

PT^ẽ H₂

PLATAFORMA TECNOLÓGICA ESPAÑOLA DEL HIDRÓGENO

Dissemination Infographics

Hydrogen Applications and the Role of R&D&I

Document Objective

These infographics provide an **overview of the current state of hydrogen technologies and their main applications**, with a particular focus on the role of R&D&I in improving performance, overcoming barriers and enabling wider deployment.

They are designed to **turn complex technical topics into clear, accessible messages**, helping readers understand where each technology stands today, which research lines are currently being explored, and why innovation remains essential for the development of the hydrogen sector.

They also aim to spark the interest of the industrial sector, public institutions and society more broadly in the technological progress being made around hydrogen and its contribution to the energy transition.

Each infographic is structured in two complementary sides:

Side A, dedicated to explaining the technology, its applications and its potential value.

Side B, focused on existing challenges and how R&D&I is working to address them.

These infographics are the result of coordinated work within the framework of the **Spanish Hydrogen Technology Platform (PTeH₂)**, through its five Working Groups, composed of entities from the industrial, technological, and scientific fields.

Based on the **contributions of PTeH₂ members and their expertise in these fields**, the contents have been consolidated to support a clearer understanding of hydrogen technologies, their applications, and the areas where R&D&I is actively driving progress.

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RE 01: Technology and Uses of Hydrogen in Critical Contexts

Participating entities:



Note on content and scope

The contents of these infographics are for **dissemination purposes** and have been designed to help a broad audience understand complex technical concepts.

The figures, examples and ranges shown are indicative and **may vary depending on the technological, geographical or regulatory context considered.**

These infographics are **not intended to provide exhaustive comparisons or replace detailed technical studies**, but rather to support the dissemination and understanding of the role of hydrogen and its associated R&D&I, while highlighting the research lines that are enabling progress towards large-scale deployment.



Infographic PRO 01: Water consumption in renewable H₂ production

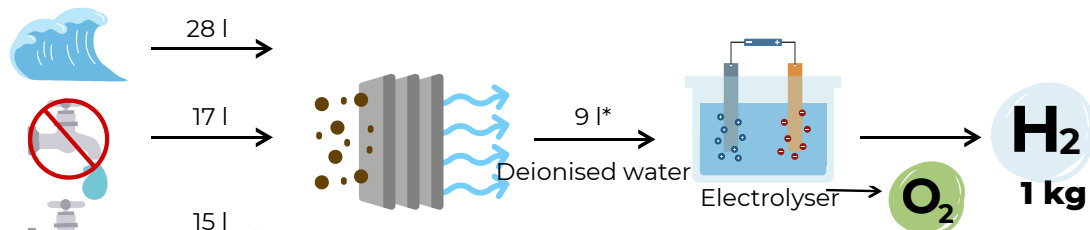
Hydrogen Production Working Group

Side A - R&D&I to reduce water consumption

According to the **National Integrated Energy and Climate Plan**, Spain aims to reach **12 GW of installed electrolysis capacity** by **2030**. This goal represents a key step towards decarbonising the energy system, by transforming renewable electricity into clean hydrogen, which can be used in various processes that currently depend on fossil fuels.

However, this progress may mistakenly generate some social concern about the water consumption associated with electrolysis, turning **good news** for the climate into a perceived **environmental threat**.

How much water is needed to produce 1 kg of hydrogen?



*This consumption must also include the water needed for **system cooling**, which varies depending on the technology, circuit design and operating conditions, and is directly related to the overall efficiency of the electrolyser.

This hydrogen contains an energy of about **33.3 kWh**, enough to:

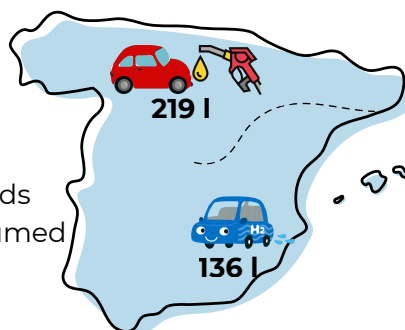
- Power a fuel cell to cover the average electricity consumption of a **Spanish household** for **one full day**.
- Keep a **LED bulb** of 10 W on for nearly **140 days** straight
- Charge a **mobile phone** about **3,000 times**

So... is it a lot of water? No, and here is why

What if we compare it with other alternatives?

Although the water consumption of hydrogen may seem high, when compared to that of fossil fuels, it turns out to be lower.

To drive by car (Barcelona–Madrid):
 A **petrol car** requires about **219 l of water**, considering the entire fuel production chain.
 A **hydrogen car** running on renewables needs **136 l of water**, corresponding to the H₂ consumed during the trip.



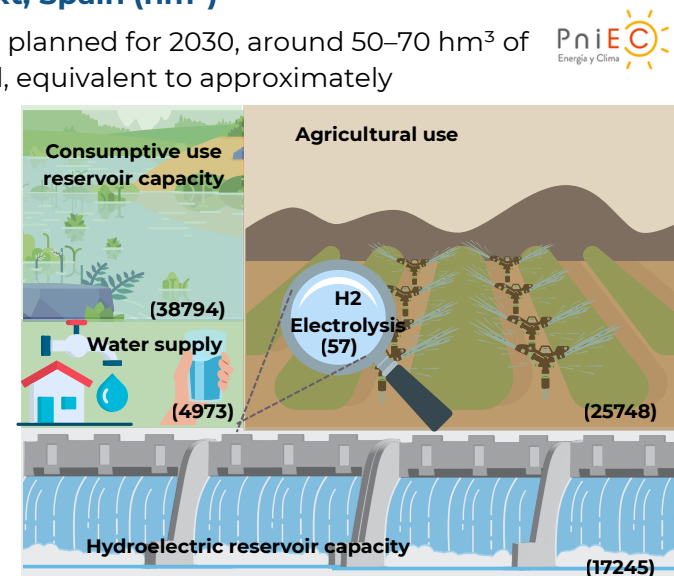
**Assuming a demand of 6.5 kg of H₂, and a water factor of 22 L of raw water per kg of H₂ for PEM electrolysis (IRENA, 2023), including process and system cooling needs.

Water quantity in context, Spain (hm³)

To reach the 12 GW of electrolysis planned for 2030, around 50–70 hm³ of water per year would be required, equivalent to approximately 0.1% of the available water in Spain (over 38,000 hm³)

Overall, this consumption is manageable, especially if desalinated, recycled or industrial process water is used.

Even so, local impact may vary depending on water availability and quality in each area, making it key to plan plants in locations with secure and sustainable sources.



Side B - R&D&I to reduce water consumption

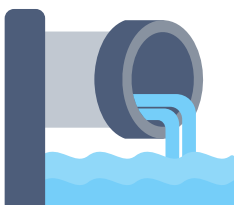
Although it has been demonstrated that renewable hydrogen does not consume more water than fossil fuels, it is **essential to keep working to reduce its impact to the minimum possible.**

In a context of growing water stress, optimising every stage of the process and ensuring that hydrogen production is sustainable in any region is essential.

R&D&I is oriented precisely towards this goal, driving solutions that allow **reducing net water use** through recirculation of cooling water and the use of non-potable sources such as wastewater or seawater.

These lines of work enable progress towards hydrogen compatible with the protection of water resources and environmental balance.

Use of wastewater in electrolysis



Integrating electrolysis with water treatment would reduce dependence on ultrapure water and allow the valorisation of urban or industrial effluents. This is especially relevant in water stress contexts, provided that process quality and equipment durability are ensured.

Main challenges:

Formation of by-products
Instability of materials against contaminants

R&D&I is working on:

Developing components capable of operating in variable media and in the presence of impurities.
Applying strategies that minimise the formation of by-products and extend the service life of equipment.

Recirculation and reuse of cooling water

The water used for cooling can represent a significant portion of total consumption. Therefore, efficient management is essential to minimise the water impact associated with H₂ production.

Main challenges:

Losses due to evaporation and constant need for replenishment.
Increased consumption in hot climates or with low-efficiency systems.

Costs associated with water treatment and recovery.

R&D&I is working on:

Developing closed, high-efficiency cooling systems that minimise evaporation and the need for fresh water input.
Implementing recovery and treatment technologies that allow reuse of cooling water without loss of performance.



Seawater electrolysis

Harnessing seawater would reduce dependence on freshwater and take advantage of an abundant and widely available resource.

Main challenges:

Formation of by-products such as chlorine during electrolysis.
Accelerated degradation of materials due to salinity and corrosive agents.

R&D&I is working on:

Developing materials and coatings resistant to corrosion and chlorine.
Optimising purification processes to avoid by-products and reduce operating costs



Infographic PRO 02: Low-emission H₂, how low is "low"?

Hydrogen Production Working Group

SIDE A: Low-emission H2, how low is "low"?

Did you know that **not all** hydrogen technologies are **zero emissions**... but they are much **cleaner than conventional sources**?

There are multiple routes to produce H2 with low emissions, combining known industrial processes with new capture (CCS) or carbon valorisation systems. These technologies represent an essential intermediate step towards full decarbonisation, allowing a drastic reduction of CO2 emissions while advancing the development of renewable hydrogen.

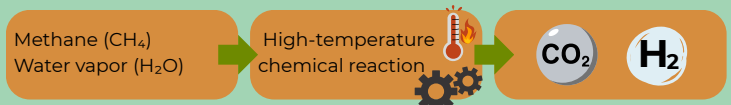
What does CCS mean?
Carbon Capture and Storage (CCS) captures CO₂ at the production site so it can be stored or reused, preventing its release into the atmosphere. This offers a key advantage over fossil fuels, whose emissions are dispersed at the point of use and difficult to recover.

Reforming with CCS

It is the most widespread method currently. It consists of heating natural gas (methane) with steam to obtain hydrogen, applying CO2 capture technologies that prevent its emission into the atmosphere.

Advantages and characteristics:

- Allows large-scale hydrogen production with existing industrial infrastructure.
- Captured CO2 can be stored or reused in industrial processes, significantly reducing net emissions.
- Mature and cost-competitive technology, easily integrable into current plants.
- Strategic bridge towards renewable hydrogen, facilitating the progressive decarbonisation of the sector.

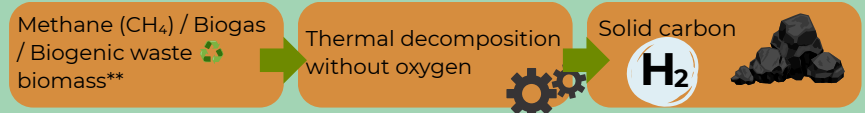


Pyrolysis

It consists of heating methane or other compounds in the absence of oxygen, producing hydrogen and solid carbon as a by-product.

Advantages and characteristics:

- The solid carbon obtained is a high-value material that can be used in batteries, electrodes, composite materials or agriculture, contributing to a more circular economy.
- Requires less energy and water than other hydrogen production processes.
- Offers multiple technological routes, from thermal processes to plasma or microwaves.
- Can achieve net negative emissions if biogenic hydrocarbons are used.



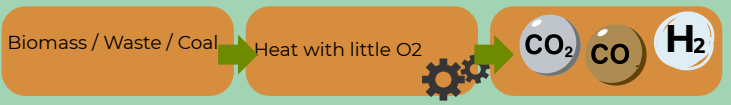
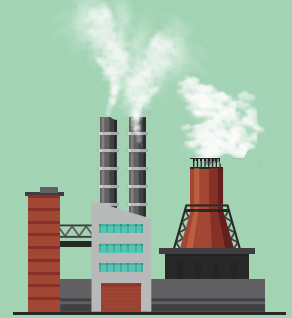
The route from **biomass produces a synthesis gas rich in H2 and other compounds (**syngas**)

Gasification

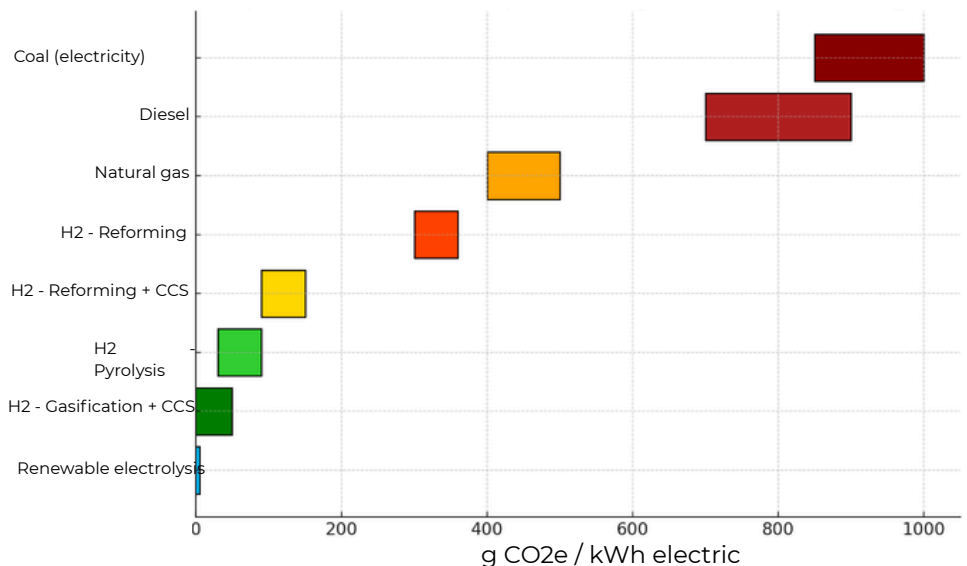
It consists of converting carbon-containing materials (such as coal, biomass or waste) into a hydrogen-rich gas mixture (syngas) through a reaction with oxygen and steam.

Advantages and characteristics:

- Allows the use of residual or biogenic resources, reducing dependence on fossil fuels.
- The CO2 generated can be captured and stored, reducing emissions associated with the process.
- Versatile process, adaptable to different raw materials and industrial scales.
- Opportunity for valorisation of by-products such as gases, slag or reusable carbon compounds.



How do they compare with other technologies?



SIDE B: Using waste as a resource: this is how R&D&I works

Beyond the conventional production routes seen on Side A, there are technologies that allow hydrogen to be generated from waste. This approach transforms waste management into an energy opportunity, reducing emissions and closing material cycles.

R&D&I is key to turning these processes into technically viable, clean and strategic solutions for the energy system.

From waste to resource: closing the loop

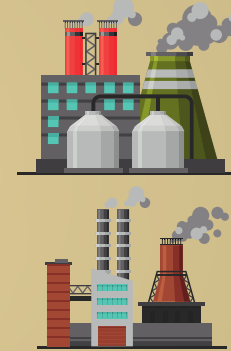
Agricultural and forestry waste



Urban organic waste



Non-recyclable plastic waste



Heat

Waste gases

The development of hydrogen production technologies that use waste as a raw material offers a **doubly strategic solution**:

It allows their valorisation, **preventing them from ending up in landfills, rivers or oceans**.
It prevents **CH₄ emissions** from decomposition

For every kg of H₂ produced from waste with CO₂ capture, up to **~17 kg of CO₂e** can be removed from the atmosphere, achieving **net negative emissions**.

Process efficiency

The production of H₂ from waste results in low conversions, formation of by-products and catalyst deactivation, which reduces efficiency and increases energy consumption.

Challenges and barriers:

- Complexity in thermochemical conversion and H₂ purification.
- Formation of by-products and catalyst deactivation.
- Difficulty of efficient industrial scaling.

Where is R&D&I acting?

- Optimisation of gasification, reforming and pyrolysis processes.
- Improvement of hydrogen separation and purification systems.
- Integration of stages to reduce energy losses.

Variability of waste

The changing composition of waste makes it difficult to standardise processes and maintain hydrogen quality.

Challenges and barriers

- Impurities that reduce efficiency and damage catalysts.
- Constant adjustments that limit scalability.

Where is R&D&I acting?

- Sensors and real-time control to adapt the process.
- More tolerant catalysts and digital modelling to improve system stability.

Valorisation of by-products

During the conversion to H₂, by-products such as solid carbon, waste gases or heat are generated, which can be reused to improve efficiency and reduce environmental impact.

Challenges and barriers:

- Variable quality and low purity of by-products.
- Limited integration between H₂ production and its utilisation.

Where is R&D&I acting?

- Valorisation of solid carbon and CO₂ for energy or industrial applications.
- Reuse of waste heat and recovery of chemical compounds to increase the circularity of the process.



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**Infographic ATD 01:
¿Sabías que el H₂ puede mover la energía
en el espacio y en el tiempo?**

Working Group on Storage, Transportation, and Distribution

SIDE A - Did you know that H₂ can move energy in space and time?

Hydrogen is a key technological solution for transporting energy through time and space. Its storage and transport capabilities allow energy to be delivered to where it is needed and used when required.



IN TIME → Storage

Store energy by transforming it into H₂ using renewable energy (sun, wind, ...), to use it later when it is not possible to produce it (at night, in winter or when there is more demand).

⚡ is transformed into H₂ → it is stored → it is used later



IN SPACE → Transport and Distribution

Transporting energy (in the form of H₂) from the point of production to the point of consumption

How is it done?

Through pipelines, tanker trucks, ships... Infrastructure is adapted or created to bring H₂ to homes, offices, industries or any user who needs energy.

Small and medium scale storage

It is used in local or industrial installations that do not require large volumes of H₂. It allows the **pre-compressed gas** to be stored at around **350-700 bar (and up to 1,000 bar)** for flexible use (refueling stations, special uses, e.g.) guaranteeing a safe and continuous supply in decentralized applications.

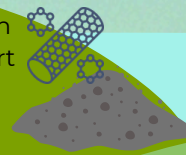


Storage in liquids

H₂ can be liquefied or transformed into carrier liquids, such as ammonia or organic compounds, facilitating its transport and storage compared to gaseous H₂.

Storage in solid materials

H₂ can be stored in solid materials, such as metals or porous structures, by **absorption or adsorption**, offering a compact and safe option for small and medium quantities.



Maritime transport

H₂ can be transported by ship in liquid form or as ammonia, LOHCs or methanol, allowing large volumes to be moved from regions with renewable resources to **consumer markets**.

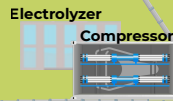


Road transport

Hydrogen can be transported in tanker trucks, either in gaseous form (at high pressure) or liquid form (at very low temperature). This option, ideal for **medium and short distances**, allows hydrogen to be delivered wherever it is needed, regardless of its place or time of production.

H₂ compression

Hydrogen (H₂) must be compressed to high pressures in order to be stored, transported in tube trailers, and dispensed at hydrogen refueling stations.



Strategic Storage / Underground

Storing hydrogen in underground formation, such as salt caverns or depleted deposits, allows for the safe and stable storage of hydrogen on a large scale, guaranteeing its **seasonal availability** for periods without production or with higher demand.

In Spain, there are already projects underway focused on the underground storage of renewable hydrogen.

Pipeline transport and distribution

Hydrogen can be transported safely and economically via **buried pipelines**, operating at high pressure to **move large volumes** and reducing it near the points of consumption. In Spain, part of the gas pipeline network can be adapted to H₂ and a **new hydrogen backbone network** of more than **2,600 km**, connected to Europe, is planned.



SIDE B - Did you know that H₂ can move energy in space and time?

There are still technical challenges to solve to make hydrogen storage and transport safer and more competitive.

As a very small, light and reactive molecule, H₂ creates unique challenges for storage, handling and transport.

R&D&I is key to improving materials, reducing costs, increasing efficiency and ensuring safety.



These solutions allow the energy system to be more flexible, facilitating the **connection** between **producing and consuming** areas and reinforcing the security of supply on a national and international scale.

Small and medium scale storage

The high-pressure containers needed to store hydrogen are expensive and heavy, and can become embrittled by the gas over time.

R&D&I is working on new materials and **lighter, safer and more economical** designs that will reduce costs and improve the durability of storage systems.



Storage in liquids

In chemical carriers, the release of H₂ requires energy. R&D is investigating **catalysts and lower-temperature processes** to reduce energy consumption and improve efficiency.

Storage in solid materials

Although these materials allow for safe and compact H₂ storage, their capacity and loading rate are limited. Research and development are underway to create new compounds to improve adsorption and reversibility.



Road transport

Transporting H₂ in tanker trucks requires operating at high pressures or very low temperatures, which increases costs and **demands strong and lightweight materials**.

R&D is working on new designs for **cryogenic** trailers and tanks, as well as on **high-strength** composite materials, to reduce weight and energy consumption during transport, while maintaining **safety**.

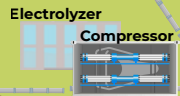
Maritime transport

It presents technical challenges due to extreme temperature and pressure conditions, as well as the safety of handling carriers. R&D is developing safer and more efficient materials, containment systems, and logistics.



Strategic Storage / Underground

Characterizing geological structures suitable for hydrogen storage is a **complex process**. Furthermore, the presence of **microorganisms** in the subsurface can affect the injected H₂, so R&D efforts are focused on improving the **geological and biological knowledge** necessary to apply this technology safely and efficiently.



Pipeline transport and distribution

Hydrogen can embrittle metallic materials if they are not suitable and diffuse into pipes made of plastic materials, posing challenges to the **integrity and durability** of the pipelines.

R&D&I works on new materials, coatings and reinforced polymer matrices that improve resistance and watertightness, as well as on the development of **adapted components** such as compressors and valves to deploy large-scale networks efficiently.





Infographic MOV 01: The role of H₂ in the mobility of the future

Working Group on Hydrogen Uses in Mobility

SIDE A - The role of H₂ in the mobility of the future

The transport sector accounts for approximately 24% of global CO₂ emissions, making it essential to reduce its impact. In this context, hydrogen produced from renewable sources is establishing itself as a key alternative, especially for transport modes that require high performance in terms of power, range, or refueling speed.

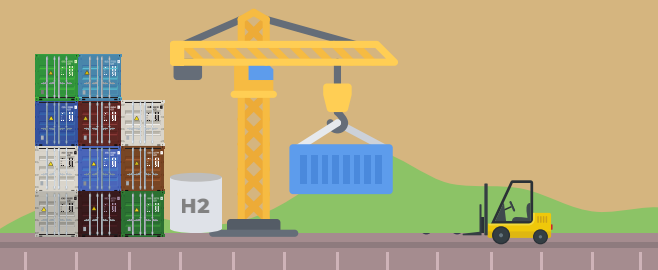
Air transport

Whether as a **direct fuel** or as a basis for producing **SAF** from CO₂, H₂ offers an alternative to decarbonize a mode of transport where electrification is complex due to weight and range limitations.



Applications in port and airport operations

The use of H₂ in **high energy demand machinery** and service vehicles, such as cranes, tractors or intensively operated loading equipment, offers greater **autonomy**, fast recharging and zero local emissions, replacing diesel engines with fuel cells and improving the efficiency and sustainability of operations.



Maritime transport

In long-distance maritime transport, H₂ is consolidating itself as one of the **few viable alternatives** to decarbonize the sector, either through its **direct use** in fuel cells or adapted engines, or as a basis for producing **synthetic fuels** such as methanol or green ammonia, capable of powering large ships without compromising their autonomy or operational capacity.

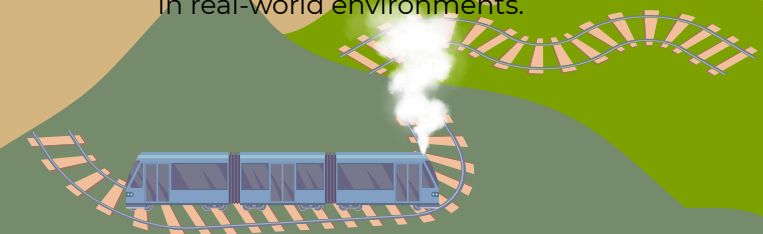


Hydrogen is produced using renewable energy and is used in various mobility solutions.



Urban transport

Especially in buses and public transport fleets, the use of hydrogen allows for reduced emissions and **improved urban air quality**. Its long range and fast refueling make it ideal for continuous operation without disrupting service schedules. In cities like Madrid and Barcelona, buses with **ranges of up to 450 km** are already in operation, demonstrating its viability in real-world environments.



Rail transport

In rail transport, hydrogen offers a sustainable **solution for non-electrified lines**, replacing diesel without the need for costly electrical infrastructure. Its use in fuel cell trains allows for reduced emissions while maintaining the range and power required for medium- and long-distance journeys.

In Spain, tests have already been carried out under real-world conditions, such as on journeys between cities in Galicia, which have demonstrated ranges close to **800 km**, confirming the viability of this technology.

Hydrogen stations and supply systems

They allow H₂ refueling in minutes, with an experience similar to conventional fuel. **A fast and standardized supply (350/700 bar)** reduces downtime and facilitates continuous operations in fleets and on long routes, benefiting both passenger cars and larger or more intensively used vehicles.



SIDE B - Why is R&D necessary to reach this scenario?

Although real-world projects already exist demonstrating the viability of hydrogen in various modes of transport, its large-scale deployment still faces significant technological, economic, and integration challenges. For renewable hydrogen to become an accessible, efficient, and competitive solution, continued investment in R&D is essential.

Air transport

Challenges:

- Keeping weight low without compromising range.
- Ensuring efficient thermal management.
- Developing components suitable for extreme flight conditions.

Where is R&D&I working?

On the development of hydrogen-based propulsion architectures, as well as advanced components and thermal management.



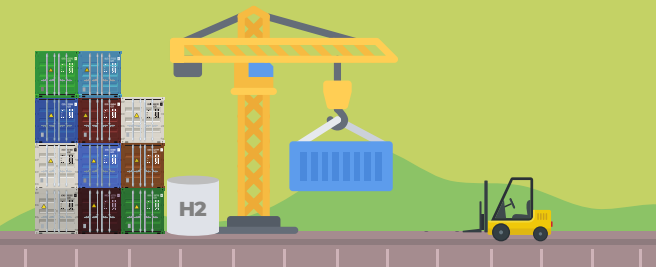
Applications in port and airport operations

Challenges:

- Deploying a complete infrastructure for H₂ operations.
- Adapting the technology to the wide range of equipment and applications involved.

Where is R&D&I working?

On the development of application-specific systems, optimising fuel cells, storage and refuelling for high-demand operating environments.



Maritime transport

Challenges:

- Salinity and corrosive environments reduce equipment durability and efficiency.
- Vibrations and limited onboard space make it difficult to integrate fuel cells and H₂ tanks.

Where is R&D&I working?

On the development of anti-corrosion materials, compact designs resistant to vibrations, and marine-specific systems for H₂ storage and consumption.



Refuelling stations and supply systems

Challenges:

- Improving the efficiency and reliability of compression, cooling and dispensing stages.
- Avoiding energy losses and failures caused by freezing or H₂ embrittlement.
- Ensuring interoperability and safety in high-pressure operations.

Where is R&D&I working?

On the development of more efficient compressors and nozzles, as well as digital monitoring systems that optimise station maintenance and safety.



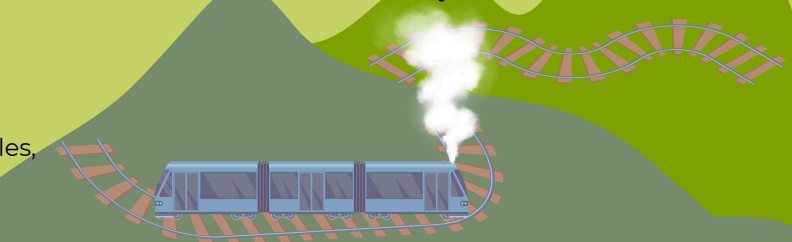
Urban transport

Challenges:

- High material costs and loss of durability under intensive use.
- Limited capacity for safe and compact H₂ storage.
- Limited integration of urban hubs connecting different transport modes.

Where is R&D&I working?

On the development of more durable and cost-effective fuel cells, advanced storage systems and interconnected infrastructure for urban H₂ mobility.



Rail transport

Challenges:

- Achieving competitive ranges without increasing train weight.
- Limiting the space required by H₂ storage and propulsion systems.

Where is R&D&I working?

On the development of hybrid and modular trains, lightweight high-pressure tanks and advanced energy management systems.



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Infographic IND 01: Same product, different footprint: sustainable industrial heat

Working Group on Hydrogen Uses in Industry

SIDE A: Same product, different footprint: Industrial heat can also be sustainable



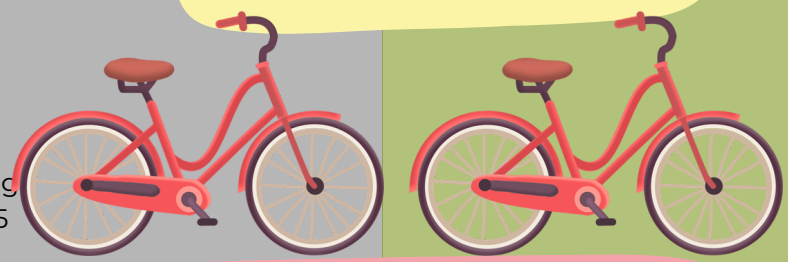
What is the difference between these two bikes?
At first glance, none.
But its carbon footprint is very different.



**The final product is the same.
The difference lies in the steel.**

This bike has been manufactured using conventional methods.

To produce the 12 kg of steel it contains, fossil fuels such as coal or natural gas have been burned. This involves reaching high temperatures by burning up to 500 kg of coke, generating approximately 1,835 kg of CO₂.



This bike has been manufactured with green steel.





Instead of using fossil fuels, renewable H₂ has been used to generate the necessary heat. This allows for a reduction of between 95% and 98% of emissions compared to the conventional route.

Clean H₂ makes possible what once seemed impossible:
Decarbonizing the most energy-intensive industrial processes, such as ceramics, glass, or cement, without compromising quality or competitiveness.

In the production of green steel, hydrogen also **replaces carbon as a chemical reagent**, eliminating one of the main sources of industrial emissions.

H₂ to generate clean heat

The manufacture of industrial materials such as steel, glass or ceramics requires very high heat inputs and, in some cases, specific process conditions, such as direct flames or controlled atmospheres. The combustion of renewable hydrogen allows that heat to be supplied directly and flexibly, adapting to different industrial processes. Although each sector has its own specific heating needs, the common principle is THE SAME: to replace fossil fuels with renewable hydrogen to generate heat without CO₂ emissions.

Process	Typical temperature (°C)	Current heat source	Potential substitution by H ₂
Ceramics 	1.200	Natural gas	H ₂ in cooking ovens
Glass and frits 	1.500 – 1.600	Natural gas / fuel	H ₂ in melting furnaces
Cement 	1.400 – 1.500	Petroleum coke	H ₂ in rotary kilns
Steel 	> 1.500	Coke / gas	Direct reduction with H ₂ and electric furnaces

How is the industry adapting to H₂?

In Spain, there are pilot projects that demonstrate the technical feasibility of using renewable hydrogen in high-temperature industrial processes, such as the manufacture of ceramic frits.

The final product may look the same. But if it was manufactured using renewable hydrogen, **its footprint is radically different without losing competitiveness.**

These experiences demonstrate the potential of hydrogen to replace fossil fuels in real-world processes, although its larger-scale deployment is conditioned by factors such as economic competitiveness, the availability of infrastructure, and an appropriate regulatory framework.

SIDE B - Innovation, key to emission-free industrial heating

Although, as seen on Side A, there are already real experiences with operational installations that support the use of H₂ in industry, its deployment requires adapting to the diversity of processes and conditions in each sector. Factors such as specific temperature, atmosphere and control requirements make it necessary to continue adjusting solutions through R&D&I.

What barriers does R&D&I try to overcome?

Reuse of existing burners

Adapting already installed burners to run on H₂ can be a more economical and viable short-term option than replacing the entire system.

Challenges:

- Embrittlement of components due to exposure to H₂.
- Control of stable and efficient combustion with variable mixtures of natural gas and hydrogen.
- Prevention of secondary emissions such as NO_x.

Where is R&D&I acting?

In new materials and control systems that improve the safety and efficiency of burners



Compatibility with processed materials

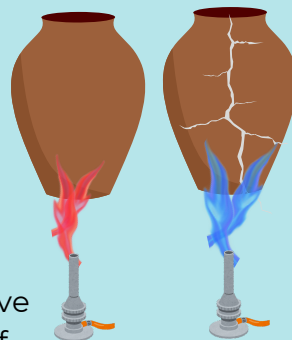
Combustion with hydrogen can modify the properties of the final product.

Challenges:

- Avoid changes in the microstructure and quality of the treated material.
- Maintain heat uniformity and control the furnace atmosphere.

Where is R&D&I acting?

Thermal profiles are being adjusted and reactive atmospheres modified to reduce the impact of hydrogen on materials and ensure they maintain the same quality, strength and appearance as traditional methods.



Development of adaptive burners

The adoption of H₂ in industrial thermal processes does not allow for a single solution.

Each sector has specific requirements for temperature, atmosphere and heat control, which demands new burner designs and associated systems.

Where is R&D&I acting?

In the development of dual and modular burners, capable of operating with variable mixtures of natural gas and hydrogen, adjusting to the conditions of each process.

These flexible technologies facilitate the transition towards the exclusive use of H₂, reducing risks and costs while validating its behaviour and safety in real-world environments.

Industrial safety

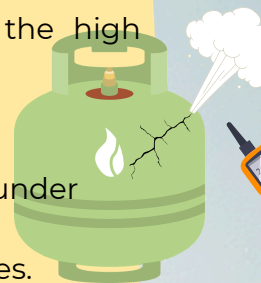
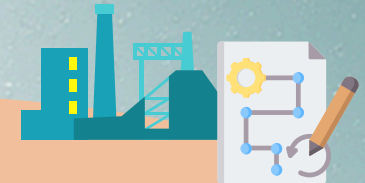
The use of hydrogen involves specific risks due to its wide flammability range, its almost invisible flames and the high pressures required for storage and use.

Challenges:

- Detecting leaks or invisible fires.
- Ensuring the integrity of materials and equipment under high pressure.
- Ensuring adequate ventilation and control in facilities.

Where is R&D&I acting?

In the development of sensors, control systems and specific standards, as well as new risk assessment and accident modelling methodologies, integrating safety as an essential part of the transition to hydrogen.





PLATAFORMA TECNOLÓGICA ESPAÑOLA DEL HIDRÓGENO

Infographic IND 02: **H₂ as a key molecule: same products, lower footprint**

Working Group on Hydrogen Uses in Industry

SIDE A - Hydrogen as a key molecule: New processes, same products, smaller footprint



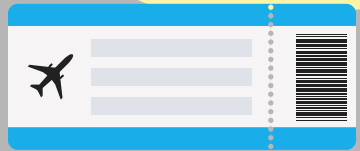
What is the difference between these two airline tickets?

At first glance, none.
 But

**Both will take you to your destination.
 The difference lies in how the plane moves.**

This ticket will take you from Madrid to Miami, as you have probably traveled before:

- In an aircraft powered by fossil-derived kerosene,
- With an estimated carbon footprint of approximately **399 kg of CO₂** per passenger.



This ticket will take you to the same destination, in the same way, but this time, the fuel that powers the plane has been produced from renewable H₂ and captured CO₂,

generating a sustainable e-fuel with a carbon footprint between **85-100% lower**.

What if everything stayed the same... but polluting much less?

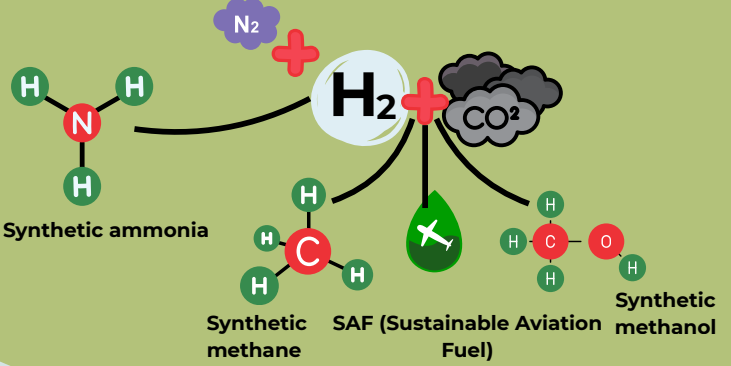
Traveling, manufacturing, farming, building. All of that can still be done, but with a much smaller footprint, thanks to renewable H₂ as the base molecule for producing fuels, plastics, fertilizers and other essential materials.

In **Spain**, there are already **pilot projects** using renewable H₂ in refineries and for the production of green ammonia, demonstrating its **technological viability** and the progress towards a more sustainable industry.

H₂ as an essential base molecule

Production of synthetic molecules (e-fuels and more)

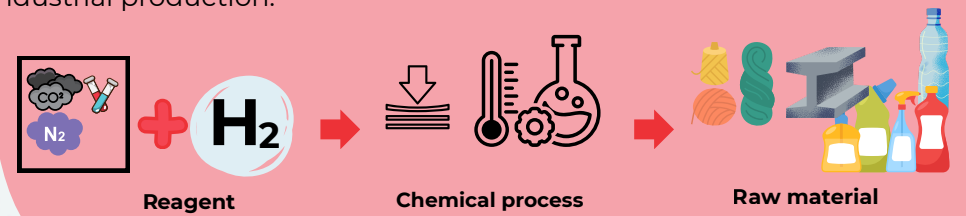
Renewable H₂ can be combined with captured CO₂ or nitrogen to form new synthetic molecules. These molecules allow traditional fossil products to be replaced by alternatives with low or zero emissions.



Production of raw materials derived from H₂

H₂ is an essential ingredient in the manufacture of numerous everyday products (plastics, detergents, fertilizers or solvents), obtained from chemical reactions where H₂ acts as a key reagent.

Until now, this H₂ has mostly come from fossil sources, but replacing it with renewable H₂ would significantly reduce the emissions associated with its industrial production.



SIDE A - Hydrogen as a key molecule:

The role of R&D&I

The hydrogen molecule is simple, but integrating it as a main reagent in the production of synthetic molecules and industrial materials poses **real challenges**: it requires adapting processes, redesigning systems, and maintaining the efficiency and quality of the final product.

Although many of these processes have been using hydrogen for decades, the **transition to renewable H₂** requires advanced technological solutions, and therefore, a clear commitment to R&D&I:

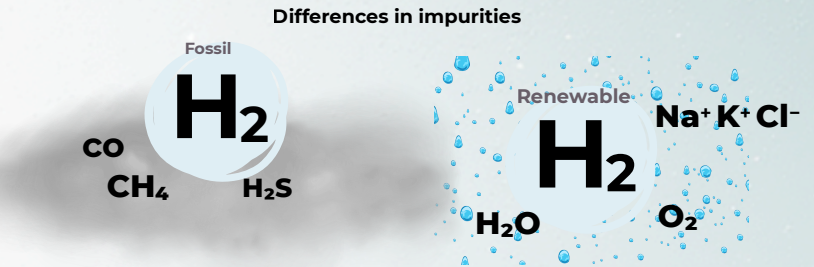
We need to innovate to scale its use safely, practically, and competitively across the industry.

From fossil-based H₂ to renewable H₂

Although the H₂ molecule is the same, its **origin and production method** (reforming, electrolysis, etc.) determine differences in purity and composition that can affect catalysts, equipment or industrial processes, reducing the useful life of the systems.

Where is R&D&I working?

In the standardization of purities, the adjustment of catalysts and reaction parameters, and the development of monitoring systems that guarantee the quality of the gas and the final chemical product.



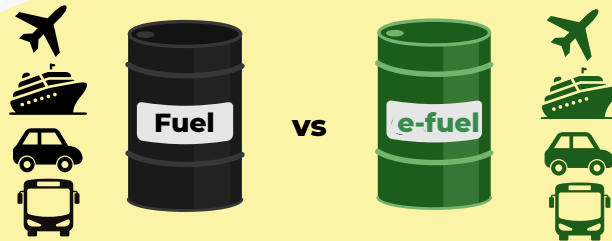
Competitiveness and cost: the great challenge

For renewable hydrogen and its derivatives to be integrated on an industrial scale, they must be economically competitive and efficient compared to current solutions based on fossil H₂ or conventional fuels.



Where is R&D&I working?

- More efficient and modular electrolysis, with lower energy consumption.
- New catalysts and more selective synthesis routes for e-fuels such as methanol or SAF.
- Integrated Power-to-Liquid (PtL) processes to reduce energy losses.
- Digitization and advanced control to optimize operation and maintenance, reducing OPEX.



Production and integration of e-fuels

E-fuels are one of the great promises for decarbonizing sectors that are difficult to electrify, such as aviation or heavy transport. But its large-scale deployment still faces major challenges such as technological maturity, high energy demand and limited availability of biogenic CO₂.

Where is R&D&I working?

- Development of more active and selective catalysts, integrated processes that reduce steps and energy losses, and new synthesis technologies.
- Work is also underway on industrial scaling and advanced digital control to improve efficiency and reduce operating costs.



PLATAFORMA TECNOLÓGICA ESPAÑOLA DEL HIDRÓGENO

Infographic RE 01: Technology and Uses of Hydrogen in Critical Contexts

Working Group on Hydrogen Uses in Energy Systems

SIDE A: Uses of H₂ in Critical Contexts

Continuous energy supply is essential for the operation of **key infrastructure** such as hospitals, data centers or transport networks, as well as for daily activity in homes and businesses.

In an energy system increasingly based on renewables, with variable generation, hydrogen is emerging as a **key solution** to reinforce grid **stability**, provide **backup** in critical situations, and cover residential and commercial applications.



Residential and commercial applications

Heat and electricity generation for homes

Integrating **micro-cogeneration** units into buildings allows them to meet their **heating** (and potentially cooling) needs, while simultaneously providing **electricity** to replace or supplement the grid supply, resulting in a significant reduction in primary energy use and a more sustainable use of resources.

Fuel cell-based micro-cogeneration can adapt its heat-power ratio to uses in both new construction and existing buildings, while maintaining **high efficiencies**.

Applications in the electrical grid

Increasing renewable energy generation is key to decarbonization, but it requires systems that provide flexibility and balance to the grid.

H₂ allows **excess renewable energy** to be stored and converted back into electricity when demand requires it, **replacing current fossil fuel systems** with a clean and manageable alternative.

Applications as backup for critical services

Emergency and off-grid generators

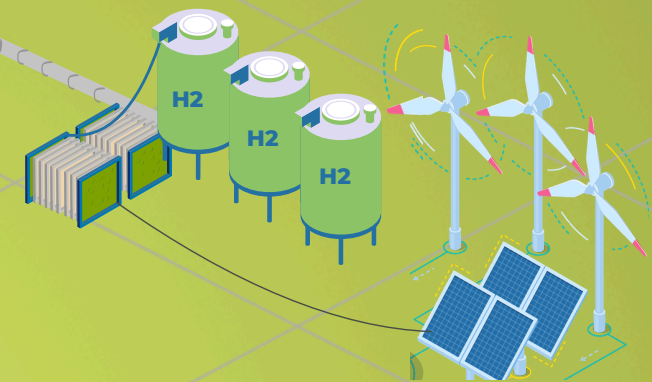
In hospitals, data centers or critical facilities, H₂-powered generator sets **guarantee supply** in case of grid failure, without polluting emissions or noise associated with diesel.

These off-grid solutions also allow operation in isolated environments, combining storage and clean generation to improve **resilience and energy autonomy**.

Electricity production using a turbine for integration into the grid

To achieve this, hydrogen can be used in **specific or adapted turbines**, capable of offering operational flexibility, quick start-up and a significant reduction in emissions.

Furthermore, the **progressive integration of H₂** into existing gas turbines allows for the use of current infrastructure, promoting an orderly transition to a cleaner and more stable electricity system.

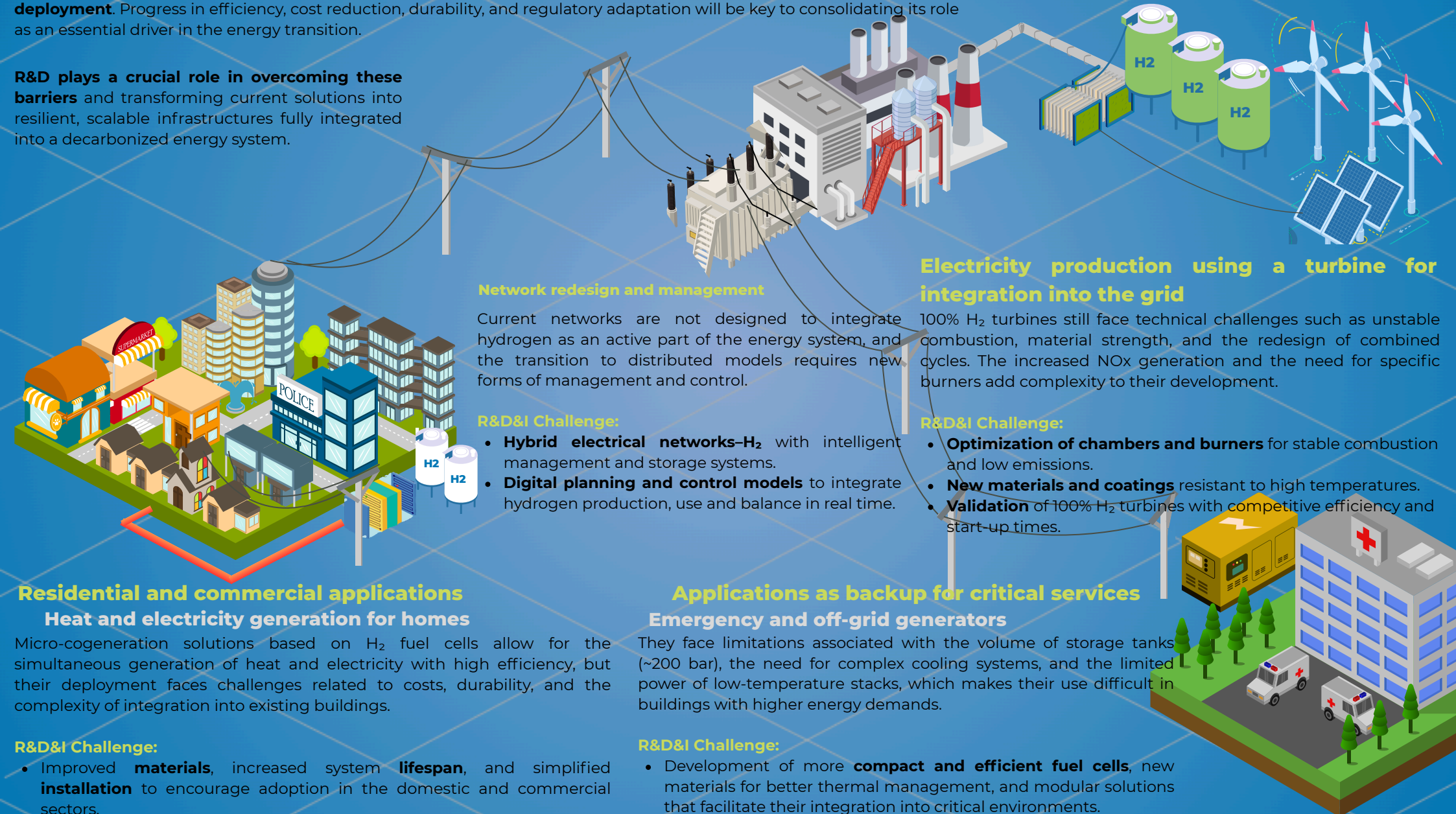


SIDE B: Why is R&D&I necessary?

Hydrogen has already demonstrated its potential to strengthen electrical grids, supply energy in critical environments, and power buildings or industries cleanly.

However, its **large-scale adoption** still faces technological, economic, and regulatory **challenges** that **limit its deployment**. Progress in efficiency, cost reduction, durability, and regulatory adaptation will be key to consolidating its role as an essential driver in the energy transition.

R&D plays a crucial role in overcoming these **barriers** and transforming current solutions into resilient, scalable infrastructures fully integrated into a decarbonized energy system.



Network redesign and management

Current networks are not designed to integrate hydrogen as an active part of the energy system, and the transition to distributed models requires new forms of management and control.

R&D&I Challenge:

- **Hybrid electrical networks-H₂** with intelligent management and storage systems.
- **Digital planning and control models** to integrate hydrogen production, use and balance in real time.

Electricity production using a turbine for integration into the grid

100% H₂ turbines still face technical challenges such as unstable combustion, material strength, and the redesign of combined cycles. The increased NO_x generation and the need for specific burners add complexity to their development.

R&D&I Challenge:

- **Optimization of chambers and burners** for stable combustion and low emissions.
- **New materials and coatings** resistant to high temperatures.
- **Validation** of 100% H₂ turbines with competitive efficiency and start-up times.

Residential and commercial applications

Heat and electricity generation for homes

Micro-cogeneration solutions based on H₂ fuel cells allow for the simultaneous generation of heat and electricity with high efficiency, but their deployment faces challenges related to costs, durability, and the complexity of integration into existing buildings.

R&D&I Challenge:

- Improved **materials**, increased system **lifespan**, and simplified **installation** to encourage adoption in the domestic and commercial sectors.

Applications as backup for critical services

Emergency and off-grid generators

They face limitations associated with the volume of storage tanks (~200 bar), the need for complex cooling systems, and the limited power of low-temperature stacks, which makes their use difficult in buildings with higher energy demands.

R&D&I Challenge:

- Development of more **compact and efficient fuel cells**, new materials for better thermal management, and modular solutions that facilitate their integration into critical environments.