FUNDACIÓN RENOVABLES GREENPEACE

DISMANTLING HYDROGEN

H2MED

EXCUSE FOR A FALSE ENERGY TRANSITION

MARCH 2023

▶ The role of hydrogen in the energy policy

The European Union (EU) identifies hydrogen as an indispensable energy vector to be able to achieve the targets set by the Paris Agreement. That is why its objective is to decarbonise hydrogen production and increase its use in sectors in which it can replace fossil fuels. However, although the EU's Hydrogen Strategy is focused on producing hydrogen with electricity from renewable energy, it also recognises the role of other low-carbon hydrogens in the transition phase in the short and medium term.

Since the approval of Regulation 852/2020 in June 2020 on the taxonomy of sustainable investments, the European Commission has been trying to simplify the approval process for hydrogen produced from non-renewable sources. In fact, on 13 February, the proposal for the second Delegated Regulation opens up the possibility for fossil-energy processes that reduce greenhouse gas emissions by 70% compared to current practices (natural gas) to be considered part of the RFNBO (Renewable liquid and gaseous Fuels of Non-Biological Origin) group, which includes hydrogen produced from water electrolysis. This means finding other means to produce hydrogen, such as from nuclear energy or even from natural gas with carbon capture. This new proposal—currently under discussion and pending approval by the Parliament and the European Council—jeopardises the acceleration of the energy transition and risks maintaining an energy system that is dependent on natural gas and nuclear power.

The European Commission's proposal is the result of constant pressure from the traditional energy sector to redirect the energy transition towards maintaining an energy concession model, where assets are largely held by companies and new large infrastructure is sought. This is instead of an energy transition with social criteria based on efficiency, active demand management, electricity, renewables and the general public.

▶ Origin and production of hydrogen

Due to its high energy capacity[1], hydrogen can cover the current energy needs that cannot be covered by electricity while retaining existing procedures and having a large storage capacity that can complement the variability and availability of renewable sources.

Whether hydrogen is considered a truly sustainable alternative depends on the process used to produce it. So, with the aim of distinguishing between the origin of primary energy and the production process in terms of its environmental impact, a colour-coding system has been

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[1] The exergy is the availability of useful energy. It defines how much of a system's energy can be used for mechanical, electrical or other types of work.

implemented. This means these fossil energy sources are separated from sustainable energy sources by a colour rather than by a ban. Furthermore, this could be considered as a **greenwashing practice, void of any official regulation, that clearly aims to validate the use of fossil energies** that we should actually stop using.

Therefore, the colour green has been chosen for hydrolysis with electricity from renewable sources, pink for electricity from nuclear sources, grey for natural gas without CO_2 capture and blue for natural gas including CO_2 capture processes.

We should remember that, according to the International Energy Agency's report The Future of Hydrogen, fossil fuels are currently used for around 95% of global hydrogen production. Natural gas accounts for most of this because of both its low cost and the ease and suitability of its chemical composition: CH_4.

Natural gas reforming has an efficiency of around 80%, releasing 10kg of CO_2 per kilogram of hydrogen produced. This calculation takes only energy use (natural gas) and the emissions from the reforming process into consideration, disregarding possible methane leakage during production, distribution and consumption. The current cost of natural gas reforming is between €1/kg and €2/kg, not including carbon capture. Some untested assumptions forecast the cost of blue hydrogen to be around €3/kg. These costs have been calculated using natural gas price levels before the current energy crisis, well below current prices and future expectations of price increases.

Green hydrogen is produced by water electrolysis using electricity from renewable sources and has a cost of around €5/kg, in which electricity represents 60% of the cost of production. In addition, the electrolyser consumes about 50 kWh of electricity for each kilogram of hydrogen produced, so it can reach an efficiency of 70%. Water consumption is approximately 17 litres per kilogram of hydrogen produced. At the current price of renewable electricity auctions, it would be below €3.5/kg.

Figure 1 shows the efficiency percentages for electricity production with renewable sources, which includes the use of hydrogen. Of course, it must be indicated that using hydrogen to generate electricity when the hydrogen has been produced by electrolysis is inefficient (with an efficiency of 29%). Therefore, the only way it can be suitable is if it covers demands and processes that cannot be achieved by direct electrical connection.

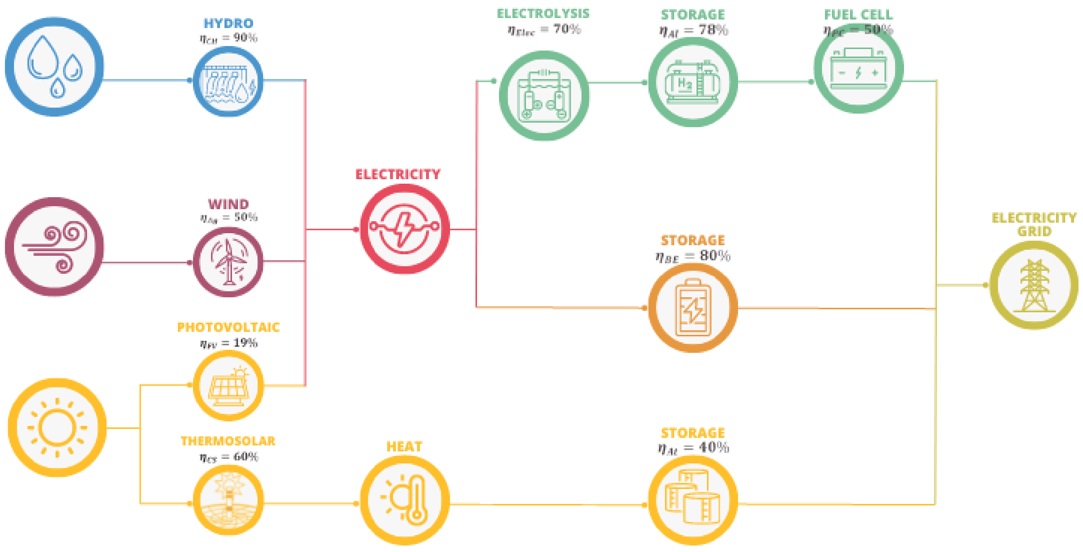

Figure 1. Summary of how efficient the main renewable technologies are in the processes of transformation, storage and reconversion of primary energy into electricity, not including the losses associated with transport. Created by Fundación Renovables.
Source: [The role of hydrogen in the energy transition. Fundación Renovables.]()

Figure 2 shows the performance of hydrogen obtained with electricity for different uses.

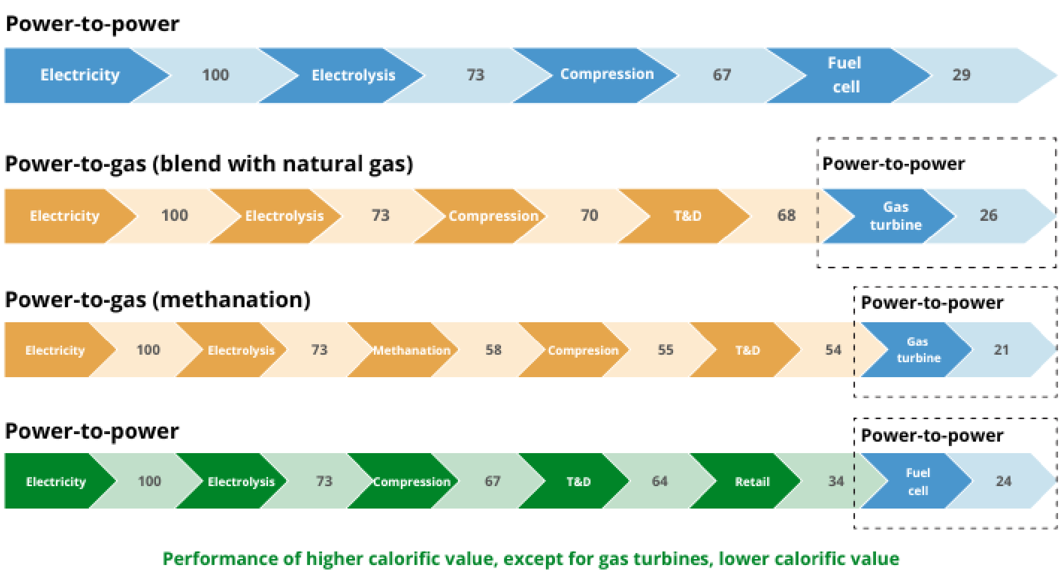

Figure 2. Efficiencies based on gross calorific value, except for gas turbines, lower calorific value. Source: INERCO

Similarly, the constant reduction of costs when generating electricity with renewable sources and the availability of a broader range of electrolysers on the market are the variables that are being used to suggest that hydrogen will become one of the main energy vectors in the future.

This cost reduction of electricity is being shaped by a two-fold scenario:

- **Using surplus electricity** in hybrid and oversized renewable electricity power plants to increase the capacity in relation to the evacuation capacity. Hydrogen would act as a storage element and would make it easier to manage the plant. Despite the consideration of zero shadow prices for the electricity used, the costs are currently higher than for other storage systems.

- Developing macro power plants using renewable energy sources for hydrogen production, theoretically off-grid, otherwise it would always be more feasible, efficient and cheaper to transport electricity than hydrogen. Figure 3 shows BloombergNEF's forecast of how production costs will evolve over time.

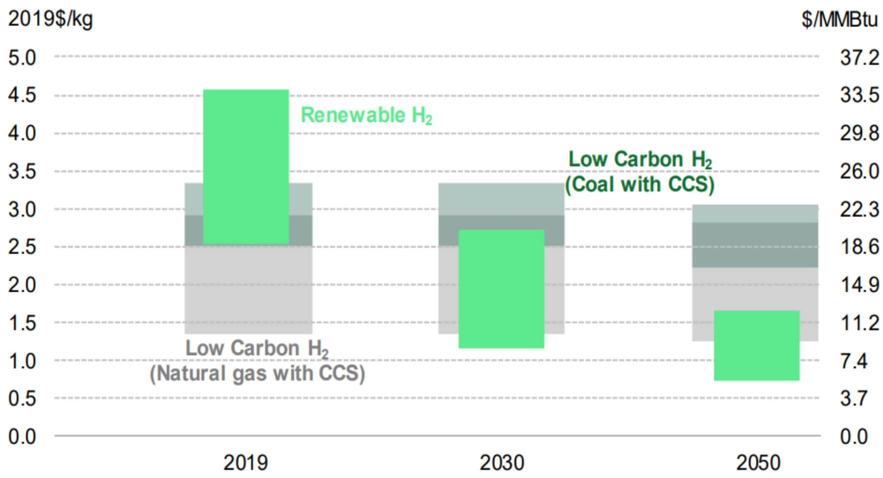

Figure 3. Cost outlook for hydrogen production.
Source: BloombergNEF.

The difference in costs between hydrogen generation via electrolysis and through fossil fuels will be reduced by technological and industrial evolution, the real costs of each energy source. This reduction will also occur by considering hydrogen as what it should be: **the high-value icing on the cake of the system that will cover the energy needs that electricity cannot** and not as an energy vector of sector-wide use because its characteristics are not sector-wide in production, distribution/transport or use.

What is beyond any doubt is the interest of the gas companies and the system manager (Enagás), who combine their profits to maintain fossil status with megalithic projects such as H2Med. This type of project is more to with the desire to maintain the status quo than with an energy transition that is truly based on eradicating fossil fuels.

The progress of the ecological transition will mean that many of the hydrogen production facilities, which are linked to existing refineries, will lose their raison d'être and, therefore, a stranded asset without profitability, with the gradual commitment to the eradication of fossil fuels.

Figure 4 shows the different initiatives proposed for hydrogen production close to port facilities and refinery or natural gas reception systems, which highlights that the public company Enagás and the traditional energy sector are not addressing the energy transition in the same way as they are telling us.

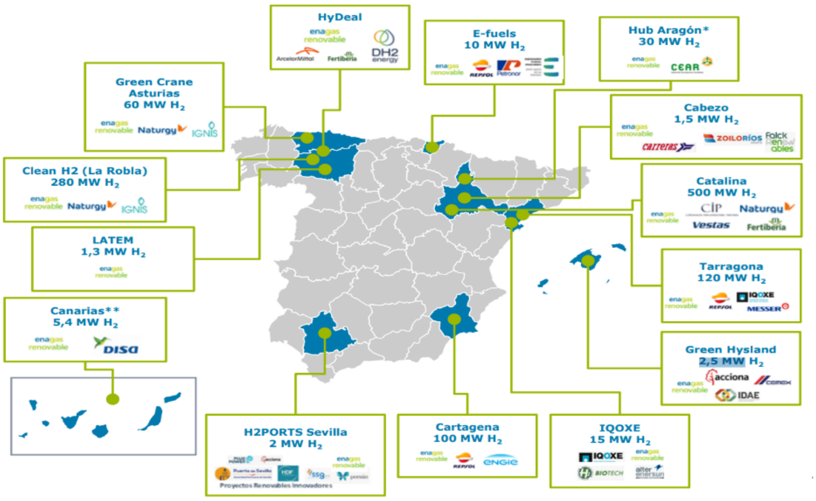

Figure 4. H2 production projects.
Source: Enagás.

▶ Availability and transport of hydrogen

Based on what has been approved by the various national roadmaps, there is no doubt that hydrogen production in the future will be based on water electrolysis, initially with electricity from renewable sources, although the European Commission and the energy lobby are trying to whitewash the use of nuclear energy as sustainable.

A key element is the speed of change and the period of coexistence between hydrogen production through fossil fuels and through electrolysis.

Growth in hydrogen demand can only be based on sustainably sourcing new and existing uses. However, as the different positions and strategies of the energy sector evolve, it is clear that the commitment to hydrogen entails a strategy of maintaining the current status of natural gas use.

The need to transport hydrogen produced from water hydrolysis arises when electricity is generated with renewable energy sources in isolated locations. This need also exists because of the seasonal variability of these renewable energy sources, which can be used to produce hydrogen in order to transfer it to the places of consumption when surpluses are generated.

The transport of hydrogen, as well as its storage, is a major barrier to the development of this vector due to two of the physical properties of hydrogen: its small size and low density. These characteristics become even more evident when compared to natural gas, which is mainly composed of methane. Methane has twice as many hydrogen atoms as one hydrogen molecule and one carbon atom. Hydrogen has a higher dispersion capacity and requires more sealing (direct emissions from hydrogen leakage have a Global Warming Potential, GWP, of 100 years), so natural gas transport systems are not valid for hydrogen, thus increasing the investment cost for its transformation process.

For this reason, until there is investment in hydroproducts, the most conservative line has been to opt for blending, which consists of mixing hydrogen in small percentages with natural gas. According to current regulations, in all countries this percentage is less than 10%. Given that hydrogen production can take place at the point of consumption, especially in industrial parks, blending hydrogen with natural gas cannot be used as excuse to maintain the gas infrastructure and keep using natural gas.

Taking into account this characteristic, blending is not the solution because hydrogen has a lower calorific value (LCV) of 120.2 MJ/kg, compared to 48.2 MJ/kg for methane, the main component of natural gas. This means that the final product has altered properties and can affect the operation of combustion equipment. This is because of the cost differential and because it does not make sense to produce a derivative to then blend it with the raw material used to produce it without also generating a clear added value in the use conditions.

Current proposals for hydrogen availability have initially maintained the idea that gas pipelines would support hydrogen distribution, through the blending formula, and then progressed to the idea that gas pipelines would become hydro-products. This solution is more than questionable because of the characteristics of hydrogen, the need to use materials that are not yet available and the operating conditions.

The practice of blending involves degrading the value of an energy vector such as hydrogen, which is a minority component in a blend with natural gas, has a lower energy capacity, is not sustainable and must be eradicated.

Initiatives that have emerged with the purpose of liquefying H_2 for transport should be abandoned, mainly because of the physical characteristics and the requirement of extremely low temperatures to reach the liquid state with the required stability (-240°C and 13 bar pressure).

Figure 5 shows the proposed hydrogen backbone network as a link between the different regasification stations that form part of the H2Med excuse. Together with what is shown in Figure 4 in reference to the "Iberian hydrogen backbone", the H2Med turns hydrogen into an energy vector that helps maintain the current centralised system, which is dependent on fossil fuels and based on the consideration of natural gas a necessary fuel for the energy transition.

Figure 5. Hydrogen backbone network in Spain in 2030.
Source: Enagás.

The Spanish government, led by ENAGAS and the traditional energy sector, is trying to turn Spain into a hydrogen hub, whereby they commit to overproducing renewable electricity in order to produce and export hydrogen. Their commitment is emphasised by the fact that over €1.6 billion of the Next Generation EU funds have been assigned to hydrogen projects. This situation calls into question the duty to democratise an energy system in which priority is given to generation close to consumption and not to a system of large power plants and infrastructure as a continuation of the current model. The difficulties in making renewables more socially acceptable should make us consider committing to integrating renewables rather than turning them into an extractive process.

Hydrogen use and demand

The key consideration when discussing hydrogen is that we are not talking about a commonly used fuel to cover our energy demands. We have to forget the idea that in the future, where we get natural gas, we will get a fuel like hydrogen. Our homes, cars and daily routines will not be based on hydrogen. This is because it comes from electricity, so it is more logical to use electricity, and because its physical characteristics make it unsafe to use in non-industrial or non-professional facilities.

Until now, hydrogen has been used more for industrial processes than as an energy vector or a fuel because it comes from the very fossil fuels we want to replace

Due to the characteristics of its production process, **developing and introducing hydrogen should aim to replace hydrogen produced from fossil fuel sources, cover the applications electricity cannot reach, and not be based on a commitment to increase supply.**

In Spain, 500,000 tonnes of hydrogen are consumed per year. 99% of this hydrogen is produced based on natural gas without capturing CO_2 (grey). In fact, 6% of total natural gas consumption in Spain is allocated to hydrogen production.

Practically all of this consumption is produced in industrial product factories and in refineries. Repsol is the largest producer and consumer of hydrogen in Spain, with 72% of the total. By sector, consumption is distributed 70% as a raw material, mainly in refineries (primarily those located in Huelva, Cartagena, Puertollano and Tarragona), 25% in factories producing chemical products for industrial use (ammonia) and the remaining 5% in industrial sectors such as metallurgy.

The energy transition towards decarbonisation should mean that, due to the disappearance of refineries in the near future, the culture of hydrogen will be separate and detached from the reality of its current use and production. This entails reviewing Spain's roadmap, in particular the plans to replace 25% of the hydrogen produced with natural gas, and to implement demonstrative uses in facilities that will not survive. Furthermore, more focus needs to be placed on the uses necessary for the reality of the energy transition and the limitations of electricity.

▶ Hydrogen in the energy transition

Due to the progress made by different technologies in terms of using renewable energy sources, the energy policy should focus on electrifying demand as a key vector to achieving a highly efficient and 100% renewable energy system as soon as possible, with a reduction in the total energy demand.

Hydrogen can play a key role if it makes management easier and covers some specific energy needs, but without losing its renewable origin and while committing to sustainability at the same time.

Hydrogen's energy capacity is the key characteristic for its consideration as a suitable energy vector to cover the demand that energy cannot. In addition to being used as part of a process, it should also be used:

- **As a fuel.** The industrial sector, and specifically the high-temperature applications in the metallurgy and chemical sectors, is heavily dependent on fossil fuels to obtain calorific energy. A possible solution has been proposed whereby hydrogen is used for industrial-level heat production, also known as power to heat (despite the emission of nitrogen oxides in its combustion). The aim is for this fuel to be green hydrogen.
    - ✓ Hydrogen combustion can cover the needs of the industrial process by using residual energy to generate electricity, therefore creating the co-generation system. However, in order to maximise efficiency, co-generation must be driven by process thermal demand. This is instead of the usual practice in fossil fuel-based co-generation, which seeks to maximise electricity generation with the aim of making the investment in the co-generation system economically profitable. This means that energy efficiency and economic profitability cannot both be achieved. In turn, this limits the real options of hydrogen for industrial co-generation to those cases in which there is no better non-fossil alternative (direct use of electricity, concentrated solar thermal energy, geothermal energy, heat pumps, residual biomass of the industry itself, etc.).
- **For electricity production for traction in transport.** Firstly, we need to reflect on the fact that we are in a circular electricity-hydrogen-electricity process which, as stated above, is insufficient. Despite this, hydrogen has an added value as it covers needs without electricity connection capacity and increases the autonomy of modes of transport by reducing the weight of the storage systems. As a technological and process-based approach, it makes sense to use fuel cells for transport systems, but only in applications where electricity cannot be the energy vector.
    - ✓ Fuel cells are capable of generating electricity from the chemical reaction between the hydrogen input in the cell and oxygen in the atmosphere, while forming water vapour as a by-product. In other words, the inverse process carried out by electrolysers. The current efficiency of fuel cells is 50%, which means half the energy contained in hydrogen is transformed into useful energy (electricity). To put this into context, a small gas turbine has an efficiency of 21% and a diesel internal combustion engine has an efficiency of around 40%.
    - ✓ It does not make sense to use hydrogen as the energy vector when using fuel cells in systems that can be directly electrified. It is unfathomable that there are proposals to use hydrogen for traction energy in trains when it should be electrified. In 2019, the Spanish railway was 63% electrified and the aim of the energy policy should be to achieve total electrification. It should also aim to make it the recommended and promoted modal system for the transport of

goods, which is currently 4% electrified, and of people, and interconnections with other countries.

- **For production of synthetic gases using renewable sources.** One of the future applications, which has been promoted and broadly publicised by the current gas industry, is the production of synthetic gases from hydrogen. The sole objective is to retain the transport systems and continue using natural gas. In fact, the European Commission's ban on the sale of petrol and diesel vehicles fails to mention natural gas vehicles. With the exception of very specific uses, we are once again putting the current fossil-fuel energy model first in order to maintain business status, which then leads to inefficiencies.
  The production of ammonia (NH_3) as an element that can simplify the storage and implicit transport of hydrogen is garnering increasing support. Ammonia is intended in particular for naval transport, but this situation must be analysed very carefully because of the added environmental risks from leaks and interactions with marine fauna and flora.

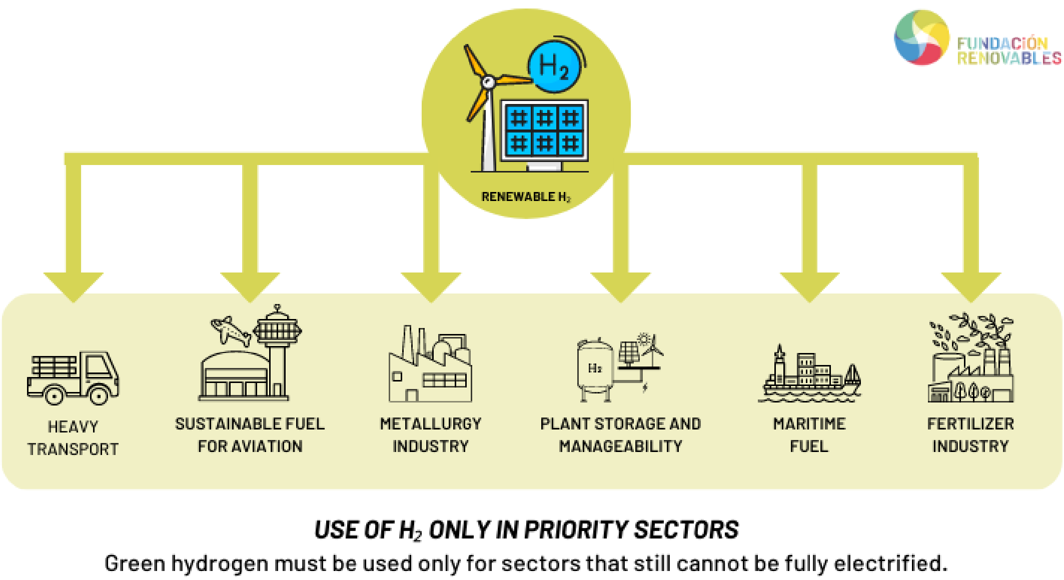

Figure 6. Uses of hydrogen.
Source: Created by Fundación Renovables.

Of course, except for reasons of efficiency, operational requirements and its seasonal storage capacity, **hydrogen must not be the energy vector used as the basis for the energy transition. In addition, its use should be subject to the evolution of demand and not exclusively to the promotion of infrastructure and supply, considering that a large part of its technological development is still in progress.**

▶ H2Med. The excuse for maintaining the current model.

It has always been said that Spain is like an island in terms of energy, and it seems that we are and want to remain so only in terms of electrical interconnection with Europe, where the interconnection targets of 10% by 2020 and 15% by 2030 have not been achieved.

In fact, in terms of installed capacity, we currently have an interconnection rate of 2.2%, with a capacity of 2,800 MW with France. This rises to 5,000 MW, i.e. 5%, with the submarine interconnection in the Bay of Biscay, which is planned for 2027 and is full of cost overruns. And in the best-case scenario, the two initiatives in the Pyrenees would take it up to 8,000 MW.

As part of the XXVII Hispano-French summit held in Barcelona on 19 January, Spain and France reaffirmed their strong commitment to cooperating on energy in order to minimise the gas price increase, both now and in the future. Both countries will explore the construction of a new power line, taking advantage of the underwater **H2Med** pipeline between Barcelona and Marseille. This means prioritising the development of this initiative over the fulfilment of existing electricity interconnection commitments.

The friendship treaty shows that France and Spain will fully respect “the right of each Member State to choose their energy structure and that both countries recognise the importance of the production, transport and consumption of clean hydrogen, which is produced from renewable sources that are low in carbon.” These statements have subsequently led to a different interpretation of what is meant by the suitability of the origin of hydrogen, especially following the European Commission's second Delegated Regulation, in which France states that hydrogen produced from nuclear energy sources should be included and that the H2Med should be used to transport hydrogen in both directions between France and Spain.

The H2Med is the result of a change of political position and interest in recovering Spain's potential as an energy hub following the invasion of Ukraine. This recovery initially focused on gas but is now focused on hydrogen too, taking up the MidCat pipeline initiative. In 2019, the current Spanish government rejected this initiative and declared it economically and socially infeasible due to the gradual reconversion from its configuration as a pipeline to a hydrogen transport system.

Different denominations have been used for this process, such as BarMar, but the name H2Med was eventually chosen. It has a budget of approximately €2.5 billion, to which €4.67 billion must be added to adapt and create infrastructure in Spain. So, the total budget would be above €7 billion. The European Investment Bank (EIB) has already started the financing process with European funds, meaning it is paid for by taxpayers.

With the approval of Portugal, France and Germany, the initiative aims to reach a flow capacity of 2 million tonnes of hydrogen per year, which would make Spain into an energy hub or logistical intermediary. This has always been the aim of the Spanish energy sector, which sees value in trading and not in generating real added value, which in this case would be green hydrogen produced by water electrolysis using renewable energy.

The growing euphoria surrounding the H2Med agreement is reflected in statements by the Enagás CEO in which he highlights that the target is to reach 2–3 million tonnes of hydrogen produced by 2030, which would increase to 3–4 million tonnes by 2040. An additional 0.75 million tonnes need to be produced in Portugal for the total hydrogen production in Spain and Portugal to cover approximately 10% of the European demand. This is partly due to the REPower EU plan, which set a target of 10 million tonnes of domestic renewable hydrogen production and 10 million tonnes of imports by 2030. The figures from this unlimited escalation of business and political ambition do not tally with the more cautious data of the Spanish Hydrogen Roadmap approved in October 2020, which set a target of 25% of industrial hydrogen consumption to be of renewable origin, i.e. 125,000 tonnes, and 4 GW of electrolyser capacity to be installed by 2030.

Based on the values included in the initiative, hydrogen production and exports would require an additional 40 GW of renewable power to be installed in Spain (considering a wind/photovoltaic mix with an average production of 2,500 kWh per kW installed and a requirement of 50 kWh per kg of hydrogen).

These initiatives go beyond what is established in the PNIEC, both in terms of the power to be installed and the structure of electricity generation with renewable sources. This then turns the energy transition into an extractive and unsustainable model that will not be socially accepted.

This initiative was preceded by the announcement from Maersk, one of the world's shipping giants, that it planned to construct a centralised hydrogen production project to be located in Galicia and Andalusia. It would form the basis of its commitment to synthetic gas production, which would require 4 GW of wind power according to its calculations. Of course, this project depends on the suitable availability of public resources in the form of subsidies and Next Generation EU funds.

According to the PNIEC, the current commitment to installed capacity in centralised wind and photovoltaic power is 80 GW by 2030, of which 43 GW are already available. Obviously, this does not include additional GW from different initiatives such as the H2Med and the Maersk project.

Bearing in mind the evacuation capacity of Spain's electricity system and the poor social acceptance of its implementation in rural areas, the development of renewables in Spain remains a complex issue. One of the reasons it is a complex issue is because we have set targets without previously establishing a framework for land use and dialogue with the different communities affected to ensure that renewables implementation has the social and environmental acceptance required.

Proposing megaprojects without being sure that they will be used operationally is an error that will increase the pressure on the energy transition and that may end up turning the hydro-duct into a failed infrastructure. This would follow a practice that is unfortunately very common in the Spanish concession model for the construction of infrastructure, such as regasification plants, radial motorways, or the Castor storage system.

The H2Med project, on the other hand, will strengthen France's nuclear commitment and ensure that the flow of hydrogen from France to Europe is produced from nuclear energy. This hydrogen would come from a deteriorated French nuclear power capacity where more than 20 plants have been shut down due to various maintenance processes and the opacity of EDF.

The aim of turning Spain into one of the main producers and exporters of hydrogen is an error resulting from a megalithic dream and the need to maintain the status of gas companies and Enagás, which has neglected its public role as the system manager and prioritises increasing income and dividends.

It is important to take into account the complementary nature of hydrogen because by analysing many of the plans submitted, it appears that hydrogen would be the centre of the energy model. This will never be acceptable in terms of performance, cost and suitability. The demand for a change in the supply model means that hydrogen cannot be the excuse to maintain the current model.

The interest in hydrogen comes from the possibility of complementing and implementing an increasingly electrified system, both in terms of storage and improved manageability, as well as covering energy demands that are not ideal for electricity.

Hydrogen should be produced at the place of consumption whenever possible, and using electrolysers supplied by electricity that is either produced from renewables on site or transported from its place of origin. It will always be better to transport electricity than hydrogen.

Rationality and commitment to democratising energy should be the pillars of our energy transition and should not, as this initiative implies, maintain the oversized infrastructure

that perpetuates concessional policies and the excessive power of the fossil fuel lobbies when it comes to energy.

▶ Observations on hydrogen and the H2Med initiative

Where can hydrogen be used?

- Due to its energy value, its energy inefficiency in production as a second derivative vector, its risk in use, and its physical characteristics, which complicate the different stages of its value chain, **hydrogen should play a specific role** with regard to its demand. The current proposals have stripped hydrogen of this specific role and have turned it into a fuel that promotes the continuation of the current energy model.
- Hydrogen should play a role in decarbonising the economy and in the future energy model, but this should be restricted to cover the needs that electricity cannot cover: heavy road, naval or air transport and certain industries, after implementing a series of efficiency measures and modal changes that minimise that demand.
- The current demand and production of hydrogen linked to refinery complexes must be analysed given that their existence in their current configuration will not be necessary in a decarbonised economy.

Where can't hydrogen be used?

- Hydrogen should be used as an energy vector and input in industrial processes, but never as a common-use fuel for supplies that can be covered by electricity. This is due to both its inefficiency and risk in use.
- **The general public's energy needs** should be covered by electricity, with hydrogen being used exclusively for very specific industries where electricity cannot be used, and in some other niche cases.
- **Under no circumstances can hydrogen replace natural gas** for what the general public currently uses natural gas for, such as boilers.

How can hydrogen be used?

- **The hydrogen approach should be based on production through water hydrolysis using electricity from renewable sources.**
- Based on current progress, the short-term focus should be on replacing the current demand for hydrogen from fossil-fuel sources with hydrogen from renewable energy sources. Transport infrastructure and supply cannot be increased without stimulating demand and prioritising the sustainability of existing demand. In the long term, there needs to be a detailed evaluation of the potential hydrogen demand that would be necessary for a 100% renewable, high-efficiency and low-cost energy system.

- **It is always better to transport electricity than hydrogen**. This means that hydrogen production must be as close as possible to the place of consumption or use and not to the electricity generation plants, which should be disconnected from the electricity network based on this criterion.

▶ Observations on hydrogen and the H2Med initiative

Viability

- Based on the previous premises, the **H2Med** initiative lacks opportunity and means committing to developing infrastructure without there being real demand for it. **We cannot turn a political commitment into a stranded asset.**

Territorial impact

- The size of H2Med project jeopardises the development of renewables and the ecological transition as it would mean increasing renewables capacity by more than 40 GW even though there is currently a strain on available land.

Nuclear risk

- Implementing the H2Med is the excuse needed to maintain the nuclear approach of France, which is trying to ensure at all costs that nuclear energy receives the same treatment as renewables. In that case, the renewable component and nuclear component of the supposedly green hydrogen transported by H2Med would be indistinguishable from each other. The second Delegated Regulation published by the European Commission on 13 February reflects the future of H2Med as an instrument that favours maintaining nuclear energy.

European funds

- The current hydrogen proposal is overvalued, contradicts what is established in the approved Spanish Hydrogen Roadmap and means maintaining the status of the current model and a concessionary energy policy with the large energy groups, whose objective is to attract more Next Generation EU funds.

- Spain cannot be the guarantor of an unsustainable energy policy for the sake of demonstrating the success of a political agreement.

Annexes

Hydrogen data

- Need for electricity: between 50/55 kWh/kg.
- Water requirement: 17 liters of H_2O per kg.
- Cost H_2.
    - natural gas without capture between €1-2/kg.
    - natural gas with capture €3/kg.
    - renewable electrolysis €5/kg with the 2021 auctions it would be €3.5/kg.
- LHV: 120MJ/kg compared to Natural Gas (48.2 MJ/kg). Burner operating problems.
- Liquid state -240ºC and 13 bar pressure.

Hydrogen production data

- 1kg of H_2 needs 50kWh at 2,500HEN. In other words, 1 MW of power would produce a maximum of 50 tons. Beware of oversizing.
- 6GW operating at 80% capacity produce 0.8 million tons of H_2.
- Reforming of natural gas: 80% efficiency but 10kg of CO_2 are released per kg of H_2. What should mean €100/tnCO2 €1/kg of H_2.

Hydrogen use yields

- Power to power: 29% concluded that it is better to transport and use electricity.
- Power to power with combined cycle 33%: Note, transport costs are not included.

Hydrogen roadmap in Spain

- Current demand 0.5 MtnH_2: 70% refineries, 25% chemical industry and 5% metallurgy industrial use.
- The 6% of natural gas consumption is used to produce H_2.
- Repsol consumes 72% of the H_2.
- In 2024: install 300/600 MW of electrolysers.
- In 2030: install 4GW of electrolyzers and cover 25% of current demand. It supposes 0.125 MtnH_2 and 6.25 TWh of electricity: 1,562 HEN from the electrolyzers and 2.5 GW of ad-hoc renewable power).

EU roadmap

- In 2024: install 4 GW.
- Between 2025 and 2030: install 40 GW of electrolyzers.
- Produce 10 MtnH_2 and import another 10 MtnH_2.

ENAGAS data

- Revenues: €970M.
- Ebitda: €797M (82%).
- Net Profit: €376M (38%).
- Shareholders: BlackRock (5.5%), Amundi (3.2%), Amancio Ortega (5%), SEPI (5%) Bank Of America (3.6%), Mubadala (3.1%) and State Street (3%).
- Green2TSO: Enagas, GRT gaz, REN, Terega. March 6, 2023.
    - Willingness to be an HNO H_2 network operator.
    - Need to sell renewable Enagás. 60% ENAGAS, 30% Hy24 Credit Agricole, Ardian and FiveT Hydrogen, 5% Pontegadea, 5% Navantia. In total 25 green H_2 and 21 biomethane projects.
- In 2030, an H_2 demand of 3.75Mt x 7.5 is estimated. In the document *H_2 renovable vector energético clave*.
    - National demand: 1.3 Mtn
    - Export: 2 Mtn
    - Carriers: 0.45 Mtn
- Additional renewable capacity: 75,000 MW

H2Med

- Budget: 2,500 + €4,670M = €7,170M
- Capacity 2 million tons/year. It would mean 40GW of minimum renewable power.
- Objective proposed by Arturo Gonzalo Aizpiri: 2-3 million tons by 2030 + 0.75 million from Portugal.
- Construction: 4 years and 6 months.

Megalithic projects

- Spain presented 150 initiatives for declarations of interest worth €50,000M, of which €1,600M have been committed.
- Maersk: Spain 4GW wind power for renewable gases. Galicia and Andalusia with wind energy.
- RWE + EQUINOR: 3GW of combined cycle power plants with hydrogen electrolysis 2GW hydrogen and natural gas. 2030 Norway 2GW of blue H_2 and 10GW in 2038.
- Germany: H2RCULES. The cost would be around 4.72 EUR/Kg H_2, according to Enervis

Spain Energy Island

- Electricity: currently 2,800 MW with France we should be at 13,000 MW. With the Bay of Biscay (2027) we would reach 5,000 MW and with everything proposed, 8,000 MW counting the pyrenean interconnection.
- Commitment 2020: 10% about 13,000MW.
- Commitment 2030: 15% over 20,000MW.

NECP data

- Renewable power in 2030: 80 GW
- Renewable power currently: 43 GW.

Generation park of the Objective Scenario (MW)				
Year	2015	2020*	2025*	2030*
Wind (terrestrial and maritime)	22.925	28.033	40.633	50.333
Solar photovoltaic	4.852	9.071	21.713	39.181
Solar thermoelectric	2.300	2.303	4.803	7.303
Hydraulics	14.104	14.109	14.359	14.609
Mixed pumping	2.687	2.687	2.687	2.687
Pure pumping	3.337	3.337	4.212	6.837
Biogas	223	211	241	241
Other renewables	0	0	40	80
Biomass	677	613	815	1.408
Coal	11.311	7.897	2.165	0
Combined cycle	26.612	26.612	26.612	26.612
Cogeneration	6.143	5.239	4.373	3.670
Fuel and fuel/gas (non-peninsular territories)	3.708	3.708	2.781	1.854
Waste and others	893	610	470	341
Nuclear	7.399	7.399	7.399	3.181
Storage	0	0	500	2.500
Total	107.173	111.829	133.802	160.837

The data for 2020, 2025 and 2030 are estimates of the PNIEC Objective Scenario.

Figure 7. Generation park of the Objective Scenario (MW).
Source: Plan Nacional Integrado de Energia y Clima (2021-2030).

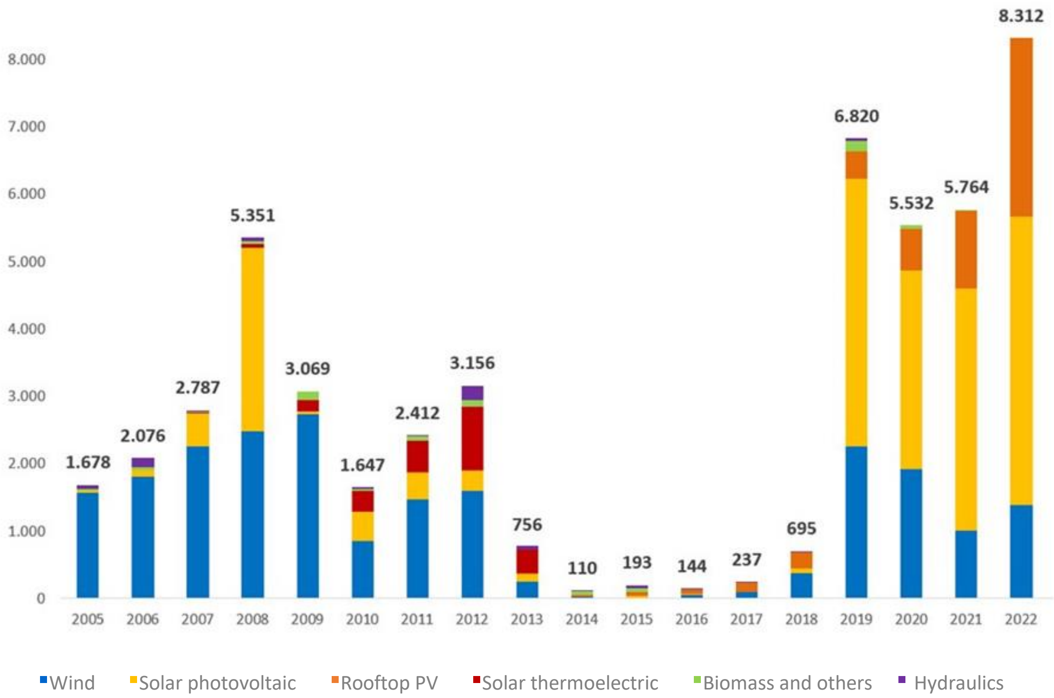

Figure 8. Evolution of installed annual renewable power.
Source: REE y APPA Renovables.