FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

Scaling-up Innovations on Renewable Hydrogen Production and Use

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European Hydrogen Forum
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Strong public-private partnership with a focused objective

A combined private-public of more than 2 billion Euro has been invested since 2008 to bring products to market readiness

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Hydrogen Europe
Industry grouping
>185 members
50% SME

European Commission

Hydrogen Europe Research
Research grouping
83 members

Energy
H_2 production and distribution
H_2 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, GoO…

45 %
€ 481 mn
153 projects

41.4 %
€ 443 mn
77 projects

6.3 %
€ 67 mn
48 projects

7.3 %
€ 79 mn
7 projects

Similar leverage of other sources of funding: € 1.08 bn

Hydrogen production, new generation of low temperature electrolysers

Project: Don Quichot (Colruyt; HRS+forklifts)
Place/date: Belgium, 2011
Electrolyser: Hydrogenics (PEM)
Funding: €5.0 m

Project: Haeolus (remote P2P)
Place/date: Norway, 2017
Electrolyser: Hydrogenics (PEM)
Funding: €5.0 m

Project: H2future (Voestalpine, steel industry)
Place/date: Austria, 2016
Electrolyser: Siemens (PEM)
Funding: €12m (oo €18 m)

Project: Djewels (BioMCN, green methanol production)
Place/date: The Netherlands, 2018
Electrolyser: McPhy (Alkaline)
Funding: €11 m (oo €44 m)

Djewels → Scale-up → HYDROGEN VALLEY

NEXT:

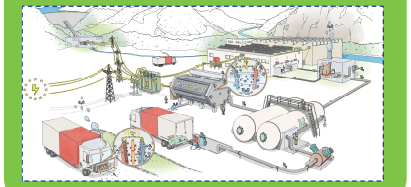
~2025: several 100 MW's

~2030: GW scale

0.15 MW → 1.2 MW → 2.5 MW → 3.4 MW → 6.0 MW → 10 MW → 20 MW → 60MW → 100 MW

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

Project: Demo4grid (MPREIS - bakery plant, food industry)
Place/date: Austria, 2016
Electrolyser: IHT (Alkaline)
Funding: €2.9 m (oo €7.8 m)



https://www.demo4grid.eu/

Project: Refhyne (Shell, refinery, gas injection in NG)
Place/date: Germany, 2017
Electrolyser: ITM (PEM)
Funding: €10 m (oo €16m)

(https://refhyne.eu/)

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

Call closed:

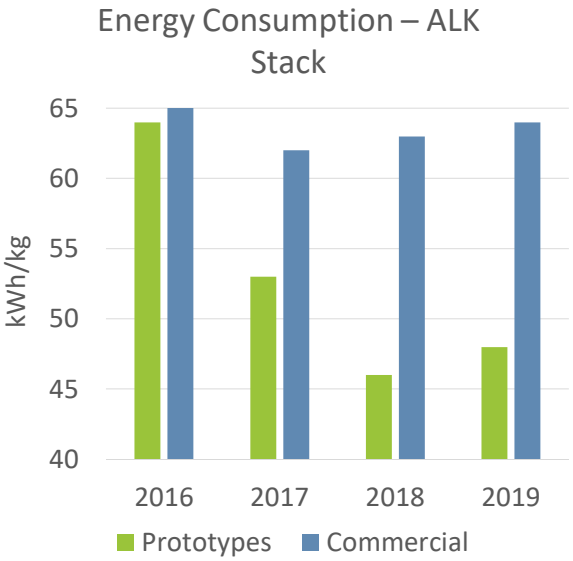
16 proposals received

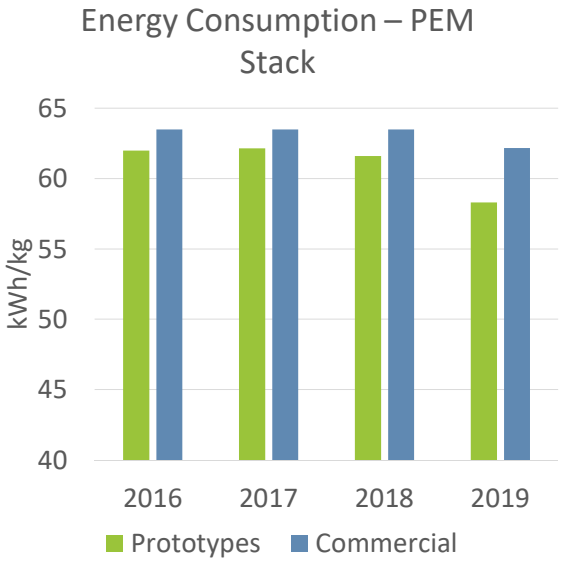
Scaling up challenges: new manufacturing processes to lower cost, increase capacity and lifetime

Low Temperature Electrolysis R&I projects

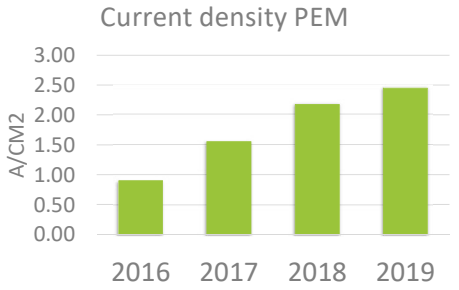
Achievement of 2020 targets safeguards Europe's leading position

Energy consumption @ system level <55 kWh/kg



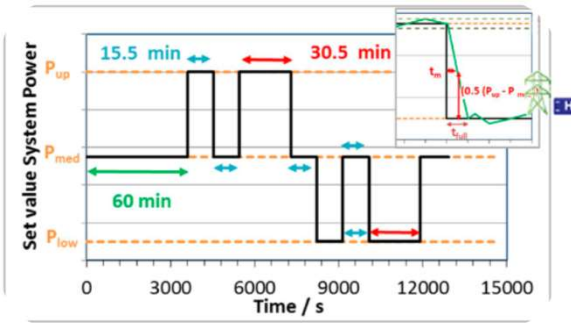


Current density > 3 A/cm²



NEPTUNE

Dynamic operation, Testing Harmonisation



QualyGridS

New generation of solid oxide electrolysers (high temperature)

High temperature electrolysers finding their place in the industrial courtyard, facilitating strategic partnerships

Paul Wurth becomes a new lead investor and technology partner of Sunfire

Rotterdam
Neste Biorefinery
2019
2.4MW

MULTIPLHY

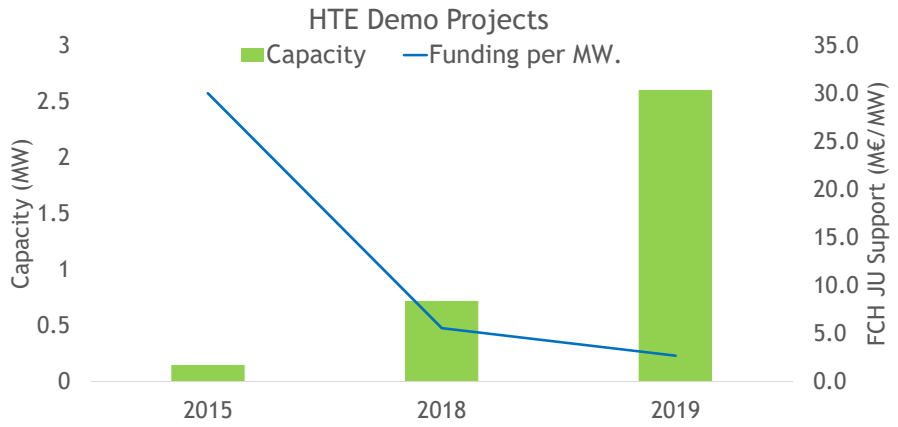
NESTE invests in Sunfire

Saltzgitter
Iron and Steel Works
2018
720kW

GrInHy2.0
Green Industrial Hydrogen

Saltzgitter
Iron and Steel Works
2015
150kW

GrInHy
Green Industrial Hydrogen



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

Scaling up challenges: new manufacturing processes to lower cost, increase capacity and lifetime

FCH
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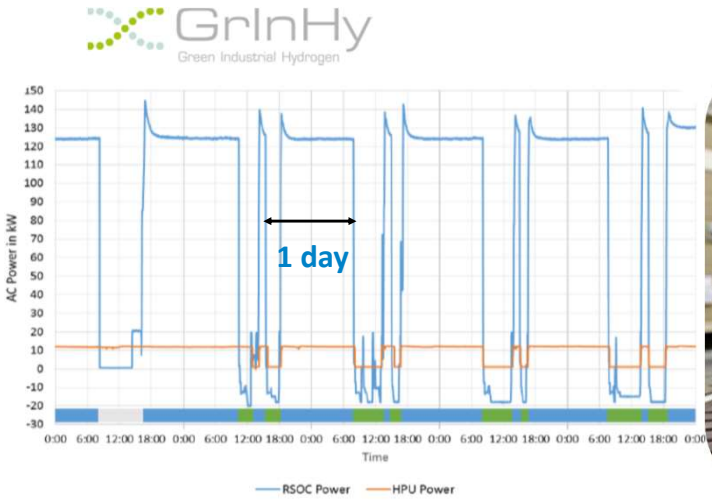
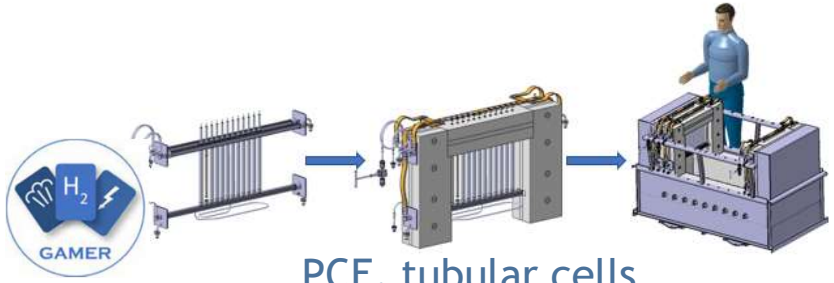
High Temperature Electrolysis R&I projects

Higher efficiencies, improved durability, innovative concepts





PCE, tubular cells

Electricity consumption < 40 kWh/kg

Production loss rate < 1.9%/1000h

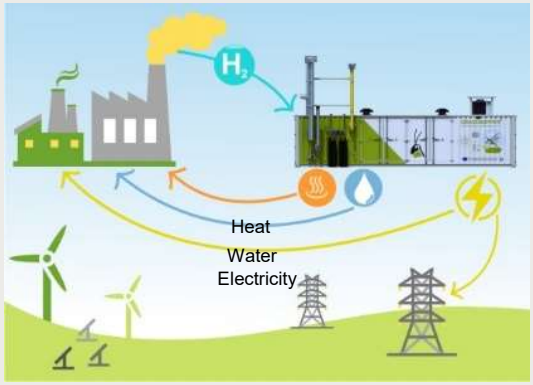
Availability >95%
Reversible FC efficiency 54%

Current density 1.25A/cm2
Steam conversion rate > 85%

Targets 2024 for the next generation of electrolysers

- CAPEX: 480 €/kW (Alk) - 700 €/kW (PEM)
- Efficiency (HHV): 80 % (Alk) – 76% (PEM)
- Limiting or eliminating the use of critical raw materials
- Dynamic operation to provide electricity grid balancing services
- Increase operating pressure from 20 bars to 80 bars to inject H2 in natural gas transmission grid without mechanical compression
- Reduce foot print by increasing current density, from 3 to 8 A/cm2 for PEM and from 0.5 to 1 A/cm2 for Alkaline
- Develop novel electrolyser types like Anion Exchange Membrane electrolysers (low temp) or Proton Conducting Ceramic electrolysers (high temp)

MW scale PEM fuel cells : H2 for decarbonisation of industry, grid balancing, district heating, power to power (P2P)



GRASSHOPPER project: modular 100kW pilot plant in Delfzijl (NL) using H2 by-product from a chlor-alkali plant.
Next step: scaling-up to a MW scale commercial plant

Building on the learning of the 2 MW DEMCOPEM project, new research led to substantial technology improvement applied on GRASSHOPPER.

CLEARgen Demo project: 1 MW fuel cell system for distributed generation, using H2 by-product from a Martinique refinery

European technology tested in several places in the world

Challenges: cost reduction (H2 purification system and fuel cell), reduction of critical raw materials, durability, standardisation in industrial environments.

Hydrogen and circular economy: Solid Oxide fuel cells for cogeneration of heat and power in cities

The DEMOSOFC plant in Torino is the first example in Europe of cogeneration plant with a medium size fuel cell fed by biogas produced in a wastewater treatment plant (102 kWe).

A market analysis showed a large market potential in Europe. In total 6,181 wastewater treatment plants have a capacity of 20,000 to 1,100,000 P.E (Population Equivalent).

Challenges : cost reduction via optimised system designs and increased production volumes, next demonstrations using a European supply chain for a large market potential

Fuel cell for domestic combined heat and power, micro CHP

Complementary to heating system

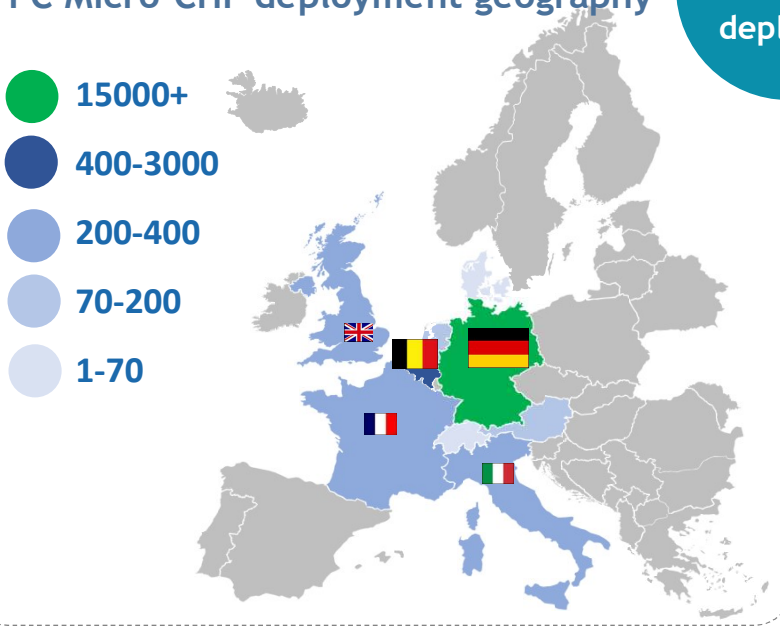
Replaces heating system

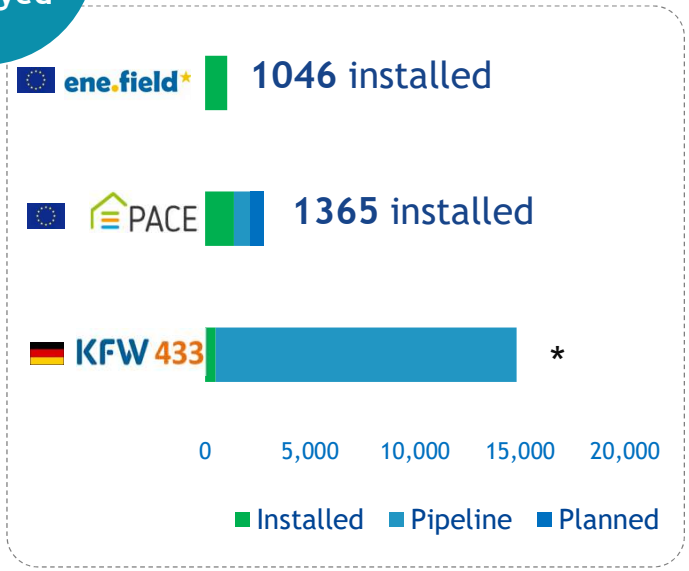
Europe market is in the order of 18,000 systems, 60% increase since 2019

European suppliers: BDR Thermea, Bosch, SOLIDpower, Sunfire and Viessmann

FC Micro-CHP deployment geography

Planned and deployed





* Applications field under German KfW since 2016

Challenges : increased production volumes to lower investment and installation costs, operation with admixtures of H2/NG, support European manufacturers to enable shift to more efficient manufacturing processes

Large deployment of Fuel Cell Buses in Europe

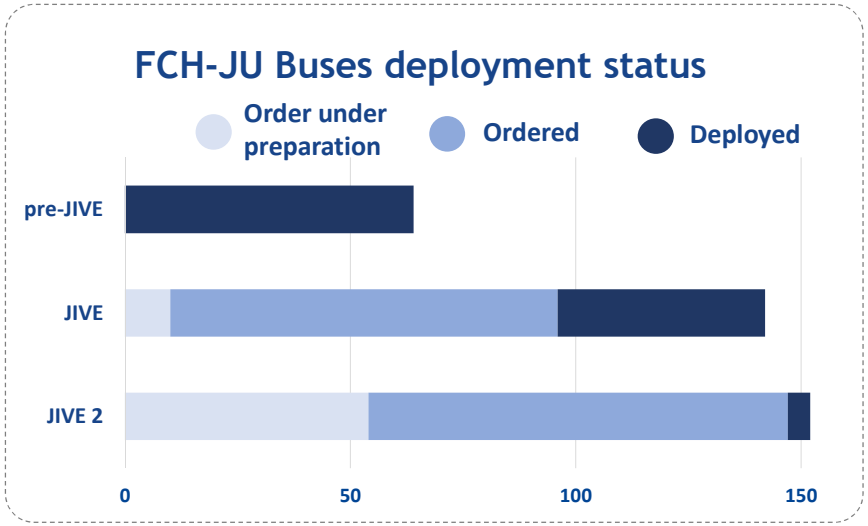
Fuel Cell Buses in operation in EU

2019

2020

2021

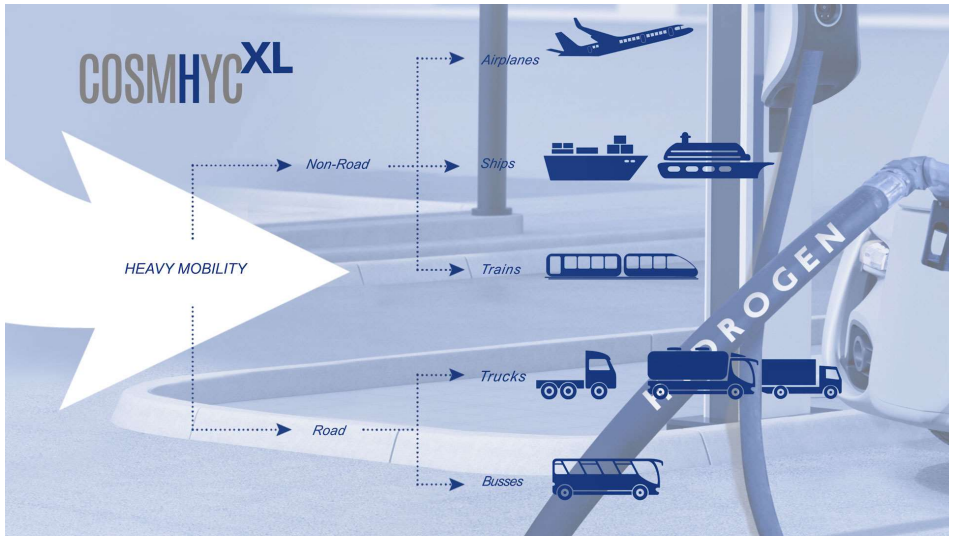
2022-2023



Fuel cell buses manufacturers Daimler (De), Van Hool (Be), Safra (Fr), VDL (Nl), Solaris (Pl), Caetano(Pt), Wrightbus (UK)

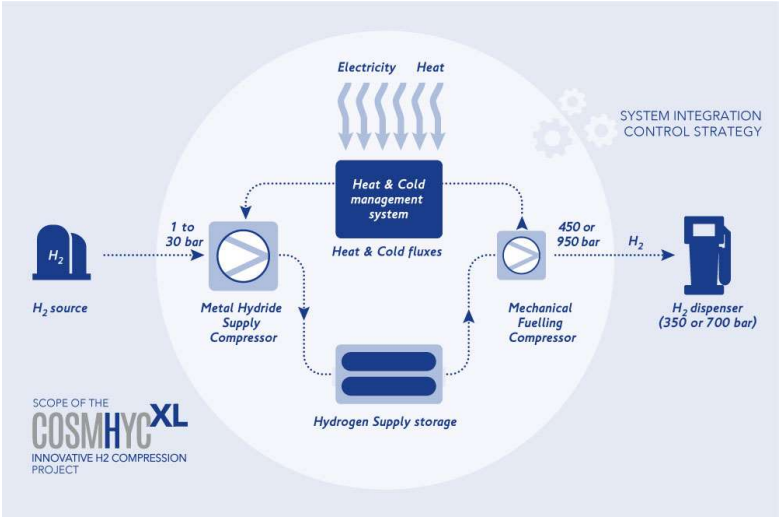
Challenges : lower price and operating costs, increase durability and availability, develop refueling infrastructure, increase payload and range for coaches, demonstrate 18 m buses

New generation of hydrogen compressors for refuelling stations



The COSMHYC XL project aims at developing an innovative compression solution for extra-large HRS addressing trucks and non road applications.

The COSMHYC project developed and tested an innovative compression solution based on a combining metal hydride and diaphragm compressors for hydrogen refueling stations (HRS).
Hydrogen cost reduced by 20%.



Challenges : standardisation, innovative compression technologies, reduce energy consumption, increase capacity to address all kinds of 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 (Air Liquide, BMW, Carrefour, Colruyt)
- 2021/2022 deployment of the trucks;

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

FCH 2 JU support for FC and H2 in maritime applications

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

Ships

2020 PEM Liquid H_2 — 3 MW

2019 sea-going vessel SOFC NH_3 — 2 MW

2018-ferry + barge pusher PEM Compr.H_2 — 2 x 0.5 MW

2017 -research vessel PEM Compr.H_2 — 0,16 MW

2013 - APU for yachts HT PEM LPG — 0,05 MW

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
- Liquid H2 distributed to a series of maritime bases in a containerized system

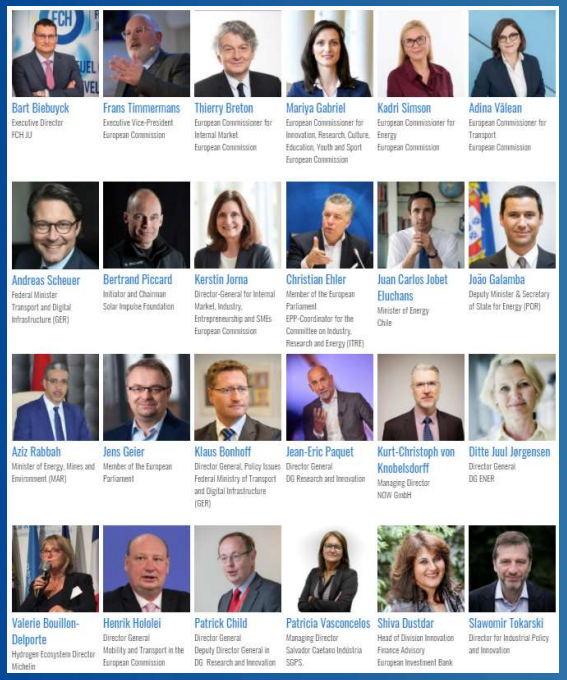
ShipFC

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

The 2nd 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



2nd European Hydrogen Week

29th Nov. – 3rd Dec. 2021

Brussels, Belgium

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