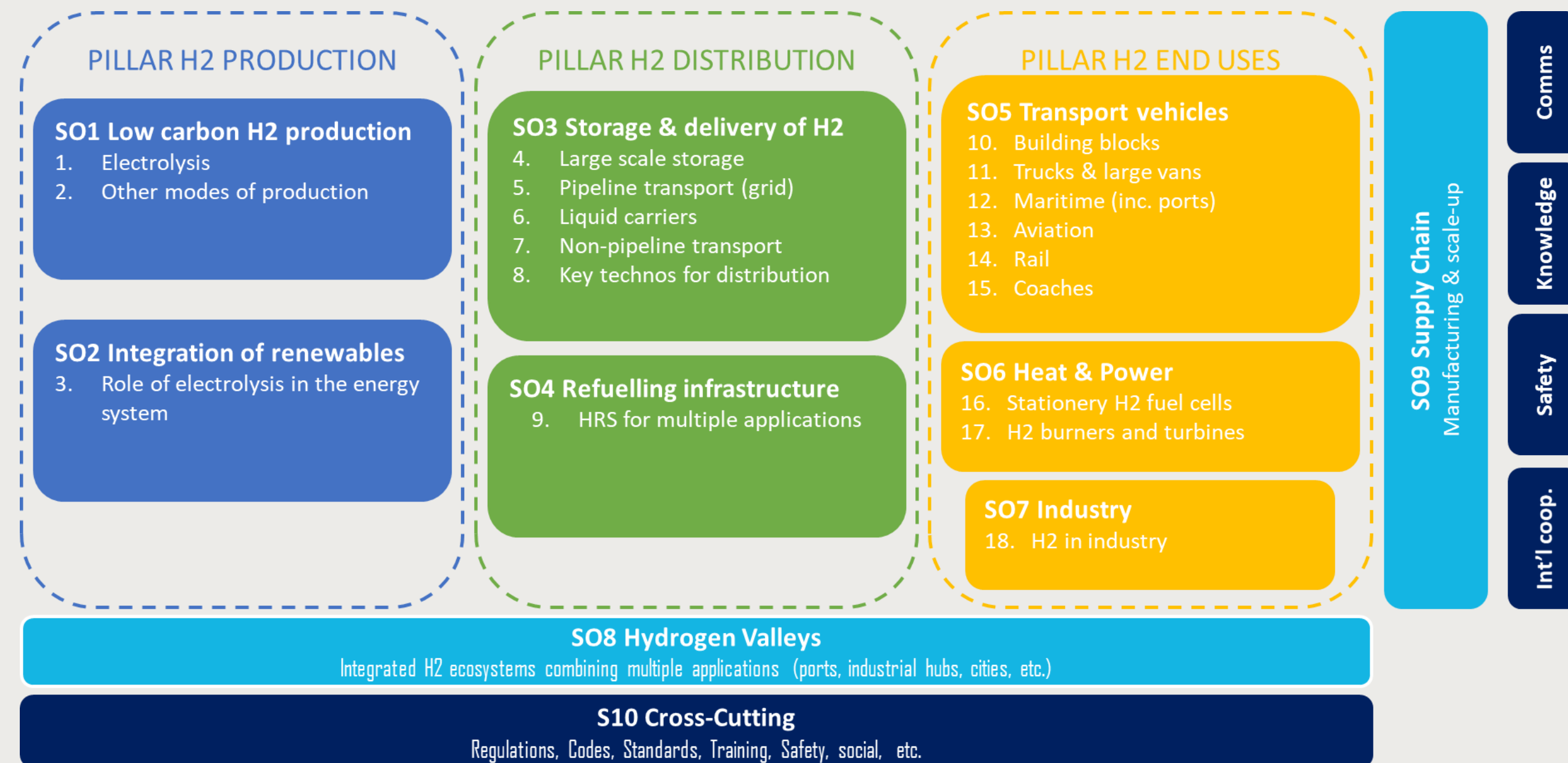
Hydrogen – Research and innovation

Partnership under Horizon Europe Programme



Maintain and strengthen EU's global leadership role through support:

- Establish Clean Hydrogen Partnership (successor of FCH-JU) by end 2021 with a budget of **1 billion EUR**
- Targeted research and innovation in Horizon Europe
- ETS Innovation Fund
- Interregional Innovation Investment Instrument with pilot action on hydrogen technologies



H2 is split in 7 partnerships in EU:

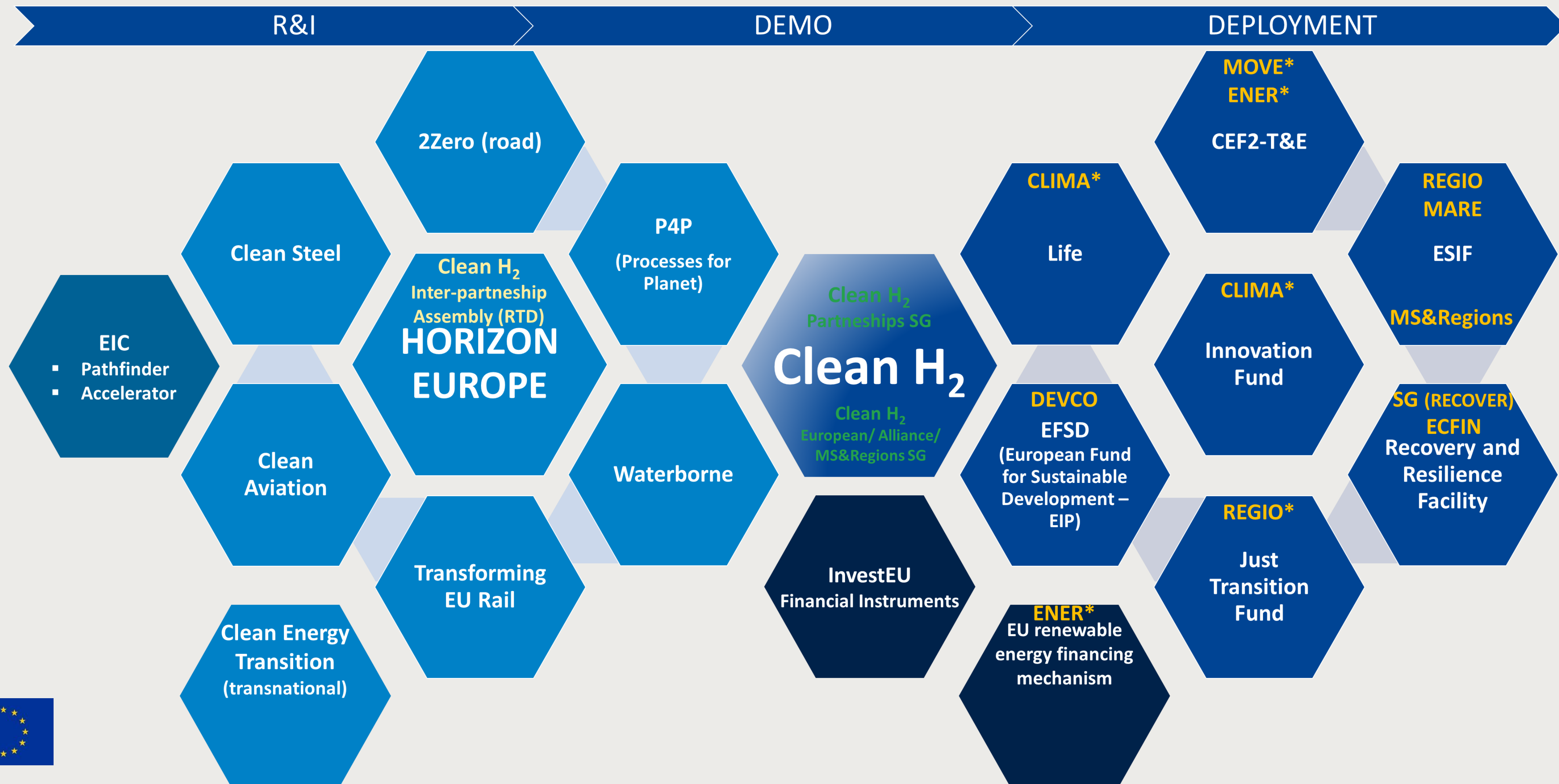
- Clean Hydrogen
- Processes4Planet
- 2ZERO
- Waterborn
- Clean Steel
- Clean Sky
- EU Rail



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

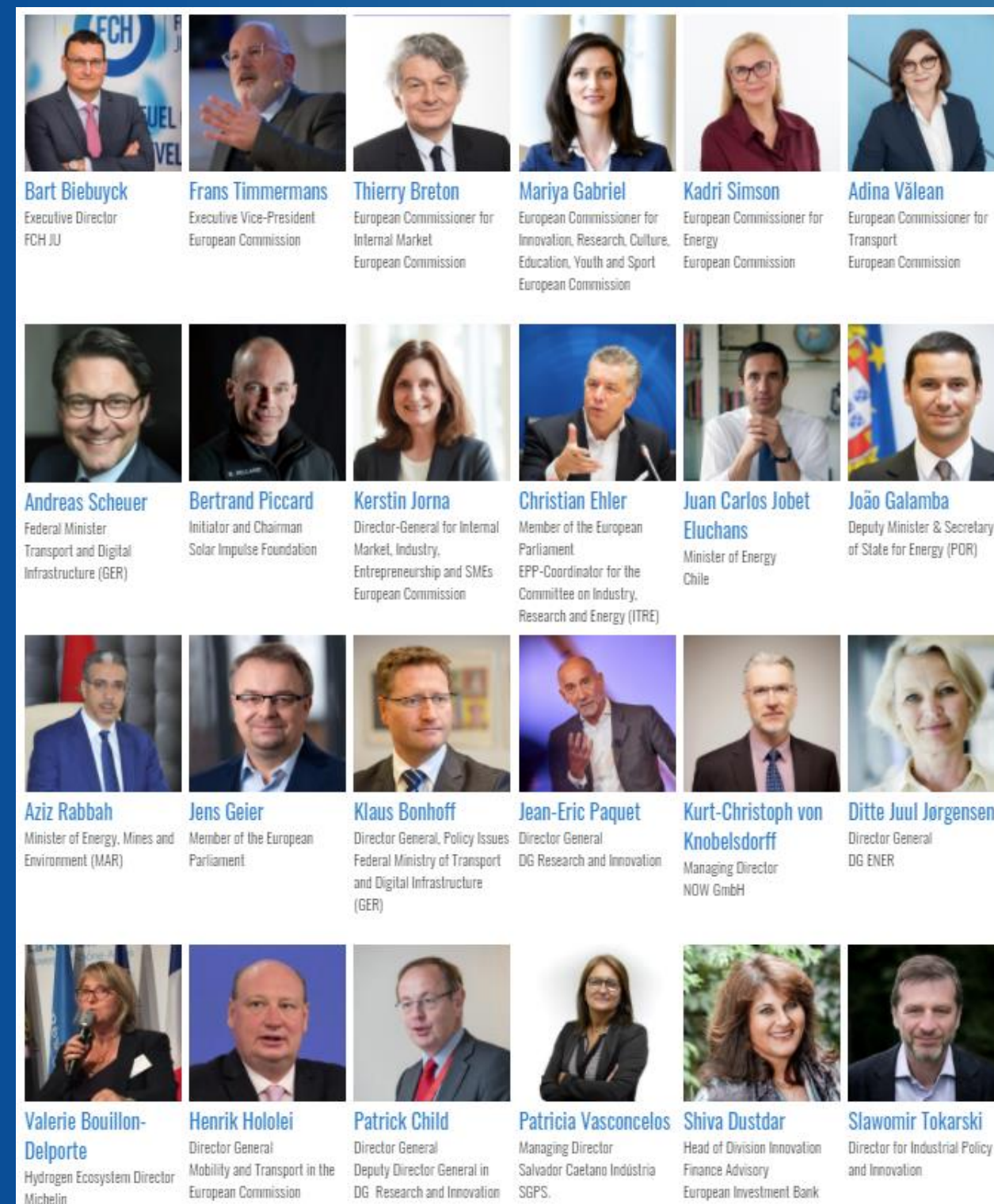


The 1st European Hydrogen Week

A huge success with many high level speakers



More than 10.000 people from 63 countries joined



The 2nd European Hydrogen Week + Launch of Clean H₂ JU

29th Nov. – 3rd Dec. 2021

Brussels, Belgium





FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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 FCH JU