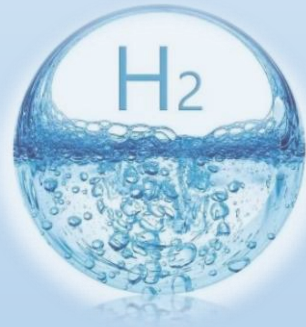
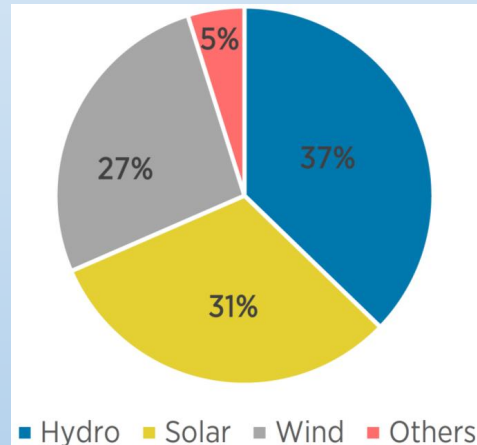


H_2O to H_2 : Mapping Portugal's Waterwise **Green Hydrogen** Projects



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GEECS: Our research team at Técnico – Universidade de Lisboa



**GEECS - Group on
Electrochemical
Energy Conversion
and Storage**

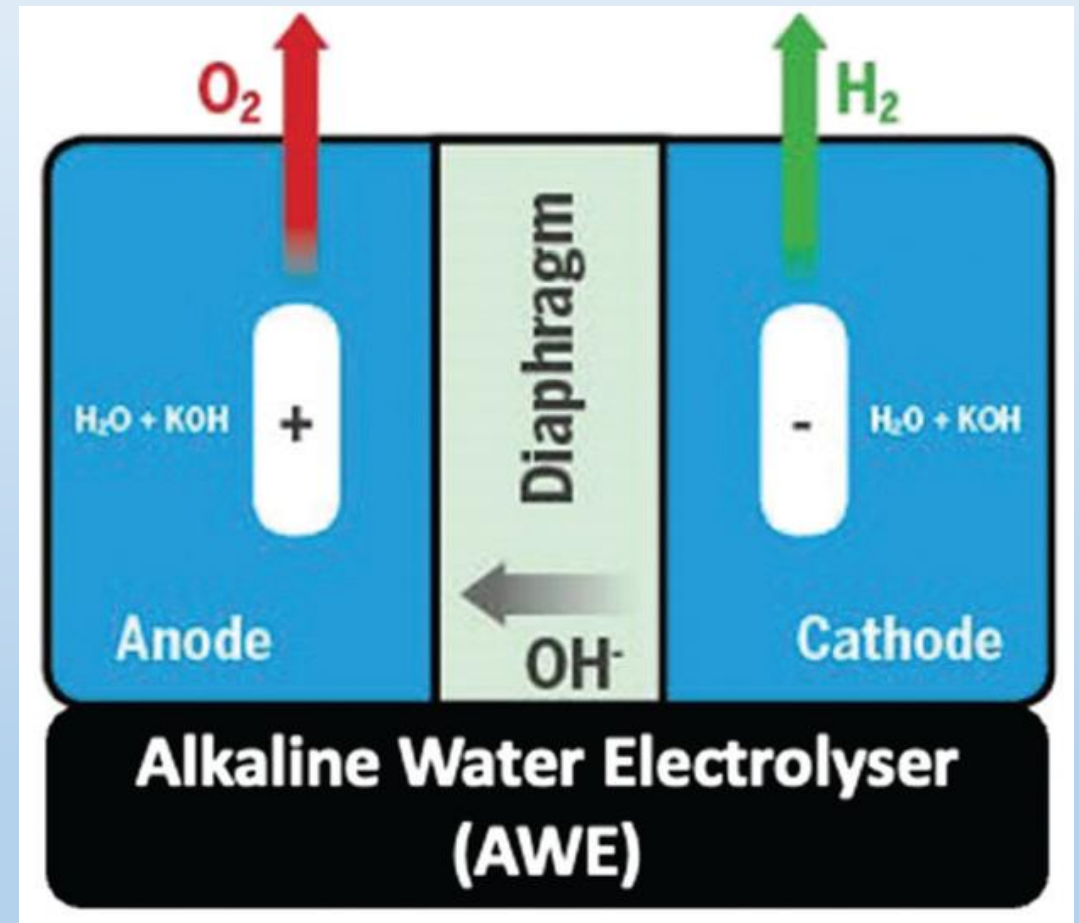


“3×H₂: A three-way approach to low-cost green hydrogen. High-efficiency electrodes, membranes, and electrolytes”

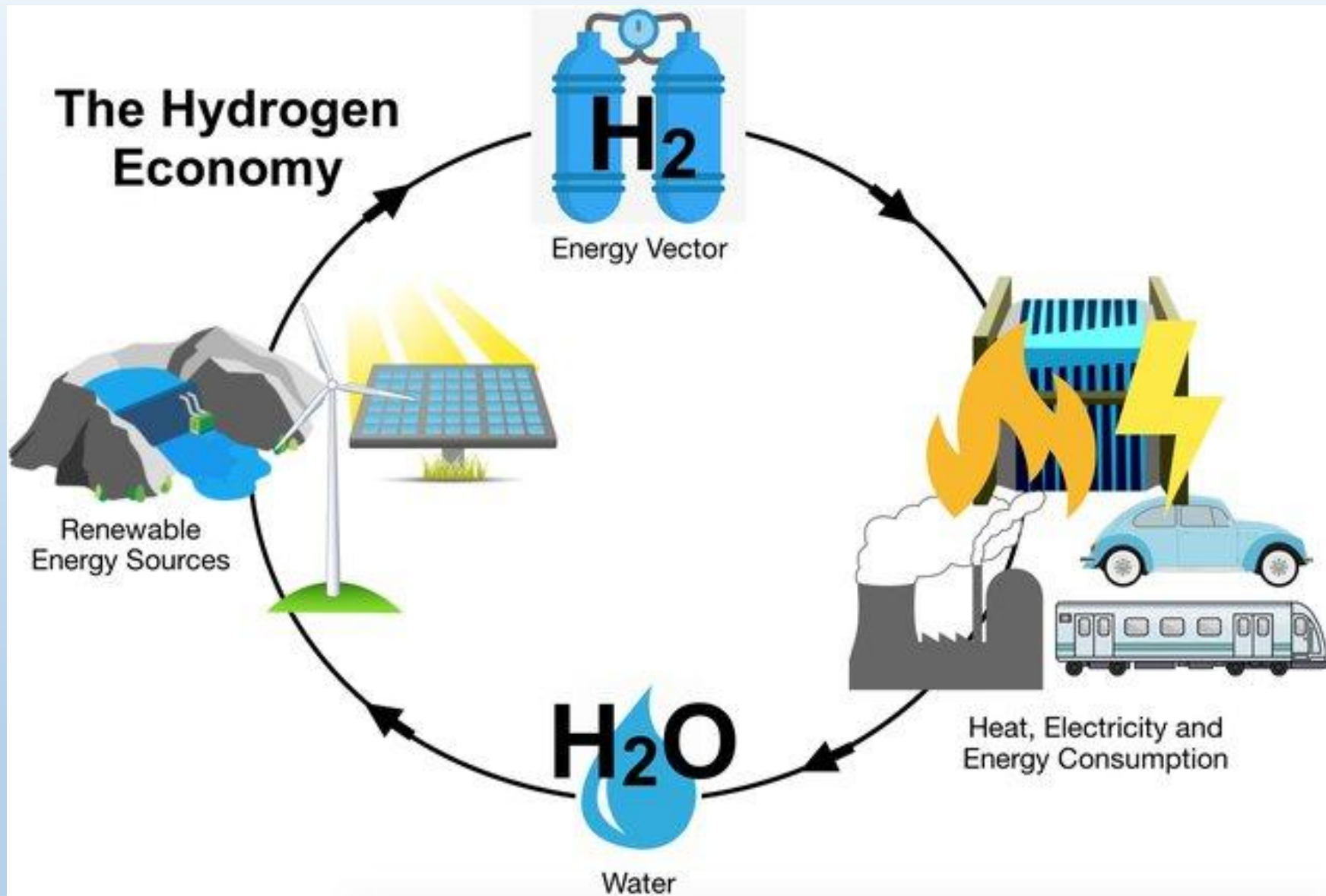
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Innovative strategies to develop:

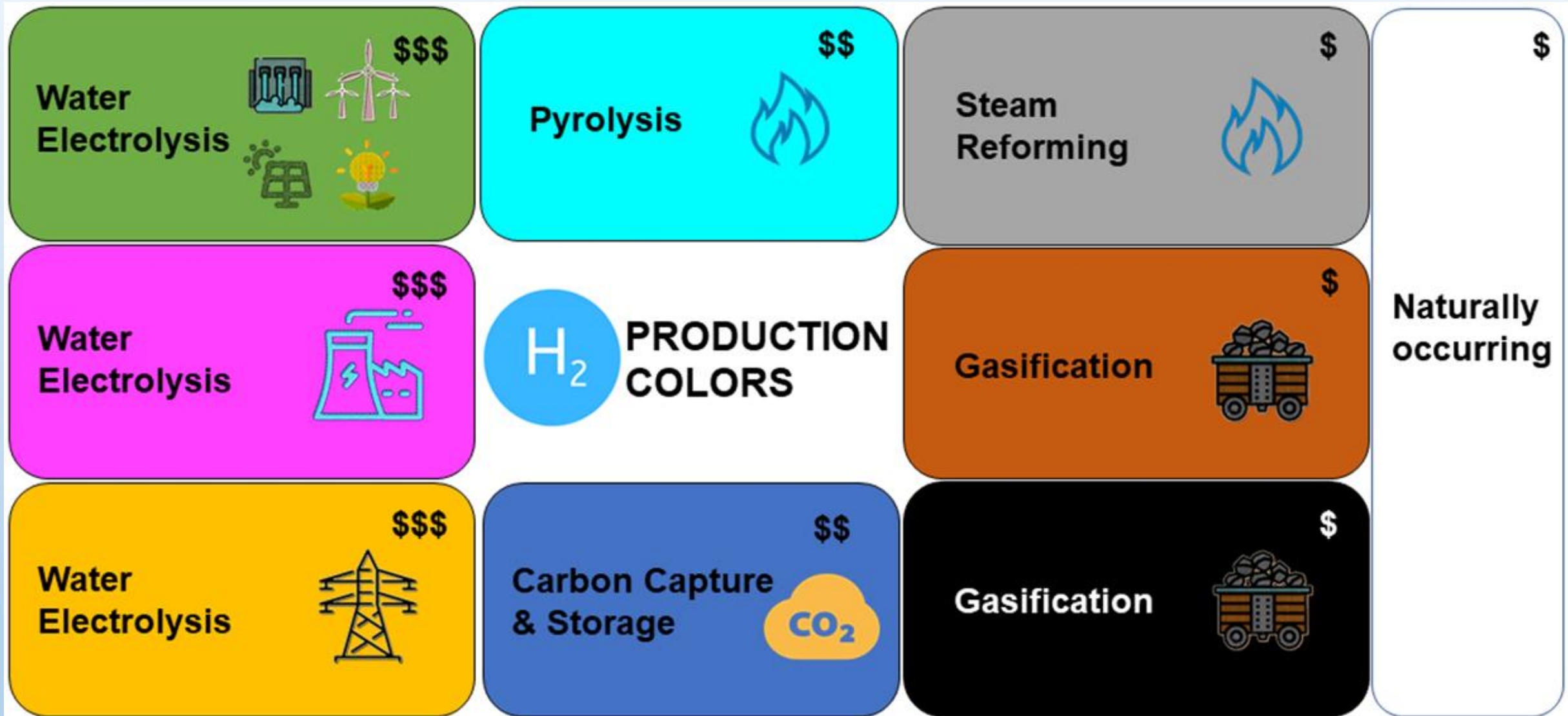
- 1) Highly active and stable electrodes
- 2) Low-cost membranes
- 3) Improved electrolyte solutions



The Hydrogen Economy



The hydrogen color spectrum



Green hydrogen for decarbonising hard-to-abate sectors

Heavy industry

(approximate share of
global CO₂ emissions)

- Steel and Iron Production (8 %)
- Cement Manufacturing (7 %)
- Chemicals and Petrochemicals (5 %)

- *highly energy-intensive*
- *account for a **significant portion** of the **global CO₂ emissions***

Heavy transportation

- Heavy-Duty Vehicles (6 %)
- Shipping and Aviation (5 %)

Transitioning these sectors to
green hydrogen greatly reduces
their carbon footprint

Comparison of Hydrogen Dispenser vs. Electric Recharging Unit

Hydrogen Fuel-Cell Bus
Refuelling time: 10 – 20 min

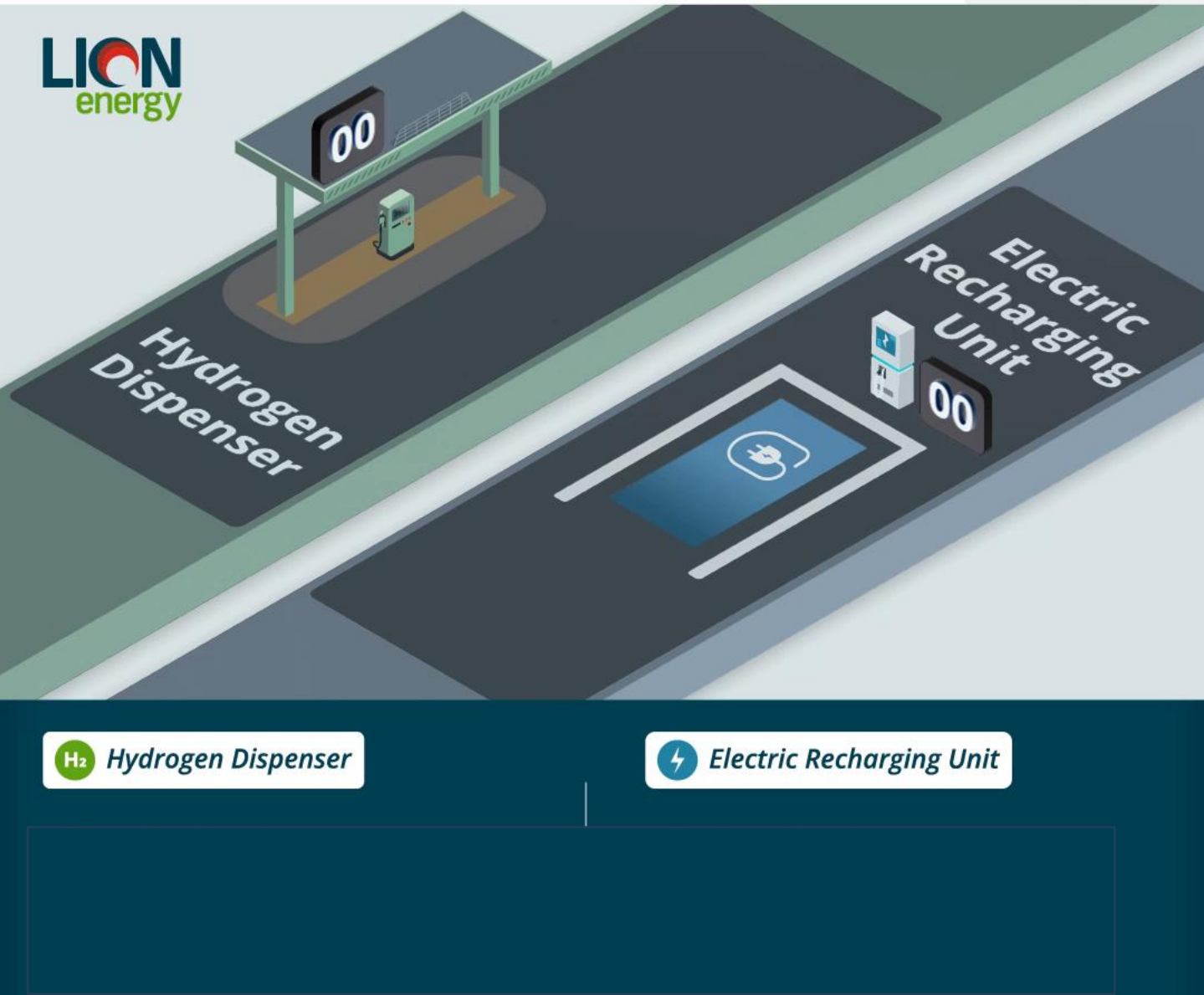
Example: Caetano H2.City Gold <10 min

Battery Electric Bus
Charging time: 2.5 – 5 hours

Fast/opportunity partial charging: 10–30 min

Source: Lion Energy Limited

Driving the Future:
Hydrogen Dispenser vs Electric Recharging Unit



Hydrogen as a fuel

Paris Olympics had 12 fuel cell buses made in Portugal

July – August 2024



H2.CityGold from CaetanoBus

500 km of range

- H₂ bus fleets operating in Madrid and Barcelona

4 buses run daily in Cascais!

Hydrogen as a fuel

HyChem SA opened in 2025 the first private green-hydrogen refuelling station for vehicles in the Lisbon region

Supplied 33 kg of hydrogen at a pressure of 350 bar to a CaetanoBus fuel cell bus (for a driving range of 500 km)



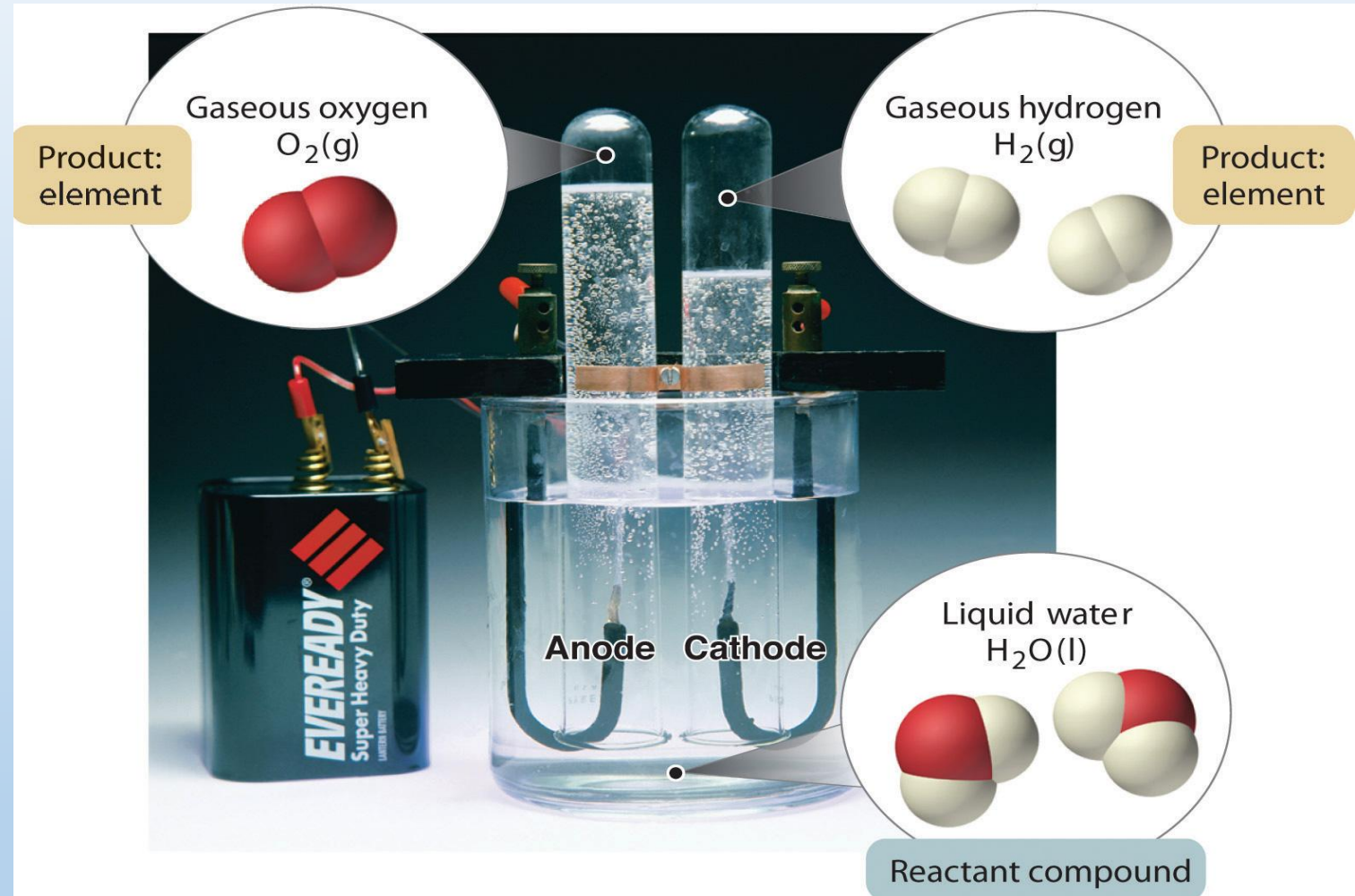
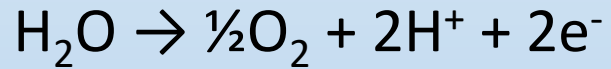
Source: HyChem

Hydrogen production from water electrolysis

Cathode



Anode



Large-Scale Green Hydrogen Production



**Solar and
wind energy**

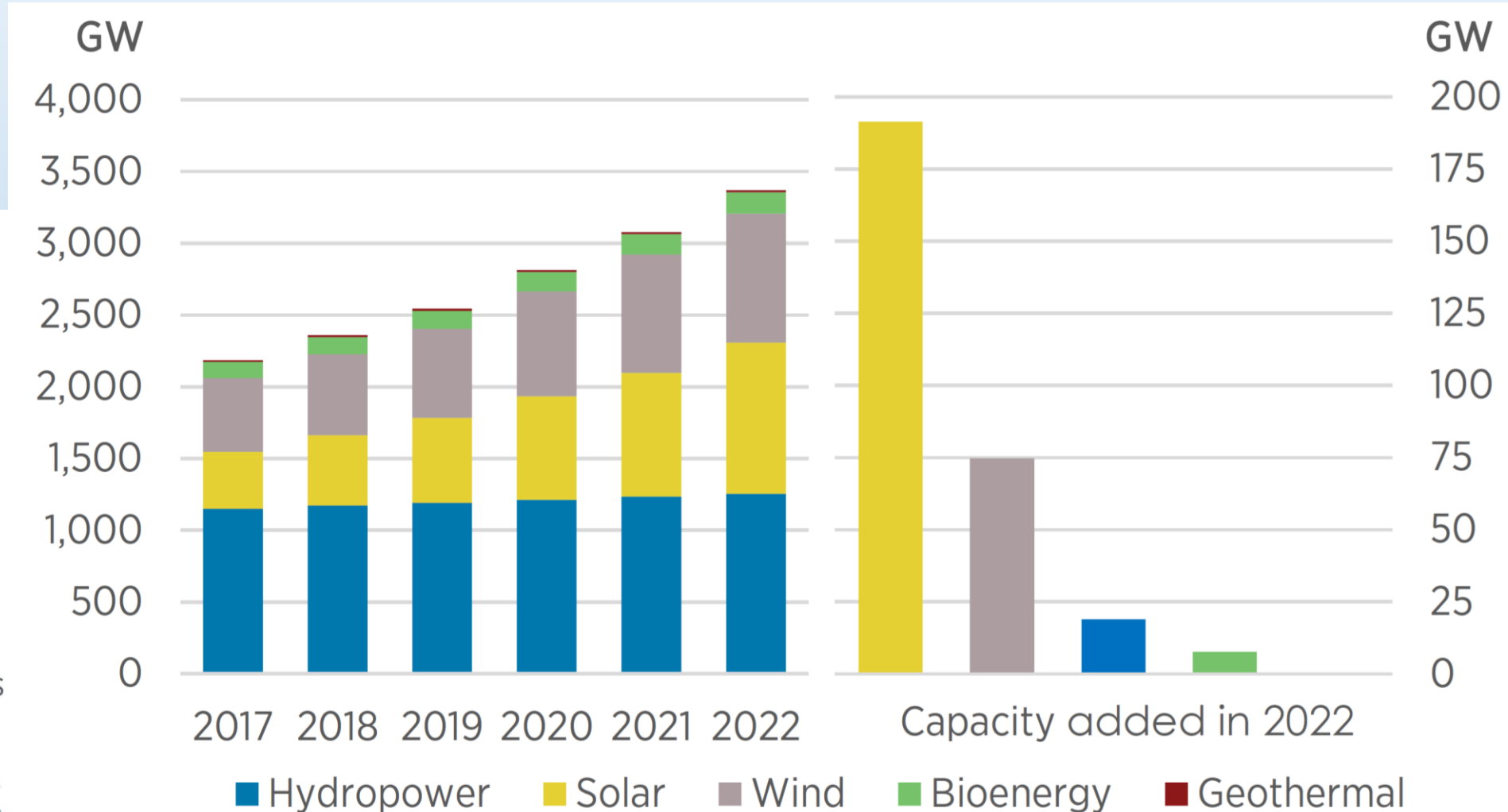
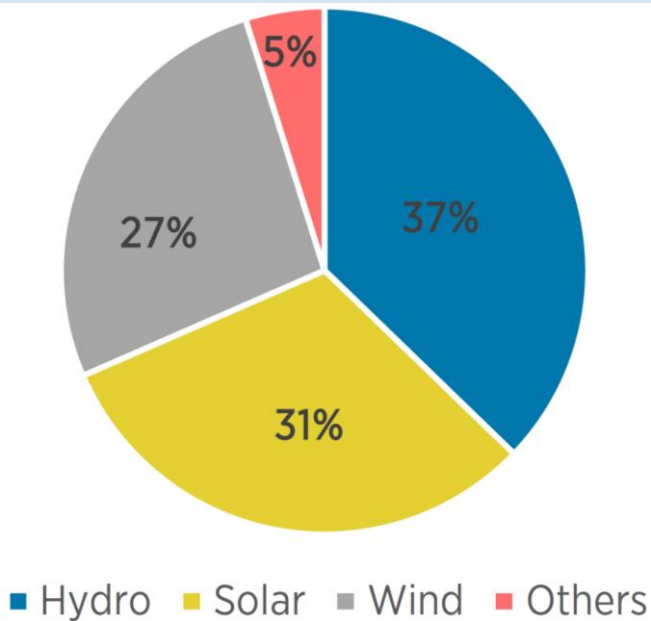
**Surplus of renewable
energy is transformed
into green hydrogen
via electrolysis**

Decarbonising
the regional chemical
industry

Providing green
hydrogen or derivatives
(green methanol,
ammonia)
to international
customers

Renewable power capacity growth

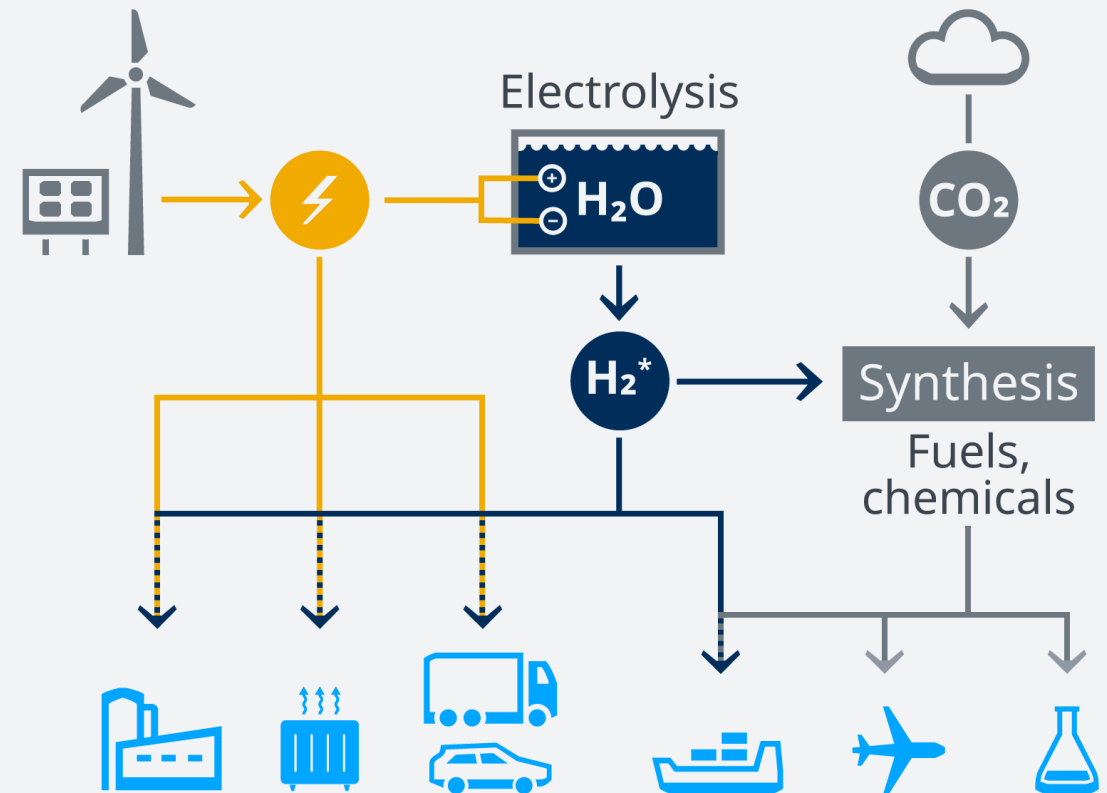
Renewable generation capacity by energy source



“Power-to-X” technologies

- Power-to-gas (H_2 , CH_4 , NH_3)
- Power-to-liquid (methanol)

Power-to-x: carbon-neutral fuels



Source: DW | H_2^* = hydrogen

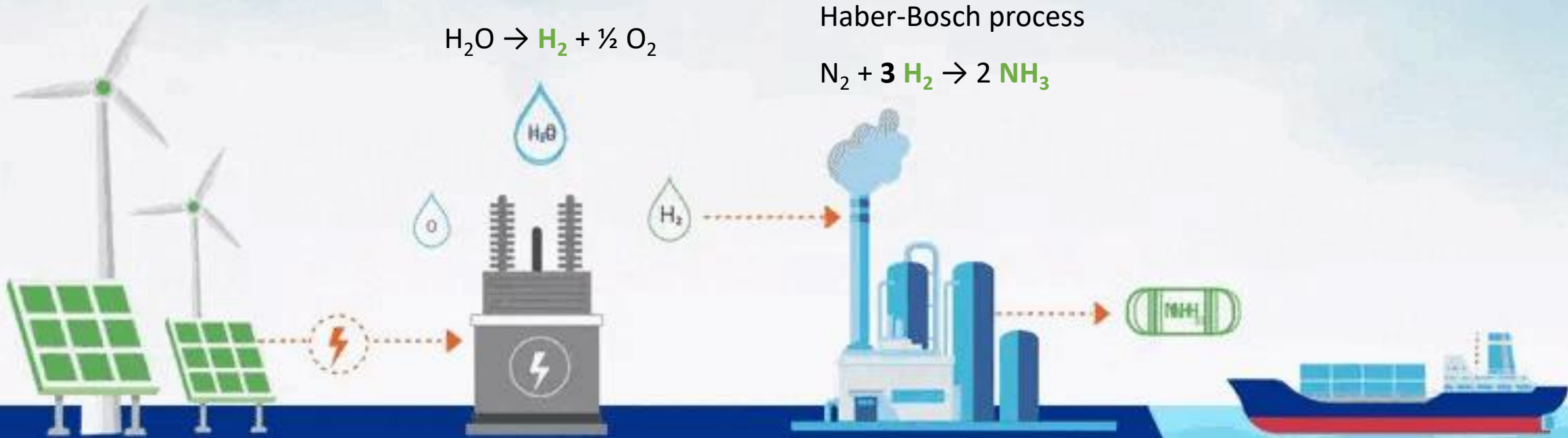
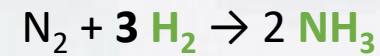
Power-to-Gas: Green ammonia production

Renewable energy

Green hydrogen



Haber-Bosch process



MadoquaPower2X project in Sines

Large-scale production of **green H_2** and **green ammonia (NH_3)**

- 1.2 GW electrolyzers
- 150k ton H_2 per year
- 1M ton NH_3 per year
- > € 2,800 M investment



Portugal's green hydrogen project landscape

Selected projects with current public information (September 2026)

Project	Location	Electrolyser	H ₂ / year	Main uses	2026 status	Water strategy / note
Galp H₂ Park	Sines	100 MW PEM	up to 15 kt	Refinery H ₂	Construction; commissioning 2H 2026	✓ Industrial recycled water
H2ALBA (Repsol)	Sines	4 MW PEM	600 t	Chemicals / polyolefins	Advanced; operation planned 2026	Water source not publicly specified
GreenH2Atlantic	Sines	100 MW ALK	>10 kt	Industry / gas grid	Conditional EIS; FID still pending	✓ Reuse or seawater required by APA
MadoquaPower2X	Sines	500 MW ALK (Phase 1)	~51 kt	H ₂ → 300 kt NH ₃	Advanced development; FID positioning	Water source not stated in current project summary
H2SINES (Beyond Green)	Sines	10 MW ALK	~1 kt	Industry / mobility	FID July 2026; production target 2027	Water source not publicly specified
H2Enable	Estarreja	40 MW ALK	~5.5 kt*	Chemicals / gas / mobility	Development / implementation	Water treatment required; source not specified
Nazaré Green H₂ Valley	Marinha Grande	40 MW ALK	—	Glass / cement	Fully licensed; FID pending	Water strategy not publicly specified

* Publicly cited target for the first 40 MW phase; figures/status vary across project sources.

Portugal: from pilot scale to industrial-scale electrolysis

There are projects using both PEM and alkaline electrolysis technologies — for different scales

4–10 MW | early industrial

- **H2ALBA (Repsol)** - 4 MW PEM
- **H2SINES (Beyond Green)** - 10 MW ALK
- Direct industrial / mobility applications

40 MW | regional industry

- **H2Enable** - Estarreja
- **Nazaré Green H₂ Valley** - 40 MW
- Chemical, glass, and cement demand

100 MW | Sines hub

- **Galp H₂ Park** - 100 MW PEM
- **GreenH2Atlantic** - 100 MW ALK
- Refinery + industry + gas grid

500 MW+ | export

- **MadoquaPower2X** - 500 MW Phase 1
- 1.2 GW planned across two phases
- H₂ → green NH₃

Waterwise green hydrogen: the water source matters

The goal is not just to “use less water” → It is to avoid competing with potable freshwater

Freshwater

High quality;
should be prioritized
only where appropriate

Treated wastewater

Circular reuse;
requires tailored
pre-treatment

Seawater

Abundant;
desalination or direct
seawater electrolysis

Pre-treatment / water conditioning

filtration • ion exchange • RO / desalination • advanced treatment

For H₂ production...

- **Water quantity is not the main scale-up constraint; electricity demand remains dominant.**
- **Water quality strongly affects membrane and catalyst operating stability and durability.**

Responsible design principle

- **Prefer alternative water sources whenever technically and environmentally appropriate.**
- **Consider the energy, chemicals, brine, and residuals associated with the water treatment.**

Water sources for electrolysis: different trade-offs

Source	Typical issue	Pre-treatment	Main opportunity	Main caution
Freshwater	Limited / competing demand	High-purity polishing, especially PEM	Simple integration	Avoid potable water where alternatives are viable
Seawater	35–45 g/L TDS; Cl ⁻	RO / desalination or direct-seawater route	Abundant coastal resource	Energy + brine; CLER / corrosion in direct electrolysis
Industrial wastewater	High TDS/COD; metals; oils	Filtration + chemical/biological treatment + membranes	Circular water reuse + wastewater treatment	Treatment energy/cost; feed variability
Greywater	Organics; surfactants; salts	Filtration + biological / membrane treatment	Decentralized reuse	Fouling, variability, micropollutants

The best option depends on the context:

- **Reusing treated wastewater** creates a **circular synergy**;
- **Seawater** can be a **good option** when **coastal access is available** and **environmental impacts** can be **managed**.

Portugal's waterwise hydrogen projects

Not every project publicly discloses its feedwater source

Galp H₂ Park | Sines

- 100 MW PEM • up to 15 kt H₂/y
- **Industrial recycled water**
- Direct replacement of grey H₂ in refinery

GreenH2Atlantic | Sines

- 100 MW ALK • >10 kt H₂/y
- APA: **water** for production/cooling must be **reused** or sourced from the **sea**
- Former coal plant → H₂ hub

H2SYMBIOTIC | Portugal

- Starts 2026 • integrated H₂ hubs
- **Water reuse + wastewater-treatment integration**
- Demonstrators include Sines and Freixo

HySEas | HyLab

- 2025–2028 Horizon Europe project
- **Direct seawater electrolysis**
- HyLab: BPMWE stack design/testing

H2Enable | Estarreja

- 40 MW ALK first phase
- Water treatment is part of the system
- Source not publicly specified

MadoquaPower2X | Sines

- 500 MW Phase 1
- H₂ → green NH₃
- Feedwater **source should be made explicit as the project advances**

HySEas: taking seawater directly to hydrogen

HyLab is a Portuguese partner in a 2025–2028 Horizon Europe project on direct seawater electrolysis



- **Project: Hydrogen from Seawater Electrolysis (HySEas)**
- 1 May 2025 → 30 April 2028
- HyLab (Sines): €700k EU contribution
- **Technology: Bipolar Membrane Water Electrolyzer (BPMWE)**

Why it matters

- Avoids dependence on freshwater by performing **direct seawater electrolysis**
- Addresses chloride-related side reactions, corrosion, and durability
- Also explores recovery/reuse of valuable elements from seawater brine

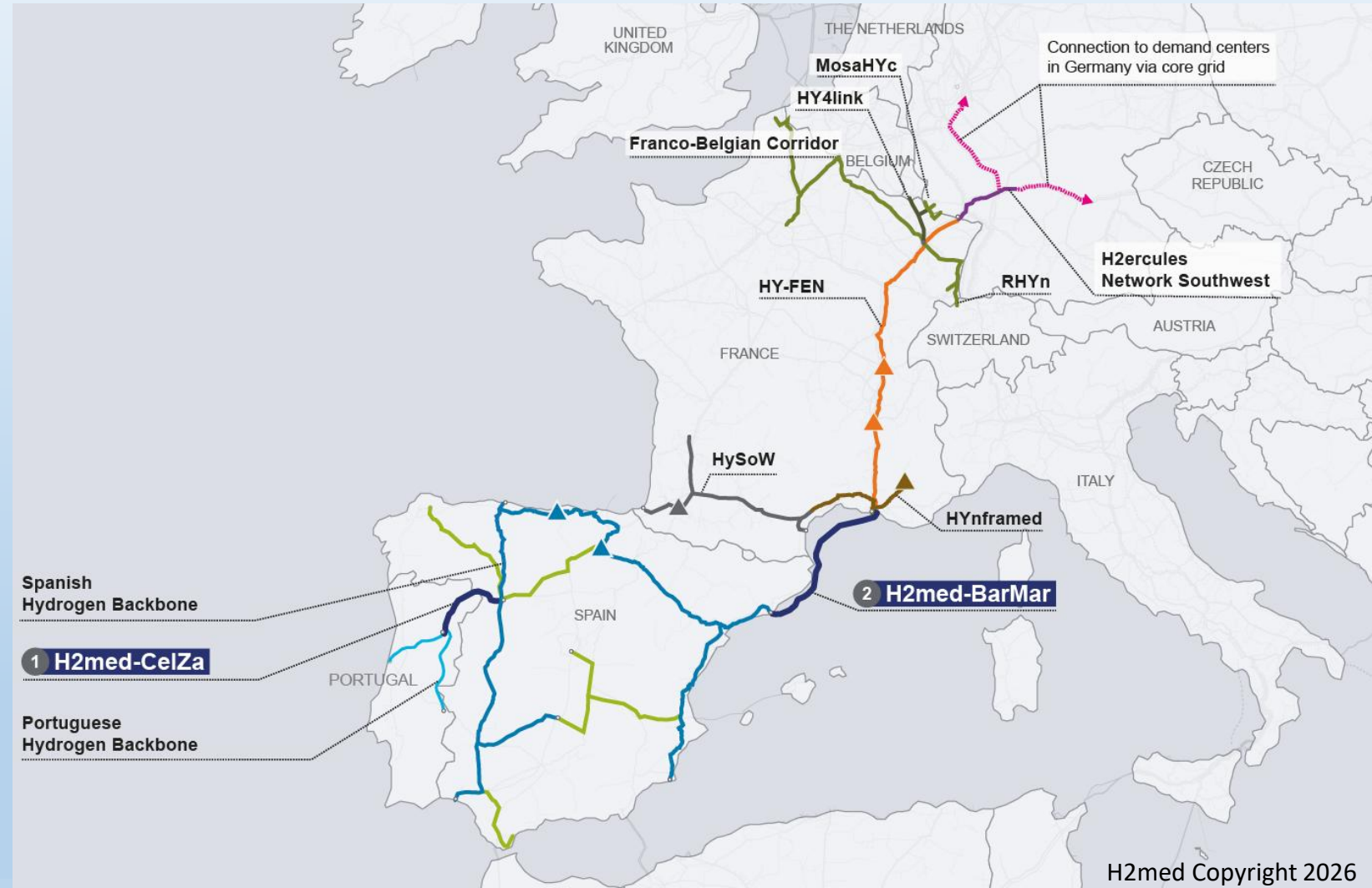
**HyLab role: leading the design of the seawater electrolyzer
and contributing to experimental BPMWE stack testing**

H2med: A Strategic Hydrogen Corridor for Europe

H2med connects the Iberian Peninsula to Central Europe



- Large-scale green hydrogen transport (~2 Mt/year)
- Links low-cost production (Portugal & Spain) to EU industry
- Supports EU decarbonization targets and energy security
- Total corridor capacity ≈ 10% of expected European H₂ consumption in 2032



H2med: A Strategic Hydrogen Corridor for Europe

H2med connects the Iberian Peninsula to Central Europe



Timeline & status

- 2022–2024: Agreement, **PCI status**, studies
- 2025–2026: Project faced some **delays**
 - Licensing and **coordination complexity**
 - **Uncertain demand** and business models
 - **Shifting national energy policy priorities**
- Final Investment Decision not fully secured
- Commercial operation target (2032)

ECONOMY | EUROPE

No green hydrogen from Portugal

Jochen Faget
27.02.2026

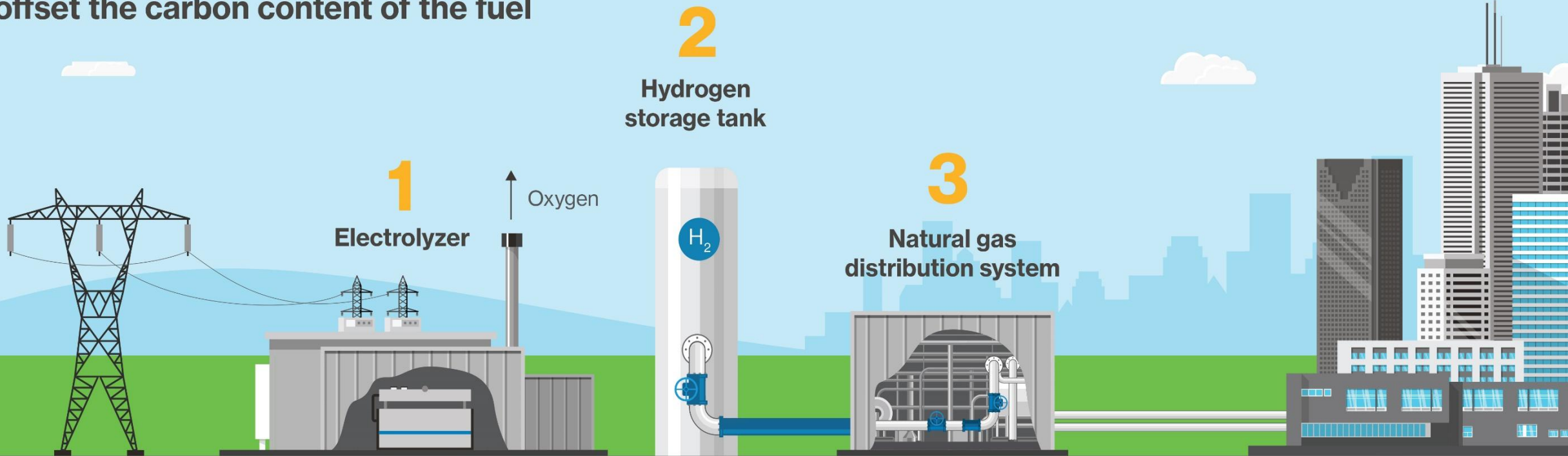
Actually, the town of Sines in Portugal was supposed to produce green hydrogen for Europe. But that's not gonna happen for now. The largely announced projects have shrunk and are delayed.



Power-to-Gas

Decarbonising the natural gas network

Future State - Blending hydrogen into the natural gas distribution system to offset the carbon content of the fuel



1 Since electricity can't be stored, when there is a surplus, the electrolyzer takes electricity and uses it to split water into hydrogen and oxygen, while balancing the power grid at the same time.



2 The hydrogen that is produced is then stored.



3 Instead of converting the hydrogen back into electricity, the hydrogen may be blended into the natural gas distribution system at a pre-determined percentage, to reduce the carbon content of the gas.



4 A lower carbon gas is delivered to customers.

Power-to-Gas: Decarbonising the natural gas network

Hidrogénio verde vai chegar a meio milhão de casas da região de Lisboa em 2027

A Floene (operadora da rede de distribuição de gás natural) assinou com a Hychem um contrato para a injeção de hidrogénio verde na rede nacional de gás. O investimento nessa ligação ronda os 4,7 milhões de euros e inclui a construção de 8,5 quilómetros de nova rede.

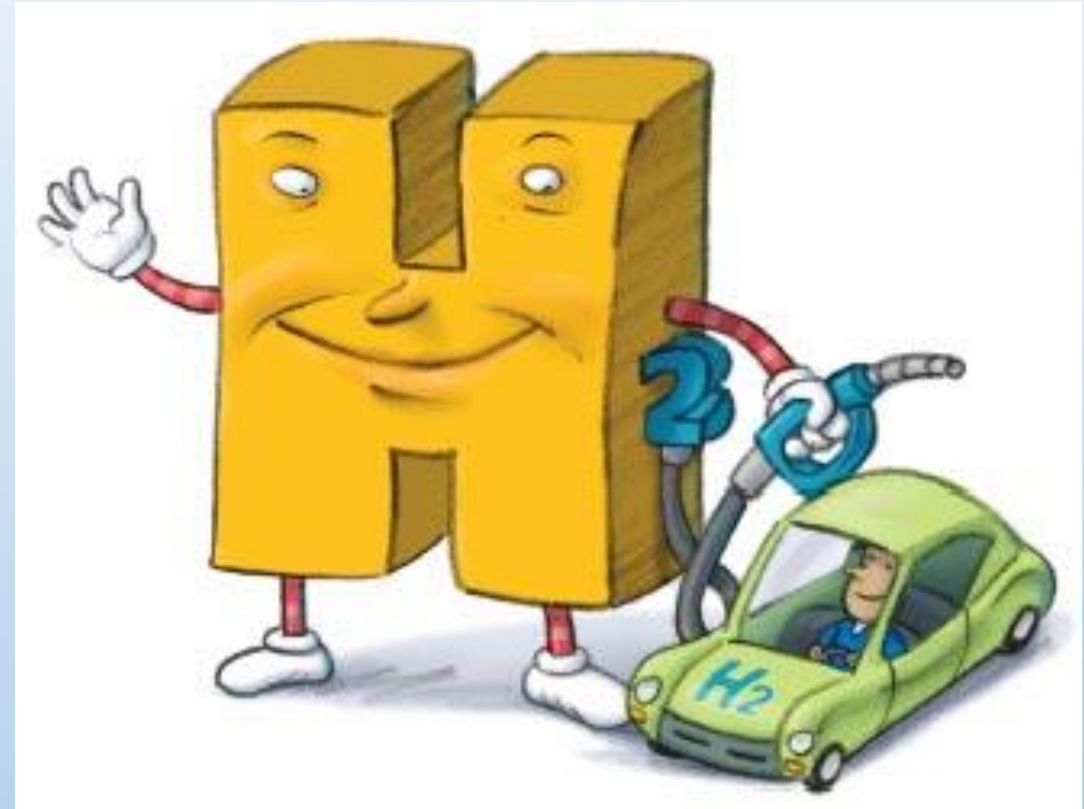
Distribution of green H₂ blended with natural gas is expected to begin in 2027, potentially serving nearly 0.5 million domestic customers and ~1,300 industrial customers in the Lisbon region

The **Portuguese National Hydrogen Strategy** has set the following targets for 2030:

- injecting **15% of green hydrogen** into the **natural gas network**
- **5% green H₂** in final energy consumption, road transport, and industry

H_2O to H_2 : Mapping Portugal's Waterwise Green Hydrogen Projects

TH₂ANK YOU
FOR YOUR
ATTENTION!



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