



**FUEL CELLS AND HYDROGEN**  
JOINT UNDERTAKING

***The Status of SOEC  
R&D in the European  
Fuel Cell and Hydrogen  
Joint Undertaking  
Programme***

***Bart Biebuyck***

Executive Director

GrinHy2.0 – 14<sup>th</sup> of July 2021



# 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



**Industry grouping**  
>270 members  
50% SME



**Research grouping**  
±100 members



### Energy

H<sub>2</sub> production and distribution  
H<sub>2</sub> storage  
F/C for CHP



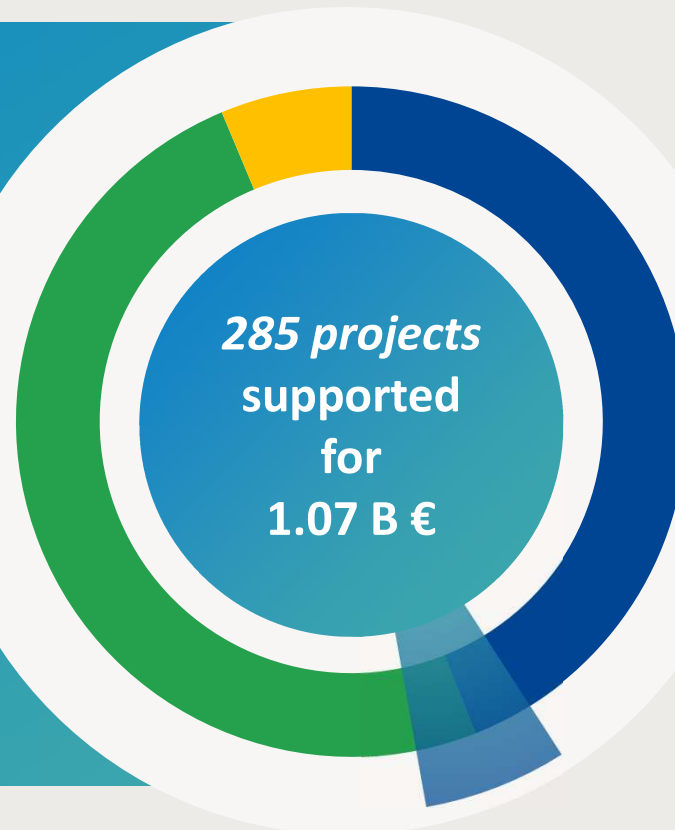
### Transport

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 €

# Support to Solid Oxide Technologies

## SO Fuel cells and Electrolysers



### Solid Oxide Total – 180.8 M€

57 projects, 17 % of total budget



■ Trials and Deployment of Fuel cell applications - Transport

■ Next Generation of products - Transport



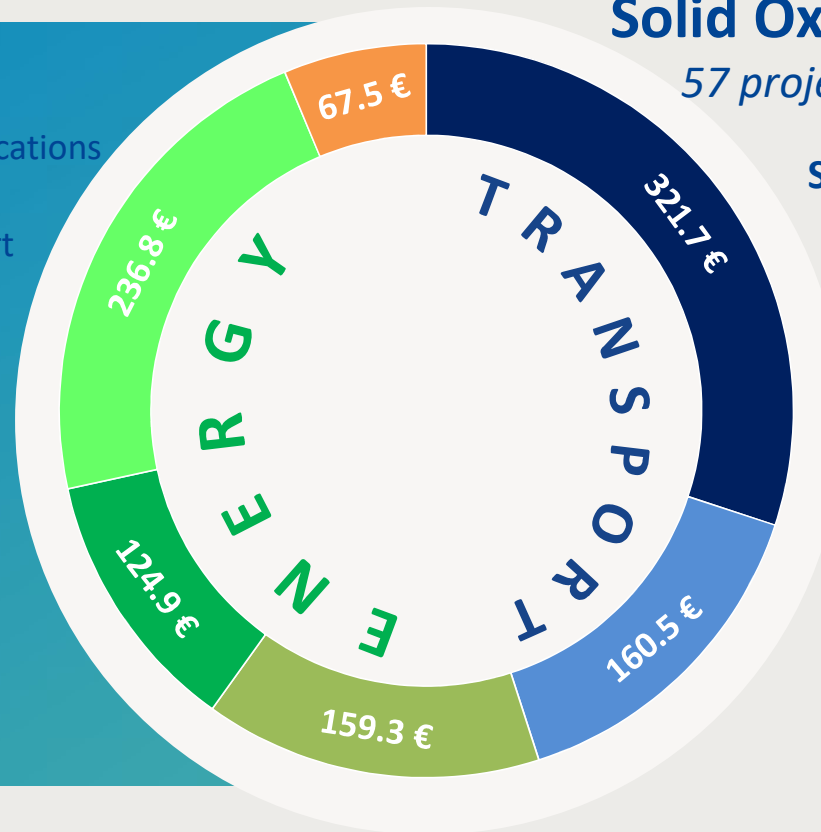
■ Trials and Deployment of Fuel Cell Applications - Energy

■ Next Generation of products - Energy

■ Hydrogen for Sectorial Integration



■ Support for Market Uptake



#### Stationary: Trials & Deployment\*

72.7 M€

17 Projects



#### Stationary: Next Generation

63.1 M€

27 Projects



#### Hydrogen Production

45 M€

13 Projects



\* For the large demonstration projects on FC micro-CHP projects 50% of the funding has been allocated to SOFC and 50% to PEMFC in line with the type of units developed to date.

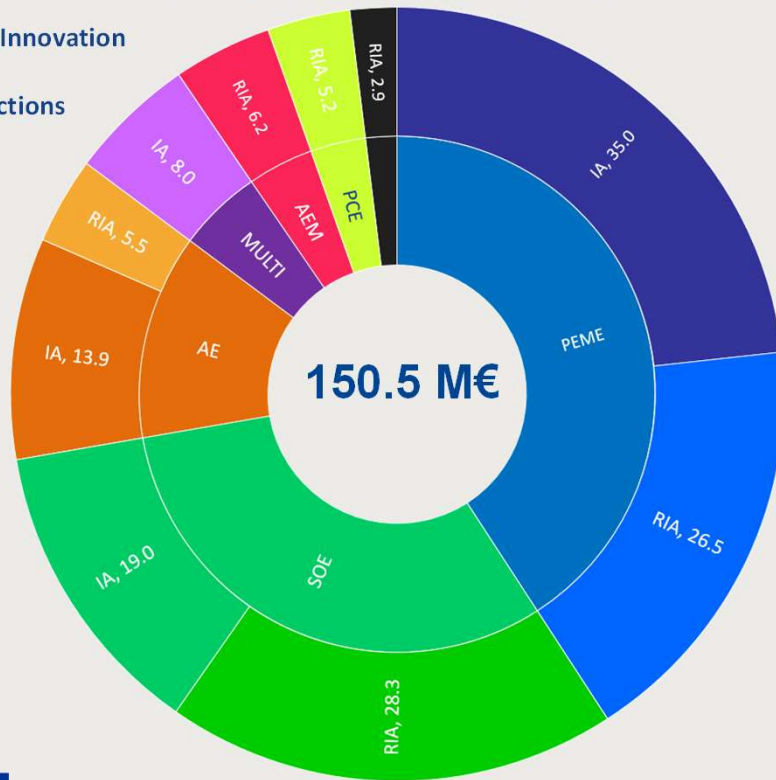
# Electrolysis Research and Demonstration

The potential of Hydrogen for the greening of industry has lead to fast capacity increase and cost reduction



Electrolysers, M€ FCH JU support

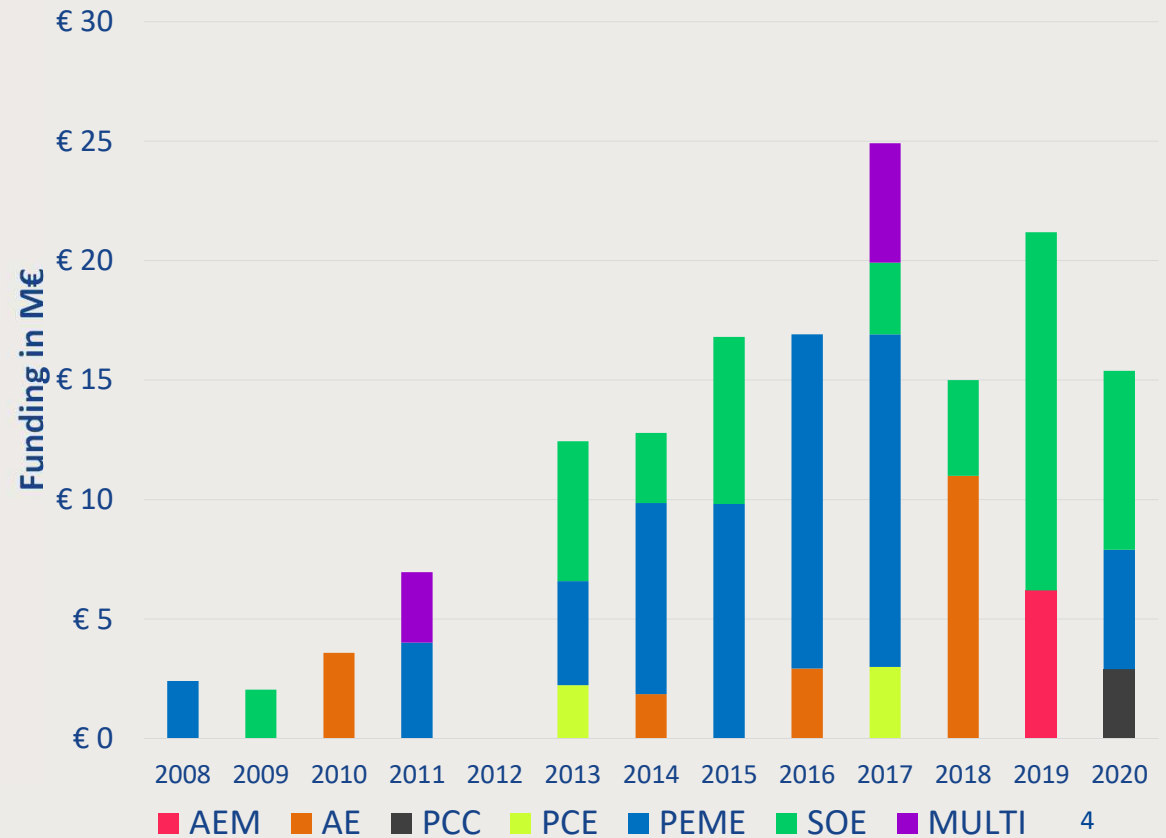
RIA: Research & Innovation Actions (RTD)  
IA: Innovation Actions (Demo)



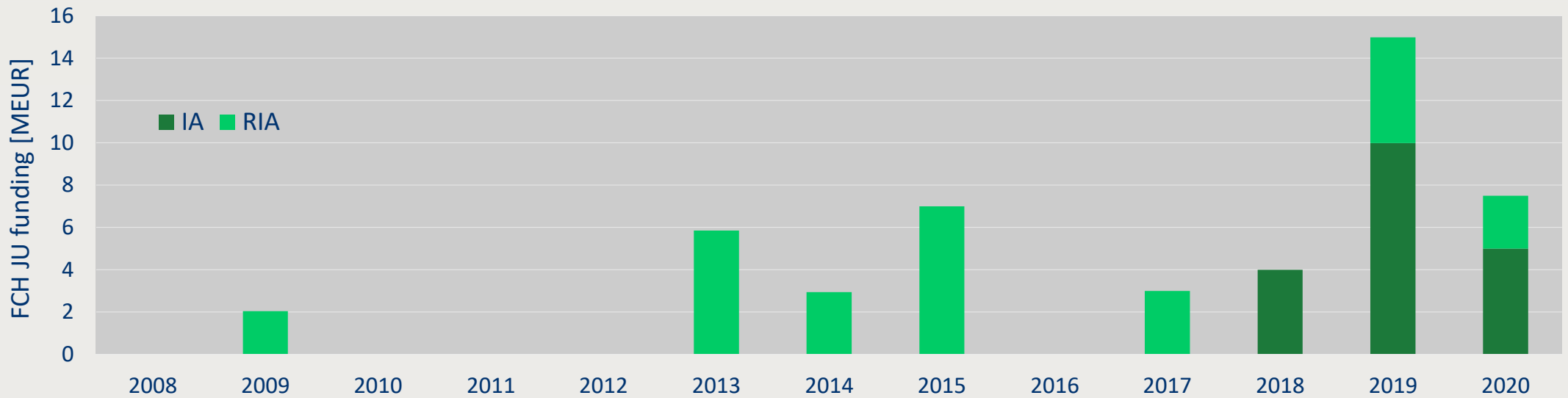
42 Projects



FCH JU funding per technology



# An 13 years journey of support to SOEs



Research on SOEs

Novel concepts

Improved performance

Largest SOE tested on-site

Performance, reversibility

1MW SOE demonstration

Reversible SOFC  
2.4 MW SOE demonstration

Megawatt co-electrolysis

# 2015: Greening steel surface treatment Industry

The GrInHy Project: Green Industrial Hydrogen via Reversible High-Temp Electrolysis



## 2015: GrInHy



- 150kW Solid Oxide Electrolyser – 6 modules, 240 cells each
- Displacing 10% of 4MNm<sup>3</sup>/a consumption of H<sub>2</sub> used for steel production
- $\eta=84\%_{LHV}$
- Can operate @ 125% SOE capacity and in SOFC mode (30kW,  $\eta=48\%_{LHV}$ )
- Operated for 10,000 hours
- Dynamic operation over 5 days



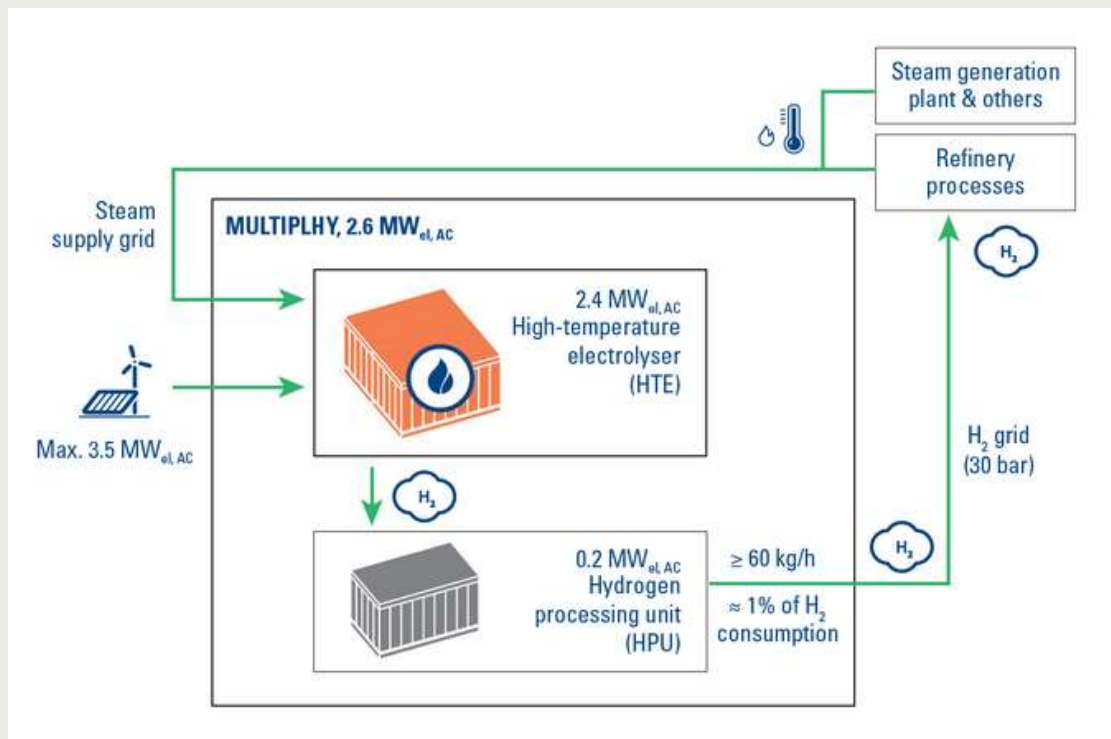
## 2018: GrInHy2.0



- nominal power input of 720 kWAC
- The system consists of up to eight modules with 720 or 1,080 SOECs each, i.e. 24 or 36 stacks, respectively.
- System has been delivered and commissioned
- By the end of 2022 it will produce 100 tons of green hydrogen at electrical efficiency of minimum 84 %LHV.

# 2019: Greening a biofuels refinery in Rotterdam

The MultiplHy project: Multimegawatt high-temperature electrolyser to generate green hydrogen for production of high-quality biofuels



- World's first Multi-MW High temperature electrolyser (2.4MW)
- Hydrogen Production Rate of 60kg/h
- Will be operated for 16,000h within the project
- As a result 8,000 tonnes of GHG will be avoided



Source: <https://multiplhy-project.eu/>

# HT Electrolysis Demonstration projects

HTEs finding their place in the industrial courtyard, facilitating strategic partnerships



PAUL WURTH BECOMES NEW LEAD INVESTOR AND TECHNOLOGY PARTNER OF SUNFIRE

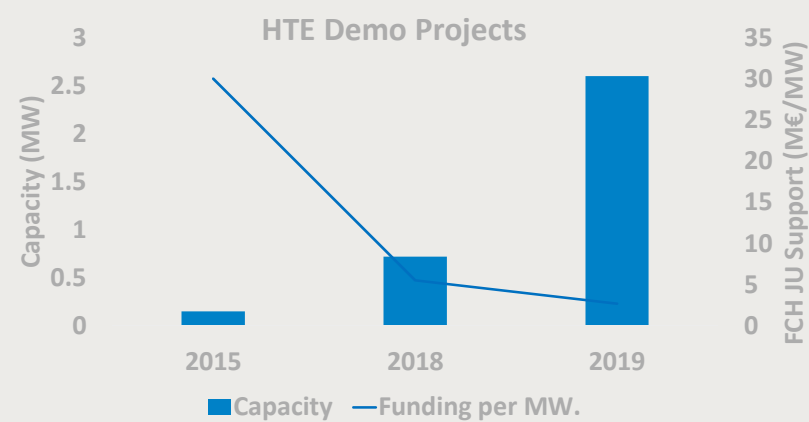
Saltzgitter Iron and Steel Works  
2018  
720kW

GrInHy2.0  
Green Industrial Hydrogen

Saltzgitter Iron and Steel Works  
2015  
150kW

Rotterdam Neste Biorefinery  
2019  
2.4MW

NESTE INVESTS IN SUNFIRE



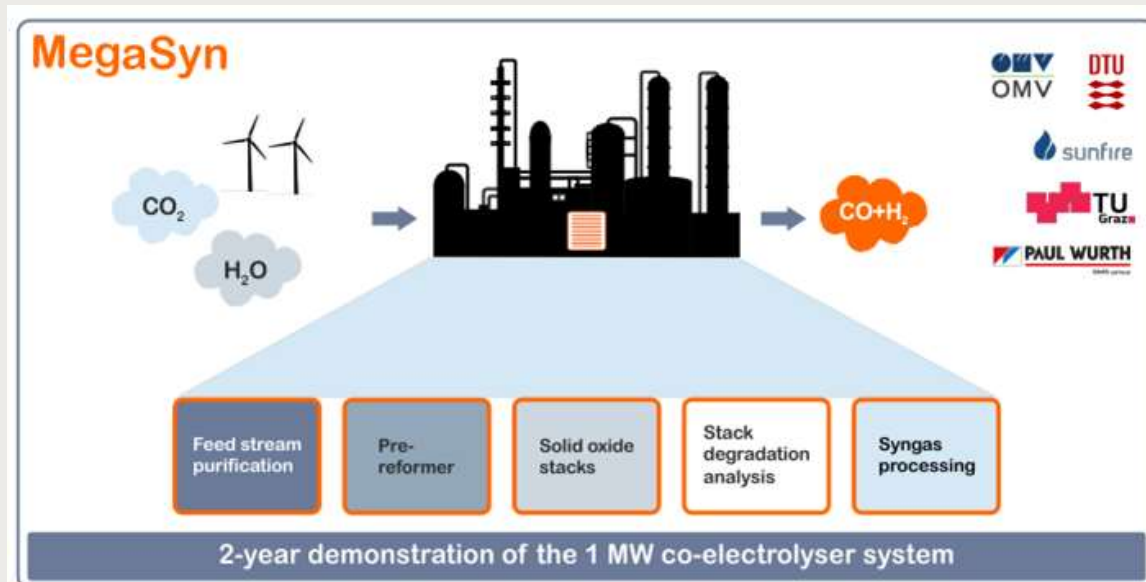
In 5 years capacity increased >10x and support reduced by 5x





# 2020: Production of renewable syngas for the refining industry

The MegaSyn project: The world's first megawatt-scale co-electrolyser for industrial production of syngas



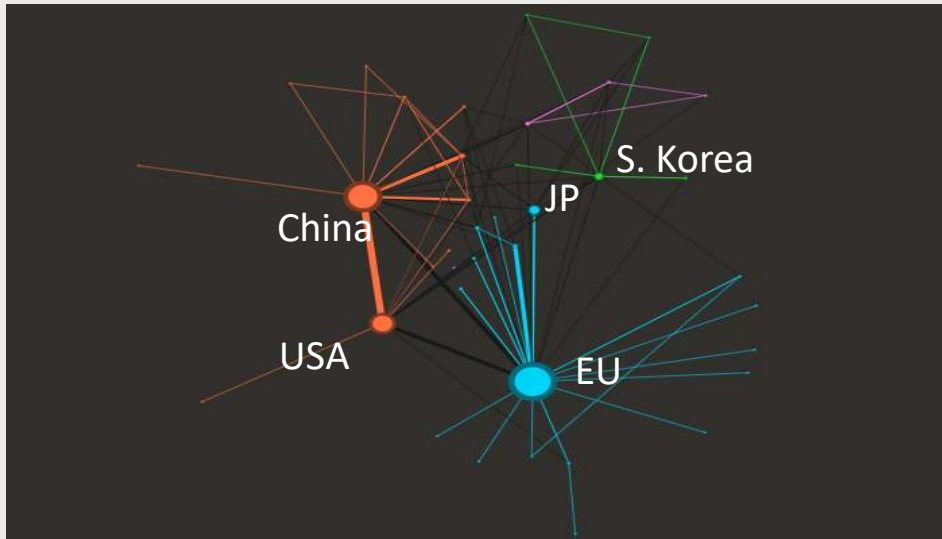
The MegaSyn project will be the world's first demonstration of syngas production by co-electrolysis on mega-watt scale in an industrial environment. The MegaSyn project will apply a high-performing solid oxide electrolysis cells (SOEC) system and operate for 2 years to demonstrate the production of >900 tons of syngas based on renewable energy.

## Targets

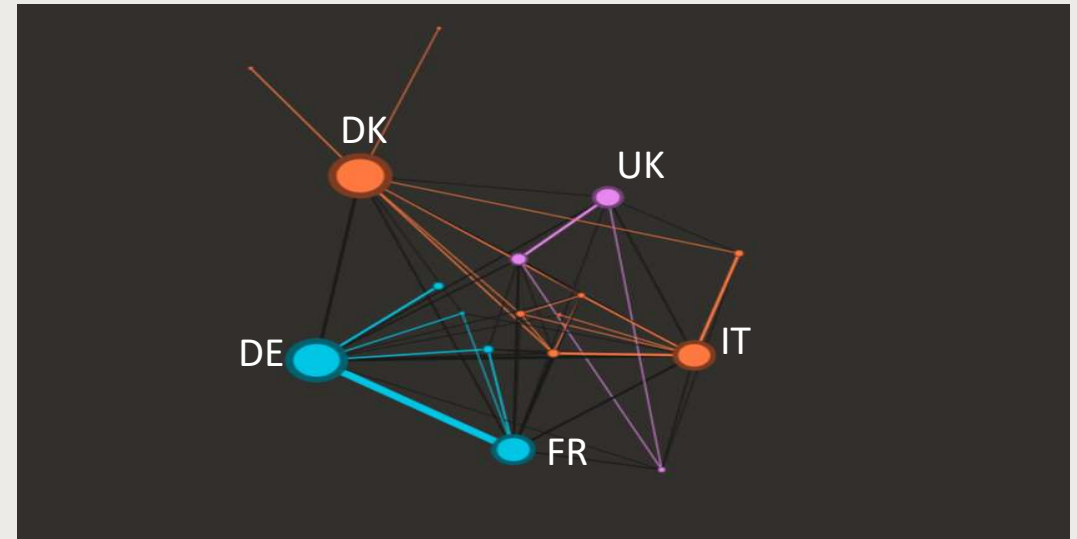
- Installation of a 1MW co-electrolysis system
- System to be fully integrated into the industrial environment of OMV's refinery located in Schwechat, Austria
- 900 tons of green syngas production
- 2 years demonstration (12,000h continuous operation)



# SOE electrolysis: Number of publications, patents, etc. 2004 - 2020

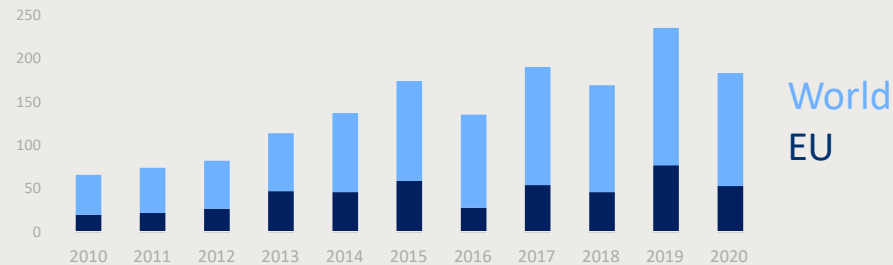


**World:** EU: 524, China: 416, USA: 273, Japan: 110, S. Korea: 87



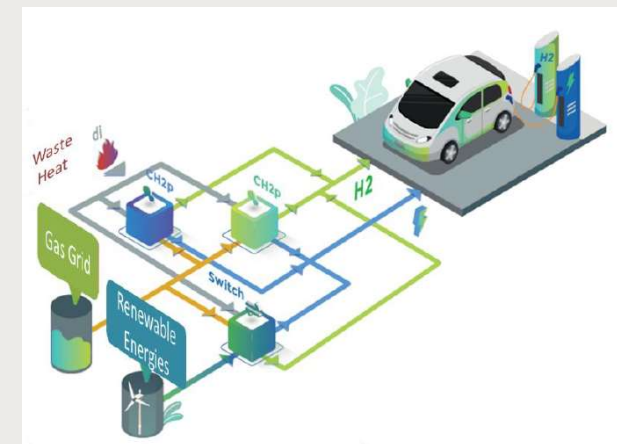
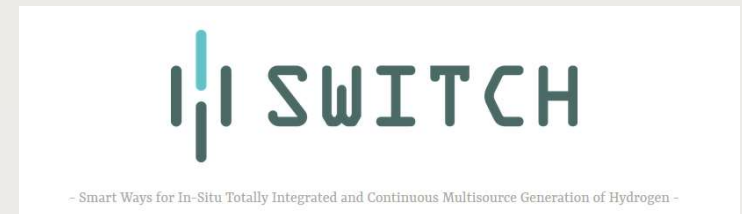
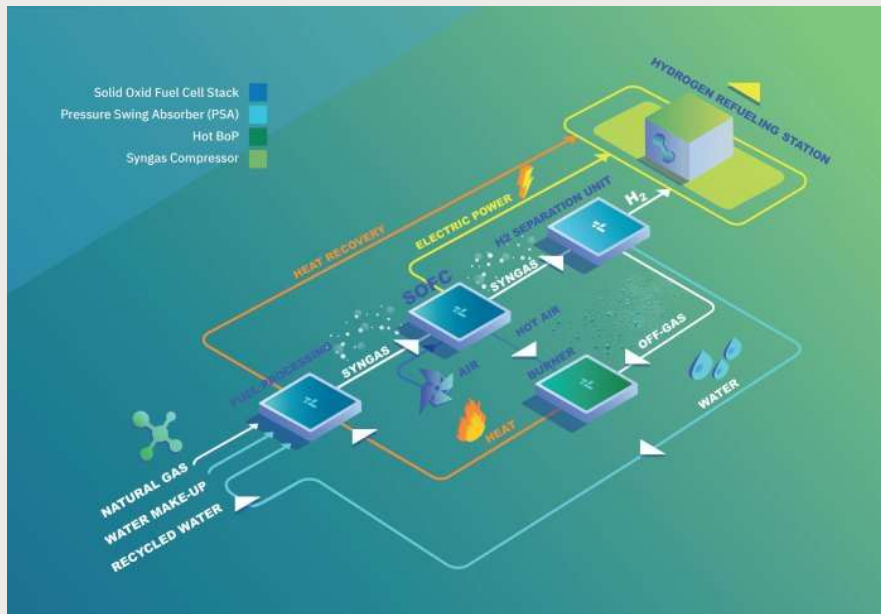
**EU:** DK: 129, DE: 126, FR: 86, IT: 84, UK: 60

Solide Oxide



# SO technologies moving to Polygeneration

The second generation will allow the operation in electrolyser mode allowing for 100% Hydrogen production



- 20kg/day hydrogen production in “Fuel cell” mode with Natural gas input
- 75kg/day hydrogen production in Electrolysis mode

Source: <https://switch-fch.eu/>

## Conclusions SOEs

European leadership on SOEC -> 720kW installed, 2.4 MW planned for 06/2022



 SOEs follow experiences gained in R&D for SOFCs -> MW<sub>e</sub> demonstration launched

 SOEs are most suitable to industrial applications where waste heat is available

 Work on-going for the coupling of SOEs to intermittent renewable heat and power

 Europe can export expertise and products

 Further demonstration needed -> track record of installation for commercial and large SOFCs / polygeneration, SOECs, rSOCs & co-electrolysis



# 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](http://www.iphe.net)

# 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



**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:** Vlaanderen, Brussels, Flanders
- United Kingdom:** London (Greater London Authority), Yorkshire, Midlands, Wales, Northern Ireland
- France:** Auvergne-Rhône-Alpes, Bourgogne-Franche-Comté, Grand Est, Hauts-de-France, Île-de-France, Occitanie, Pays de la Loire, Provence-Alpes-Côte d'Azur, Nouvelle-Aquitaine
- Spain:** Aragón, Castilla-La Mancha, Cataluña, Madrid, Murcia, País Vasco, Galicia, Asturias, Cantabria, Castilla y León, Extremadura, Castilla-La Mancha, Murcia, País Vasco, Galicia, Asturias, Cantabria
- Italy:** Emilia-Romagna, Marche, Umbria, Lazio, Abruzzo, Molise, Basilicata, Puglia, Campania, Sicilia, Calabria, Liguria, Piemonte, Valle d'Aosta, Trentino-Alto Adige, Friuli Venezia Giulia, Veneto, Lombardia, Piemonte, Valle d'Aosta, Trentino-Alto Adige, Friuli Venezia Giulia, Veneto, Lombardia
- Netherlands:** North of Netherlands
- Austria:** Styria, Carinthia, Lower Austria, Upper Austria, Salzburg, Tyrol, Vienna, Burgenland
- Portugal:** Norte, Centro, Alentejo, Algarve, Lisboa
- Norway:** Akershus, Oslo, Viken, Rogaland, Hordaland, Vestland, Nordland, Troms og Finnmark
- Ireland:** Dublin, Galway, Cork, Kerry, Wick, Donegal, Leitrim, Sligo, Mayo, Roscommon, Louth, Monaghan, Westmeath, Wick, Donegal, Leitrim, Sligo, Mayo, Roscommon, Louth, Monaghan, Westmeath
- Sweden:** Gästrikland, Västmanland, Örebro, Östergötland, Småland, Blekinge, Skåne, Halland, Väst, Jönköping, Kronoberg, Östergötland, Småland, Blekinge, Skåne, Halland, Väst, Jönköping, Kronoberg
- Finland:** Helsinki, Tampere, Jyväskylä, Oulu, Rovaniemi
- Denmark:** North Denmark, Central Denmark, South Denmark
- Estonia:** Tallinn, Tartu, Pärnu, Võru, Rapla, Viljandi, Valga, Järva, Lääne-Virumaa, Lääne, Harju, Ida-Virumaa, Pärnu, Võru, Rapla, Viljandi, Valga, Järva, Lääne-Virumaa, Lääne, Harju, Ida-Virumaa
- Latvia:** Riga, Ventspils, Liepāja, Jūrmala, Valmiera, Jelgava, Daugavpils, Rēzekne, Tukums, Krāslava, Valmiera, Jelgava, Daugavpils, Rēzekne, Tukums, Krāslava
- Czech Republic:** Brno, Olomouc, Zlín, Vyškov, Blatná, Písek, Tábor, Jihlava, Brno, Olomouc, Zlín, Vyškov, Blatná, Písek, Tábor, Jihlava
- Slovenia:** Ljubljana, Kranj, Novo Mesto, Ptuj, Celje, Koper, Izola, Pirana, Tolmin, Kranj, Novo Mesto, Ptuj, Celje, Koper, Izola, Pirana, Tolmin
- Croatia:** Zagreb, Rijeka, Zadar, Šibenik, Trogir, Makarska, Dubrovnik, Ploče, Vukovar, Osijek, Karlovac, Varaždin, Međimurje, Zagreb, Rijeka, Zadar, Šibenik, Trogir, Makarska, Dubrovnik, Ploče, Vukovar, Osijek, Karlovac, Varaždin, Međimurje
- Romania:** Bucharest, Cluj-Napoca, Timișoara, Iași, Brașov, Sibiu, Constanța, Galați, Buzău, Giurgiu, Prahova, Vaslui, Bacău, Suceava, Maramureș, Bihor, Harghita, Mureș, Arad, Cluj-Napoca, Timișoara, Iași, Brașov, Sibiu, Constanța, Galați, Buzău, Giurgiu, Prahova, Vaslui, Bacău, Suceava, Maramureș, Bihor, Harghita, Mureș, Arad
- Bulgaria:** Sofia, Plovdiv, Varna, Burgas, Ruse, Bled, Dobrich, Sliven, Stara Zagora, Plovdiv, Varna, Burgas, Ruse, Bled, Dobrich, Sliven, Stara Zagora
- Greece:** Athens, Thessaloniki, Patras, Ioannina, Larissa, Volos, Thessaloniki, Patras, Ioannina, Larissa, Volos
- North Macedonia:** Skopje, Bitola, Ohrid, Gostivar, Prilep, Kumanovo, Struga, Gevgelija, Struga, Gevgelija
- Albania:** Tirana, Durrës, Shkërbërë, Elbasan, Korçë, Vlorë, Berat, Gjirokastrë, Shkërbërë, Elbasan, Korçë, Vlorë, Berat, Gjirokastrë
- Malta:** Valletta, Sliema, St. Paul's Bay, Gzira, Marsaxlokk, Mdina, Valletta, Sliema, St. Paul's Bay, Gzira, Marsaxlokk, Mdina
- Poland:** Poznań, Wrocław, Łódź, Katowice, Gdańsk, Wrocław, Łódź, Katowice, Gdańsk
- Slovakia:** Bratislava, Košice, Žilina, Banská Bystrica, Prešov, Košice, Žilina, Banská Bystrica, Prešov
- Bulgaria:** Sofia, Plovdiv, Varna, Burgas, Ruse, Bled, Dobrich, Sliven, Stara Zagora, Plovdiv, Varna, Burgas, Ruse, Bled, Dobrich, Sliven, Stara Zagora
- Croatia:** Zagreb, Rijeka, Zadar, Šibenik, Trogir, Makarska, Dubrovnik, Ploče, Vukovar, Osijek, Karlovac, Varaždin, Međimurje, Zagreb, Rijeka, Zadar, Šibenik, Trogir, Makarska, Dubrovnik, Ploče, Vukovar, Osijek, Karlovac, Varaždin, Međimurje

**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/>

**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 H<sub>2</sub>, storage, distribution and end use (transport, stationary & industry)



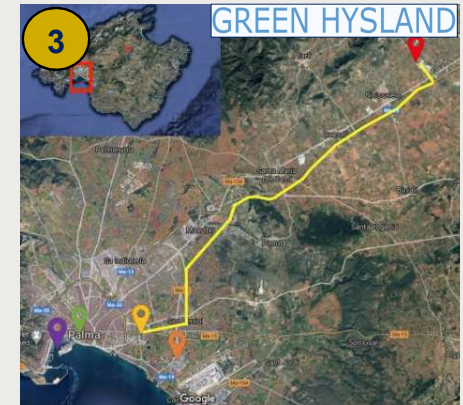
## Orkney's Island (Scotland):

- H<sub>2</sub> 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 H<sub>2</sub> production,
- H<sub>2</sub> Mobility: buses, passenger cars and trucks
- H<sub>2</sub> Refueling stations
- E-Kerosene for aviation
- H<sub>2</sub> for an inland water transport barge
- Domestic Heat applications
- Underground H<sub>2</sub> storage (Hystock)



## Hydrogen Island (Spain)

- H<sub>2</sub> production from solar
- H<sub>2</sub> injection in gas-grid
- Use: heat (hotel, municipality buildings), power (port of Palma), mobility (buses)



**Future Possible (cross border) H<sub>2</sub> valleys:** Ports, Airports, Industrial hubs, Logistical hubs, A H<sub>2</sub> city (or area)

# Mission Innovation: Hydrogen Valleys are a global phenomenon

Integrated projects are emerging all around the world, the platform will be continued and enhanced during M.I. 2.0

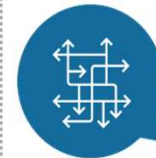


The Hydrogen Valley Platform offers a variety of insights into projects globally and also provides a way to connect

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



## ... featured on the new platform



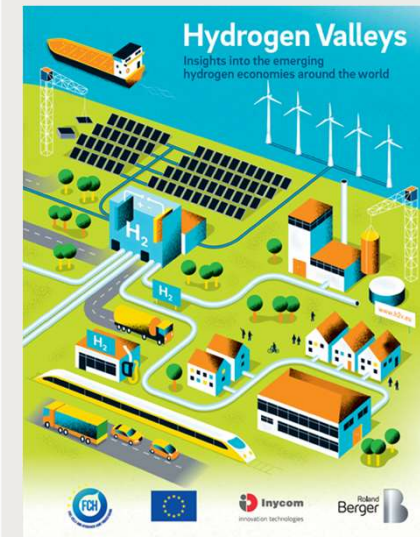
> 34 valleys from 19 countries



> 3,500 data points



10 in-depth best-practice profiles



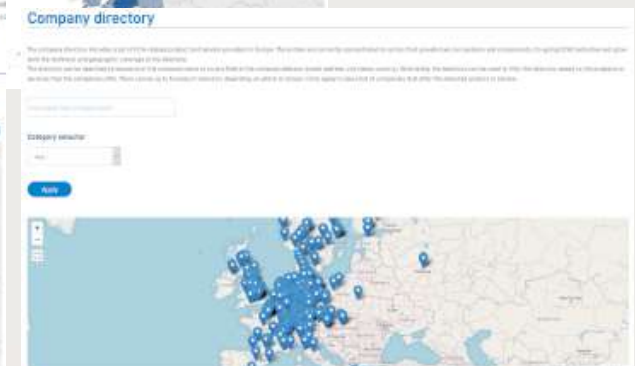
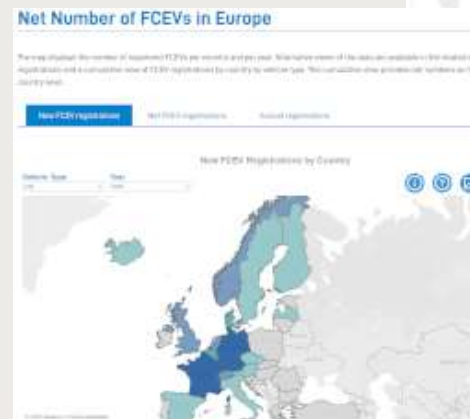
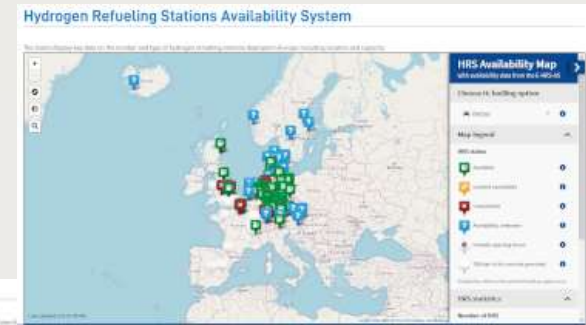


# Fuel Cells and Hydrogen Observatory (Launched 15 Sept '20)



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](http://www.fchobservatory.eu)**  
*info@fchobservatory.eu*



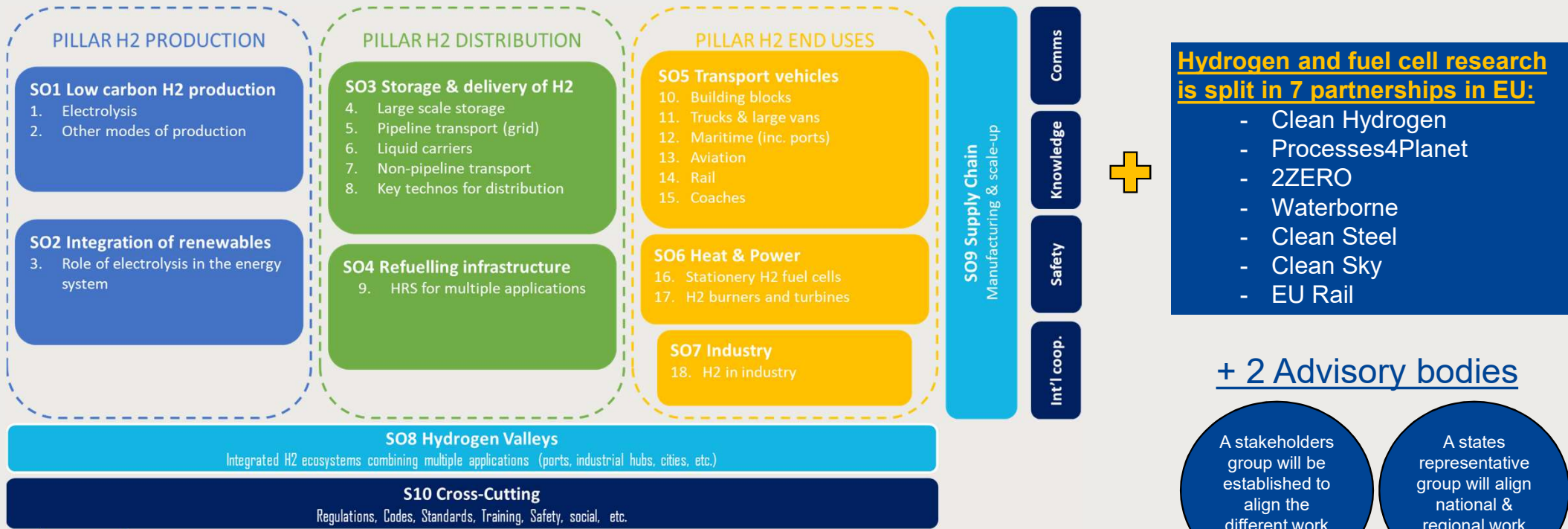
The Fuel Cells and Hydrogen Observatory has been prepared for the FCH 2 JU under a public procurement contract

# 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 €)

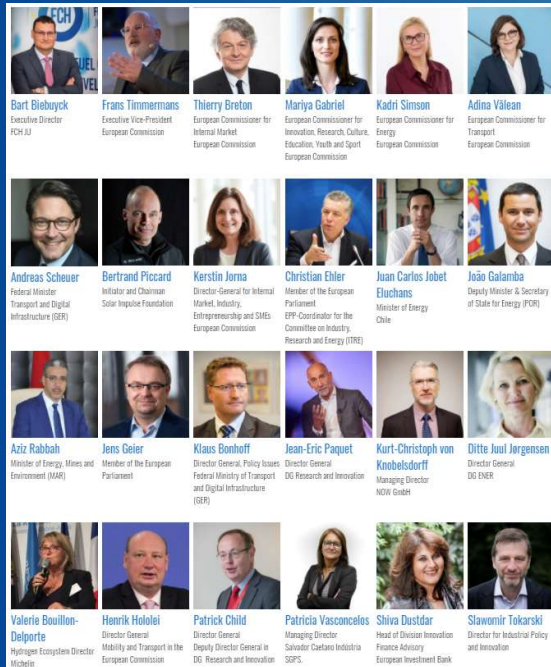


# The 2<sup>nd</sup> European Hydrogen Week

The biggest European hydrogen conference hosting key policy makers at European, National and regional level.



In 2020, >10.000 people from 63 countries



2<sup>nd</sup> European Hydrogen Week  
with the  
Launch of Clean H<sub>2</sub> JU

29<sup>th</sup> Nov. – 3<sup>rd</sup> Dec. 2021

Brussels, Belgium





# FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

**Bart Biebuyck**

Bart.Biebuyck@fch.europa.eu

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**For further information**

[www.hydrogeneurope.eu](http://www.hydrogeneurope.eu)



@fch\_ju



Fch-ju@fch.europa.eu



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