"H_2: Present and Future in Spain"

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SH2E/eGHOST SPRING SCHOOL URJC, Madrid 20 Mayo 2024

www.cnh2.es

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European initiatives to promote hydrogen

Renewable Hydrogen: towards a climate-neutral age in 2050

July 8th
Hydrogen "D Day"

Energy System Intregation Strategy

EU Hydrogen Strategy

EU Clean Hydrogen Alliance

- ✓ Reach Green Deal targets
- ✓ Boost economic recovery
- ✓ Decarbonise the economy in 2050

The EU Taxonomy encompasses a standard set of definitions for sustainable activities centered around six environmental objectives:

"H_2: Presente y Futuro" SH2E/eGHOST SPRING SCHOOL CNH2, 20 Mayo 2024 Dr. Emilio Nieto – CNH2 4

EU Hydrogen Strategy

EUROPEAN COMMISSION

Brussels, 8.7.2020
COM(2020) 301 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

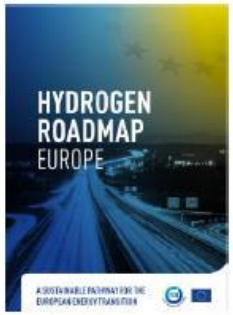
A hydrogen strategy for a climate-neutral Europe

Main points - Stages:

- 2020 a 2024: 6 GW renewable H2 electrolysers.
- 2025 a 2030: 40 GW renewable H2 electrolysers & 10M tons of renewable H2. H2: integral part of the EU's energy system.
- 2030 a 2050: technological maturity of renewable H2 technologies & massive and full-scale deployment in the economic sectors that are emission-intensive.

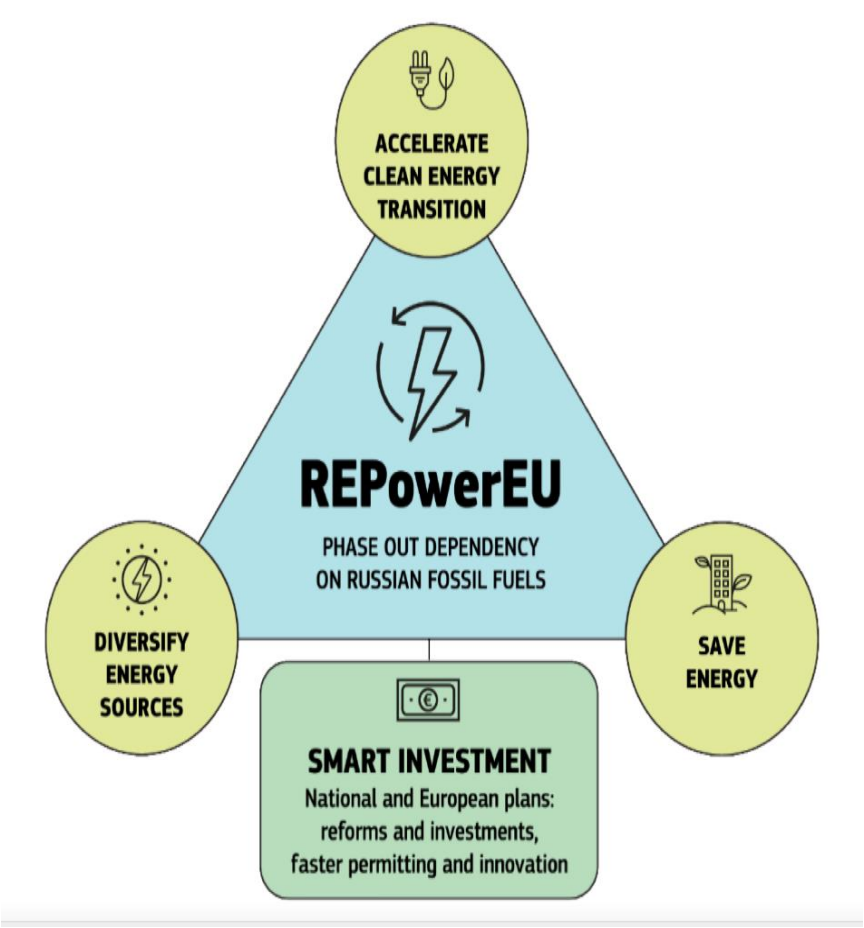
Support to the decarbonisation of industry, transport and others in Europe, by means of:

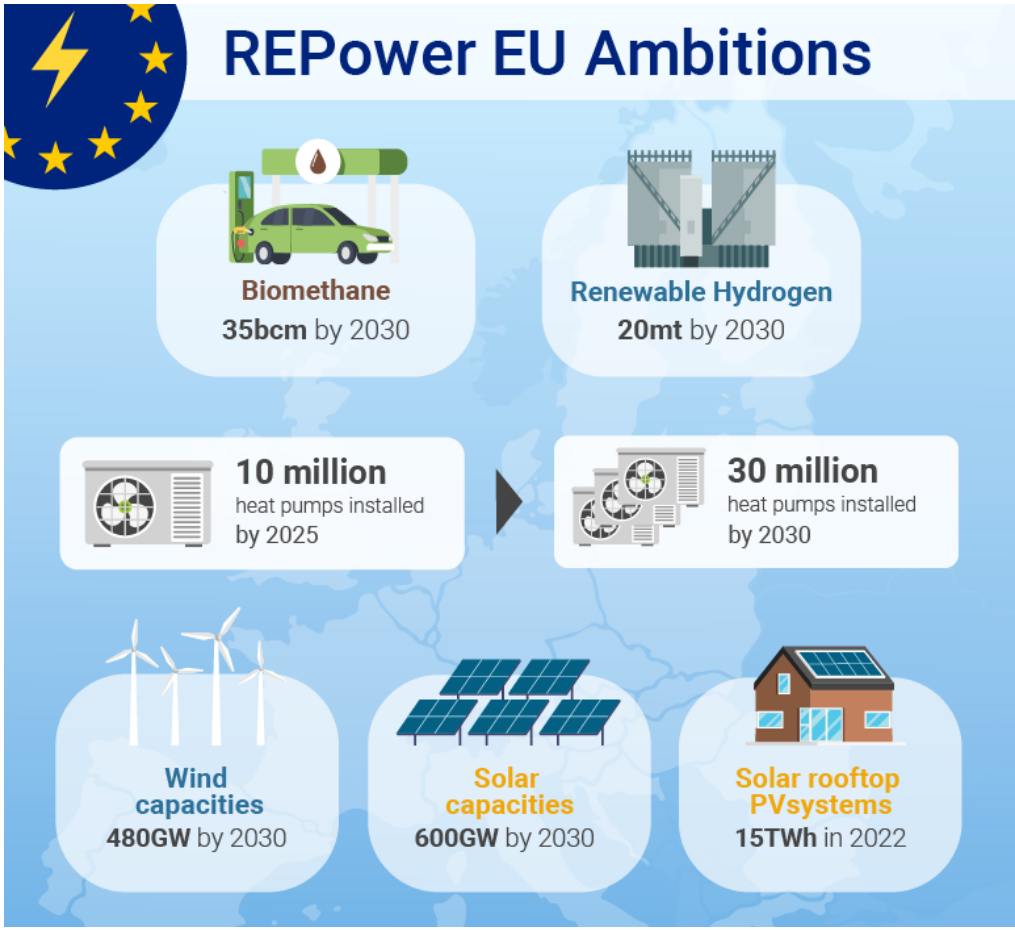
- ✓ Investments.
- ✓ Regulation.
- ✓ Market making.
- ✓ Research and Innovation.



~24%	~560 Mt	~EUR 820bn	~15%	~5.4m
of final energy demand[1]	annual CO_2 abatement[2]	annual revenue (hydrogen and equipment)	reduction of local emissions (NO_x) relative to road transport	jobs (hydrogen, equipment, supplier industries)[3]

REPowerEU


ACCELERATE CLEAN ENERGY TRANSITION
REPowerEU
PHASE OUT DEPENDENCY ON RUSSIAN FOSSIL FUELS
DIVERSIFY ENERGY SOURCES
SAVE ENERGY
SMART INVESTMENT
National and European plans: reforms and investments, faster permitting and innovation


REPower EU Ambitions
Biomethane
35bcm by 2030
Renewable Hydrogen
20mt by 2030
10 million
heat pumps installed by 2025
30 million
heat pumps installed by 2030
Wind capacities
480GW by 2030
Solar capacities
600GW by 2030
Solar rooftop PVsystems
15TWh in 2022

Delegate Acts EU

The rules for producing renewable hydrogen

(Renewable fuels of non-biological origin)

Jake Stones and Andrea Battaglia (ICIS)

If a company aims to produce renewable hydrogen, it must do so via one of the following pathways outlined below:

Direct connection

The hydrogen plant is **directly connected** to a renewable asset. The renewable asset cannot come into operation earlier than **36 months** before the hydrogen plant

Grid connection

If the proportion of renewable power exceeds **90%** over the previous calendar year in the bidding zone where the hydrogen plant is operating

Grid connection

Hydrogen production takes place in a bidding zone where the emissions intensity of the grid is lower than **18gCO2e/MJ**. However, the hydrogen plant must acquire a **renewable PPA**, temporal and geographical correlation also apply

Grid connection

Power supply can be considered renewable if taken from the grid during **an imbalance period**. The power is either redispatched, or avoids redispatch

Grid connection

A **renewable PPA** is signed for the supply of power, and the principles of additionality, temporal and geographical correlation apply

Associated principles for the production of renewable hydrogen

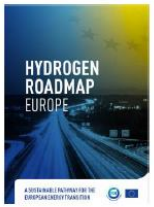
Principle	Conditions	Exemptions
Additionality Article 5	The renewable asset came into operation not earlier than 36 months before the hydrogen plant. It also cannot have received operating or investment aid	Principle of additionality shall not apply until 1 January 2038 to hydrogen plants that come into operation before 1 January 2028
Temporal correlation Article 6	Up to 31 December 2029: Hydrogen production occurs **within the same calendar month** as the renewable power was generated under the renewable PPA Beyond 1 January 2030: Hydrogen production occurs **within the same hour** as the renewable power was generated under the renewable PPA	Temporal correlation is considered always met if the hydrogen production occurs within the one-hour period where the clearing price for power resulting from the Day-ahead market is lower than or equal to €20/MWh, or lower than 0.36 times the EU ETS
Geographical correlation Article 7	**Considered met if one of the following are fulfilled:** • The renewable asset and hydrogen plant are in the same bidding zone • The renewable asset and hydrogen plant are located in interconnected bidding zones. The renewable asset is located in a bidding zone where the power price is equal to or higher than that of the hydrogen plant • The renewable asset is located in an offshore bidding zone to the hydrogen plant	

ICIS

EU Investment Bank

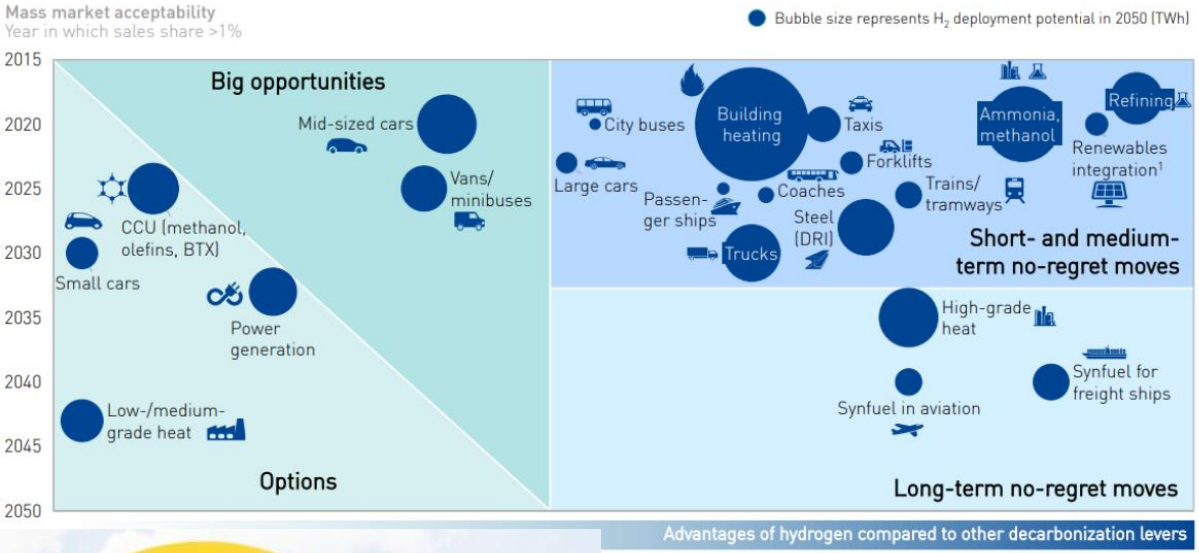
- European helps to a hydrogen production volumen based on prize policy per kilogram of renewable hydrogen produced up to a máximum limit of 4,5 euros/kg → classified from low to high offer prize up to finish the auction budget (800M€ + 2.200M€). Should start the renewabe hydrogen production in five years time.
- Selected projects will receive the funds plus the market incomes from selling the renewable hydrogen up to 10 years maximum.
- Not accumulative funds with other Mes helps to guarantee the equal conditions to everybody.
- Auction as a service → new voluntaire mechanism of the hydrogen bank to fund particiopant projects no selected by the auction by members states → low administrative charge and costs for all.

- **132 projects.**
- **17 European Countries.**
- **8,5GWe in 10 years.**
- **8,8 MTn Renewable H2 (10% RePowerEU 2030).**
- **Auction as a service → Germany 350M€.**
- **Grant Agreements to be signed in November 2024.**

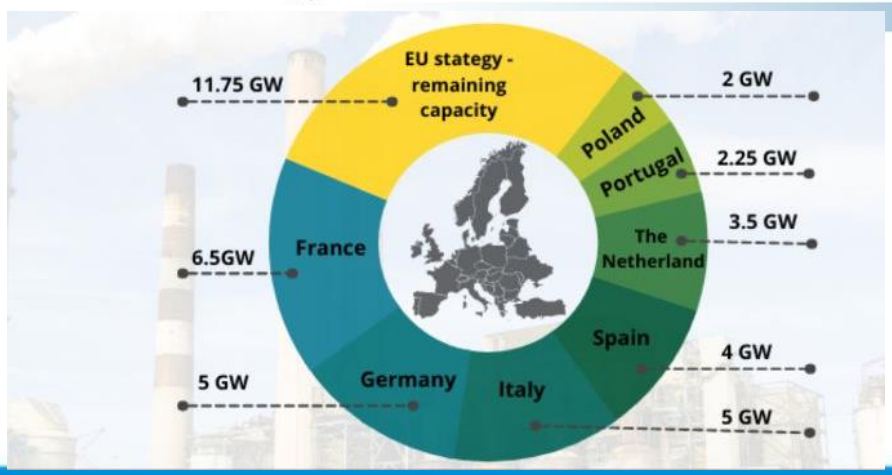


Hydrogen Roadmap Europe

Establishing an actionable hydrogen transition work plan



Source: Hydrogen Roadmap Europe



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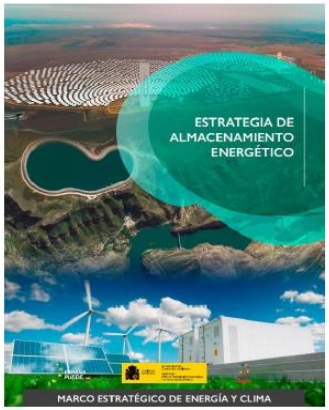
Spanish Strategies

March 2021

May 2021

October 2020

November 2020



February 2021

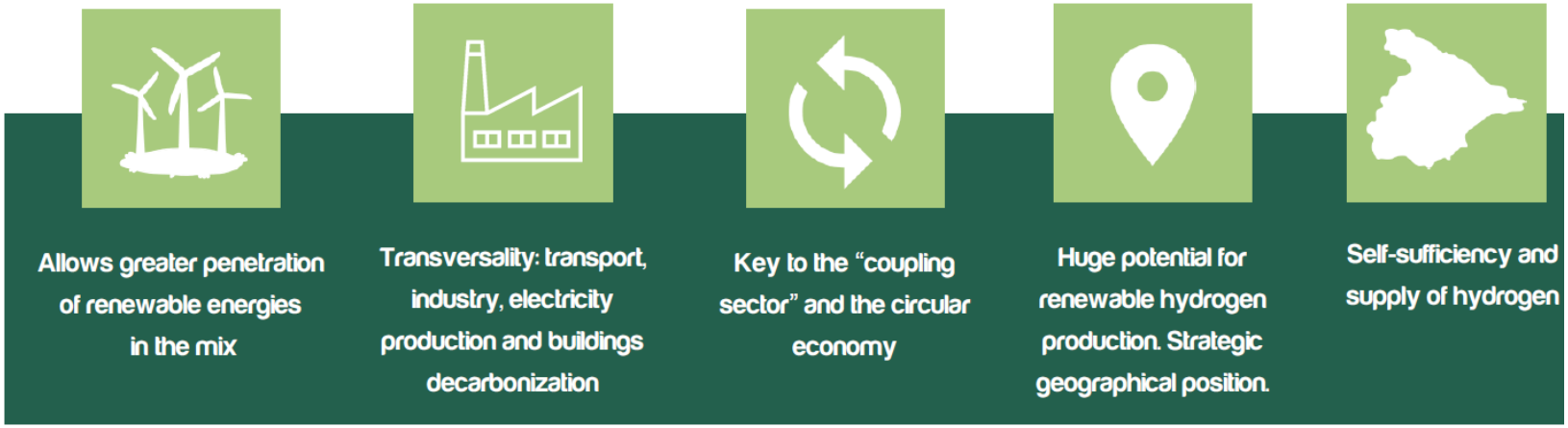
October 2021

November 2021

April 2022

2023

H2 Potential in Spain



Strengths

PNIEC – National Integrated Plan of Energy and Clima

	Resultados en 2030	
	PNIEC 2020	PNIEC 2023
Reducción de emisiones de GEI respecto a 1990	23%	32%
Reducción de emisiones de GEI respecto a 2005 – Sectores ETS	-61%	-70%
Reducción de emisiones de GEI respecto a 2005 – Sectores difusos	-39,1%	-43%
Porcentaje de renovables en la generación eléctrica	74%	81%
Número de vehículos eléctricos	5 millones	5,5 millones
Número de viviendas rehabilitadas	1.200.000	1.377.000
Potencia total y renovable del mix energético	Total: 160 GW Ren.: 113 GW	Total: 214 GW Ren.: 160 GW
Porcentaje renovables sobre energía final	42%	48%
Eficiencia Energética. Reducción de consumo de energía primaria	-39,5%	-42%
Eficiencia Energética Reducción de consumo de energía final	-41,7%	-44%
Dependencia energética	61%	51%

Challenges for 2030

Reduction of emisions

Renewable on electricity

Total and Renewable power

% Renewable vs Total Energ

Energy dependency

H2 Spanish Roadmap

11 GW

4GW installed power of electrolysers

25% hydrogen consumption in industry

100-150 public access hydro generators

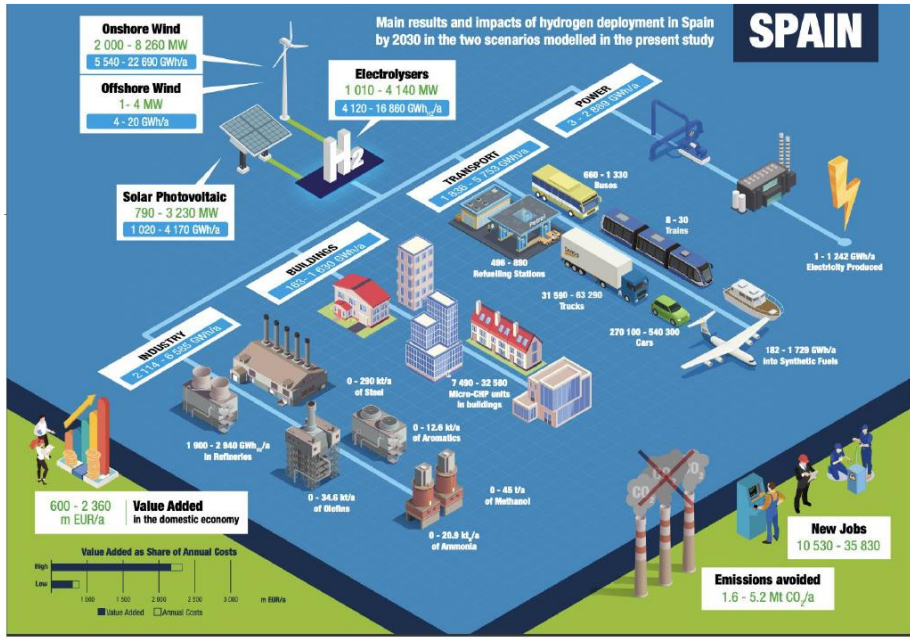
150-200 FCEV buses

5,000-7,500 FCEV road vehicles

2 commercial lines H2-powered trains

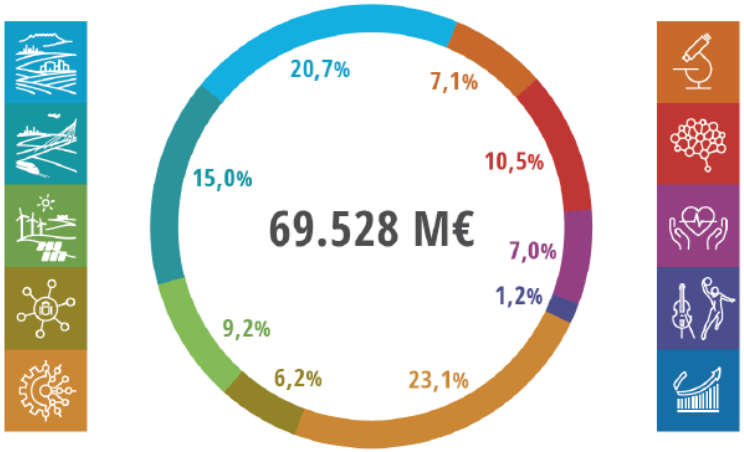
8.9B€ estimated mobilised investment

4.6 Mton CO2eq reduced



H2 Moment

Lever 3; Action 9. - Roadmap for renewable hydrogen and its sectorial integration (total budget: 1,555 M EUR)



Lever 6; Action 17.- Institutional reform and strengthening of the capacities of the national system of science, technology and innovation (total budget: 3,456 M EUR)

"7.900 M€ to mobilize private investments up to 16.000 M€ → 1.555 M€ to renewable hydrogen getting up to 2.800 M€ of private investment"

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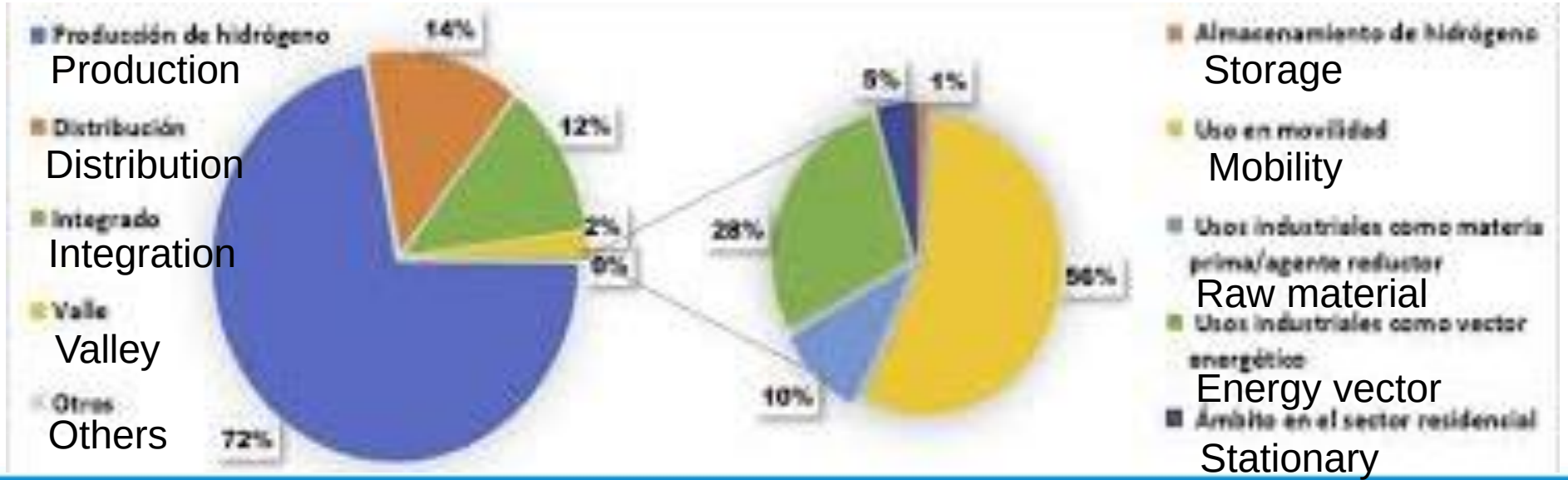
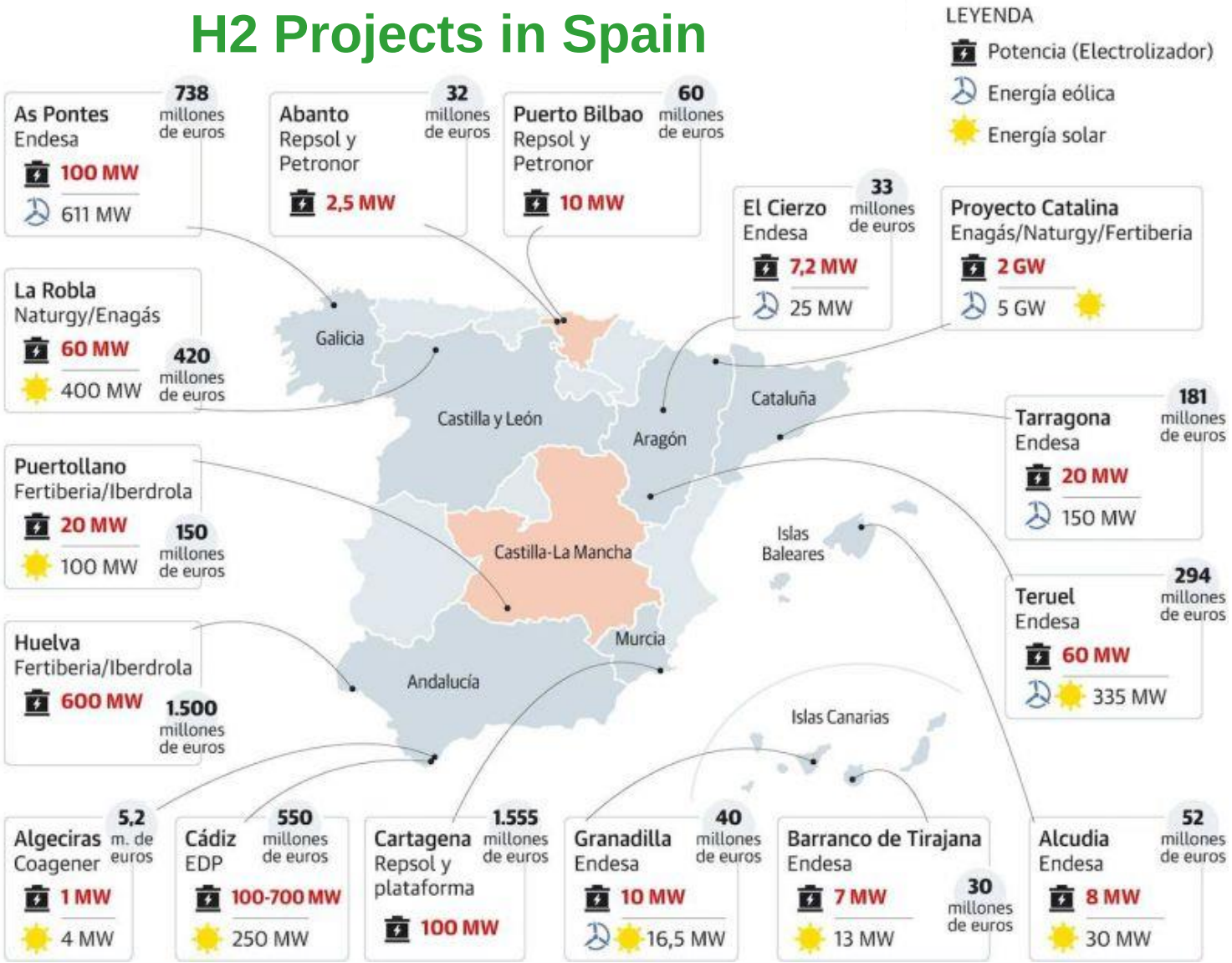
H2 Projects in Spain

123 projects that cover the whole value chain from 46 entities.

Investment up to 2030 will raise **21.000 M€**.



H2 Projects in Spain



Innovation Funds

PIONNERS

Focused on the integration of renewable hydrogen within industrial sector, as well as supply to transport, electric generation and thermal uses.

- 129 proposals, 746 M€ → 63 projects in 13 CCAA 343 M€ → 19 passed
- Cover the whole hydrogen value chain, but too focused on production.

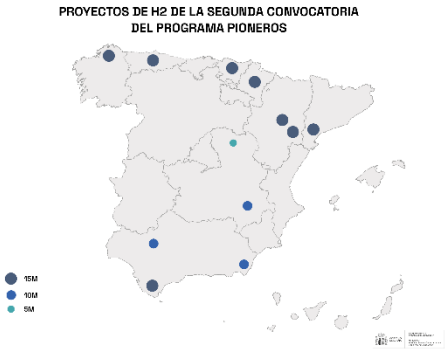
➢ **150M€ available each round → Technological performances**

Economic viability

Work creation

Transition areas (old energetic plants)

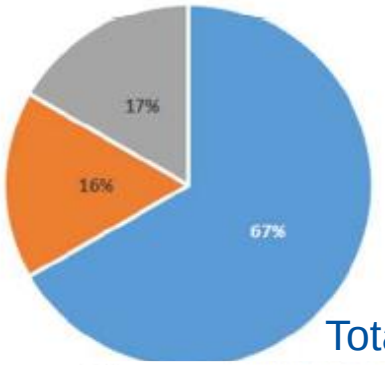
- Second round 2023 → 12 proposals passed out of 101 presented, with 309 MW electrolysis and 578,14 M€ investment → cover all the industrial applications, and 10 are developed in transition areas (84%)c Communitties, Andalucía (3), Aragón (2), Castilla-La Mancha (2), and others with 1 Project in Navarra, País Vasco, Cataluña, Galicia y Asturias.



ADDED VALUE CHAIN

Focused on supporting actions to SMEs and Technological Centres in order to increase their production and technological transfer capabilities.

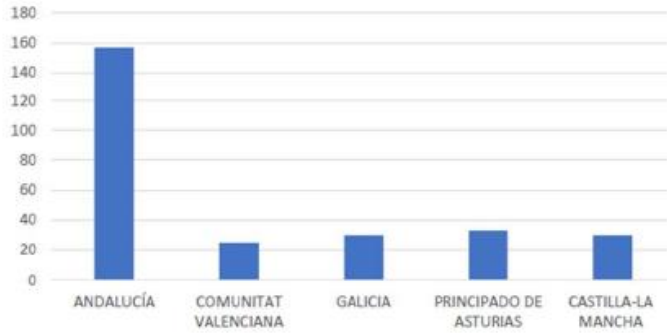
- 25 applications → 11 passed → 7 approved
- 250M€.
- Focused on Public-Private collaborations.
- To comply with hydrogen roadmap.

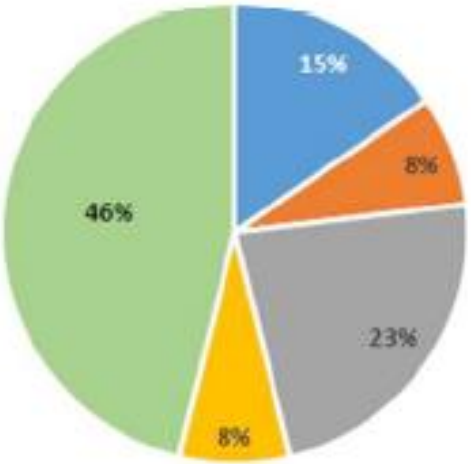


Added Value Chain

- Electrolysis
- HRS
- Transversal

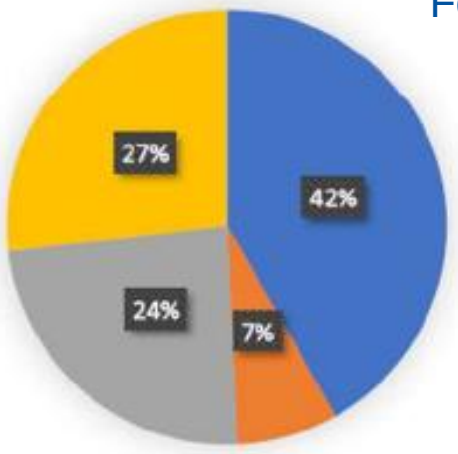
Total of Electrolysis (MW)





Transport

- Air
- Maritime
- Rail
- Handling
- Road



Focused on:

- Generation
- Transport & distribution
- Storage
- Use

Second round presented and waiting results.

IPCEI

Commission approves up to €5.4 billion support by 15 Member States for an Important Project of Common European Interest (IPCEI) in the Hydrogen Technology value chain "IPCEI Hy2Tech"

Hydrogen Generation Technology	Fuel Cells Technology	Storage, Transportation and Distribution Technology	End User Technology
1s1 Energy*	1s1 Energy*	Arkema	Alstom FR
Advent*	Advent*	B&T Composites*	Alstom IT
Ansaldo	Alstom	Daimler Truck	Bosch AT
AVL	Ansaldo	Enel	Daimler Truck
Christof Industries	Arkema	Faurecia	Fincantieri
De Nora	Bosch DE	NAFTA	HYVIA
Elcogen*	Daimler Truck	Neste	Iveco CZ
Elogen	De Nora	Ørsted	Iveco ES
Enel	EKPO	Plastic Omnium FR	Iveco IT
Genvia	Elcogen*		Neste
H2B2*	Fincantieri		Ørsted
Cummins	Genvia		Plastic Omnium AT
John Cockerill	HYVIA		Plastic Omnium FR
John Cockerill	Iveco		
McPhy*	Nedstack*		
Nordex	Plastic Omnium AT		
Ørsted	Symbio		
Sener			
Stargate			
Sunfire*			
Synthos			

4 Projects

*SME

El Gobierno concede ayudas de 74 millones a cuatro proyectos de hidrógeno en España

- Son iniciativas de las empresas H2B2, SENER, Nordex e IVECO, que canalizarán una inversión total de 245 millones
- La Comisión Europea los ha seleccionado entre 41 proyectos de 15 estados europeos en la primera convocatoria de IPCEI para apoyar la investigación y la industria del hidrógeno renovable

10 de enero de 2023 – El Consejo de Ministros, a propuesta del Ministerio para la Transición Energética y el Reto Demográfico (MITECO), ha aprobado un Real Decreto para la concesión de 74 millones de euros para la puesta en marcha de cuatro proyectos de hidrógeno renovable en España, de las empresas H2B2, SENER, Nordex e IVECO, que movilizarán una inversión total de más de 245 millones. La adjudicación se enmarca en el Proyecto Importante de Interés Común Europeo (IPCEI), aprobado por la Comisión Europea –denominado Hy2Tech– para apoyar la investigación, la innovación y la fabricación en su primer despliegue industrial en la cadena de valor del hidrógeno renovable.

Commission approves up to €5.2 billion support by 13 Member States for an Important Project of Common European Interest (IPCEI) in the Hydrogen value chain "IPCEI Hy2Use"

Hydrogen Infrastructure	Hydrogen applications in Industry
Air Liquide France	Borealis
Air Liquide Netherlands - CurtHyl	Enel Green Power/Endesa
Air Liquide Netherlands - ELYgator	ENGIE Belgium
Bay of Biscay Hydrogen (Petronor/Repsol)	Everfuel*
Bondalti	Hybrit Development
Cartagena Hydrogen Network (Repsol)	IAM Caecius
ENGIE Belgium	NextChem
ENGIE Netherlands	RINA-CSM
Fluxys	RONA
H2 Aboño (EDP)	SardHy Green Hydrogen
H2-Fifty	Solar Foods*
H2 Los Barrios (EDP)	South Italy Green Hydrogen
HyCC	TECforLime
Iberdrola	TITAN Cement
MassHylia (TotalEnergies and ENGIE France)	VERBUND
Ørsted	
P2X Solutions*	
PKN Orlen	
Shell	
Uniper	

7 Projects

*SMEs

Hydrogen Refuelling Stations - HRS

CIP y MIP

- **166** proposed energetic trans frontiers projects (RTE-E), to fulfil “European Green Deal" throughout **Common Interest Projects (CIP)** within the EU and **Mutua Interest Projects (MIP)** to connect the EU with other countries → faster administrative processes & protocols for authorization & standardization (Financial European Mechanism funds "Connect Europe" (MCE).

- **Objective** → contribute to increase the European capacity network up to 20230 and comply with the 42,5% of renewable energy objective defined.

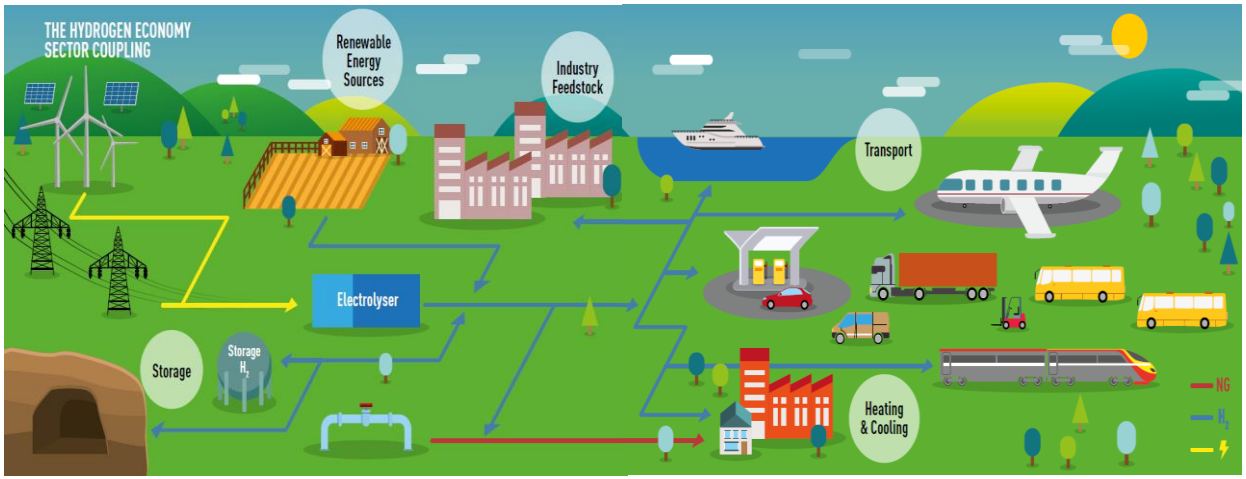
- **85** are electricity related projects, offshore and smart grids (in service in 2027-2030); including projects of hydrogen and electrolysers (**65**); and **14** CO2 network projects (CC&US).

- **H2Med** hydrogen project are integrated. Highlighting →
  - 9.1.1 Internal Hydrogen Infrastructure in Portugal.
  - 9.1.2 Interconnection Portugal – Spain.
  - 9.1.3 Internal Hydrogen Infrastructure in Spain.
  - 9.1.4 Hydrogen Interconnection Spain - France (BarMar).
  - 9.1.5 Internal Hydrogen Infrastructure in France to link with Germany (HyFen).
  - 9.1.6 Internal Hydrogen Infrastructure in Germany to link with France (H2Hercules Sur).
  - 9.24.1 Storage H2 Norte - 1, Spain.
  - 9.24.2 Storage H2 Norte – 2, Spain.

- **Next steps** → to present to European Parliament and Council to analyse (2 months to final approval).

Science, Innovation and University Ministry – Complementary Plan

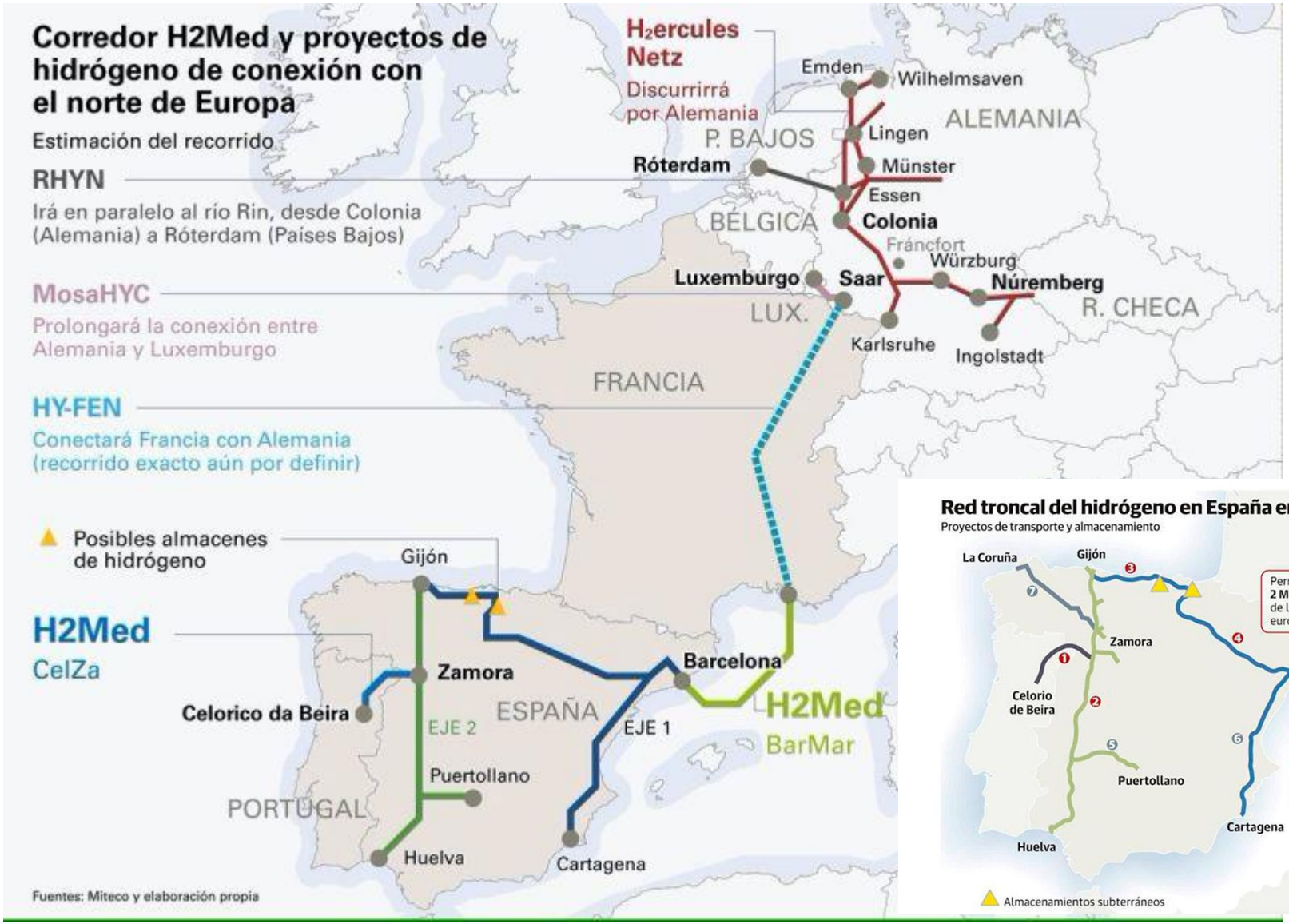
Strategic actions based on hydrogen towards the transformation of the current Energy paradigm to minimise the emissions



Community of País Vasco
Community of Asturias
Community of Aragón
Community of Castilla-La Mancha
Community of Canarias
Community of Navarra
Community of Extremadura
Community of Madrid
Community of Castilla y León
Community of Cantabria
CSIC
CNIIAE

Line 1: Generation of hydrogen at low temperature from renewable energy.
Line 2: Generation of hydrogen at low temperature from Eolic off-shore energy.
Line 3: Generation of hydrogen at high temperature from renewable energy by residual heat recovery.
Line 4: Generation of hydrogen and biomethane from biomass.
Line 5: Generation of biofuels from Hydrogen and CO2.
Line 6: Development of storage systems under pressure and supply of renewable hydrogen.
Line 7: Uses of Hydrogen on Heavy Duty. Aeronautic and maritime sectors.
Line 8: Uses of Hydrogen on industrial combustion.
Line 9: Uses of Hydrogen on industrial y domestic sector throughout a fuel cell.
Line 10: Uses of Hydrogen on industrial sector to reduce CO2 emissions and as chemical agent.
Line 11: Techno-economical studies and utility model market development. Diffusion, formation and capacities development of new researchers.
Line 12: General management of the project.
Line 13: Creation of National Iberic Research of Energy Storage Centre - CNIIA.

H2MED corridor



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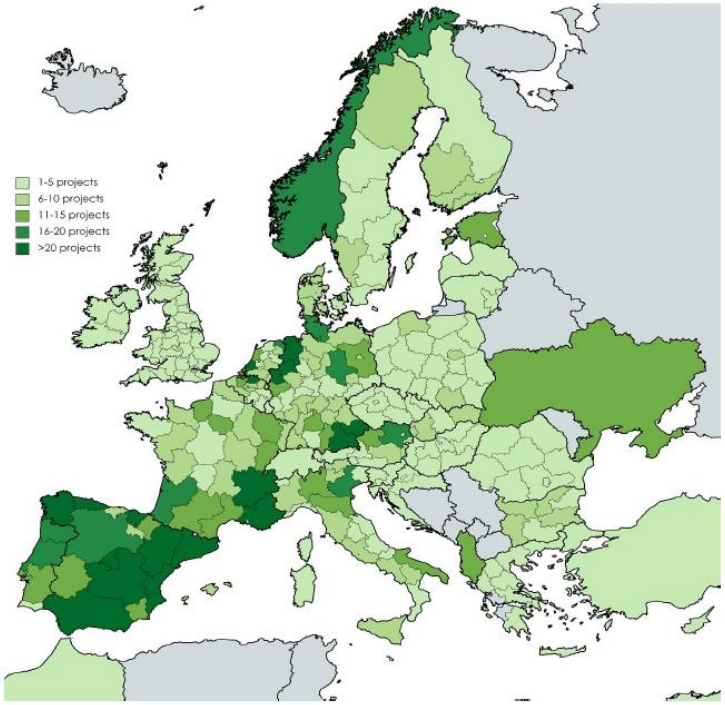
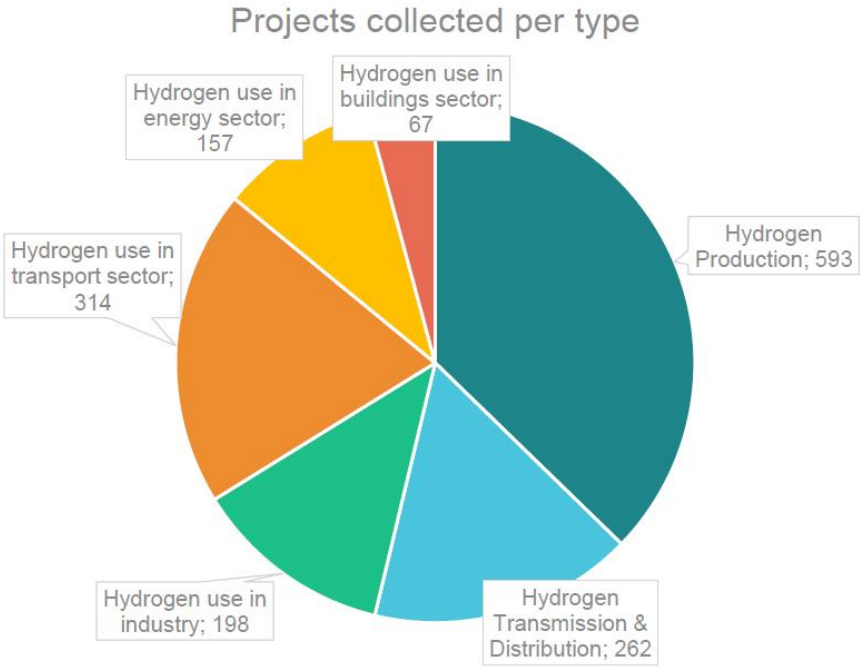
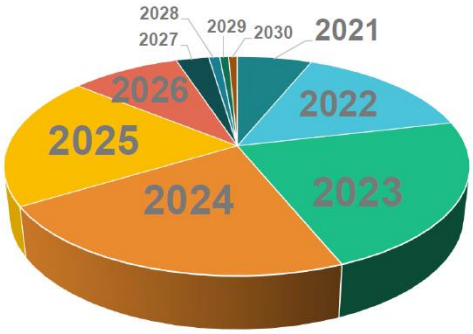
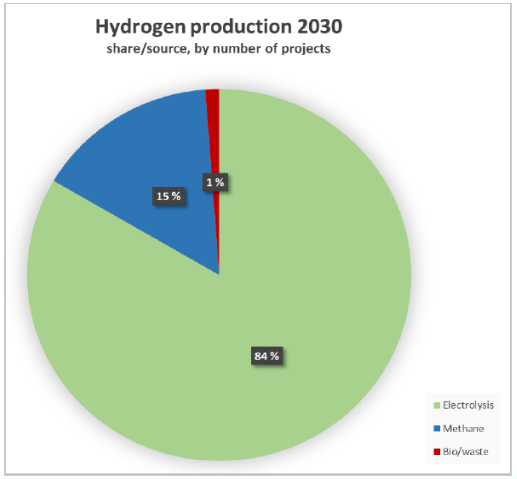
EU H2 PROJECTS PRESENTED



* Actual project location by NUTS2 region; a project covering more than one region appears more than once



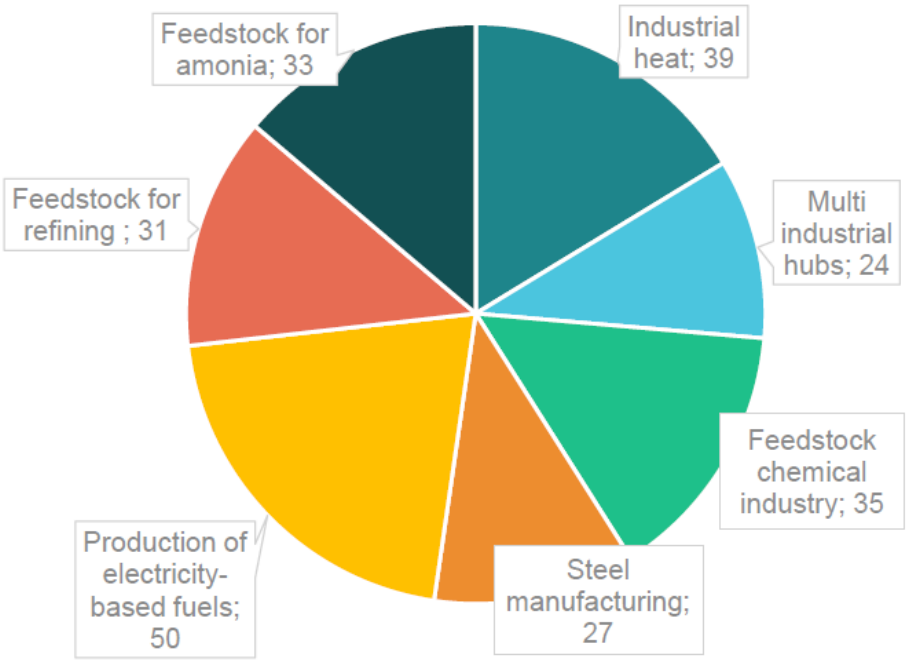




European Commission

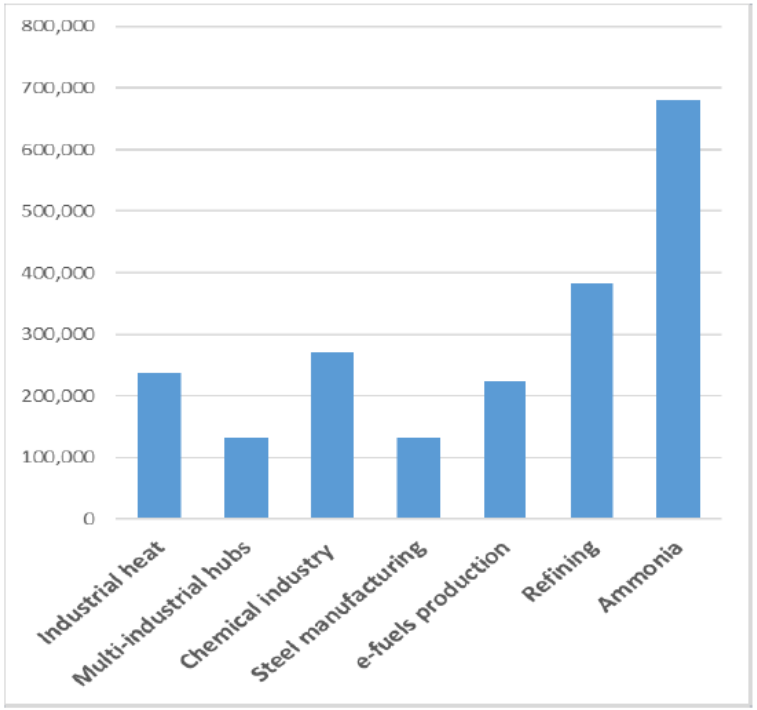
EU H2 PROJECTS CONSUMPTION

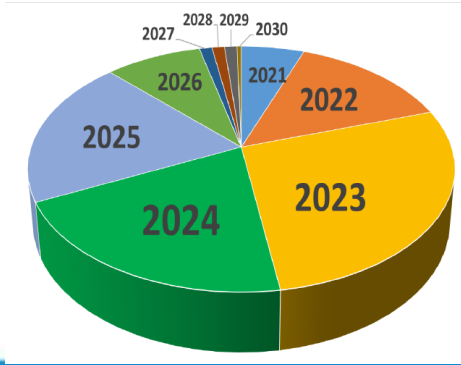
239 projects per industry application (all EU)

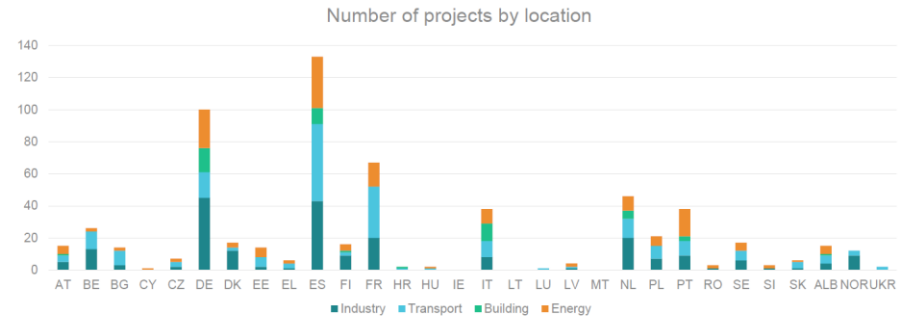


Hydrogen demand in industry applications

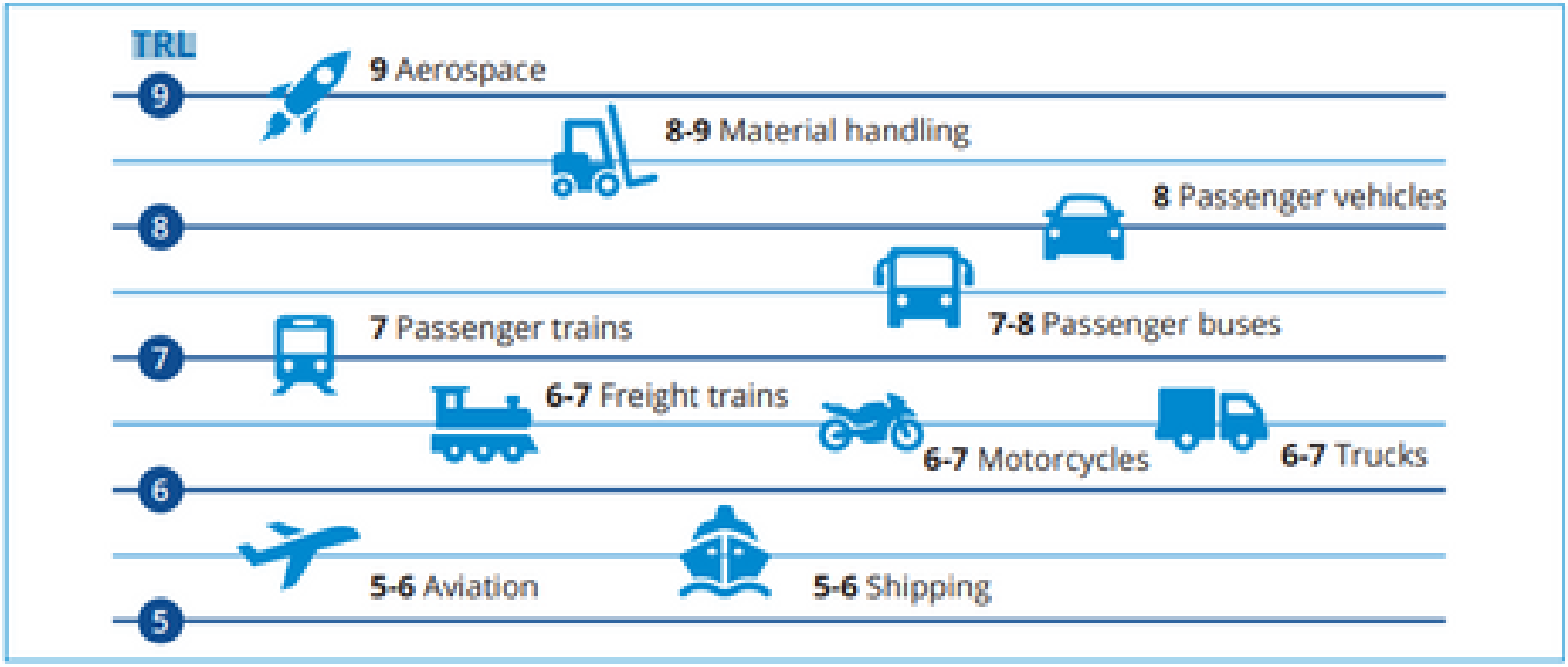
- **Around 2 million tonnes/year by 2026**







TRLs H2 Projects



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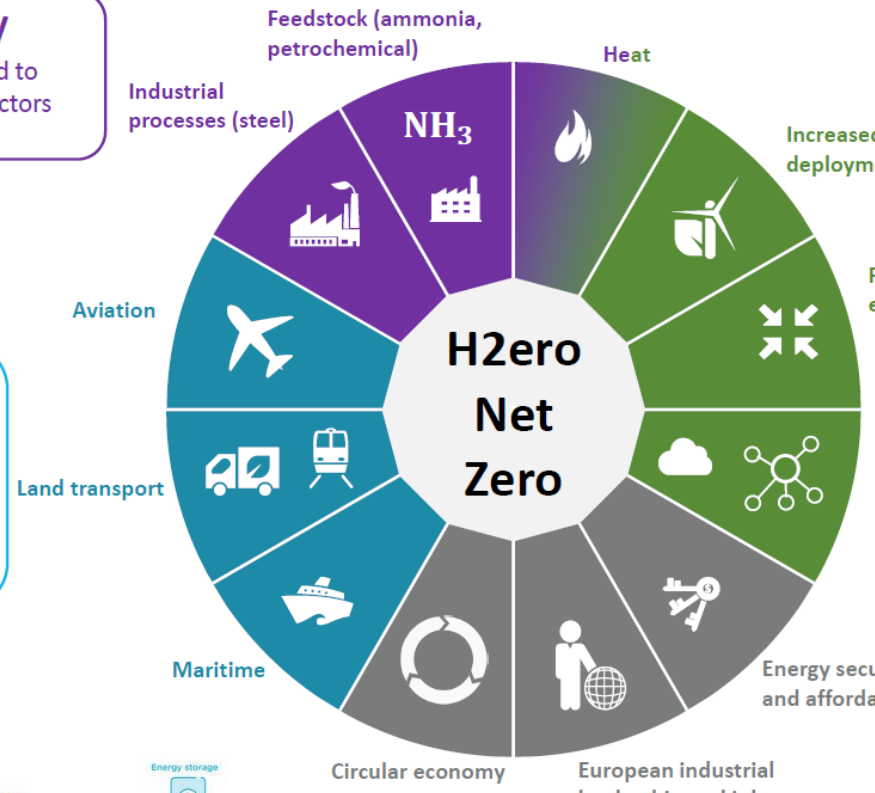
- European Strategy
- Spanish Strategy
- H2 Projects
- EU Projects
- Challenges

Key EU Objectives on H_2

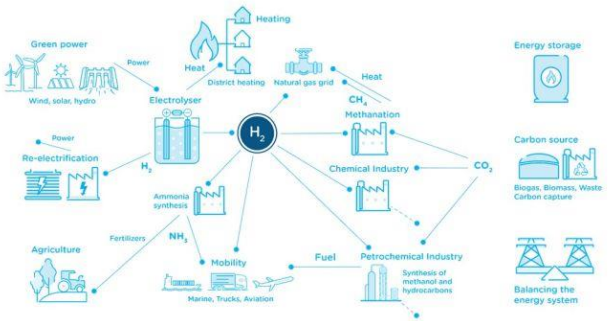
Industry
- Decarbonizing "hard to abate" industrial sectors

Transport
- No transport mode left behind
- No compromise (range, refuel time)
- No consumer segments left behind (fleets, long-distance travelers)



Energy
- Making a net-zero energy system possible

Societal
- Ensuring prosperity
- Reducing waste



Hydrogen Europe

Key EU Objectives on H_2

Technology solutions for travel modes to reach a net-zero economy in 2050

1 icon represents limited long-term opportunity 2 icons represents large long-term opportunity 3 icons represents greatest long-term opportunity	BATTERY/ELECTRIC	HYDROGEN	SUSTAINABLE LIQUID FUELS
Light Duty Vehicles (49%)*		–	TBD
Medium, Short-Haul Heavy Trucks & Buses (~14%)			
Long-Haul Heavy Trucks (~7%)			
Off-road (10%)			
Rail (2%)			
Maritime (3%)		†	
Aviation (11%)			
Pipelines (4%)		TBD	TBD
Additional Opportunities	• Stationary battery use • Grid support (managed EV charging)	• Heavy industries • Grid support • Feedstock for chemicals and fuels	• Decarbonize plastics/chemicals • Bio-products
RD&D Priorities	• National battery strategy • Charging infrastructure • Grid integration • Battery recycling	• Electrolyzer costs • Fuel cell durability and cost • Clean hydrogen infrastructure	• Multiple cost-effective drop-in sustainable fuels • Reduce ethanol carbon intensity • Bioenergy scale-up

* All emissions shares are for 2019

† Includes hydrogen for ammonia and methanol

Renewable H2 Costs

	2020	2030	2050
Battery packs for transport applications (USD/kWh)	130 - 155	75 - 90	55 - 80
Low-temperature electrolysers (USD/kW_e)	835 - 1 300	255 - 515	200 - 390
Natural gas with CCUS (USD/kW H_2)	1 155 - 2 010	990 - 1 725	935 - 1 625

Notes: kWh = kilowatt-hour; kW_e = kilowatt electric; CCUS = carbon capture, utilisation and storage; H_2 = hydrogen. Capital costs for electrolysers and hydrogen production from natural gas with CCUS are overnight costs.

Source: IEA analysis.

Falling electrolyser costs

Economy of scale
Learning curve effects

900 €/kW (2020) | 500 €/kW (2030) | 150 €/kW (2050)

Falling renewable electricity costs

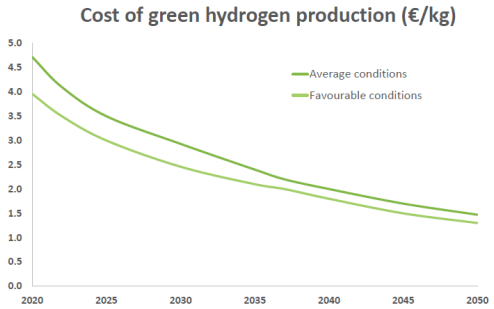
70-90% falling already seen in the last decade

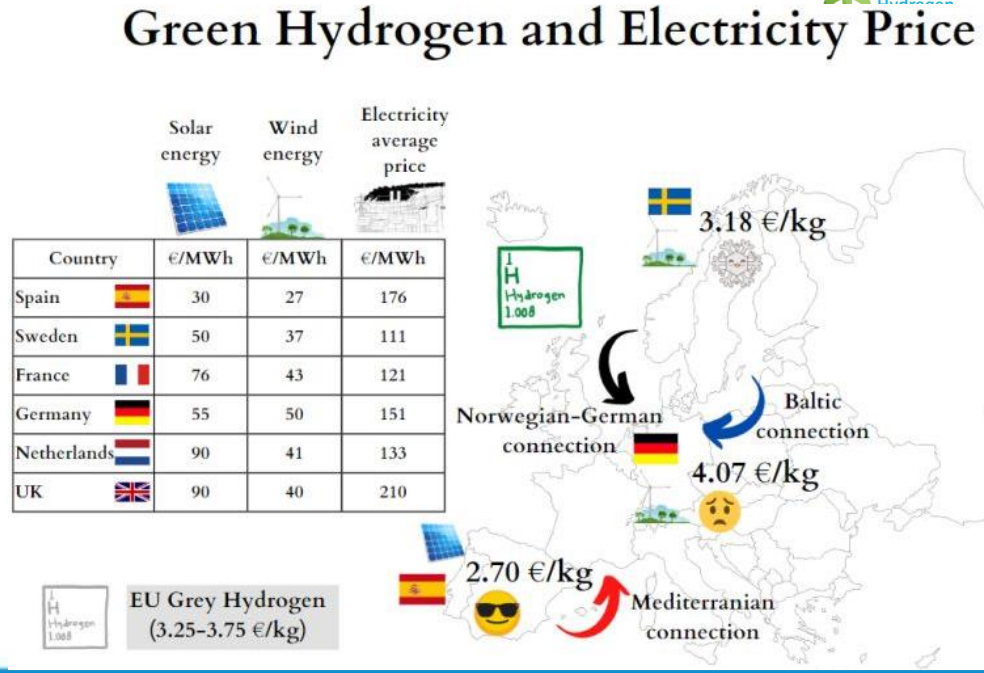
Favourable PV conditions:

50 €/MWh (2020) | 17 €/MWh (2030) | 12 €/MWh (2050)

Favourable on-shore wind conditions:

37 €/MWh (2020) | 25 €/MWh (2030) | 17 €/MWh (2050)





Busting 5 Myths

Dispelling common misconceptions about hydrogen.

Green hydrogen is too expensive

When considering global events driving up oil prices and subsidies for its production, green hydrogen is right now cheaper than jet fuel. The three to fourfold increase in hydrogen demand predicted over the next decade will require 30% annual growth of global installed electrolyzer capacity every year until 2050. Every component in the hydrogen value chain will fall in price. The cost of electrolyzers could easily drop by 40% in a few years while some electrolyzer manufacturers projecting even faster declines.

Then comes the continuously falling price of the renewable electricity needed to make green hydrogen. Costs for utility-scale solar power, for example, have fallen 85% between 2010 and 2020. Some projections for renewable power fall to 2 cents per kWh by 2025, leading to a cost of green hydrogen at $1.5 per kg.

Source: Universal HydrogenAssociation

Hydrogen is a renewable energy source

No. Hydrogen is a gas: it is the most abundant element in the universe, and here on Earth it typically needs to be extracted from water or organic compounds. We use renewable energy sources such as wind and solar power to extract hydrogen more sustainably with water vapor as a by-product and zero emissions. Today, the production of 'grey' hydrogen (from natural gas still dominates the international landscape, but 'green' hydrogen from renewables is taking off. Learn more about the different colours of hydrogen here.

Source: American Public Power Association

Mainstream hydrogen is futuristic

While some estimates pin 2050 as when green hydrogen could become cost competitive, many factors, including the relative price of renewables, supportive policies, and ramped-up technology development could make using hydrogen more attractive as early as the 2030s. A 2020 review by the Hydrogen Council asserts that 22 of 35 applications for green hydrogen would be cost competitive relative to other noncarbon options before 2030. Projects are already underway with goals to convert generating plants to 100% hydrogen in the 2040s or earlier.

Source: American Public Power Association

Hydrogen as a fuel is new

Not so new. Hydrogen was first produced by electrolysis in 1789 and first used as a fuel in 1792 when it was produced as a constituent of coal gas. The modern oil industry dating back to 1847 is youthful by comparison. Although hydrogen is a fuel in that it contains chemical energy, it is not like fossil fuels. It is artificially made, transported, then used to power something. As such, it is an energy carrier medium, more akin to electricity or steam.

Source: FuelCellsWorks

Hydrogen gas is unsafe

Hydrogen presents the same, if not fewer, hazards than other fuels due to its non-toxic and low-volatility characteristics. Since hydrogen is 14x lighter than air and 57x lighter than gasoline vapor, it will typically rise and disperse rapidly when leaked, greatly reducing the risk of ignition at ground-level.

Source: Swagelok

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