Hydrogen: the new panacea?

Myths and realities of hydrogen hopes in the Spanish State

ecologistas en acción

ODG
OBSERVATORI DEL DEUTE EN LA GLOBALITZACIÓ

Title
HYDROGEN: THE NEW PANACEA?
Myths and realities of hydrogen hopes in the Spanish State

Authors
Javier Andaluz Prieto, Sagrario Monedero López and Josep Nualart Corpas

Edition
2021

Content review
Íñigo Antepara López de Maturana, Emma Avilés Thurlow, Nuria Blázquez Sánchez, Carmen Duce Díaz, Francisco Ramos Muñiz and Nicola Scherer

Compiled by
Ecologistas en Acción and the Debt Observatory in Globalisation [Observatori del Deute en la Globalització, ODG]

Design and layout
Andrés Espinosa

Contact
Observatori del Deute en la Globalització
C/Girona, 25, principal 1a. 08010 Barcelona. observatori@odg.cat • Tel: 93 301 17 93 • www.odg.cat

Ecologistes en Acció
C/Peñuelas 12,Bajo 28005 Madrid • Tel: 915312739 • www.ecologistasenaccion.org

Supported by:

Agència Catalana de Cooperació al Desenvolupament
Generalitat de Catalunya
Ajuntament de Barcelona

Index

Executive summary

In recent months, we have seen a constant stream of promises and announcements in connection with green hydrogen, which have positioned it in political and media debates as a kind of panacea for the problems and challenges of decarbonising our productive and energy models.

We at Ecologistas en Acción (EeA) [Ecologists in Action] and the Debt Observatory in Globalisation [Observatori del Deute en la Globalització, ODG] would like to join the chorus of critical voices from academia, science and social and environmental organisations highlighting the risks and uncertainties involved in the proposals promoted by administrations and businesses.

Firstly, it is important to emphasise that hydrogen is not a primary source of energy, but an energy carrier which can store energy for later use. To do so, energy is consumed to produce pure hydrogen from the compounds containing hydrogen mixed with other elements where it is normally found, such as oxygen, carbon or nitrogen. The energy source used determines the type of hydrogen obtained: currently, less than 1% of global H_2 (pure hydrogen) is "green" hydrogen, produced from renewable energy sources.

Hydrogen's physico-chemical properties are decisive in determining the role it has to play, as they complicate storage and transport. Currently, the hydrogen production process is between 20% and 40% efficient (varying by sector and technology used), which implies very significant energy losses.

In the Spanish State, hydrogen consumption sits at around 500,000 tonnes/year. Most of this is grey hydrogen, used as a material resource in refineries (around 70%) and in chemical production plants (25%), with the rest used in sectors such as metalworking.

The elevated costs of production of this gas and other technical problems such as the need to compress it at high pressures in some applications are behind its slow development. Often, the virtues and potential of hydrogen have been overestimated and, to date, exaggerated promises have yet to be fulfilled and economically viable applications continue to be delayed.

Finding green hydrogen's role in the energy transition cannot be uncoupled from the need to adequately shape an energy mix which respects the limits of the planet. This model should be based on the fundamental pillars of energy efficiency, energy saving and reduced consumption, reducing energy demands and adapting them to a future availability which will be significantly lower than at present, both in qualitative and quantitative terms. Our model should be based on clean energy, reducing resource extraction, land occupation, ecosystem damage and waste generation impacts as far as possible.

Green hydrogen's potential, provided that strict environmental conditions are applied and that it is developed within an energy system which respects the limits of the planet, is to::

- Replace grey H_2 as a material resource: hydrogen is currently used as a material resource in various industries (refineries, metalworking, etc) and it is mostly obtained using fossil fuels. However, we cannot uncouple the priority supply of hydrogen as a material resource to these industries from the predicted future demand for the goods they produce. Therefore, we should determine which of these applications should be continued and which should be reduced or eliminated due to their elevated climate, ecological or social costs.
- Solve problems with non-electrifiable technologies: low efficiency means that hydrogen is inadvisable for those applications which use electricity or can be easily electrified. However, there are some applications which require high-density energy technology where electricity is unsuitable.
- Act as a short-term back-up in times of low electricity production.
- Displace the demand for certain minerals: hydrogen production and storage technologies require different minerals to current battery-based systems and they are much more durable.
- Support industrial sectors which are very vulnerable to decarbonisation: there are industrial processes which require very high temperatures to operate.

However, we should not forget that green hydrogen does have impacts. The main impacts are:

- Impacts related to the installation of renewable energy technology and hydrogen production.
- The production of green hydrogen requires the production of energy from renewable sources, but these are not free of impacts:
  - Impacts from mining the materials required.
  - Transformation and occupation of land where the technology is installed.
  - Competition for space with places conserved for non-human species or agro-ecology.
  - Energy losses.
- Hydrogen production and storage involves significant energy losses, reducing the efficiency of the process to 20% for many of its applications.
- Additional infrastructure and pressure on other resources.
- The construction of new infrastructure has allowed for the reactivation of the sector with projects which were originally connected with natural gas now planned to be revived for hydrogen.
- Disruption of the true focus of the ecological transition.
- Properly tackling the ecological transition requires going beyond debates centred exclusively on the substitution of one technology with another.

The key blind spot of the energy transition is the need to regulate uses and technologies through proper planning. This is one of the fundamental questions in achieving true decarbonisation. We should start to apply a principle of a hierarchy of uses so that it becomes clear which way we should direct each sector. We have to do the sums to see how much energy is available and using which technologies, adjusting this mix and distributing it amongst the priority uses, such as food, the production of certain goods or appropriate adaptations to climate change. Therefore, we should establish a hierarchy of uses, listing in order of importance:

1. Uses of hydrogen as a material resource
2. Uses in high-temperature applications
3. Uses in sectors where there is no better alternative
4. Backing up conventional generation
5. Other uses

The large energy companies and fossil fuel lobbies are spreading a narrative in which hydrogen has a central role to play in decarbonisation and in which it is blue hydrogen which is developed at scale given the limitations of green hydrogen. This narrative would allow them to play a central role in the energy transition and benefit from the European "NextGeneration EU" recovery and resilience funds. In the Spanish State, Iberdrola, Endesa and Naturgy have applied for almost all the subsidies granted to the Spanish State to implement its energy transition, presenting proposals for a significant part of the infrastructure required to achieve the objectives set out in the Renewable Hydrogen Roadmap 2030 ["Hoja de Ruta del Hidrógeno Renovable para 2030"].

In terms of energy geopolitics, hydrogen is an element which will shape international relations in the years to come due to its capacity to decarbonise the economy whilst continuing under the same capitalist system. Various countries have already elaborated their own strategies and roadmaps for hydrogen and have identified key regions for the import of this energy carrier. These countries have begun to draw up bilateral agreements with future exporting countries to ensure supplies and diversify the pool of actors they currently deal with, while exporting countries are looking for support to develop their infrastructure and maintain their role in the future energy market.

Another relevant factor in hydrogen's development is the creation of a global market. Public institutions are incorporating funding for this energy carrier in sections of their recovery and resilience plans and approving programmatic frameworks for the green transition, while the financial world is beginning to make its first predictions of the value of the hydrogen market over the coming decades. What is more, there are financial instruments such as Green Bonds which promote the financing of green and blue hydrogen projects and are piquing the interest of actors which had previously been supporting the fossil fuel sector.

The Spanish Government has written the Renewable Hydrogen Roadmap as a guide for the development of this energy carrier at national level. Although it emphasises ensuring capacity for green hydrogen generation, the strategy behind the document is for the Spanish State to become a hydrogen-supplying region for the rest of Europe or a transit point for hydrogen imported from other parts of the globe. This strategy is aligned with proposals made by Enagás and other European gas network operators to repurpose gas pipelines and build new infrastructure to create a trunk route for hydrogen transport at European scale, as well as developing supply chains between various countries.

Ultimately, hydrogen should be seen as a transition phase on the way towards a model based on energy sovereignty, in which energy-aware individuals, communities and peoples make their own decisions about energy generation, distribution and consumption in a way which is sensitive to local ecological, social, economic and cultural circumstances and does not impact negatively on others.

Introduction

In recent months, we have seen a constant stream of promises and announcements in connection with green hydrogen, which have positioned it in political and media debates as a kind of panacea for the problems and challenges of decarbonising our productive and energy models.

We at Ecologistas en Acción (EeA) [Ecologists in Action] and the Debt Observatory in Globalisation [Observatori del Deute en la Globalització, ODG] would like to join the chorus of critical voices from academia, science and social and environmental organisations which are highlighting the risks and uncertainties involved in the proposals promoted by administrations and businesses.

This study aims to address the reality of hydrogen and the current uncertainties about its environmental, economic and social viability in an informative way, and to warn of the huge risk which we are taking by allowing a hydrogen bubble to form.

To do so, we will go down to the technical level, analysing the physico-chemical properties of hydrogen and its value chain, focusing on the main advantages and challenges that it presents and using these to evaluate which applications it is and is not suitable for. In addition, we will analyse what is behind the promotion of hydrogen at scale, the financial flows and interests connected to it and the new geopolitical energy landscape which is opening up around hydrogen.

Finally, we will identify some of the main projects which energy companies in the Spanish State, supported by administrations, have launched in recent months.

What is hydrogen?

Hydrogen is the lightest, smallest molecule in the periodic table and the most abundant element in the universe. It is normally found combined with other elements, such as oxygen in the case of water (H_2O), carbon in the case of hydrocarbons (CHx) and nitrogen in the case of ammonia (NH_3). This means it can be used as an energy carrier which can be used to store and transport energy. The energy to be transported is used to separate hydrogen from the molecules it is found in and obtain pure hydrogen (H_2). Therefore, it is important to emphasise that hydrogen is not an energy source, but an energy carrier which is able to store energy for later use.

Apart from the trails which hydrogen-powered aircraft would create[1], hydrogen does not directly emit greenhouse gases during its combustion or use, but it can emit them indirectly through the processes used in its production or use. Therefore, it is important to emphasise the idea the hydrogen is only as clean as the energy sources used to produce and process it.

Today, less than 1%[2] of global H_2 is produced using renewable energy. According to data from the IRENA (International Renewable Energy Agency) report, 99% of the 130 million tonnes of hydrogen produced annually for industrial processes is still obtained through gasification of coal, lignite or natural gas.

1 Water vapour has some long-term effects which appear to be influenced by the physico-chemical characteristics of the atmosphere and the water cycle, and therefore tend to be excluded from climate change monitoring. What is more, it is believed that the emission of this water vapour in the highest levels of the atmosphere could have significant local climate impacts. More information: https://elpais.com/elpais/2019/06/27/ciencia/1561614117_113095.html [in Spanish]

2 IRENA, "Hydrogen: A renewable energy perspective", September 2019 https://www.irena.org/publications/2019/Sep/Hydrogen-A-renewable-energy-perspective

Figure 1. The hydrogen rainbow

The gas industry is hyping hydrogen as 'clean' and 'green'. But look behind the hype and we find not all hydrogen is the same; some types are more polluting than others. Globally, almost 80 percent of hydrogen is made using fossil gas ie methane, a greenhouse gas more than 100 times worse for global warming than CO_2 over a ten year period. Both drilling for and transporting methane leaks it into the atmosphere, meaning it is as bad for the climate as coal; and gas extraction also wrecks local communities and ecosystems, as we've seen for decades in the Niger Delta.

Process:
Gasification (adding steam and oxygen)

CO_2 emissions?
Very big

Verdict:
Climate and community killer

Process:
Steam Methane Reformation (SMR)

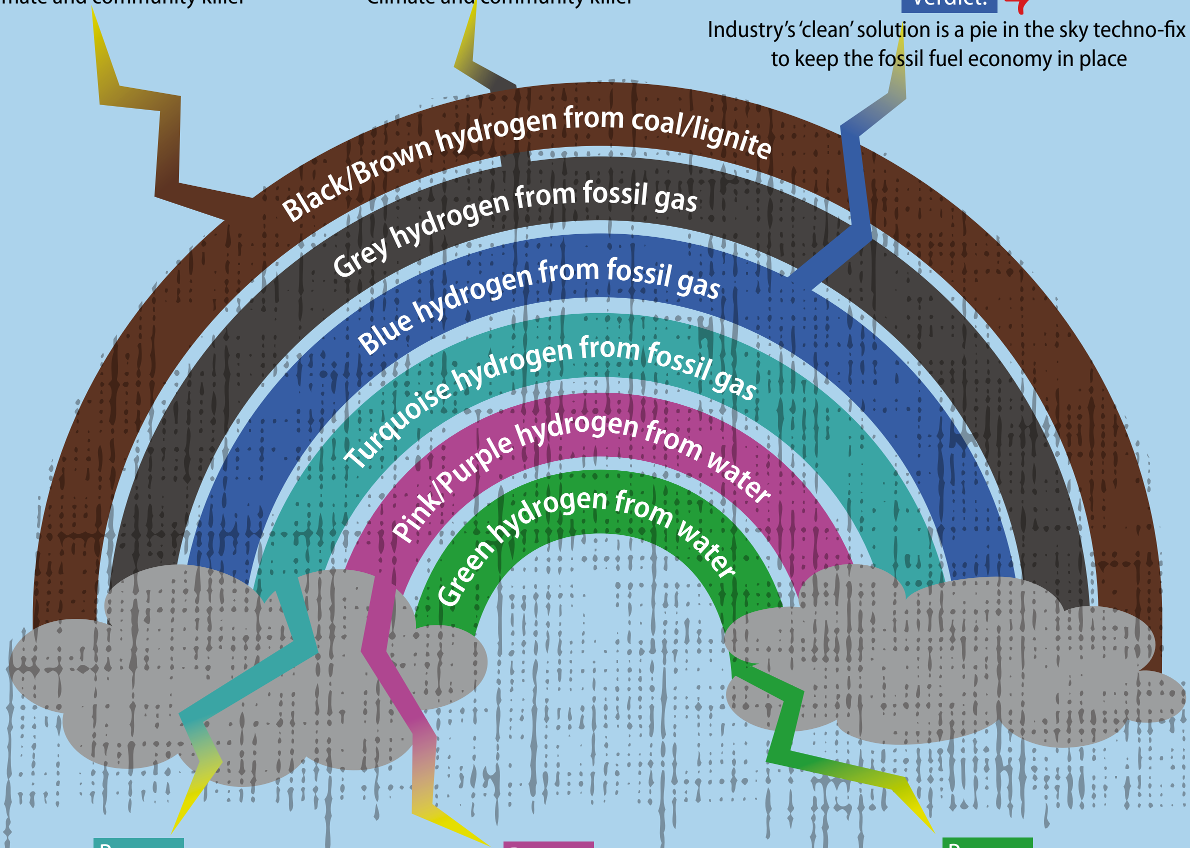
CO_2 emissions?
Lots from SMR, as well as methane leakage all along the life-cycle of gas

Verdict:
Climate and community killer

Process:
SMR but with carbon capture and storage or usage (CCS/U)

CO_2 emissions?
Claims to capture CO_2 via costly, experimental technology (see Box 2: Carbon capture), but still has methane and CO_2 leakage

Verdict:
Industry's 'clean' solution is a pie in the sky techno-fix to keep the fossil fuel economy in place



Process:
Process: without oxygen)

CO_2 emissions?
Produces a solid carbon byproduct, not CO_2, but heating process could produce CO_2

Verdict:
Still based on climate and community-wrecking fossil gas

Process:
Nuclear-powered electrolysis (splitting water molecules using electricity)

CO_2 emissions?
The mining and processing of uranium to produce nuclear energy is carbon intensive

Verdict:
Latest failed attempt by the nuclear industry to be relevant

Process:
Renewable-powered electrolysis (like nuclear)

CO_2 emissions?
Will the electricity be from wind, waves and sun, or polluting biomass/waste incineration?

Verdict:
Cleanest form, but at scale relies on neocolonial mega projects outside EU

Source: Corporate Europe; Food and Water Action Europe and Re:Common

Physico-chemical characteristics

H_2 contains a large amount of energy per unit of mass: that is to say, it has a high energy density. However, it is a very low-density gas. Therefore, we can say that it has a high energy density by mass but a low energy density by volume. This means it needs to be compressed, liquefied or transformed into other fuels and this also requires energy which we need to account for. The following table shows a comparison of the physical properties of hydrogen and natural gas[3]:

Chart 1. Physical properties of hydrogen and natural gas

Property	Hydrogen	Relative to natural gas
Density (gas)	0.089 kg/m$_3$ (0 °C, 1bar)	1/10
Density (liquid)	70,79 kg/m$_3$ (-253 °C, 1bar)	1/6
Boiling point	-253°C (1 bar)	-90 °C
Energy density (by mass)	120 MJ/kg	x2
Energy density (by volume)	10,8 MJ/Nm$_3$	1/3
Wobbe index	11,29 kWh/Nm$_3$	5/6

Comparison of the physical properties of hydrogen and natural gas. Extracted from *Hidrógeno: Vector Energético de una economía descarbonizada*. Various authors, Naturgy Foundation.

The physico-chemical properties of hydrogen have a significant impact on its efficiency and are decisive in determining the role which it could play:

- The very small size of the molecule increases the risk of leaks.
- It is highly flammable, although this risk is mitigated by its high diffusivity.
- It requires very high pressures.
- It weakens materials used for storage and transport (corroding pipes, for example).
- Its flame is colourless and impossible to smell, which makes detection of fires and leaks difficult.

Some of the main problems linked with these characteristics are:

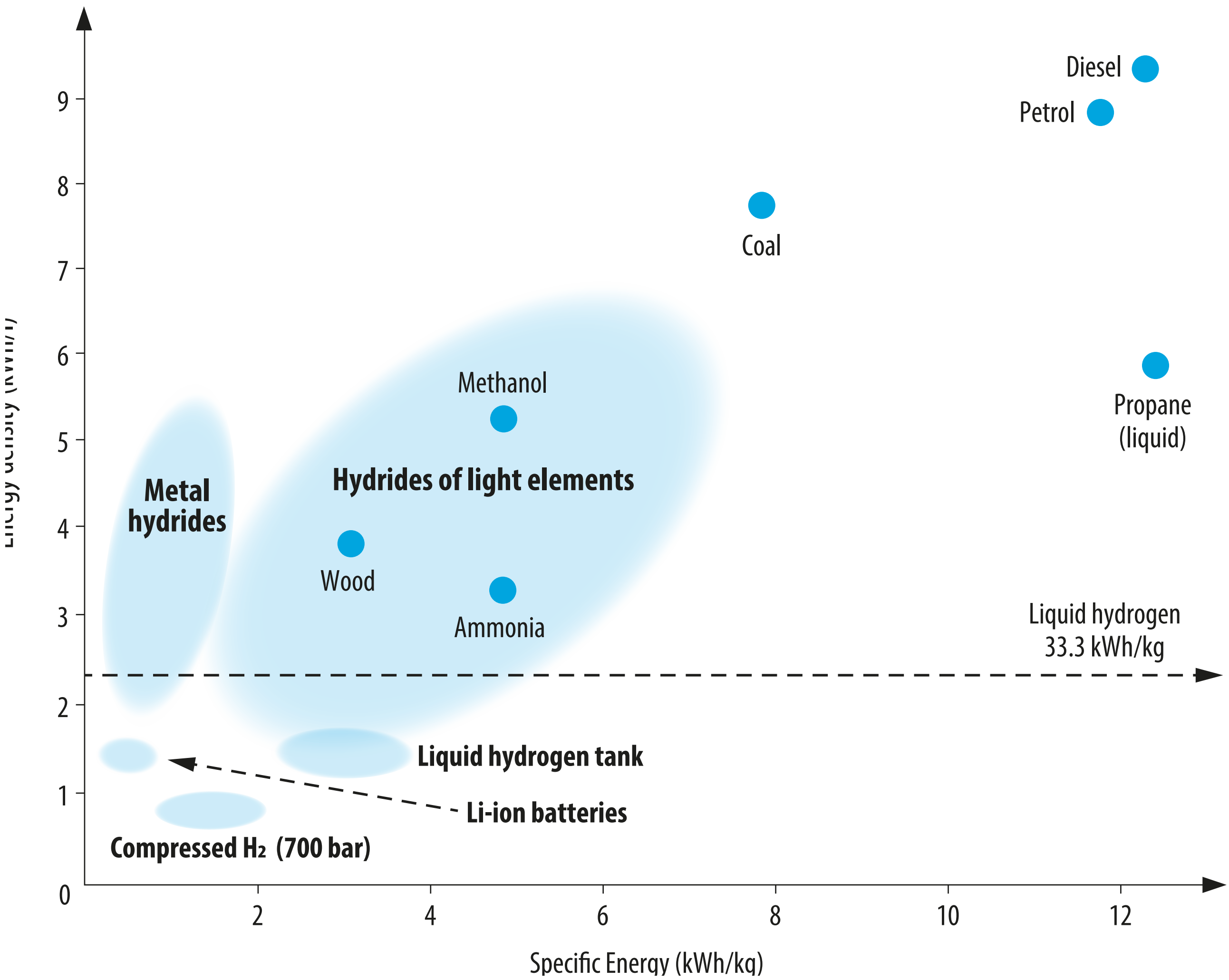
- Hydrogen production is low-efficiency (varying from 20% to 40% efficient according to numerous reports, depending on the sector and the technologies used in its application). As it is not an energy source in itself this could mean losses of up to 70% over the whole production, storage and transport process, for applications in vehicles[4].

3 Extracted from *Hidrógeno: Vector Energético de una economía descarbonizada*. Various authors, Naturgy Foundation.

4 According to Antonio Turiel, "Counting all the losses, the energy efficiency from the beginning of production to the movement of the vehicle's motor (well to wheel) is usually around 25%, compared to 75% or more for an electric vehicle. What is more, the fuel cells make the vehicles more expensive and contain scarce materials like platinum." It is also interesting to read the efficiency analysis done by Pedro Prieto for the 15-15-15 portal at https://www.15-15-15.org/webzine/2020/12/07/un-breve-analisis-de-la-eficiencia-de-ciclo-completo-de-la-economia-del-hidrogeno-verde/ [in Spanish]

- Hydrogen transport is complex. As we have already noted, hydrogen liquefies at high pressures and very low temperatures, and is very volatile, easily leaking and diffusing through the smallest cracks.
- Hydrogen storage requires high pressure to achieve decent energy density by volume. This requires containers with very thick and strong walls (which are therefore very heavy), with a risk of explosion.

Chart 2. Comparison between energy storage systems



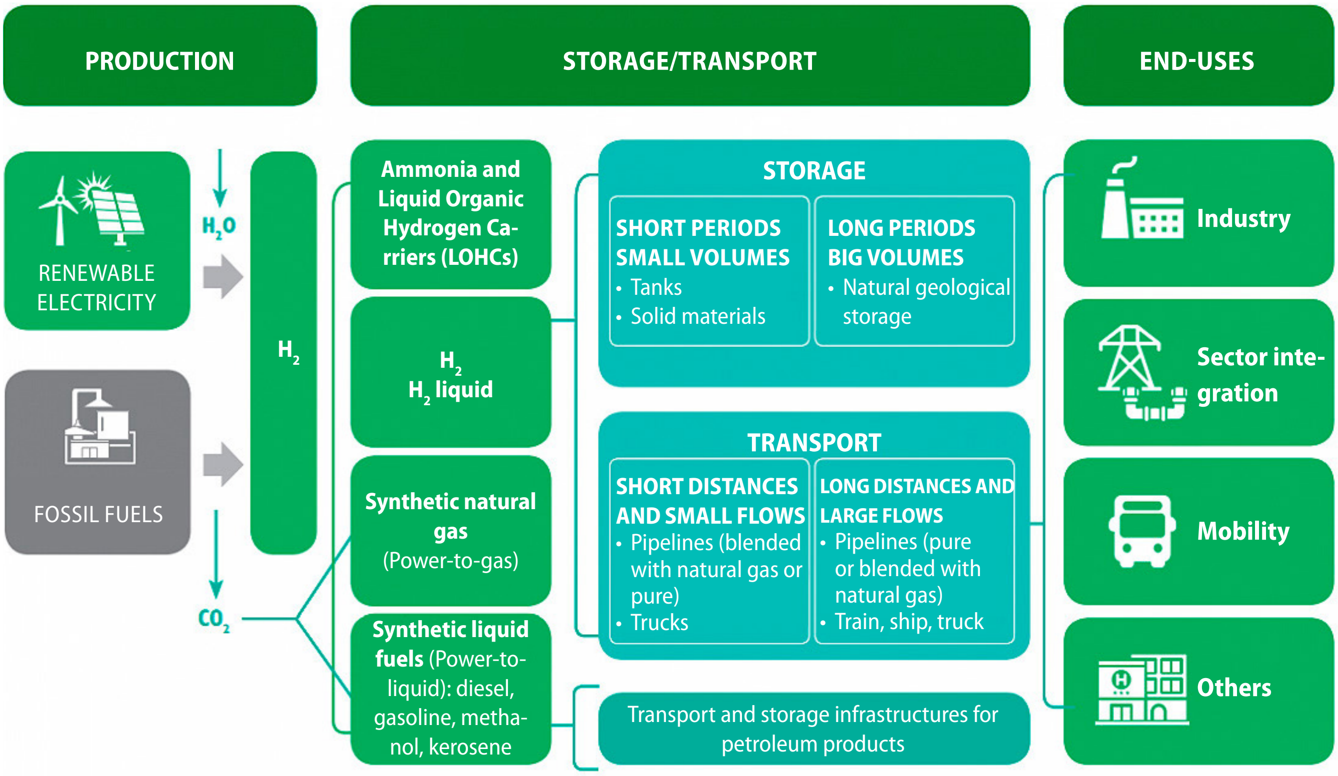
Sartbaeva, A., Kuznetsov, V. L., Edwards, P. P., & Wells, S. A. (2008). Hydrogen nexus in a sustainable energy future. Energy & Environmental Science, 1(1), 79-85. https://doi.org/10.1039/b810104

As a result of everything discussed so far, the economic viability of hydrogen is currently very poor and it is proving to be a very expensive energy solution. According to some projections, green hydrogen will quickly become more competitive relative to grey hydrogen over the next few years. Today, however, green H_2 is much more expensive than other, much more mature, technologies.

The hydrogen supply / value chain

The stages in the H_2 value chain are shown in the following graphic[5]:

Chart 3. Stages in the hydrogen value chain



Source: MITECO

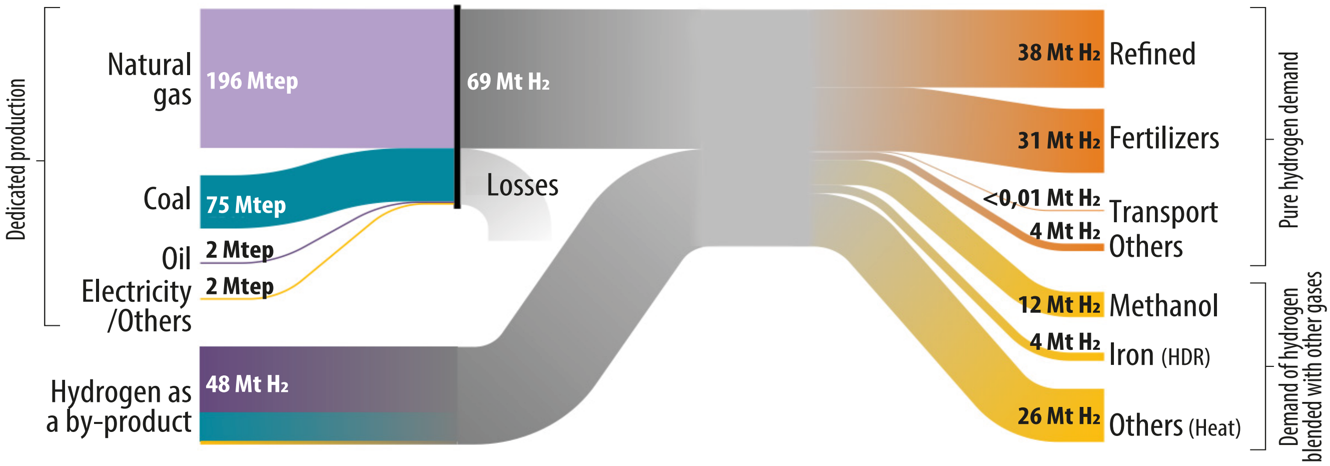
Today, according to data from the European Parliament[6], 43% of global hydrogen production is used to produce ammonia (mainly used to make ammonia-based agricultural fertilisers), 52% is used to refine and purify hydrocarbons and the remaining 5% is used for methanol synthesis and other applications.

5 Extracted from the Renewable Hydrogen Roadmap. Accessed at https://www.miteco.gob.es/es/ministerio/hoja-de-ruta-del-hidrogeno-renovable.aspx [in Spanish]

6 European Parliament resolution of 19 May 2021 on a European Strategy for Hydrogen (2020/2242(INI))

In the Spanish State, hydrogen consumption sits at around 500,000 tonnes/year. Most of this is grey hydrogen, used as a material resource in refineries (around 70%) and in chemical production plants (25%), with the rest used in sectors such as metalworking. In many cases, production happens in the same plant as consumption, using steam methane reforming installations[7]. This is typical situation, as the overwhelming majority of hydrogen produced today is used as a material resource for industrial purposes:

Chart 4. Current hydrogen value chain



Source: International Energy Agenc

1 Production

Various hydrogen production technologies exist. Here we will comment on some of the most relevant:

- Hydrogen from renewable energy: the main method is electrolysis, which is the separation of water molecules into oxygen and hydrogen in a gaseous state using a continuous electric current. An energy supply delivers the current into two electrodes, and the separation of the molecules happens on the surface of these electrodes. Electrolysers come in various forms (the most common today are alkaline electrolysers)[8]. There are also other methods for generating green hydrogen from water molecules such as thermolysis and photoelectrochemical (PEC) water splitting. However, these are currently very immature methods.
- Hydrogen from natural gas: the process of extracting hydrogen from natural gas is known as reforming. This process produces gaseous carbon oxides as by-products, generating around 11 tonnes of CO_2 per tonne of hydrogen. There is another process, methane pyrolysis, which produces solid carbon as the by-product: 3 tonnes of coal per tonne of hydrogen[9].

7 Data extracted from the Renewable Hydrogen Roadmap [Hoja de Ruta española para el hidrógeno renovable]. https://www.miteco.gob.es/es/ministerio/hoja-de-ruta-del-hidrogeno-renovable.aspx

8 To learn more about the various types of electrolysers, consult the Spanish Renewable Hydrogen Roadmap.

9 Extracted from XXXX , Naturgy Foundation. Extraído del libro de Fundación naturgy-PONER BIEN LA REFERENCIA

2 Storage and transport

H_2 can be stored and transported in various ways: for example, as a gas (using dedicated infrastructure), as a compressed gas (in tanker lorries or trains) or as a liquid (by road or in ships similar to the tankers which transport LNG)10. Alternatively, H_2 can be injected into natural gas networks (with the mixture later being consumed as it is or separated out at its destination) or in the form of carriers such as ammonia (which has the advantage over other organic liquids of not containing carbon and already having a well-developed dedicated storage and transport infrastructure).

10 *Perspectivas de desarrollo de un mercado global de hidrógeno. Implicaciones para la CAPV* Orkestra, 2021. https://www.orkestra.deusto.es/es/investigacion/publicaciones/informes/cuadernos-orkestra/2169-210006-perspectivas-desarrollo-mercado-global-hidrogeno-implicaciones-capv [In Spanish]

What role should hydrogen play in the new energy model?

Hydrogen is an energy storage technology which is difficult to categorise. It is not a new technology: it has been researched for many years. Although it was first developed in the 1920s, it was not until the 1990s that the publication of J. Rifkin's book "The Hydrogen Economy" gave rise to the first wave of interest in hydrogen.

The elevated costs of production of the gas and other technical problems such as the need to compress it at high pressures in some applications are behind its slow development. The virtues and potential of hydrogen have often been overestimated and, to date, exaggerated promises are still to be fulfilled and economically viable applications continue to be delayed. For example, the German Federal Government has been investigating applications of hydrogen since 1975 through a range of different programmes[11], and in 2007 it announced the National Innovation Programme which promised to mobilise more than €700 million in public funds to support businesses in the sector to achieve a significant penetration of hydrogen technology in Germany[12]. This promised penetration has not been realised, and the few opinion polls undertaken to date show a clear lack of citizen awareness of the impacts of the technology[13.]

The industrial and governmental sectors are concentrating huge efforts on the development of hydrogen technology. They argue that it could form one of the few storage solutions available, alongside electric batteries. It would have the advantage over these that, thanks to its larger energy density, it could be more useful in applications such as long-distance heavy freight transport, shipping or aviation. It could also provide solutions to industrial sectors for energy in addition to use as a material resource.

However, the promises of the sector are still a long way from being fulfilled, as many of the projects being proposed are a long way off the level of economic, energetic or environmental viability required for a successful energy transition. Hydrogen publicity ignores the fact that we cannot uncouple hydrogen from the impacts of the renewable energy sources used to obtain it, or ignore the energy inefficiency of the process, which renders the gas unusable for many applications where electrification is a more suitable solution (such as light-duty vehicles).

11 More information on the German Innovation Programme at https://onlinelibrary.wiley.com/doi/10.1002/fuce.200800124

12 More information on hydrogen in the German Innovation Programme at https://juser.fz-juelich.de/record/135833/files/78_11.pdf

13 More information on the German population's attitudes in René Zimmer and Jörg Welke's article "Let's go green with hydrogen! The general public's perspective." Available at: https://www.sciencedirect.com/science/article/abs/pii/S0360319912004909

Green hydrogen could…

Provided that strict environmental conditions are applied and that it is developed within an energy system which respects the limits of the planet, green hydrogen could:

- **Replace grey hydrogen as a material resource**: currently, hydrogen is used as a material in various industries, and it is mainly obtained using fossil fuels. Although hydrogen is often discussed purely from an energy perspective, it is also used as a material in many applications, including[14]:

  - **Production of ammonia and its derivatives**: at the European level 43% of hydrogen consumption relates to the production of ammonia and a series of other chemical compounds widely used in the world today. The ammonia is mostly used to produce chemical agricultural fertilisers.
  - **Production of alcohols and organic compounds**: these are necessary for the synthesis of a highly diverse range of chemicals (cyclohexane, amines, aliphatic alcohols) as well as some plastics. This accounts for 5% of hydrogen consumption.
  - **Metalworking industry**: hydrogen is used for the production of many metals. Various proportions of hydrogen are usually added to the gas streams used in many cutting and welding processes. It is also used in semiconductor production to insert impurities, in a process is known as "doping" which is vital for important technological applications such as photovoltaic cells.
  - **Refineries, to desulphurise or lighten heavy crude oils**: hydrogen is used to remove sulphur from "dirty" crude oils or to lighten them when they are very heavy. This is the sector which consumes the most hydrogen in the EU, consuming 52%.
  - We should not consider the prioritisation of hydrogen as an material resource for industries without considering the predicted future demand for the goods they produce. Therefore, we should determine which of these applications should be continued and which should be reduced or eliminated due to their high climate, ecological or social costs. An example could be the pesticides sector, which accounts for a large proportion of ammonia consumption but should be drastically scaled back for environmental and health reasons. Instead, the hydrogen could be used for the doping of photovoltaic cells, which are relied on in the long-term for energy supply for numerous applications. In fact, **more than 90% of current European hydrogen consumption is used for fossil fuels and chemical fertilisers, two sectors which should disappear in order to achieve climate neutrality**.

- **Solve problems with non-electrifiable technologiess**: one of the dilemmas of the energy transition is which technologies to use to decarbonise each sector. The answer is complex and various aspects of each technology need to be evaluated, including their process efficiencies and the most comprehensive possible comparative life cycle analyses. In hydrogen's case we can see that its low efficiency makes it unsuitable for applications which use electricity or could be easily electrified, such as railways. On the other hand, there are applications which require high energy density technology in places where electricity is unsuitable, such as shipping, aviation or large construction machinery. Here, hydrogen (specifically the use of electrofuels) could provide solutions. However, this again

14 More information on the use of hydrogen as a material resource is available in "Hydrogen as Raw Material" by W. Schnurnberger available at: https://link.springer.com/chapter/10.1007/978-3-642-61561-0_4

requires coherent planning, taking into account that the current number of air[15] and sea[16] journeys is highly unsustainable.

- **Act as a short-term back-up in times of low electricity production**. A sustainable renewable energy system should, undoubtedly, use a diverse range of technologies in harmony with local resources and values. Diversity in energy sources and storage systems and sensible scaling are key for the energy transition. Within this model, there may be small- and medium-scale solutions in which hydrogen could provide an additional advantage.
- **Displace the need for certain minerals**. Hydrogen production and storage technologies require different minerals to current battery-based systems[17] and they are much more durable[18].
- **Support industrial sectors which are very vulnerable to decarbonisation**. Some industrial processes which require very high temperatures to operate, such as smelting, are highly dependent on fossil fuels. Only combustion-based technology is able to achieve the high temperatures required. For these applications, incorporating hydrogen in a sustainable and rational way could reduce the pressure on bioenergetic resources, such as biofuels[19]. What is more, it could provide an alternative in places impacted by the closure of thermoelectric and nuclear power plants. It would also avoid the construction of new electric power lines and substations but could threaten many places with the construction of hydrogen pipelines. Therefore, decisions would need to be made on a case-by-case basis, guaranteeing (amongst other things) that there is sufficient capacity in the region for a sensible rollout of the associated renewable energy infrastructure.

15 More information in the report "Decrecimiento de la aviación: la reducción del transporte aéreo de manera justa", by Ecologistas en Acción. Available at: https://www.ecologistasenaccion.org/136912/aviacion-y-emisiones-una-relacion-de-altos-vuelos-que-es-necesario-frenar/ [in Spanish]

16 Especially worrying is the increase in activities such as cruise tourism. More information in the press release from Ecologistas en Acción "El turismo de cruceros crece en volumen y también en contaminación e impactos socioambientales". Available at: https://www.ecologistasenaccion.org/134447/el-turismo-de-cruceros-crece-en-volumen-y-tambien-en-contaminacion-e-impactos-socioambientales/ [in Spanish]

17 More information in the International Energy Agency report "The Role of Critical World Energy Outlook Special Report Minerals in Clean Energy Transitions". Available at: https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/mineral-requirements-for-clean-energy-transitions

18 For an estimate of the energy costs of hydrogen and battery energy storage consult "Hydrogen or batteries for grid storage? A net energy analysis". Available at: https://www.researchgate.net/publication/275056722_Hydrogen_or_batteries_for_grid_storage_A_net_energy_analysis

19 More information in: "Biocombustibles: más leña al fuego", a report by Ecologistas en Acción. Available at: https://www.ecologistasenaccion.org/138703/informe-biocombustibles-mas-lena-al-fuego/ [in Spanish]

Chart 5. Current hydrogen value chain

Source: https://elperiodicodelaenergia.com/casos-de-uso-del-hidrogeno/

The impacts of green hydrogen

- **Impacts related to the installation of renewables for hydrogen production**.
  Producing green hydrogen requires energy from renewable sources. Although renewable technologies are widely used and are undoubtedly required in order to decarbonise the electricity system, they are not free of impacts. Their main impacts are[20]:

  – Impacts related to mining the materials required.
  – Transformation and occupation of land where the technology is installed.
  – Competition for space with land reserved for non-human species or agro-ecology (which should be the backbone of the socioecological transition) or for the installation of solar energy plants.

  The twin objectives of the fight against climate change and the fight to prevent biodiversity loss must be indisputable and complementary. Past experience makes us critical of the current lack of planning and the fact that current environmental impact assessment processes have been unable to prevent many impacts.

- **LEnergy losses**.
  The dilemmas of the ecological transition are more apparent than ever in green hydrogen, which is nowhere near being the most efficient process. Its production and storage involve significant losses, which could reduce the efficiency of the process to 20% for many applications.
  What is more, hydrogen storage requires very high pressures, while its high volatility makes it difficult to store for very long periods. Handling hydrogen also involves safety risks as it is highly explosive.

- **Extractivism and resource consumption**[21]
  When we speak about hydrogen production, we are fundamentally referring to the process of electrolysing water. There are currently three such technologies with different mineral requirements:

20 More information in "Manifiesto de Ecologistas en Acción ante el proceso transición energética e implantación de renovables"https://www.ecologistasenaccion.org/wp-content/uploads/2021/04/manifiesto-renovables.pdf

21 More information in the International Energy Agency report "The Role of Critical Minerals in Clean Energy Transitions", available at: https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/mineral-requirements-for-clean-energy-transitions

- Alkaline electrolysers: used since the 1920s, the largest example is a 10 MW plant in China. This technology does not require large quantities of precious metals but does require around 1 tonne of nickel per MW.
- Proton exchange membrane (PEM) electrolysers: the fastest-growing technology, with electrolysers of up to 20 MW. Their advantages include their small size and increased flexibility in operation. However, they are still an immature and expensive technology requiring 0.3kg of platinum and 0.7kg of iridium per MW, both of which are very scarce. Therefore, the growth in this technology would substantially increase the demand for these materials.
- Solid oxide electrolyser cell (SOEC): the least mature of these three technologies. Currently only small-scale and research applications exist. Despite its promise, it is not expected to be available in the short term. Its material requirements include nickel (200 kg per MW), zirconium (40 kg per MW), yttrium (5 kg per MW) and lanthanum (20 kg per MW).

As well as the electrolysers themselves we must consider the additional mineral demands of catalytic technologies and storing the hydrogen produced. For applications in vehicles, the International Energy Agency estimates that for the best-case demand reduction scenarios for platinum in fuel cells, platinum demand will reach 100 tonnes per year in 2040.

- **Additional infrastructure and pressure on other resources**.
The construction of new infrastructure is one of the largest threats hidden behind the development of hydrogen. In parallel with the revival of the sector we have seen the reactivation of projects which were originally connected with natural gas and are now being revived and repurposed for hydrogen – as could happen with MidCat or the Cantabrian corridor. New proposals are also being put forward such as the Basque hydrogen corridor. The impacts of these infrastructures are severe, in terms of energy requirements, carbon emissions, fragmentation and destruction of habitat and health. In a scenario where energy consumption is reduced in line with the fight against climate change the construction of new gas infrastructure in Spain is unthinkable in most cases.

The most important impact is on water resources, as hydrogen is obtained by the electrolysis of water. This could increase water demands in a water-scarce country where climate change will further reduce water availability. On the other hand, it could be used as a way of purifying highly polluted water in places where conventional treatment is impossible.

- **Disruption of the true focus of the ecological transition**.
Properly tackling the ecological transition requires going beyond debates centred exclusively on the substitution of one technology with another. Even though technological solutions exist which could transform fossil-based sectors it is impossible to avoid the reality that we live on a planet with finite resources. Therefore, we need a plan considering which demands need to be fulfilled in the short-, medium- and long-term and reconciling these with the energy, mineral and material resources available. Carrying on without considering present and future supply requirements could put the maintenance of services and goods which are important for everyone (food, health, education…) in jeopardy in the coming decades. A lack of clear definitions puts decisions over what will be installed, where and for whom in the hands of economic actors and large energy companies. This is happening now with hydrogen, with companies like Enagás or Repsol moving to the front of the queue to receive huge multi-million euro sums of public money to prop up their obsolete sectors and make themselves look green while they do it. However, nobody has considered whether their projects are ecologically and economically viable, or for example if they are at odds with the decarbonisation of the electrical sector or what impacts they would have on the land they would occupy.

Who is behind the promotion of green hydrogen?

The new energy geopolitical landscape

The energy transition towards renewables is a global challenge, not only because we need to reduce CO_2 emissions to comply with the Paris agreement, but due to the energy-related international relationships existing between countries and regions.

The dependency of the world's energy systems on fossil fuels has given increased bargaining power to countries with fossil fuel reserves in territories they control. However, the majority are characterised by dictatorships or authoritarian regimes, as is the case of Saudi Arabia, Russia, Iran and Algeria. This political landscape and the end of fossil fuels constitutes a threat to the political and social stability of these countries, as they are highly indebted and their Gross Domestic Product (GDP) is highly reliant on fossil fuel exports.

The element which will shape international relations concerning energy over the coming decades will be hydrogen, as it is being promoted as an energy carrier which will allow us to decarbonise the economy without challenging the mantra of growth which harbours neoliberalism.

Last February, the Hydrogen Council (a global-level hydrogen business association)[22], along with the consulting company McKinsey, presented a report entitled "Hydrogen Insights: A perspective on hydrogen investment, market development and cost competitiveness"[23] to describe how the hydrogen market is developing and what its future outlook is over the next decade. The report details how more than 30 countries have already created national strategies for the development of this energy carrier and have proposed more than 220 projects along the entire value chain, with a total investment of almost €350 billion. Notably, more than half of these projects have been proposed in Europe[24], followed by Australia[25], Japan[26], South Korea[27], China[28] and the United States[29]. It is also worth noting that all of these places have also drafted a national hydrogen strategy or roadmap.

22 For more on the Hydrogen Council: https://hydrogencouncil.com/en/

23 More information in "Hydrogen Insights: A perspective on hydrogen investment, market development and cost competitiveness", a report from the Hydrogen Council. Available at: https://hydrogencouncil.com/en/hydrogen-insights-2021/

24 For more on the European Commission's Hydrogen Strategy see: https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

25 For more on the Australian Hydrogen Strategy see: https://www.industry.gov.au/sites/default/files/2019-11/australias-national-hydrogen-strategy.pdf

26 For more on Japan's Hydrogen Roadmap see: https://www.env.go.jp/seisaku/list/ondanka_saisei/lowcarbon-h2-sc/PDF/Summary_of_Japan%27s_Hydrogen_Strategy.pdf

27 For more on South Korea's Hydrogen Strategy see: https://www.ifri.org/sites/default/files/atoms/files/sichao_kan_hydrogen_korea_2020_1.pdf

28 For more on China's Hydrogen Strategy see: https://www.ispionline.it/en/pubblicazione/chinas-emerging-hydrogen-strategy-30431

29 For more on the US Hydrogen Strategy see: https://www.energy.gov/sites/prod/files/2020/07/f76/USDOE_FE_Hydrogen_Strategy_July2020.pdf

Also noteworthy is the fact that the countries and regions which have developed hydrogen strategies or roadmaps are in the Global North and are currently the main consumers of fossil fuels. This has meant that the countries currently exporting fossil fuels have created alliances in order to demand that they be included in the planning of the new global-level energy model[30], whilst the countries with the necessary resources to position themselves as hydrogen exporters or otherwise adapt to the new context are welcoming it with open arms. In this category we find Saudi Arabia, Australia and Chile which are positioning themselves to be the largest hydrogen exporters by 2030[31].

If we look at the case of the European Union, we see that it has a strong energy dependency on fossil fuels and therefore on the countries which export them. In 2019, the largest exporters of fossil fuels to the European region were Russia (27%), Iraq (9%), Nigeria (8%), Saudi Arabia (8%), Kazakhstan (7%) and Norway (7%)[32].

The hydrogen strategy for a climate-neutral Europe[33] published by the European Commission in July 2020 points out specifically that hydrogen should be a key element in energy policy involving other regions of the planet. One of the main alliances is with the neighbouring countries and regions to the south and east, such as north Africa and Ukraine, which are predicted to have an installed electrolyser capacity of 40 GW by 2030. The report also identifies other regions with which no strong relationships have yet been established concerning energy, such as the central and southern parts of the African continent. Interest is growing in the large potential for solar and hydroelectric power generation in this region and therefore the potential for producing clean hydrogen. This is to be realised through the existing Africa-Europe Green Energy Initiative[34].

Proof of the interest in hydrogen in the African continent on the part of some countries which have developed hydrogen strategies can be seen in the conference organised by the African Solar Industry Association and the African Hydrogen Partnership at the end of March 2021. This conference highlighted the need to develop the hydrogen economy to take advantage of the strong solar radiation the region receives, suggesting that over-dimensioning green hydrogen production could help with water supply, due to an increase in desalination plant capacity[35].

This same logic is being applied by the government of the Democratic Republic of Congo to the Inga Dam III hydroelectric project, which would increase current capacity from 1.42 GW to 4.8 GW. This project is the third phase of the Grand Inga hydroelectric complex, which has ambitions to become the largest hydroelectric generation plant in the world, with a power output of 45 GW once completed. The Inga Dam III project was conceived to allow energy exports to other countries in the region, such as South Africa, and also to other regions of the planet, such as Europe, by means of extra high voltage power lines crossing the continent. For its part, Germany has already demonstrated its interest in this project through negotiations between the German

30 More information in "Gas plays critical decarbonization role, says GECF panel", an article by Compressortech2. Available at: https://www.compressortech2.com/news/gas-plays-critical-decarbonization-role-says-gecf-panel/8011172.article?utm_source=pocket_mylist

31 More information in "Hidrógeno verde: 6 países que lideran la producción de una de las "energías del futuro" (y cuál es el único latinoamericano)", a BBC Mundo news article. Available at: https://www.bbc.com/mundo/noticias-56531777?utm_source=pocket_mylist [in Spanish]

32 More information in "From where do we import energy", a Eurostat article. Available at: https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-2c.html

33 For more on the hydrogen strategy for a climate-neutral Europe see: https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf

34 For more on the Africa-Europe Green Energy Initiative: https://ec.europa.eu/international-partnerships/system/files/communication-eu-africa-strategy-join-2020-4-final_en.pdf

35 More information in "African green hydrogen could feed German and Japanese industry and water drought-stricken nations", an article in PV magazine. Available at: https://www.pv-magazine.com/2021/03/29/african-green-hydrogen-could-feed-german-and-japanese-industry-and-water-drought-stricken-nations/?utm_source=pocket_mylist

and Congolese governments and German companies and investors which are promoting the development of hydrogen as an energy carrier within the framework of the German National Hydrogen Strategy[36]. However, Germany is not the only interested country, as European investors see green hydrogen as an opportunity to align with the European Green Deal. It is also worth bearing in mind that the Democratic Republic of Congo is a strategic country for the renewable energy transition as it contains more than half of global cobalt reserves[37].

The use of the Inga Dam III hydroelectric project to generate green hydrogen for export to Europe is questionable, as the viability of transporting green hydrogen over large distances is very poor and its yield at the point of consumption is also very poor due to the various transformation processes undergone along the supply chain and the energy required to carry them out (see the chapter on "What is hydrogen?"). What is more, only 20% of the Congolese population has access to electricity and various civil society organisations are demanding that the money be invested in implementing small, local energy production projects which are better suited to the needs of the African population. At the same time, the implementation of hydroelectric megaprojects like this has inherent environmental impacts, such as the loss of local biodiversity and ecosystems in the flooded land and the displacement of people living there.

An oxygen pump for the big energy and fossil fuel companies

Nations are not the only actors interested in taking a leading role in the energy transition. The promotion and development of the hydrogen market is happening hand-in-hand with large oil and energy companies and lobbies with the clear objective of maintaining their positions of power and their profit margins.

This is shown in the article published recently by the European Network of Corporate Observatories (ENCO)[38] and the Fossil Free Politics campaign[39] entitled "Hijacking the recovery through hydrogen: how fossil fuel lobbying is siphoning Covid recovery funds"[40]. This report analyses how large energy and fossil fuel companies and lobbies have influenced national and European recovery plans so that hydrogen (and not only green hydrogen) can benefit from European public funds.

To take a few examples, in 2020 the various hydrogen lobbies had more than 160 meetings with senior executives at the European Commission, and in the case of the Directorate-General for Energy these comprised 35% of the meetings the department had in the whole year. What is more, the lobbies spent more than €58 million on lobbying activities directed at European Commission executives[41].

It is worth noting that the main European-level hydrogen lobby, Hydrogen Europe[42], is formed

36 For more on the German Hydrogen Roadmap: https://www.fraunhofer.de/content/dam/zv/de/ueber-fraunhofer/wissenschaftspolitik/Positionen/2019-10-a-hydrogen-roadmap-for-germany.pdf

37 More information in "Green deals in a time of pandemics: The future will be contested now", a book by the Debt Observatory in Globalisation (ODG). Available at: https://odg.cat/en/publication/green-deals-pandemics/

38 For more on the European Network of Corporate Observatories (ENCO): https://corpwatchers.eu/

39 For more on the Fossil Free Politics campaign: https://www.fossilfreepolitics.org/

40 More information in the report "Hijacking the recovery through hydrogen: how fossil fuel lobbying is siphoning Covid recovery funds" by the European Network of Corporate Observatories. Available at: https://corpwatchers.eu/es/investigaciones/recoverywatch/

41 More information available in "The hydrogen hype: gas industry fairy-tale or climate horror story", a report by Corporate Europe Observatory, Re:Common y Food & Water Action Europe. Available at: https://corporateeurope.org/en/hydrogen-hype

42 For more on Hydrogen Europe: https://www.hydrogeneurope.eu/

of various sectors including the gas sector. The companies representing this sector are: Uniper, Enagás, Snam, Vattenfall, GRTgaz and Gasuine. It is these companies which have taken it upon themselves to influence the various processes of drafting and reforming European energy policy so that it includes blue hydrogen as a transition fuel on the path to green hydrogen. To begin with this was justified by the lack of development and cost-competitiveness of green hydrogen relative to blue hydrogen, but now lobbies are arguing that blue hydrogen will be necessary to cover demands which green hydrogen cannot meet, ignoring the fact that carbon capture and storage technology (CCS), crucial for blue hydrogen, has not been developed at scale either and is surrounded by questions about its safety and environmental and economic costs.

In the Spanish State it is the large energy companies which are pushing to lead the energy transition. This can be seen in proposals from Iberdrola[43], Endesa and Naturgy[44] which, as a group, have presented projects for a total of €53 billion to take advantage of the España Puede recovery and resilience plan.

Looking at green hydrogen, Iberdrola has presented 53 projects to the Ministry for the Ecological Transition for an installed electrolyser capacity of 1 GW along with 4,000 MW in renewable energy installations to power them for a total of €4 billion[45], while Endesa has presented 23 projects for an installed electrolyser capacity of 340 MW and 2,000 MW in renewables for a total of €2.9 billion[46]. Iberdrola's proposal would account for 25% of the installed electrolyser capacity set out by the Spanish Government for 2020 in its Renewable Hydrogen Roadmap[47].

For its part, Naturgy has gone for the development of the network of "hidrogeneras" (hydrogen filling stations for vehicles) using the existing Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG) infrastructure[48]. On completion of its second phase this would achieve the objective set out for 2030 in the Renewable Hydrogen Roadmap.

The Spanish company which is proposing the most projects for implementing hydrogen in Spanish territory is Enagás. The most significant project is the "Valle del Hidrógeno de Catalunya" [Hydrogen Valley of Catalonia][49], one of 27 flagship projects in the Next Generation Catalonia[50]. recovery plan (see the chapter on "Concrete project examples"). In addition, it is a member of various European-level consortia and platforms promoting the creation of a European hydrogen market (see the chapter on "The Iberian Peninsula as a hydrogen hub").

43 More information in "Iberdrola propone más de 21.000 millones en inversiones con 150 proyectos para los fondos europeos", an article by Invertia. Available at: https://www.elespanol.com/invertia/empresas/energia/20210208/iberdrola-propone-millones-inversiones-proyectos-fondos-europeos/557444884_0.html?utm_source=pocket_mylist [in Spanish]

44 More information in "Endesa y Naturgy buscan fondos para movilizar 32.000 millones", an article by Expansión. Available at: https://www.expansion.com/empresas/energia/2020/12/26/5fe653e5e5fdeaf46c8b456e.html?utm_source=pocket_mylist [in Spanish]

45 More information in "Iberdrola invertirá 2.500 millones en proyectos de hidrógeno verde", an article by Cinco días. Available at: https://cincodias.elpais.com/cincodias/2021/02/10/companias/1612980821_945540.html [in Spanish]

46 More information in "Endesa destina 2.900 millones a 23 proyectos de hidrógeno verde que cubren la mitad de la potencia prevista hasta 2023", an article in El País. Available at: https://elpais.com/economia/2021-02-01/endesa-invertira-2900-millones-en-23-proyectos-de-hidrogeno-verde-en-espana.html?ssm=FB_CM&utm_source=Facebook#Echobox=1620388290 [in Spanish]

47 For more information on the Spanish Government's Renewable Hydrogen Roadmap: https://www.miteco.gob.es/images/es/hojarutahidrogenorenovable_tcm30-525000.PDF [in Spanish]

48 More information in "Naturgy transita del gas natural como combustible vehicular al hidrógeno", an article in Energías Renovables. Available at: https://www.energias-renovables.com/hidrogeno/naturgy-transita-del-gas-natural-como-combustible-20210209 [in Spanish]

49 For more on the Hydrogen Valley of Catalonia: https://www.h2valley.cat/es/ [in Spanish]

50 For more on Next Generation Catalonia: http://economia.gencat.cat/web/.content/20_departament_gabinet_tecnic/arxius/pla-recuperacio-europa/next-generation-catalonia.pdf [in Catalan]

When will we see a regional / global hydrogen market?

Actors, roles and instruments

The promotion of hydrogen by the big energy and fossil fuel companies also responds to the needs of their shareholders (largely investment funds and other financial actors) who want to maintain their profits. The simplest way to make sure that they can influence the promotion of this energy carrier is to create its own free market, ensuring that decisions are made for financial reasons rather than for reasons of real utility. Furthermore, they also seek support from public institutions through guarantees, which would very probably allow them to cover their losses if hydrogen turns out to be a speculative bubble.

There is currently no hydrogen market, but the first pieces are being put together. At national level, the Spanish Government intends to invest €9 billion up to 2030, of which €1.5 billion (at least) will come from the España Puede plan budget.

Chart 2. **Distribution of investment amongst various reform levers and components in the España Puede plan**

Distribution of investment amongst various reform levers and components	Million euros	%
I.Urban and rural agenda, the fight against rural depopulation and agricultural development	14.407	20,7%
1.Action plan to ensure sustainable, safe and connected mobility in urban areas	6.536	9,4%
2.Housing refurbishment and urban renewal plan	6.820	9,8%
3.Transformation and digitalisation of the supply chain of the agri-food and fisheries system	1.051	1,5%
II.Resilient infrastructures and ecosystems	10.400	15,0%
4.Conservation and restoration of marine and terrestrial ecosystems and their biodiversity	1.642	2,4%
5.Preservation of the coast and water resources	2.091	3,0%
6.Sustainable, safe and connected mobility	6.667	9,6%
III.A just and inclusive ecological transition	6.385	9,2%
7.Deployment and integration of renewable energy	3.165	4,6%
8.Electrical infrastructure, promotion of smart networks and deployment of energy storage	1.365	2,0%
9.Roadmap for hydrogen and its sectorial integration	1.555	2,2%
10.A Just Transition Strategy	300	0,4%

IV.An Administration for the 21st century	4.315	6,2%
11.Modernisation of public administrations	4.315	6,2%
V.Modernisation and digitalisation of the industrial fabric and SMEs, recovery of the tourism sector and promotion of Spain as an entrepreneurial nation	16.075	23,1%
12.Spain 2030 Industrial Policy	4.894	5,4%
13.Fostering the growth of SMEs	3.782	7,0%
14.Modernisation and competitiveness plan for the tourism sector	3.400	4,9%
15.Digital Connectivity, cybersecurity and 5G deployment	3.999	5,8%
VI. Pledge for science and innovation and strengthening the capabilities of the national health system	4.949	7,1%
16.National Strategy for Artificial Intelligence	500	0,7%
17.Institutional reform and strengthening capacities in the national science, technology and innovation system	3.380	4,9%
18.Renewing and widening the capabilities of the national health system	1.069	1,5%
VII.Education and knowledge, lifelong learning and capacity building	7.317	10,5%
19.National Plan for Digital Skills	3.593	5,2%
20.Strategic Plan for Vocational Training	2.076	3,0%
21.Modernisation and digitalisation of the Education system, including early-life education (0-3 years)	1.648	2,4%
VIII.The new care economy and employment policies	4.855	7,0%
22.Emergency Plan for the care economy and the strengthening of inclusion policies	2.492	3,6%
23.New public policies for a dynamic, resilient and inclusive labour market	2.363	3,4%
IX.Promotion of the culture and sports industries	825	1,2%
24.Revaluation of the cultural sector	325	0,5%
25.Spain Audio-visual Hub	200	0,3%
26.Development of the sport sector	300	0,4%
X.Modernisation of the tax system for inclusive and sustainable growth	-	-
27.Law on measures to prevent and combat tax evasion	-	-
28.Adaptation of the tax system to the reality of the 21st century	-	-
29.Improving the effectiveness of public spending	-	-
30.Sustainability of the public pension system under the Toledo Pact	-	-
Total	**69.528**	**100%**

Compiled by the authors based on data from the Spanish Government

In turn, the governments of the Global North are approving programmes and policies which give centre stage to an energy transition based on renewable energy, such as the Green New Deal in the United States and the European Green Deal[51]. Just like the hydrogen strategies and roadmaps, they set out a plan for the energy transition at a global scale, without considering local needs or the socioecological impacts created in exporting countries. In reality, populations made vulnerable by fossil fuel extraction continue to be threatened, this time by the extraction of critical raw materials required for the energy transition in the Global North.

The approval of programmes and policies focused on an energy transition based on renewables and new energy carriers sends a signal to the financial market that it should divest from fossil fuels and support hydrogen and renewables if it is to maintain public support for its investments.

This can be seen in the Goldman Sachs report "Green Hydrogen: The next transformation driver of the utilities industry"[52] which estimates that the hydrogen market could be worth €10 trillion in 2050. This valuation has been carried out for three regions of the planet: Asia, the United States and the European Union, with estimated market values of €4.4 trillion, €2.9 trillion and €2.2 trillion respectively. In the case of the European Union, it is notable that almost two thirds of this investment will be allocated to renewable energy plants required to power electrolysers.

Chart 3. Estimation of the value of each component of the European hydrogen market.

	Capital investments (Capex) by 2050, in trillions of euros	% market share	Function
Renewables	1,4	65%	To power 500 GW of electrolysers
Hydrogen plants	0,4	15%	450-500 GW of peaking capacity to satisfy 10% of European demand
Electrolysers	0,4	15%	500 GW of electrolysers
Gas infrastructure	0,1	5%	Pipeline reconfiguration
Total	**2,2**	**100%**	

Compiled by the authors using data from Goldman Sachs.

Another aspect of markets to consider are the instruments and mechanisms which exist to keep them running. More than a decade ago, "Green Bonds"[53] were created to differentiate investments which respected the climate and environment from the rest. The largest issue that they present is that there is no unified set of criteria defining which activities would be included and if the conditions imposed are obligatory.

Looking at the criteria used in the European Union (the EU Green Bond Standards), we see that the issuer should comply with the do-no-harm principle as set out in the European taxonomy, publish a framework policy on the green bonds in advance, monitor the destination of the funds and the impacts generated and undergo an evaluation by an external and/or independent

51 For more on the European Commission's European Green Deal: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

52 More in formation in "Green Hydrogen: The next transformation driver of the Utilities industry", a report by Goldman Sachs. Available at: https://www.goldmansachs.com/insights/pages/gs-research/green-hydrogen/report.pdf

53 For more on Green Bonds: https://www.climatebonds.net/market/explaining-green-bonds

organisation[54]. Two organisations which can fulfil this requirement are EQA[55] and the Climate Bond Initiative[56].

The Climate Bond Initiative categorises projects involving green hydrogen or low-emission hydrogen (such as blue hydrogen) all the way along the value chain as potential beneficiaries of green bonds[57]. Along with other actors in the private and financial sectors, it identifies the following challenges: public sector investments, competition and trade and distribution networks.

Import-export deals

The free market is not the only space where commercial relationships in the energy sector can develop. There are also bilateral contracts between parties containing conditions unique to each agreement. This is what fossil fuel exporting and importing countries have historically used, although in the last decade there has been a proliferation of contracts managed through the free market. The duration of these contracts tends to be measured in decades to guarantee that the exporting country can amortise the investment made in constructing infrastructure for the extraction and transport of the fossil fuel.

In the hydrogen sector we are already seeing the first bilateral agreements between different regions of the planet, although they apply to the future because the projects in question are still in the conception or construction phases. One of those which has caused most of a stir is the agreement between Chile and the Netherlands[58]. The purpose of this alliance is the development of one of the largest windfarms on the planet to generate green hydrogen in the Magallanes region in the south of Chile, which will in turn promote Rotterdam as the main import and export point for this energy carrier in the European Union.

Another European country with plans to import hydrogen from various regions of the planet is Germany. In March Germany signed a contract with Canada to import blue hydrogen, since the north American country continues to develop fossil fuels as an energy source for the generation of hydrogen[59], whilst in April it signed an agreement with Australia to import green hydrogen[60]. The agreement with Australia is believed to be not entirely coherent because the shipping technology which would be required to import the energy carrier or the by-products, such as ammonia, is still in development and could generate large CO_2 emissions. What is more, Germany's strategy is linked to the use of liquefied natural gas (LNG) import plants which are currently in the design and construction phases.

54 For more on Green Bonds: https://www.somo.nl/a-voluntary-eu-green-bond-standard/

55 For more on the EQA: https://eqa.es/

56 For more on the Climate Bond Initiative: https://www.climatebonds.net/

57 More information in the "Climate investment opportunities: Climate-aligned bonds & issuers 2020" report by the Climate Bond Initiative. Available at: https://www.climatebonds.net/files/reports/cbi_climate-aligned_bonds_issuers_2020.pdf

58 More information in "Hidrógeno verde: Magallanes lidera en Latinoamérica", an article in El Pinguino. Available at: https://elpinguino.com/noticia/2021/03/28/hidrogeno-verde-magallanes-lidera-en-latinoamerica

59 More information in "Canada, Germany sign green energy deal in bid to power fledgling hydrogen sector", a CBC article. Available at: https://www.cbc.ca/news/politics/canada-germany-energy-transition-1.5951584

60 More information in "El absurdo y poco sostenible acuerdo de Alemania para traerse hidrógeno desde Australia", an article in El periódico de la energía. Available at: https://elperiodicodelaenergia.com/el-absurdo-y-poco-sostenible-acuerdo-de-alemania-para-traerse-hidrogeno-desde-australia/amp/ [in Spanish]

Japan has also started to draft contracts with future hydrogen exporters. Last April it reached an agreement with the United Arab Emirates to collaborate on the development of hydrogen projects to satisfy its demand[61]. These projects will generate blue and green hydrogen and will replace the trade in fossil fuels currently existing between the two countries. Japan is prioritising the Arabian Peninsula, having reached an agreement in Saudi Arabia in March of the same year to undertake feasibility studies of projects related to the supply chains of blue hydrogen and ammonia.

61 More information in "Japan, UAE sign hydrogen co-operation deal", an article in Argusmedia. Available at: https://www.argusmedia.com/en/news/2203675-japan-uae-sign-hydrogen-cooperation-deal

A new energy model for hydrogen

The elevated cost of investment and of the product itself continues to be the hydrogen sector's greatest challenge. This has led public institutions to try to incentivise investment in it, as after decades of development there are still no truly viable applications. In fact, the most relevant projects today are mostly pilot projects, research projects or projects investigating hydrogen's potential. However, this has not stopped the largest energy companies seeing hydrogen as a new business niche and throwing themselves at projects which are, in many cases, questionable and not as profitable as claimed.

The EU hydrogen strategy sets out an objective to produce 10 million tonnes of green hydrogen by 2030, which would represent just 11% of total current hydrogen consumption in the Union. According to the International Energy Agency, the demand for hydrogen for various industrial uses in 2018 was 73.9 million tonnes. Only 0.1% of this hydrogen is currently green. The key issue is that although replacing the current consumption of fossil-based hydrogen should be the priority, most proposals are based on using hydrogen in inefficient applications such as trains or private vehicles.

Today, considering the announcements made singing the praises of the sector and the speculative activity following them, it is important to warn of the Spanish economy's vulnerability to economic bubbles. When they burst, they have especially concerning impacts on the most vulnerable people in society. The Spanish energy scene is a star pupil in these speculative processes. It should be enough to remember the gas bubble which we suffered at the beginning of this century, when the governments rashly provoked the big energy companies to opt for combined cycle gas power plants and regasification terminals, with the renewables sector ending up paying the price in the form of moratoriums and state assistance freezes.

Finding green hydrogen's role in the energy transition cannot be uncoupled from the need to adequately shape an energy mix which respects the limits of the planet. As set out in the Energy Horizon 2050, the basic pillars of the model should be efficiency, energy savings and reducing consumption. That is to say, the demand for energy should be reduced through increased efficiency in order to adapt to a notably lower energy availability in the future, in both quantitative and qualitative terms. Our model should be based on clean energy, reducing resource extraction, land occupation, ecosystem damage and waste generation impacts as far as possible.

Ultimately, hydrogen should be seen as a transition phase on the way towards a model based on energy sovereignty, in which energy-aware individuals, communities and peoples make their own decisions about energy generation, distribution and consumption in a way which is sensitive to local ecological, social, economic and cultural circumstances and does not impact negatively on others.

1. A model tied to the minimisation of energy surpluses: which should be done through sufficient planning, prioritising a framework for a net reduction in energy consumption in the short term. This is especially important, as it turns out to be infeasible to substitute the energy consumption of sectors such as transport with hydrogen, whether green or not. In the planning process it is clear that the installation of renewables should first and foremost replace the large amount of fossil and nuclear power in the electrical system. This substitution will lead to peaks of production in very sunny or windy conditions, and so it is desirable to store this energy for use when there is no sun or wind.

2. Sensible dimensioning of the capacity to be installed. Green hydrogen technology requires the installation of renewables, probably solar and wind power, which despite having low greenhouse gas emissions do cause a series of impacts if improperly planned. We are seeing cases where these technologies are installed in unsuitable sites, causing significant impacts on local ecosystems and populations. Therefore, it is fundamental that the installations are sized in line with local needs wherever possible and that the lowest-impact options are chosen, avoiding large projects aimed at exports which constitute a significant pressure on certain places.

3. A flexible model based on a diverse range of technologies. The design of the electricity network should include a suitable energy mix, with various sources, storage systems and backups. The more diversity there is in renewable energy sources and technologies, the more resilient the system will be to future issues. The capacity to build flexible systems which do not depend on a single energy source and can be adapted to various situations is a key pillar of energy sovereignty.

A key concept to be established now is a hierarchy of management criteria, which should prioritise achieving adequate demand management and a better use of different types of energy. This would avoid mistakes like obtaining hydrogen from one single source due to the trend of building ever-larger projects or using hydrogen as long-term energy storage as it already seems evident that it is only suitable for short- or medium-term storage due to leakage.

4. Appropriate usage planning. The key blind spot of the energy transition is the need to regulate uses and technologies, which favours a capitalist productive system which seeks deregulation and the maximisation of profits. This is one of the fundamental questions in achieving true decarbonisation. We should start to apply a principle of a hierarchy of uses so that it is clear in which way to direct each sector. A good example is private vehicles (cars), a sector where we see a proliferation of all possible technologies, from batteries to hydrogen, despite the fact that we know its net energy requirements are unsustainable. It is not worth our while to continue down dead-end streets. We have to do the sums to see how much energy is available and using which technologies, adjust this mix and distribute it amongst priority uses, such as food, the production of certain goods or appropriate adaptations to climate change before sending signals to sectors like the automotive sector. This is a fact recognised by companies in the industry such as Volkswagen, which in 2019 was already demonstrating the huge energy losses in hydrogen cars compared to electric cars[62].

Therefore, we should establish a hierarchy of uses, listing in order of importance:

1. Uses of hydrogen as a material resource
2. Uses in high-temperature applications
3. Uses in sectors where there is no better alternativer
4. Backing up conventional generation
5. Others

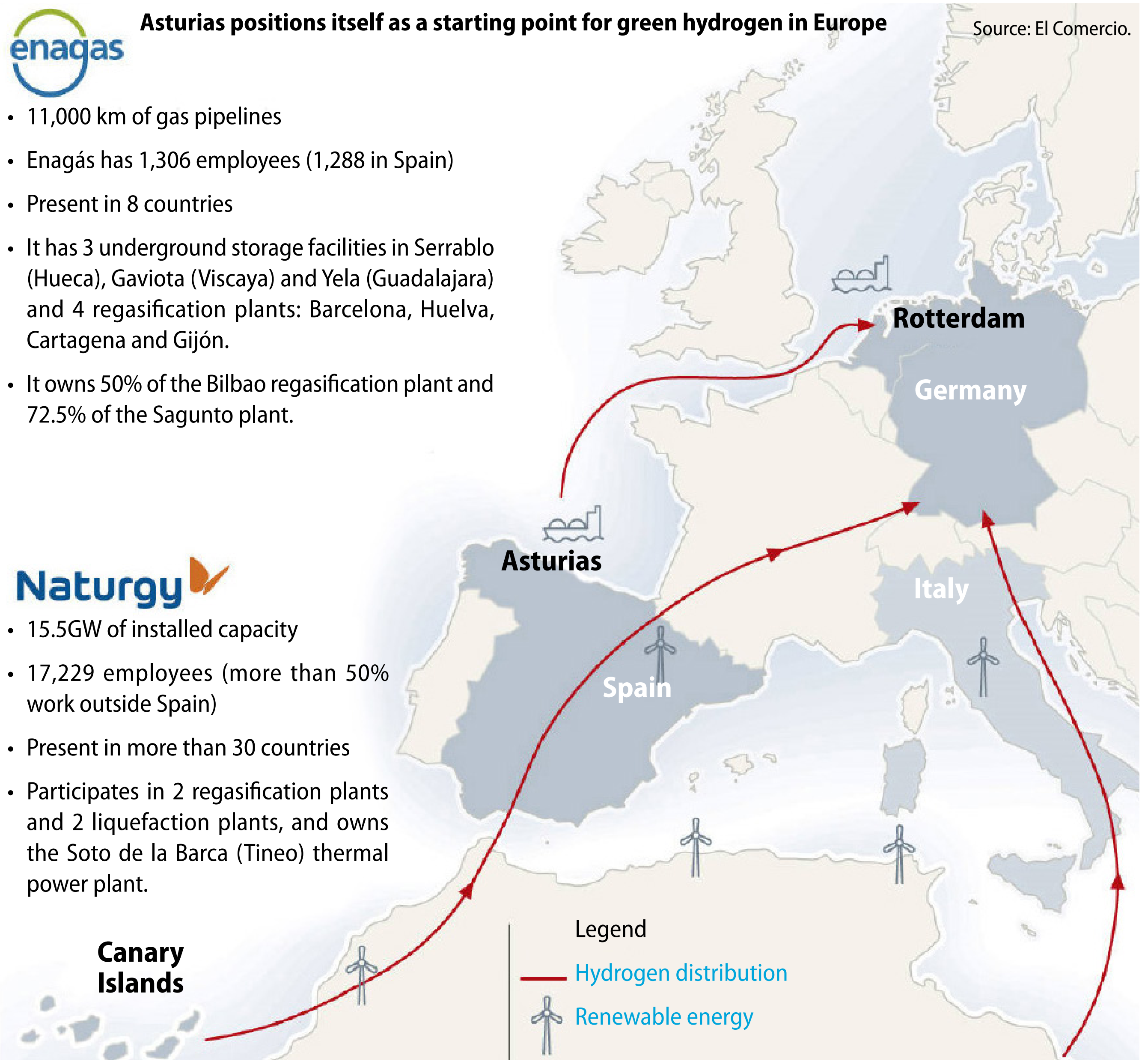
The Iberian Peninsula as a hydrogen hub

The Renewable Hydrogen Roadmap approved by the central Spanish Government in October 2020 identified an opportunity to "turn Spain into one of the European renewable energy generation powers". A few paragraphs later it indicates that this should be done through the promotion of green hydrogen, biomethane and biogas. However, more noteworthy is that it also emphasises a need to reduce national and European-level energy dependencies, which sounds very similar to the discourse used a decade ago to promote fossil natural gas.

62 https://www.volkswagenag.com/en/news/stories/2019/08/hydrogen-or-battery--that-is-the-question.html

Running along the same lines is the mission of Hydrogen for Climate Action63. Hydrogen for Climate Action is a consortium containing the Directorate-General for the Internal Market, industry, entrepreneurs and SMEs and Hydrogen Europe, which proposes projects and regulations to allow the creation of an internal hydrogen market. Enagás is part of this consortium and more specifically part of the Green Spider project64, which aims to use current gas infrastructure to develop the use of hydrogen as an energy carrier in the regions of Aragon, the Balearic Islands, the Basque Country and Castilla-la Mancha and put the El Musel regasification plant (at Gijón) into operation to transport hydrogen to central Europe. It has used the same idea in Italy through the Silver Frog65 project (which along with Green Spider forms the Green Crane project) with the objective to promote the industrialisation of central Europe.

Figure 6. The Green Crane project, comprising the Green Spider project and the Silver Frog project.



63 For more on Hydrogen for Climate Action: https://www.hydrogen4climateaction.eu/

64 For more on the Green Spider project from Hydrogen for Climate Action: https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9f24f459c7f056aca5a74f/1570710781671/4.A+Green+Spider+project.pdf

65 For more on the Silver Frog project from Hydrogen for Climate Action: https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9f252986e0ee312c638cf6/1570710833197/4.B+SilverFrog+project.pdf

The description of the Green Spider project only speaks of hydrogen production within Spain's borders, but in the corresponding image lines are shown indicating imports from North Africa. This is aligned with the European Commission's hydrogen strategy, although in the case of imports through Italy it refers to a connection which had been planned but does not currently exist, the Galsi gas pipeline.

The same has happened with the MidCat/STEP project, which would be the third gas connection between the Spanish and French states with the promotion of the European Hydrogen Backbone[66] by Gas for Climate[67]. This platform consisting of gas system operators from 21 European Union countries aims to create a network of almost 40,000 km of hydrogen pipelines by 2040, 69% of which would be repurposed natural gas pipelines. The remaining 31% would be newly constructed pipelines, reactivating old gas interconnections, as in the MidCat/STEP project.

Sectorial and cross-cutting regulatory instruments

Hydrogen is a new arrival in Spanish legislation, although it is treated as part of the so-called "alternative fuels", a mixed bag encompassing various technologies. However, with the creation of the Climate Change and Energy Transition Law (Law 7/2019) and the National Integrated Climate and Energy Plan, the gas has begun to attract legislative attention. In fact, the latter considers green hydrogen specifically in the form of various measures[68], such as the Long-term Strategy 2050, which considers renewable hydrogen as one of the main ways of decarbonising various economic sectors.

The economic crisis sparked by COVID-19 and the pandemic recovery plans have been the key drivers of the push to promote the hydrogen sector: plans which have enjoyed a marketing drive from the Ministry of the Ecological Transition and the Demographic Challenge and the Secretary of State for Energy, and from the creation of the "Hydrogen Roadmap". The Roadmap presents this energy storage technology as a panacea, which will not only reduce emissions but also solve enormous structural problems.

The government deems the technology worthy of its own section in the Recovery and Resilience Funds, in which it appears as component 9, based on the proposals compiled in the Hydrogen Roadmap. Although it is excellent to see that the Spanish strategy only considers green hydrogen (in contrast to the European strategy), it is also true that it will be very difficult to guarantee that this hydrogen is truly sustainable if it does not develop within better, more restrictive mechanisms. For example, it is imperative to develop a guarantee of origin regime which ensures that the hydrogen used complies with the European Renewables Directive. Even this directive is not as comprehensive as would be required to avoid the inclusion of raw materials with negative impacts such as some first-generation bioenergy products.

66 For more on the Hydrogen European Backbone from Gas for Climate: https://gasforclimate2050.eu/wp-content/uploads/2021/06/European-Hydrogen-Backbone_April-2021_V3.pdf

67 For more on Gas for Climate: https://gasforclimate2050.eu/

68 Specifically, measures 1.1, 1.2, 1.8, 1.18, 2.4, 3.2, 3.3 and 4.7.

Chart 4. Four Measures proposed in the Roadmap.

Measure	Evaluation
4 GW of installed electrolyser capacity in Spain in 2030.	Depends on the final use of the hydrogen produced.
Minimum 25% of total hydrogen consumption to be renewable hydrogen in 2030 in all hydrogen-consuming industries, whether as a raw material or an energy source.	As discussed, material uses for hydrogen are different to energy uses. A distinction must also be made between disappearing and transforming sectors.
5,000-7,500 light and heavy hydrogen-powered vehicles and 150-200 fuel-cell-powered buses.	Light vehicles should not be part of the hydrogen sector. The solution to transport relies on the reduction of private vehicle use.
Network of at least 100-150 public hydrogen filling stations ("hidrogeneras").	As above.
Regular use of hydrogen-powered trains on at least two commercial medium- or long-distance routes on currently non-electrified tracks.	The rail network should be electrified: powering trains with hydrogen is not the best solution.
Introduction of goods handling machinery69 using renewable hydrogen fuel cells and supply points in the five largest ports and airports by volume of goods and passengers respectively.	It is necessary to study the efficiency of electric handling machinery relative to hydrogen-powered, choosing only the best technology (in energy and environmental terms).

69 Goods handling machinery is the machinery used to manipulate, transport and store packages and goods. It is key machinery for management and logistics in large international trade ports.

Concrete project examples

The Hydrogen Valley of Catalonia

The Hydrogen Valley of Catalonia is one of the 27 flagship projects in the Next Generation Catalonia plan and aims to be an industrial hub for southern Europe with projects connected to industry, mobility, the circular economy, production and logistics, research, development and innovation and training and outreach.

It will be located in the Port of Tarragona due to its key geostrategic position and is driven by more than 100 commercial actors, including Repsol, Enagás, Naturgy, Celsa, ICL, etc., enjoying the support of several public institutions: the Generalitat de Catalunya [Catalan government], the Àrea Metropolitana de Barcelona [Metropolitan Area of Barcelona] and the Diputació de Tarragona [the Tarragona provincial council].

It is also linked to the Hydrogen for Climate Action Green Crane project, and its budget is over €6.5 billion, which may be funded with public funds through Next Generation EU and the 2021-2027 EU budget.

Endesa and its 23 hydrogen projects

Endesa was founded as the "National Electricity Limited Company" (ENDESA for the Spanish acronym). Today, its majority shareholder is the Italian public electricity company Enel. Until it began to close its coal-fired power stations it was the company which emitted the most greenhouse gases in Spain.

The projects according to the company itself[70].

"Endesa has communicated to the Ministry of the Ecological Transition its interest in developing up to 23 renewable hydrogen projects in Spain at various points in the value chain of the fuel. The associated investment rises to more than €2.9 billion to put 340 MW in electrolyser capacity into operation, powered by 2,000 MW in renewable energy.

The electrolysis projects on the Iberian Peninsula (As Pontes, Huelva, Teruel, Almería, Tarragona, Valle del Ebro, Compostilla and Seseña) involve a total investment of €2 billion for the construction of 8 electrolysers with a capacity of 315 MW.

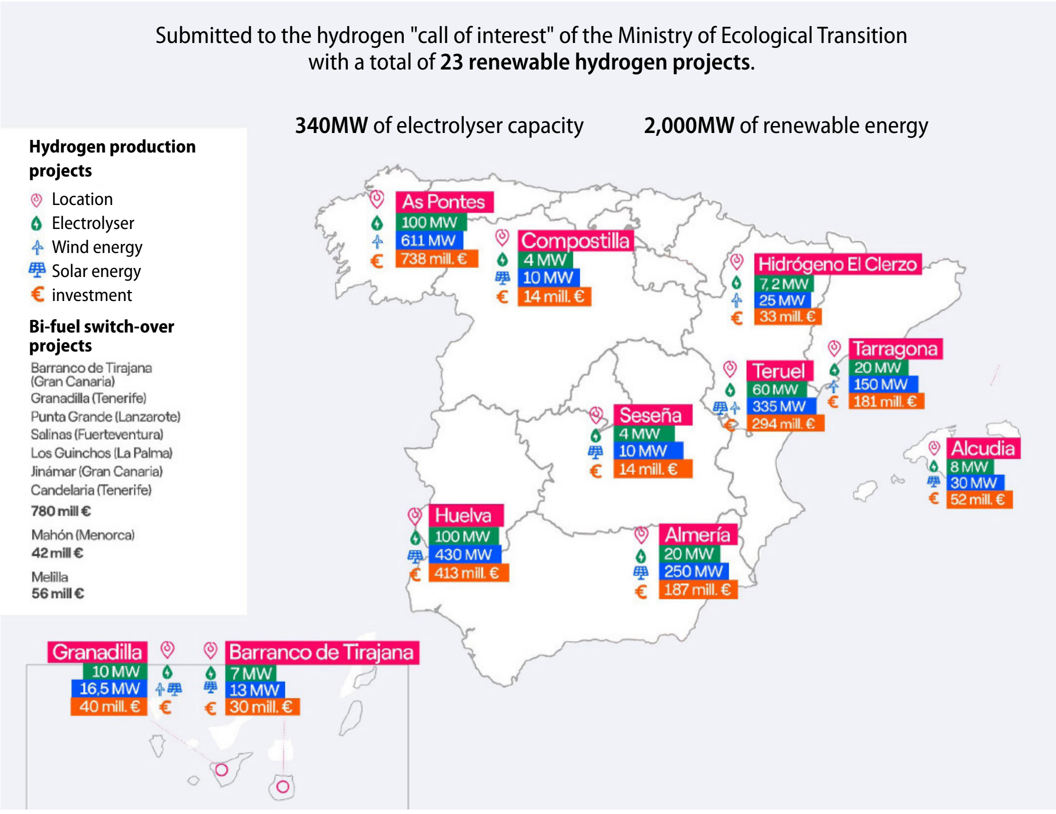
Projects outside the peninsula will absorb €900 million in investment, including options ranging from green hydrogen production in generation plants (Barranco de Tirajana, Granadilla and Alcudia, with a total electrolyser capacity of 25 MW) to the conversion of operative plants to bi-fuel operation and replacing the output of other operating plants with hydrogen or gas.

Applicable funds:

- Just Transition Funds
- Recovery and Resilience Funds (Next Generation EU)

70 https://www.endesa.com/es/prensa/sala-de-prensa/noticias/transicion-energetica/endesa-contempla-desarrollo-23-proyectos-hidrogeno-verde-espana

Figure 7. Endesa's hydrogen projects



Source: Endesa.

Basque Hydrogen Corridor

Petronor (the Basque subsidiary of Repsol) is leading the so-called Basque Hydrogen Corridor[71]. This envisions the production of 20,000 tonnes of hydrogen per year and an investment of €1.3 billion up to 2026, of which €650 million is allocated to green hydrogen. Another €250 million is for technological and industrial development along the entire supply chain and digitalisation, and €50 million is for investigating hydrogen applications in mobility, the residential sector and industry.

A consortium of 78 organisations has been formed: 8 institutions, 12 knowledge centres and businesses associations and 58 businesses. A few businesses worth mentioning from the long list are: steelmakers like ArcelorMittal; steel tube manufacturers Tubacez, Tubos Reunidos, Celsa and Sidenor; businesses from the rail industry (CAF and Talgo); mobility businesses including Siemens, Ingeteam, Irizar; shipping companies like Balearia and the shipbuilder Murueta and engineering companies like Sener and Idom.

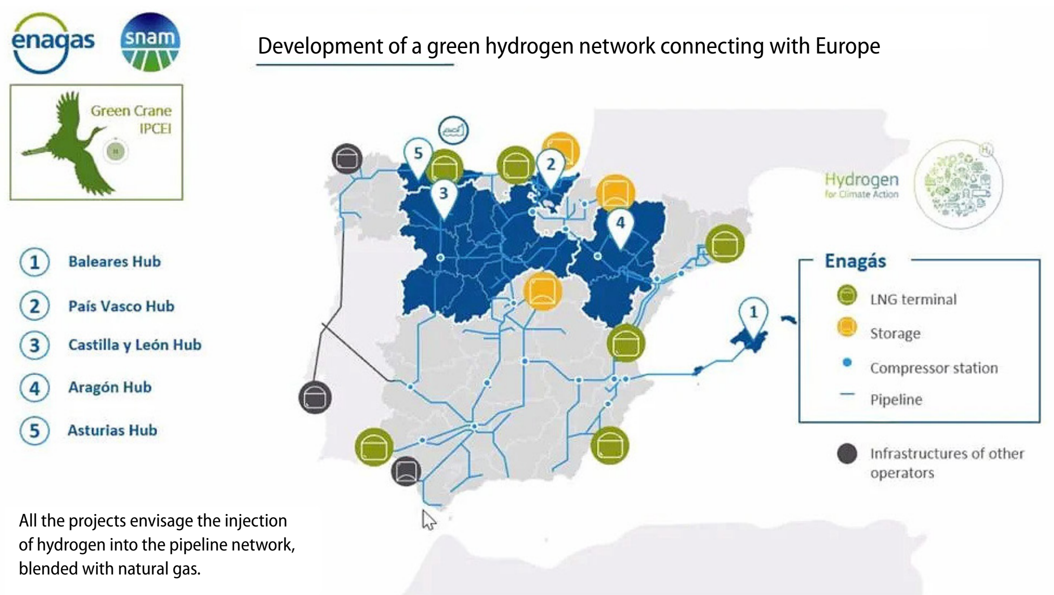
Petronor is currently consuming H_2 produced using fossil fuels to desuphurise "dirty" oil, as are some other companies participating in the consortium. However, we consider that most of the H_2 production planned would not make sense from an efficiency perspective, considering that efficiency could be less than 10%.

71 More information on the company's own webpage at: https://petronor.eus/es/2021/02/el-corredor-vasco-del-hidrogeno-implica-a-78-empresas-e-instituciones-de-la-mano-de-petronor-repsol/

El Musel-Gijón

The use of the El Musel regasification plant at Gijón, Asturias, declared illegal by several judicial verdicts, appears in several projects led by Enagás involving hydrogen exports to other countries. The most prominent is known as Green Crane[72] (in an earlier phase, before the Italian company Snam become involved, it was known as Green Spider) and aims to create a European hydrogen production and distribution network using Enagás' transport network and electrolysis plants using clean energy situated in five Autonomous Communities: Asturias, the Basque Country, Castile and León, Aragon and the Balearic Islands. This project has been submitted to the call for Important Projects of Common European Interest (IPCEIs) with the support of the Ministry of Industry.

Figure 8. Enagas and Snam hydrogen projects



In addition to this large project aimed at hydrogen export to northern Europe, Naturgy and Enagás have joined forces in another project involving the El Musel plant requiring an investment of nearly €400 million. The project envisages producing green hydrogen from a 250 MW floating marine wind farm and a 100MW land-based wind farm in Asturias for consumption by industry within the Autonomous Community itself. The initiative would allow the energy transition to advance, by favouring the decarbonisation of sectors such as steelmaking and shipbuilding, which could make sense and be extended to other sectors through the injection of renewable hydrogen into the gas network.

There are so many news items and announcements about new green hydrogen products that it becomes difficult to distinguish one from the other.

72 Information on this can be found in various places: https://www.elcomercio.es/economia/enagas-promovera-nuevo-parque-eolico-hidrogeno-musel-20210424002027-ntvo.html?ref=https%3A%2F%2Fwww.elcomercio.es%2Feconomia%2Fenagas-promovera-nuevo-parque-eolico-hidrogeno-musel-20210424002027-ntvo.html [in Spanish] Enagás presentation on the Green Crane Project: https://www.comunidad.madrid/sites/default/files/anton_martinez_-_enermadrid_2020.pdf [in Spanish]

Conclusions

Today, less than 1% of global hydrogen is produced using renewable sources. According to official data, 99% of the 130 million tonnes of hydrogen produced per year for use in industrial processes is obtained by gasification of coal, lignite or natural gas. Therefore, the reality of hydrogen today is a long way off the objectives set out for green hydrogen.

The big energy companies and fossil fuel lobbies are creating a narrative in which hydrogen plays a central role in decarbonisation and in which it is blue hydrogen which is developed at scale, due to the limitations of green hydrogen. This narrative would allow them to take on a leading role in the energy transition and take advantage of the Next Generation EU recovery and resilience funds. In the Spanish State, Iberdrola, Endesa and Naturgy have applied for almost all the subsidies granted to the Spanish State to implement its energy transition, presenting proposals for a significant part of the infrastructure required to achieve the objectives set out in the Renewable Hydrogen Roadmap 2030.

Finding green hydrogen's role in the energy transition cannot be uncoupled from the need to adequately shape an energy mix which respects the limits of the planet. This model should be based on the fundamental pillars of energy efficiency, energy saving and reduced consumption as set out in Energy Horizon 2050, reducing energy demands and adapting them to a future energy availability which will be significantly lower, both in qualitative and quantitative terms. Our model should be based on clean energy, reducing resource extraction, land occupation, ecosystem damage and waste generation impacts as far as possible.

Furthermore, the key blind spot of the energy transition is the need to regulate uses and technologies through proper planning. This is one of the fundamental questions in achieving true decarbonisation. We should start to apply a principle of a hierarchy of uses so that it is clear in which way we should direct each sector. We have to do the sums to see how much energy is available and using which technologies, adjusting this mix and distributing it amongst priority uses, such as food, the production of certain goods or appropriate adaptations to climate change. In this way we can give a realistic role to hydrogen, as although it could indeed be useful in decarbonising sectors with particular complexities or as a replacement for fossil fuel-based hydrogen, the technology involved is not free of impacts. The additional renewable energy output required, the materials used, and the trend towards large infrastructure could cause significant impacts on ecosystems and society, as is already happening in connection with the extraction of many of the minerals required.

Hydrogen is an element which will shape international relations over the years to come due to its capacity to decarbonise the economy whilst continuing under the same mantra of "growth". The countries and regions in the Global North will have the most negotiating power because they are the ones planning hydrogen's development through hydrogen strategies and roadmaps. In Europe's case, it has identified north Africa and the central and southern regions of the African continent as key regions for importing the energy carrier.

There is currently no regional or global hydrogen market, but the first pieces are being put into place, such as the creation of specific sections in the national recovery and resilience plans and the approval of programmes under the Green Deal framework. Financial actors like Goldman Sachs are starting to compile reports of the estimated values of hydrogen markets in various regions of the planet. Let us not forget that there is a conflict of interest here, because these actors are usually shareholders in the large companies which are promoting the development of this energy carrier. Green Bonds are a financial instrument which could be used to finance low-emission hydrogen projects (both green and blue) and differentiate them from projects using fossil fuels. However, the criteria used vary depending on the organisation and / or region applying them.

The free market is not the only space where commercial relationships in the energy sector can develop. Countries in various regions of the planet are currently establishing bilateral contracts. There are a range of strategies and motives, as there are exporting countries which are seeking support to develop their infrastructure whilst others are trying to maintain their current role in a future energy market. In the case of importers, the intention is to diversify supply chains, no matter which type of hydrogen is involved, or consolidate existing relationships.

The Spanish Government sees the Renewable Hydrogen Roadmap as an opportunity to reduce European and national energy dependencies, which is reminiscent of the discourse used a decade ago to promote fossil natural gas. Enagás participation in various European-level consortia and platforms has led to the consideration of repurposing some natural gas infrastructure within the Spanish State and resurrecting a controversial connection with France (the MidCat/STEP project), to create an internal hydrogen market. The Spanish State would be a transit country, as it already was for natural gas, and/or generate hydrogen for transport to countries in central Europe, who would be the main beneficiaries of the market.

Ultimately, hydrogen should be seen as a transition phase on the way towards a model based on energy sovereignty, in which energy-aware individuals, communities and peoples make their own decisions about energy generation, distribution and consumption in a way which is sensitive to local ecological, social, economic and cultural circumstances and does not impact negatively on others.

ecologistas en acción

ODG

OBSERVATORI DEL DEUTE EN LA GLOBALITZACIÓ