Clean Hydrogen Partnership

Developing the building blocks for hydrogen in aviation

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Clean Hydrogen Joint Undertaking

EU Institutional Public-Private Partnership (IPPP)

To facilitate the transition to a greener EU society through the development of hydrogen and fuel cell technologies

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Clean Hydrogen JU Objectives

Support a sustainable hydrogen economy, contributing to EU's climate goals

Support the implementation of the Commission's Hydrogen Strategy

Stimulate research and innovation on clean hydrogen production, distribution, storage and end use applications

Strengthen the competitiveness of the EU clean hydrogen value chain

Contribute to the EU ambitious 2030 and 2050 climate ambition

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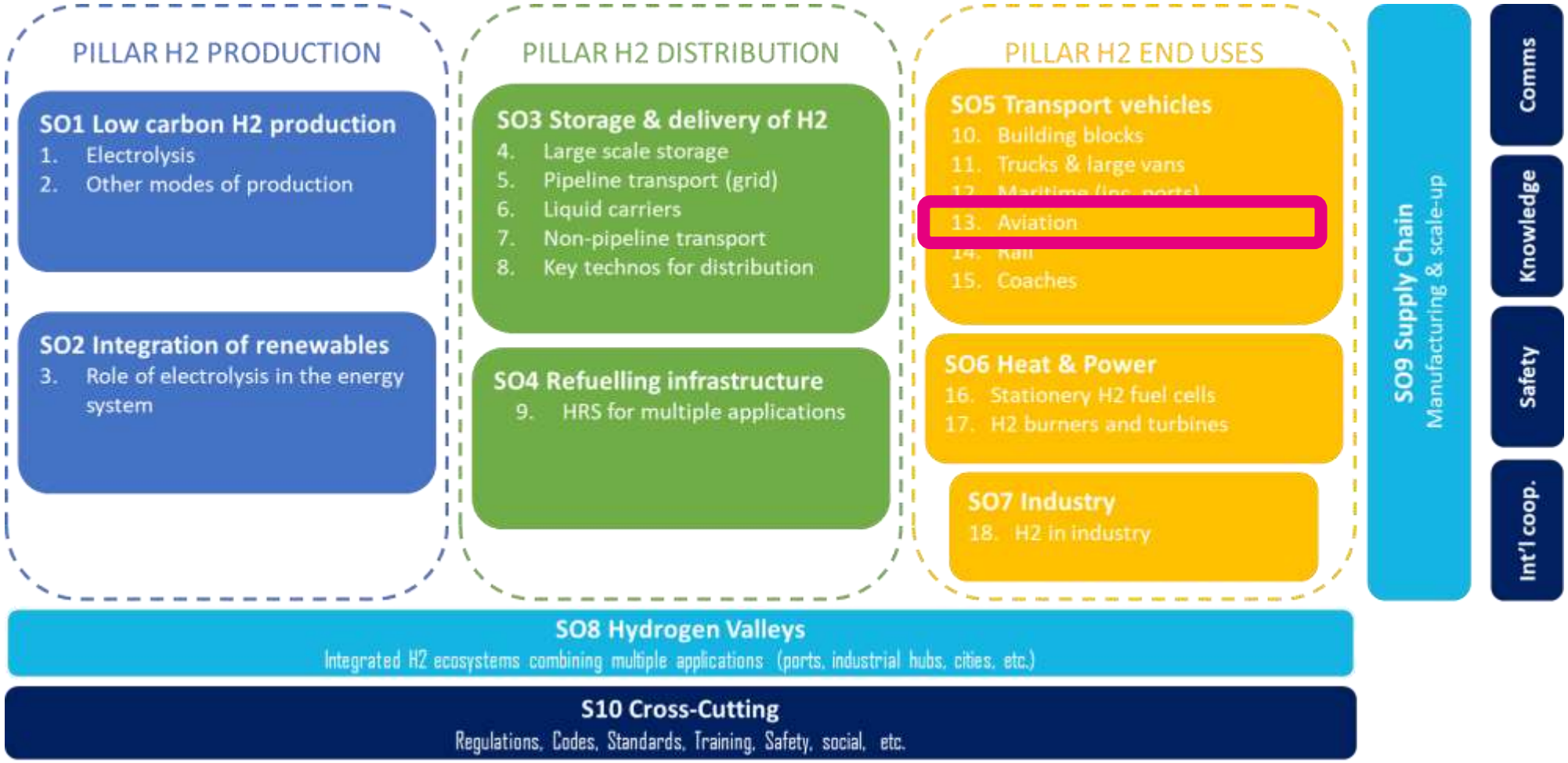
Clean Hydrogen Partnership

Research and Innovation priorities in Clean Hydrogen JU

Maintain and strengthen EU's global leadership role through a € 2.4 bn research program



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Hydrogen in aviation supported projects by FCH-JU

Five research projects for 18.5m € and one study was conducted

From APU → **to aircraft propulsion**

2012
APU for secondary electrical system

2017
FC for emergency operation

2018
Aircraft propulsion

Five Projects 2008 - 2021

HYPER

SUAV Solar Unmanned Aerial Vehicle

HYCARUS AIRBORNE FUEL CELLS

HEAVEN Cryogenic Hydrogen Test Aircraft

FLHY SAFE

Hydrogen-powered aviation - Joint Study Clean Sky 2 JU – FCH 2 JU: key take-aways

Technology	Research & Innovation	Economics	Climate impact
Hydrogen is a compelling option	Demonstrator by 2028	Less than 18 EUR per PAX	Zero CO2 and 70% total climate impact reduction

https://www.fch.europa.eu/sites/default/files/FCH%20Docs/20200507_Hydrogen%20Powered%20Aviation%20report_FINAL%20web%20%28ID%208706035%29.pdf

Clean Hydrogen call for proposals 3 topics for 35m €

All topics in our call received multiple proposals and at least one was successful for each topic

Topic	Type of action	Ind. budget (m€)	Deadline	Received proposals	Awarded
HORIZON-JTI-CLEANH2-2022-03-06: Development and optimization of dedicated Fuel Cells for Aviation	RIA	20	31/05/'22	3	1
HORIZON-JTI-CLEANH2-2022-03-07: Development of specific aviation cryogenic storage system with a gauging, fuel metering, heat management and monitoring system	RIA	10	31/05/'22	2	1
HORIZON-JTI-CLEANH2-2022-03-08: Development and optimization of a dedicated Fuel Cells for Aviation: disruptive next-gen high temperature Fuel Cells technology for future aviation	RIA	5	31/05/'22	2	1

In addition Clean Aviation has 4 topics on hydrogen for 182m € in synergy (complementary) with Clean Hydrogen call

Both JU's spend together **217m € in 2022** on aviation research

Identification Code	Title	Type of Action	Ind. Value (Funding in M€)
Hydrogen-powered aircraft topics			
HORIZON-JU-CLEAN-AVIATION-2022-01-HPA-01	Direct Combustion of Hydrogen in Aero-engines	IA	115
HORIZON-JU-CLEAN-AVIATION-2022-01-HPA-02	Multi-MW Fuel Cell Propulsion System for Hydrogen-Powered Aircraft	IA	50
HORIZON-JU-CLEAN-AVIATION-2022-01-HPA-03	Large Scale Lightweight Liquid Hydrogen Integral Storage Solutions	IA	10
HORIZON-JU-CLEAN-AVIATION-2022-01-HPA-04	Near Term Disruptive Technologies for Hydrogen-Powered Aircraft	IA	7

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TOPIC 1: Fuel cell for aviation

Development and optimization of Fuel cell for aviation

HORIZON-JTI-CLEANH2-2022-03-06: Development and optimization of dedicated Fuel Cells for Aviation: from dedicated stack (100s kW) up to full system (MWs)

Development of an aviation-specific stack and FC system fit for aircraft integration:

- Development of a 250 kW stack with module scalability to at least 1.5 MW
- Stack adaptation to the aviation requirements (i.e. temperature, pressure, vibration, durability, safety)
- Proposals should target a fuel cell system with a power density > 1.5kW/kg at a power level of at least 1 MW.
- The goal is to bring the technologies and sub systems to TRL5 at the end of the project.
- Lab & ground tests to prove the feasibility of the concept

Project results are expected to contribute to all of the following objectives of the Clean Hydrogen JU SRIA:

- FC module durability [h]: 20,000 in 2024 and 30,000 in 2030;
- FC system efficiency [%]: 45 in 2024 and 50 in 2030;
- FC system availability [%]: 95 in 2024 and 98 in 2030;
- FC system gravimetric index [kW/kg]: 1 in 2024 and 2 in 2030.

In addition to the KPIs above and when considering a system size of 1.5MW the proposal should also contribute to the achievement of the following:

- Power Densities @stack level > 3kW/kg in nominal power (and not peak power);
- Membrane Electrode Assembly > 1.25 W /cm2;
- Understanding of the ageing kinetics (= performances degradation in time) ;
- Environmental conditions: temperature, pressure, vibration and other area of interest (i.e. DO 160) compatible with aircraft environment;
- Demonstration fully answers the qualification needs.

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TOPIC 2: Liquid hydrogen storage tank

Development of a liquid hydrogen storage system with all its components

HORIZON-JTI-CLEANH2-2022-03-07: Development of specific aviation cryogenic storage system with a gauging, fuel metering, heat management and monitoring system

Advancements in LH2 aviation storage through 2 demonstrators in the range of 50 kg – 150 kg LH2 capacity due to technical objectives and the available budget:

- Demonstrator 1: focus on lightweight and materials selection for the LH2 tank
- Demonstrator 2: design & integration of the storage solution including the development of BoP components
- Focus on safe operations

Project results are expected to contribute to all of the following objectives of the Clean Hydrogen JU SRIA:

- Tank gravimetric efficiency [%weight]: 16 in 2024 and 35 in 2030
- LH_2 tank capacity [$kgLH_2$]: 50-150
- Dormancy: >24 hours
- Venting rate: < 2%/day
- Filling rate: 300-500 kg/h (for analysis 5 t/h)
- Boil-off : < 2%/day after dormancy
- Maximum diameter: < 1 m (for analysis <3m)
- Minimum operating pressure: 1 bar (pump fed) – 3 bar (pressure fed)
- Maximum operating pressure: 3 bar (pump fed) – 8 bar (pressure fed)
- Insulation Vacuum: 1*10^-5 mbar

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TOPIC 3: Next Generation Fuel Cell technology

Development of high temperature fuel cells

HORIZON-JTI-CLEANH2-2022-03-08: Development and optimization of dedicated Fuel Cells for Aviation: disruptive next-gen high temperature Fuel Cells technology for future aviation

Development of an aviation-specific disruptive fuel cell.

- KPIs: Durability, performance, mechanical strength
- Design a fuel cell technology working at 120°C+ (constant operation)
- In the scope: the development of single components and MEA overall architecture

Project results are expected to contribute to all of the following objectives of the Clean Hydrogen JU SRIA:

- FC module durability [h]: 20.000 in 2024 and 30.000 in 2030;
- FC system efficiency [%]: 45 in 2024 and 50 in 2030;
- FC system availability [%]: 95 in 2024 and 98 in 2030.

In addition to the KPIs above and when considering a system size of 1.5MW the proposal should also contribute to the achievement of the following:

- Fuel cell Gravimetric index @system level > 1.5 kW/kg nominal power, under nominal aviation environmental conditions. Note: For computation, the following “system” definition is proposed: Fuel Cell stack + Anode & Cathode BoP (incl. by-products management) + Thermal Management BoP (excl. Heat exchanger);
- Fuel cell Gravimetric Index @stack level > 3 kW/kg in nominal power (and not peak power);
- Power density @ Membrane Electrode Assembly > 1.25 W/cm^2;
- Ageing kinetics (= performances degradation in time) is understood;
- Environmental conditions: temperature, pressure, vibration and other area of interest (Ie DO 160) compatible with aircraft environment.

EU policies under development: REfuelEU

Hydrogen propulsion is mentioned but not enough, so the EU parliament is pushing harder for zero emissions technologies like hydrogen to be more visible in the regulation

REfuelEU: From 2025 onwards every 5 year there is a new target for SAF and its share of synthetic aviation fuel

- Part of "Fit for 55" package, proposed on 14th July 2021 by the EC. Hydrogen was mentioned in the text only 2 times and was seen as a technology for the future which needed much more research.
- European Parliament "ITRE" committee draft opinion on 20th January 2022 putted much more focus on the role of hydrogen and was now mentioned 24 times in the proposed amendments.
- On 7th July 2022, the European Parliament adopted a text with proposed amendments for the REfuelEU, hydrogen is mentioned 14 times. In addition, the SAF target incl. synthetic fuel by EP is higher (By 2050 SAF: EC 63% and EP 85% // Synthetic fuel min share EC 28% and EP 50%)

Recital 8:

"*Sustainable aviation fuels are aviation fuels that comprise liquid, drop-in fuels, fully fungible with conventional aviation fuel and compatible with existing aircraft engines,* ***as well as hydrogen*** *and electricity*."

"Hydrogen is a very promising technology and is expected to progressively contribute to the decarbonisation of air transport, beginning with short-haul flights. This regulation will further accelerate scientific v=development and deployment of this technology"

Recital 22:

"When electric or hydrogen-powered aircrafts become mature and commercially available, it will be necessary for airports covered by this Regulation ***to take all necessary measures to facilitate an appropriate infrastructure for hydrogen*** *and electric recharging for aircrafts…"*

Article 9: (about the yearly reporting obligation):

"(ca) where applicable, ***the amount of hydrogen*** *and/or electricity, supplied at each Union airport, expressed in tonnes of kerosene equivalent.*

Article 11a: A sustainable Aviation Fund:

"… to ***support investment in*** *innovative technologies and infrastructure for the production, uptake, deployment and storage of sustainable aviation fuels, other innovative aircraft propulsion technologies, including* ***hydrogen*** *…"*

Hydrogen will be key for the decarbonisation of the aviation industry be it in its pure form or as a building block.

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Educational Activities – Overview

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

Educational and training programs tailored to multiple target groups

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***

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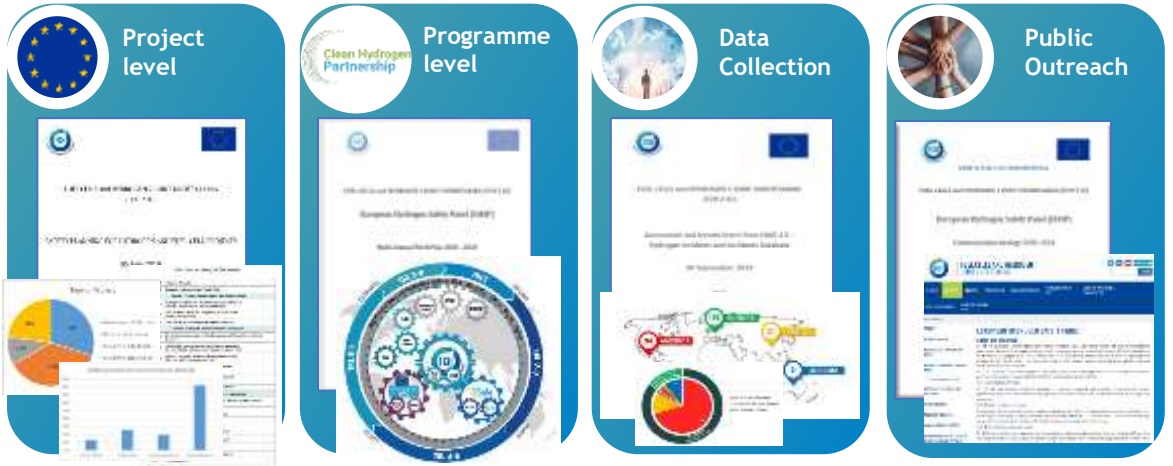
Clean Hydrogen Partnership safety-related activities

European Hydrogen Safety Panel (EHSP) – Expert group supporting the Programme and beyond

- Assuring that hydrogen safety is adequately managed
- Promoting and disseminating a high-level hydrogen safety culture



Working groups

Clean Hydrogen Partnership

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

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

FCHO FUEL CELLS AND HYDROGEN OBSERVATORY

- **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**

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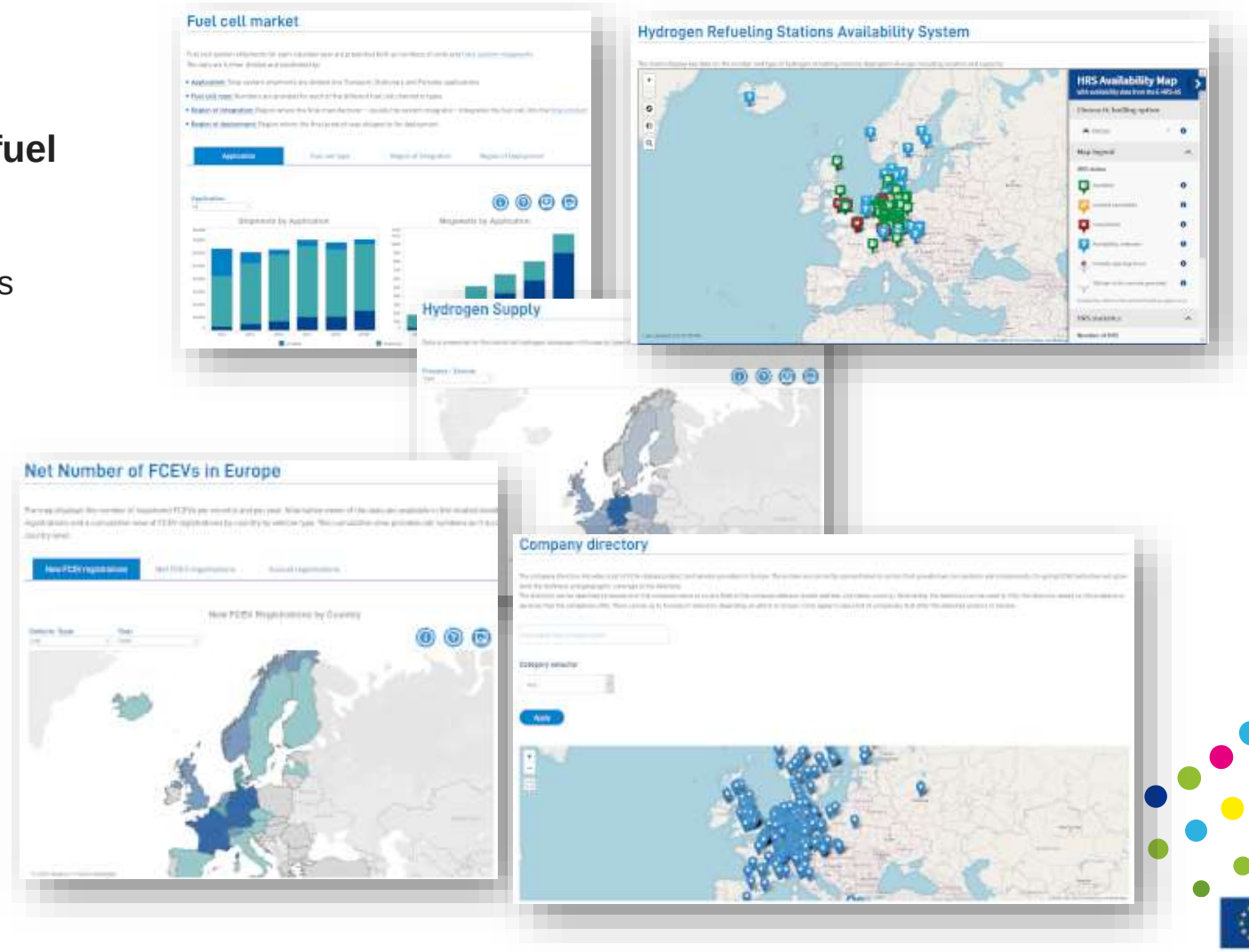

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European Hydrogen Week announcement

It will include a big exhibition for the first time at Brussels Expo Heysel

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