SPAIN

Opportunities for **Hydrogen Energy Technologies** Considering the National Energy & Climate Plans

2

Contract details
Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU)
Study on Opportunities arising from the inclusion of Hydrogen
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Introduction

The **Fuel Cells and Hydrogen Joint Undertaking** (FCH JU), in close cooperation with the **European Commission - DG Energy**, has commissioned a study on the "Role of Hydrogen in the National Energy and Climate Plans". This study is being conducted by the consultancies **Trinomics and LBST**.

This fiche represents one of the outputs of the study; it comprises two major parts:

- Analysis of **national opportunities for hydrogen deployment**, based on the national hydrogen production and demand potential, the gas infrastructure and the enabling environment. In this context, the role of hydrogen in the current National Energy and Climate Plan is in particular analysed.
- Assessment of **national economic, environmental and technical impacts of hydrogen deployment** under a high and a low scenario.

This information is expected to provide useful information to EU Member States that are considering to include renewable or low-carbon hydrogen deployment in their decarbonisation policies or roadmaps.

SPAIN

Main results and impacts of hydrogen deployment in Spain by 2030 in the two scenarios modelled in the present study

Onshore Wind
2 000 - 8 260 MW
5 540 - 22 690 GWh/a

Offshore Wind
1- 4 MW
4 - 20 GWh/a

Solar Photovoltaic
790 - 3 230 MW
1 020 - 4 170 GWh/a

Electrolysers
1 010 - 4 140 MW
4 120 - 16 860 GWh_{H2}/a

POWER
3 - 2 889 GWh/a

TRANSPORT
1 836 - 5 753 GWh/a

660 - 1 330 Buses

8 - 30 Trains

496 - 890 Refuelling Stations

31 590 - 63 290 Trucks

270 100 - 540 300 Cars

1 - 1 242 GWh/a Electricity Produced

182 - 1 729 GWh/a into Synthetic Fuels

BUILDINGS
163 - 1 630 GWh/a

7 490 - 32 580 Micro-CHP units in buildings

INDUSTRY
2 114 - 6 585 GWh/a

0 - 290 kt/a of Steel

1 900 - 2 940 GWh_{H2}/a in Refineries

0 - 12.6 kt/a of Aromatics

0 - 34.6 kt/a of Olefins

0 - 45 t/a of Methanol

0 - 20.9 kt_N/a of Ammonia

600 - 2 360 m EUR/a | **Value Added** in the domestic economy

Value Added as Share of Annual Costs

New Jobs
10 530 - 35 830

Emissions avoided
1.6 - 5.2 Mt CO_2/a

EXECUTIVE SUMMARY

Spain's commitment for hydrogen deployment according to its NECP

According to its NECP, Spain considers renewable hydrogen as a key technology to increase the production of renewable electricity and renewable gases in parallel, and to decarbonise sectors with limited low carbon solutions, like the transport and gas sectors.

Spain is in a favourable starting position for hydrogen deployment given the activities of its national Hydrogen Association, the commitment of its industry and research players, its current investments in hydrogen research and in pilot & demonstration projects, its existing gas infrastructure, and its various flagship projects like the H2Ports / Fuel Cells and Hydrogen in the port of Valencia[1] and the Hydrogen Masterplan in Aragon 2016-2020[2]. Spain is involved in the Green Spider[3], Zero-emission Urban Delivery @ Rainbow UnHycorn[4] and Blue Dolphin[5] IPCEI potential projects. Spain was also involved in the HyLaw[6] project, which identified and assessed major regulatory barriers in view of prioritizing measures to address them.
The Spanish Hydrogen Association (AeH2) has become an important actor in the hydrogen community in Spain and abroad and is expected to play an important role in this emerging industry.[7]

The Spanish NECP does not provide hydrogen targets nor specific hydrogen-related measures.

The scenario assessment shows substantial potential benefits of hydrogen deployment in Spain by 2030

Hydrogen demand

Two (high and low) scenarios of hydrogen demand in 2020-2030 were developed, based on different levels of ambition linked to the national context. The resulting values are summarised in the scheme in the previous page. For Spain, a significant development of hydrogen demand is assumed in the considered scenarios in **transport**, especially for passenger cars, buses, trucks and trains, and to a limited extent in aviation (through hydrogen-based liquid fuels or PtL) and navigation[8]. A significant development of hydrogen demand is also assumed in the scenarios in **industry**, especially in the iron and steel sector and refining. Some industries use fossil-based hydrogen as feedstock or reducing agent, which could be replaced by renewable hydrogen. Switching high temperature heat processes fuels to renewable hydrogen could represent another important potential use in the considered scenarios.

In the **building** sector, hydrogen can replace part of the current use of natural gas and can be distributed via existing gas grids through admixture to natural gas. The building sector is expected to have in the Low scenario a limited demand of hydrogen by 2030 but would have a stronger demand in the High scenario.

The scenarios assume in the Low scenario only a marginal share of electricity generation from hydrogen by 2030, coming from combined heat and power installations. This situation would change in the High scenario, where the share of hydrogen demand for power generation is substantially more important, as Spain is assumed to be one of the frontrunners in this domain.

Hydrogen production

To cover the estimated hydrogen demand from new uses and from substitution of fossil-based hydrogen, 2.8 to 11.5 GW of dedicated renewable electricity capacity would have to be installed to produce green hydrogen via electrolysis. While "surplus" electricity might be available in times of high renewable electricity production, the main share will have to be covered by dedicated sources. In the two scenarios, part of the 2030 hydrogen demand would still be covered by fossil-based hydrogen produced via steam-methane reforming using fossil fuels.

In its NECP, Spain estimates an installed capacity in 2030 of 109.5 GW in wind parks and 65.2 GW in solar PV, generating almost 87 TWh of variable renewable electricity in 2030. The technical potential for renewable electricity production in Spain seems however significantly higher[9]. Building additional renewable electricity capacity dedicated for hydrogen production thus could be a feasible scenario.

Estimated socio-economic and environmental impacts

The annual costs to produce green hydrogen (including the cost of dedicated renewable electricity sources), to develop the transport infrastructure (or adapt the existing one) and end-user applications would in the considered scenarios reach respectively 800 and 2 650 million EUR. These activities will generate value added in the domestic economy, amongst others by creating jobs in manufacturing, construction and operation of hydrogen technologies and will contribute to greenhouse gas emission reductions. This is in particular important in hard-to-decarbonize industries. According to the European EUCO3232.5 scenario[10], the Spanish GHG emissions should be reduced by 133 Mt CO_2 in 2030, compared to 2015. In the scenarios considered, the deployment of hydrogen could contribute 1.6 – 5.2 Mt CO_2 to this goal, which is equivalent to 1.2% - 4% of the required emission reduction.

1 *https://sustainableworldports.org/project/port-of-valencia-h2ports/*
2 *https://hidrogenoaragon.org/wp-content/uploads/2016/07/director_plan_2016_2020_en.pdf*
3 *https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9ee2ee0bbfa367a02565c5/1570693882860/Green+Spider+poster.pdf*
4 *https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9b5ee7f5229f74dc24aa73/1570463472420/Rainbow+Unicorn+poster_print.pdf*
5 *https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9c7b1d9ada8b5691aa0536/1570536236724/Blue+Dolphin+poster.pdf*
6 *https://www.hylaw.eu/sites/default/files/2018-10/National%20Policy%20Paper%20-%20Denmark%20%28EN%29.pdf*
7 *http://www.aeh2.org/index.php?option=com_content&view=article&id=203&Itemid=79&lang=en*
8 *Detailed assumptions are available in the methodology annex of the report, that can be consulted via the following link : http://trinomics.eu/project/opportunities-for-hydrogen-in-necps.*
9 *The technical potential for renewable electricity production is based on the study commissioned by DG ENER Impact of the use of the biomethane and hydrogen potential on trans-European infrastructure (Trinomics, LBST, E3M; 2019).*
10 *EC, 2019. Technical Note on Results of the EUCO3232.5 scenario on Member States. Available at https://ec.europa.eu/energy/sites/ener/files/technical_note_on_the_euco3232_final_14062019.pdf*

HYDROGEN IN THE NECP OF SPAIN

According to its NECP, Spain considers renewable hydrogen as a key technology to increase the production of renewable electricity and gas in parallel, and to decarbonise its energy supply. The NECP is also referring to the climate change impact, as electrolysis is using much water, while this is becoming a scarce good in Spain.

To reach its greenhouse gas (GHG) emissions reduction target in the non-ETS sectors (23% in 2030 compared to 1990), Spain considers the production of green hydrogen as one of the four policy measures to decarbonise the transport sector, next to modal shift in the transport system, advanced biofuels and electro-mobility. The uptake of hydrogen driven vehicles will contribute to increasing the penetration of renewable energy in the transport sector. An adequate framework is needed to guide the deployment and use of a hydrogen refuelling stations infrastructure, including the dissemination of information regarding the fuel cost and the stations' locations.

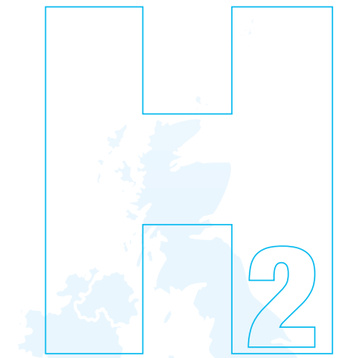
According to its NECP, Spain considers the availability of electricity output when supply exceeds demand as an opportunity to deploy a renewable hydrogen market. The NECP also refers to the possibility to increase significantly the production of renewable electricity at low cost and to use power-to-hydrogen to provide the required flexibility to the electricity system, while also avoiding curtailments of renewable electricity plants that are currently occurring rather frequently in Spain. The produced renewable hydrogen could either be stored, or injected into the natural gas or dedicated hydrogen network, or be transported via other means (e.g. trucks) to consumers. The gas infrastructure in Spain will continue to play an important role to facilitate the integration of renewable electricity through power-to-gas and to enable the development, transport and storage of renewable gases such as biomethane and hydrogen.

According to Spain's NECP, the expected reduction in the cost of electrolysis technology, in addition to the cost decrease of renewable electricity, will allow to generate renewable hydrogen at a competitive cost and hence spur its market uptake. Spain considers that the deployment of renewable hydrogen as energy carrier and flexible vector could become relevant in the medium to long term, also in view of facilitating the deployment of other renewable energy vectors.

In its NECP, Spain identified several barriers to the deployment of renewable hydrogen and other renewable gases, and intends to adopt a specific renewable hydrogen plan to address these barriers, to develop targeted R&D&I activities and to promote the uptake of renewable hydrogen.

According to its NECP, Spain intends to convert existing LNG storage capacity into an EU physical hub for natural and renewable gases, including hydrogen.

According to Spain's NECP, 15 hydrogen projects were financed in the frame of the Energy Research & Innovation programme (2014-2016) for a total budget of 1,9 Million EUR.



OPPORTUNITY ASSESSMENT

Hydrogen production potential & its role in energy system flexibility

The technical variable renewable electricity production potential in Spain is more than ten times higher than the expected electricity demand in 2030, which, according to the assessment, creates a significant opportunity to use this renewable electricity potential to produce hydrogen via electrolysis. According to the NECP, Spain would by 2030 only use 5% of its technical potential in renewable electricity generation, so there is a great margin for building up additional dedicated renewable electricity sources for hydrogen production.

There is also an opportunity to use power-to-hydrogen conversion as a flexibility provider, as the Spanish electricity system is forecasted to have in 2030 higher installed capacity of variable renewable electricity generation than its average load. This opportunity is however limited by a significant capacity of pumped-storage hydroelectricity, but also positively affected by the fact that the electricity interconnection level of Spain is expected to remain limited, especially when compared to the installed variable renewable electricity generation capacity and its geographical position on the periphery of the European energy market.

Technical variable renewable electricity potential (TWh/yr)	Technical renewable electricity generation potential compared to forecasted gross electricity consumption in 2030 (NECP)	NECP estimate of variable renewable electricity production in 2030 (TWh/yr)	NECP estimate of variable renewable electricity production in 2030 compared to its technical potential	Ratio between variable power generation capacity in 2030 and average load	Readiness for CO_2 storage
3 264	1 241%	174.64	5%	based on NECP 299%	Low

Spain has limited readiness for wide-scale deployment of low-carbon hydrogen generation using fossil fuels coupled with CCS. Even though there are plans in place to use CCS technologies and some research projects are under way, there is only limited indication of progress towards using captured CO_2 in industrial processes and/or utilizing the potential storage capacities.

Energy infrastructure

Spain can consider using its existing methane infrastructure for hydrogen transport and distribution, by blending hydrogen in the public grid in the short (2025-2030) and medium term (2030-2040) and potentially converting (part of) its network to hydrogen in the long term (>2040). As the share of polyethylene in the distribution network is relatively high, it could be converted to hydrogen at relatively low cost. However, conversion of the network to dedicated hydrogen pipelines would be a longer-term consideration, as the hydrogen production volumes are expected to be relatively low until 2030 (as mentioned in section 1). In the short and medium term, hydrogen could hence be blended with methane in the existing grid, without the need for physical adjustments to the transport and end-use infrastructure.

Technical and economic feasibility of converting gas distribution networks to hydrogen (share of polyethylene pipelines in distribution grid)	Natural gas demand in residential and services sectors / length of gas distribution network (GWh/km)	Existing salt cavern natural gas storage sites (TWh)	Suitable geological formations (potential for future hydrogen storage)
84%	N.A.	0	YES
MS range 16%-99%			

Spain currently operates 2 underground gas storage facilities for natural gas, and several are under development.[11]

There are also important underground salt layers that could provide additional underground gas storage opportunities. The availability of suitable formations to develop storage sites for seasonal hydrogen storage represents an opportunity for Spain and offers it a competitive advantage compared to other Member States.

[11] *https://www.enagas.es/stfls/EnagasImport/Ficheros/513/97/Folleto%20Yela%20-%20Ingl%C3%A9s.pdf*

Current and potential gas & hydrogen demand

In Spain, substantial opportunities for the deployment of hydrogen seem to exist across sectors. In industry, the deployment of renewable or low-carbon hydrogen in ammonia production and refineries can help to reduce the GHG emissions associated with existing hydrogen use and in the medium to long term it can replace conventional fossil-based production processes in steel industry. More generally, hydrogen deployment can contribute to the decarbonisation of the gas supply in industry and act as a low-emission solution for the provision of high-temperature process heat. In the built environment, hydrogen provides the opportunity to (partially) replace the existing natural gas use, which is the dominant fuel for heating, meaning that hydrogen could potentially make a significant contribution to GHG emissions reduction in this sector. Similarly, hydrogen is one of the solutions to replace the remaining oil-based heating systems. Lastly, there are opportunities to deploy hydrogen for a range of applications in the transport sector. Together with electrification hydrogen is one of the promising solutions for the decarbonisation of road and rail transport. On the medium to long term, hydrogen and derived fuels can also be used to decarbonise shipping and aviation.

Opportunities for hydrogen demand in industry

Spain seems to have significant potential for hydrogen use in industry. First of all, the country has ammonia industry and refineries, both of which currently use fossil-derived hydrogen. Spanish refineries represent 11% of the total refinery capacity in the EU, whereas ammonia represents 3% of the total production capacity. Replacement of the existing use of fossil derived hydrogen in this sector with renewable or low-carbon hydrogen represents an opportunity for these industries to reduce their GHG emissions. Apart from this, Spain is responsible for 5% of the primary steel production in the EU, which is currently still done via the conventional fossil-based route, which can (eventually) be replaced by a hydrogen-based process producing direct reduction iron. Next to this, natural gas accounts for more than a third of industrial energy demand in Spain and this natural gas can be replaced relatively easily with renewable or low-carbon hydrogen. Lastly, 45% of the energy demand in industry is used to generate heat for high-temperature processes. Hydrogen is one of the few low-emission energy carriers that is well-suited for this purpose.

	Presence of ammonia industry / share of ammonia production capacity in EU28 total	Presence of refineries / Share of Spanish refineries in total captive hydrogen production by refineries in the EU28	Share of Spain in total primary steel production in the EU28	Share of natural gas in industrial energy demand (2017)	Share of high-temperature (>200°C) process heat in industrial energy demand (2015)
Spain	3%	10.5%	5%	36%	45%
EU	MS range 0%-16%	MS range 0%-26%	MS range 0%-30%	Average 32% MS range 0%-43%	Average 38% MS range 9%-60%

Opportunities for hydrogen demand for heating and cooling in the built environment

In Spain, 56% of the energy demand in the built environment is used for heating purposes and two thirds of this demand is fulfilled with the combustion of fossil fuels. Natural gas accounts for almost 40% of the energy demand for heating and oil for more than 25%. On the short to medium term, hydrogen is one of the solutions that can be deployed to replace the current natural gas use. On the medium to long term, it could also be deployed to decarbonise the part of the heating demand that is currently satisfied by oil combustion. Lastly, a significant amount of energy in the built environment in Spain is used for cooling purposes. On the long term, hydrogen-based solutions might complement electric cooling systems.

	Share of natural gas in the household and service sector energy demand (2017)	Share of heating in the household and service sector energy demand (2015)	Share of cooling in the household and service sector energy demand (2015)
Spain	24%	56%	8%
EU	Average: 34% MS range: 0% - 60%	Average: 74% MS range: 41% - 82%	Average: 3% MS range: 0% - 46%

Opportunities for hydrogen demand in transport

In Spain, the opportunities for the deployment of renewable or low-carbon hydrogen in the transport sector seem to be considerable. Like in most EU countries, road transport is still largely dependent on fossil fuels. Together with electrification, hydrogen can contribute to the decarbonisation of the energy use in this sector, especially in heavy-duty transport, which is responsible for 37% of the energy use in road transport. Together with electrification, hydrogen can play a role in the decarbonisation of passenger car transport, where fuel cell electric vehicles will be especially useful because of their large driving range compared to battery electric vehicles and because they represent a suitable solution to decarbonise the segment of large passenger cars. The rail sector in Spain is largely electrified, but diesel trains still account for 20% of the energy use in rail transport. Hydrogen trains are one of the low-carbon solutions that can replace the use of diesel trains. The energy use of the aviation sector in Spain is equivalent to 16% of the total domestic energy use in transport and hydrogen and derived fuels represent one of the few solutions that can decarbonise this sector. The same holds for the decarbonisation of domestic and international shipping, where the latter accounts for an equivalent of more than 20% of the total energy use for domestic transport. Although international aviation and shipping are currently not yet covered by European or international climate legislation, EU countries need to make a collective effort to support the decarbonisation of these sectors.

	Share of heavy transport (trucks, buses & vans) in total energy demand in road transport in 2020	Share of fossil fuels in energy use of rail transport (and absolute consumption) in 2017	Share of inland shipping in overall energy demand for transport in 2017	Energy use by international shipping relative to total (domestic) final energy use in transport in 2017	Share of domestic and international aviation in overall energy demand for transport (incl. energy use int. aviation) in 2017	Share of fossil fuels in energy use of road transport in 2017
Spain	37% (112 555 GWh)	20% (920 GWh)	3.0% (11 135 GWh)	21.1% (77 700 GWh)	16% (64 410 GWh)	97% (313 719 GWh)
EU	Average 32% MS range 18%-48%	Average 30% MS range 0%-95%	Average 1.5% MS range 0%-9.8%	Average 14% MS range 0%-1011%	Average 14% MS range 1%-25%	Average 95% MS range 79%-100%

Enabling environment: national hydrogen policies and plans, projects and industry

The assessment shows that Spain is in a favourable position for the deployment of green hydrogen in the current decade and beyond. Spain has included hydrogen in a broad way in its NECP, referring to its use in the transport sector, as a flexibility provider in the energy system and as an energy carrier that can be used for seasonal energy storage. The current and planned policies, along with the efforts in RD&D investments and other hydrogen-related projects, provide an enabling framework to support and develop renewable hydrogen as a cross-sector decarbonisation solution. Taking into account its important potential for hydrogen deployment using renewable electricity, it would be appropriate that Spain considers hydrogen in a comprehensive way within its energy and climate policy to address the decarbonisation challenges in all energy end-use sectors, considering the initiatives and policies at EU level. The national association for hydrogen and the Spanish Technological Platform for Hydrogen and Fuel Cells (PTE-HPC) can provide support for such an exercise. According to its NECP, Spain will provide further support to dedicated hydrogen related research and facilitate the implementation of pilot and demonstration projects, which can contribute to paving the way for the use of renewable hydrogen as a means to achieve deep decarbonisation.

Existence of (or concrete plans for) national hydrogen roadmaps or strategies — Positive environment ✗

According to its NECP, Spain recognises the interest to develop a specific plan for the deployment of hydrogen.

GHG mitigation gap in non-ETS sectors (need for additional GHG reduction measures) — Positive environment

Spain plans to overachieve its non-ETS GHG reduction target by 12 percentage points. From this perspective, the incentive to implement additional measures based on the deployment of hydrogen would remain limited.

Existence of (active) hydrogen national association — Positive environment ✓

Current and planned hydrogen refuelling infrastructure for the transport sector

Alternative fuels infrastructure directive (2014/94/EU)

In its National Policy Framework (or NPF set in the context of the alternative fuel infrastructure directive (2014/94/EU)) Spain planned the deployment of 20 publicly accessible hydrogen refuelling points and 500 hydrogen fuel cell vehicles by 2020.

Inclusion of hydrogen in national plans for the deployment of alternative fuels infrastructure (2014/94/EU)	Existence of hydrogen refuelling stations (2019)	which is equivalent to 1 refuelling station per … cars	
YES	6	3 916 734	
	Total 156	Average 1 677 543	

Existence of (investment on) hydrogen-related projects

There were in 2019 6 refuelling stations operational in Spain. There was also one industrial project in operation and another one under construction, meaning that Spain is effectively acquiring experience in the production, delivery and use of hydrogen.

Existing R&D and pilot projects directly related to hydrogen	RD&D annual expenditure on hydrogen & fuel cells (m EUR) (average 2013-2017)	Activities and projects in industry to use hydrogen as feedstock	Number of power-to-gas projects (existing and planned)
NO	3.1	NO	2

Existence of national tax incentives (CO_2 pricing mechanisms & car taxation)

Spain has set up a CO_2 pricing mechanism in 2014 and introduced a carbon related taxation for vehicles; both measures are key to support the progressive shift to low carbon vehicles (including on hydrogen).

Positive environment

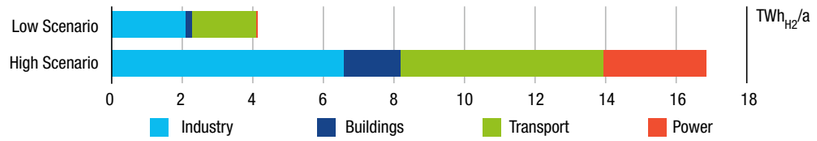
Fossil energy import dependence and bill

Like many EU Member States, Spain is strongly dependent on imports for its natural gas as well as its oil consumption. Switching from fossil fuel to nationally produced hydrogen for industrial processes, heating and transport applications will contribute to reducing the energy import dependence and bill.

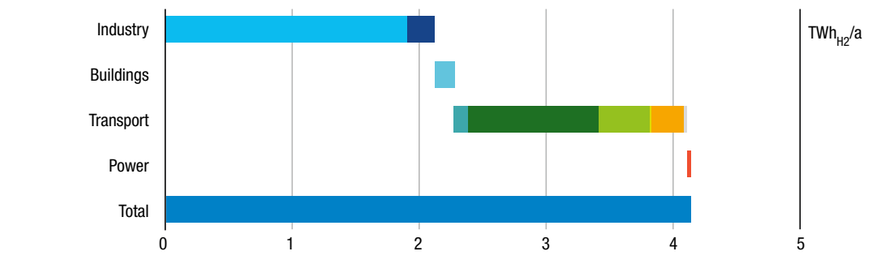
	Import bill for natural gas as share of national Gross Value Added	Import bill for all fossil fuels
	0.6%	**1.9%**
	Average: **0.6%** MS range: 0% - 1.5%	Average: **2%** MS range: 0% - 7%

SCENARIO ASSESSMENT
Estimated renewable/low carbon hydrogen demand for Spain by 2030

Hydrogen demand in the year 2030 has been estimated in a low and a high scenario covering the range of uncertainty. Today, conventional hydrogen mainly used in industry is produced from fossil fuels (e.g. through steam methane reforming) or is a by-product from other chemical processes. Both scenarios assume that in 2030 renewable hydrogen will be provided to partially substitute current conventional production and to cover additional demand (e.g. from transport sector).

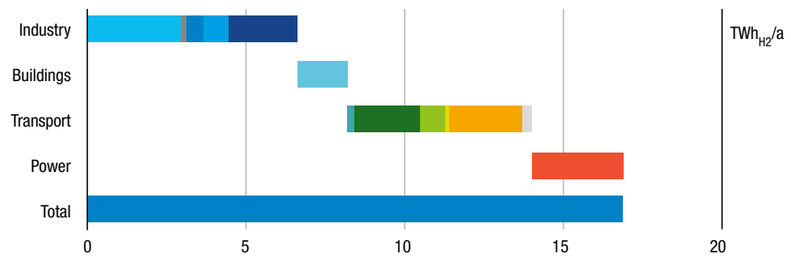


Low scenario



In the low scenario, renewable hydrogen accounts for 0.5% of final total energy demand (i.e. 4.1 out of 868 TWh/a) or 3.4% of final gas demand (120 TWh/a) according to EUCO3232.5.

High scenario

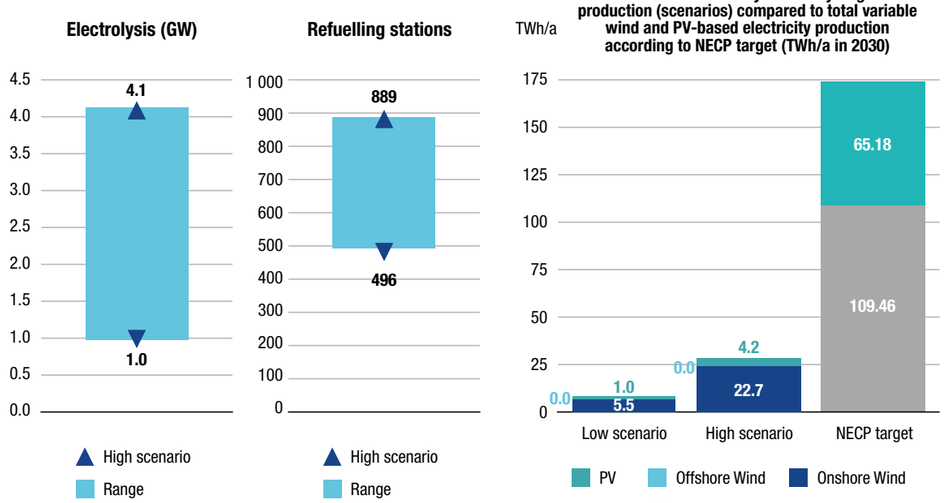


In the high scenario, renewable hydrogen accounts for 1.9% of final total energy demand (i.e. 16.9 out of 868 TWh/a) or 14.0% of final gas demand (120 TWh/a) according to EUCO3232.5.

Hydrogen generation, infrastructure and end users in Spain by 2030

The analysis of renewable hydrogen generation, infrastructure and end use is based on the demand estimates presented above. Renewable hydrogen is generated from variable renewable power using electrolysis.

Renewable hydrogen generation and infrastructure



The required renewable power production accounts for 0.4% of the overall technical renewable power potential in the low scenario and for 1.6% in the high scenario.

End users

End user	Unit	Low scenario	High scenario
Passenger cars	Nº	270 100	540 300
Buses	Nº	660	1 330
Lorries	Nº	30 300	60 700
Heavy duty vehicles	Nº	1 290	2 590
Trains	Nº	8	30
Substituted fuel in aviation	GWh/a	162	1 538
Substituted fuel in navigation	GWh/a	20.1	191.1
Micro CHP	Nº	7 490	32 580
Large CHP	Nº	0	0
Iron&Steel	% of prod.	0%	2%
Methanol	% of prod.	0%	5%
Ammonia	% of prod.	0%	5%

According to the estimations, the hydrogen refuelling station network will by 2030 encompass between 500-890 stations for 302 000-605 000 fuel cell vehicles on the road.

In addition, the analysis estimates substitution of up to 2% of the conventional steel production by renewable hydrogen-based steelmaking.

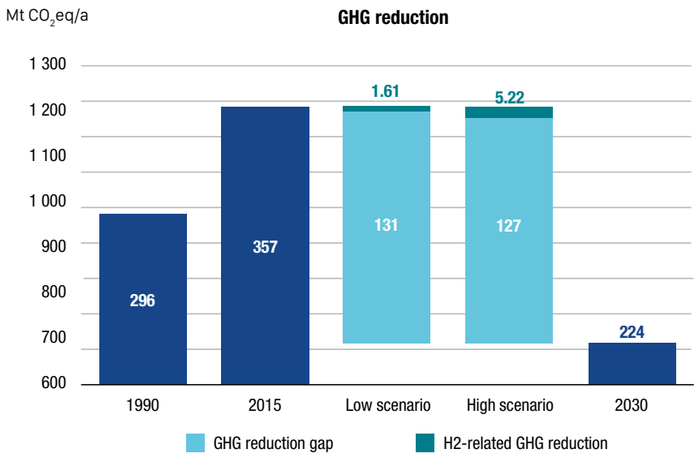
Futher use of renewable hydrogen is foreseen in ammonia production (up to 5%).

Finally, the introduction of 7 490-32 580 stationary fuel cells for combined power and heat production is estimated.

Environmental and financial impact in Spain by 2030

Greenhouse gas (GHG) emission reductions were calculated by estimating the fuels replaced by hydrogen, and their respective greenhouse gas footprint. Comparing these to the 2030 GHG reduction targets results in the contribution of hydrogen to achieving these targets.

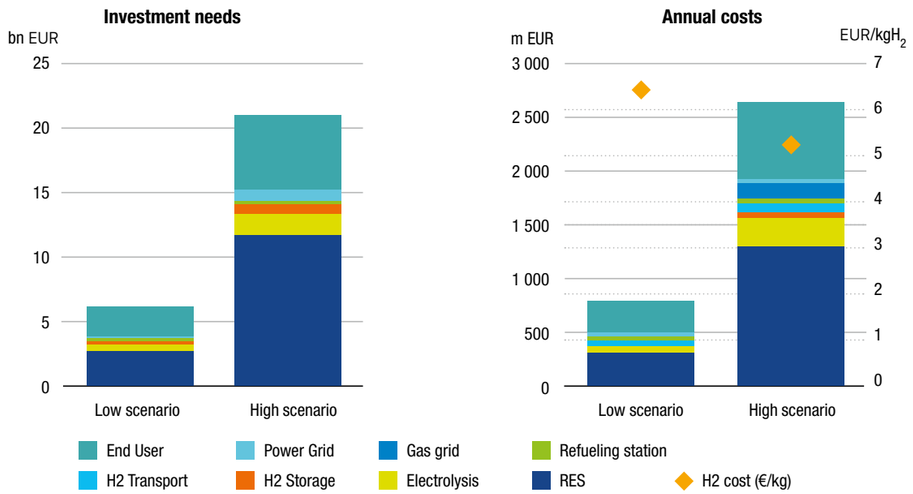
Environmental impact



An additional GHG emission reduction of 1.6-5.2 Mt CO_2 is estimated in 2030 corresponding to 1.2%-3.9% of the overall GHG emission reduction gap towards 2030 target (based on EUCO3232.5).

Financial impact

The financial scenario assessment includes investments (CAPEX) until 2030 and operating expenses (OPEX) per year in 2030. Cumulative investments in hydrogen technologies are estimated at 6.2-21.0 billion EUR until 2030, while annual expenditure would amount to 800-2 650 million EUR (including end user appliances as well as power and gas grids).

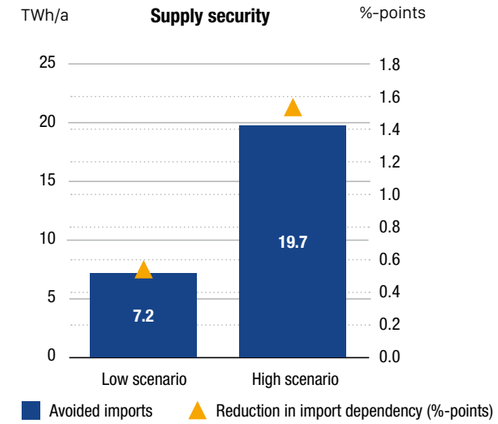


Impact on security of supply, jobs and economy in Spain by 2030

Hydrogen contributes to the energy supply security objective by reducing fossil energy import dependence and enhances energy supply diversification by facilitating deployment of renewable energy sources. This is assessed by estimating imported fossil fuels that will be replaced by hydrogen based on domestic renewable sources.

Security of energy supply

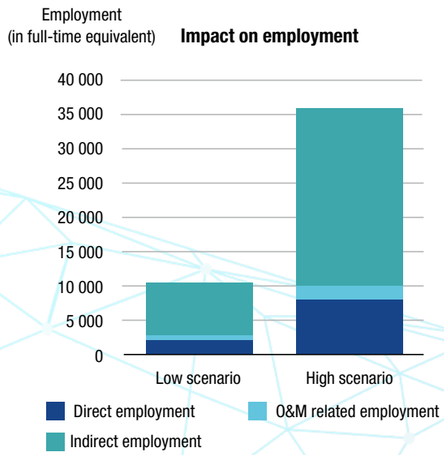
Deployment of renewable hydrogen would lead to 7.2-19.7 TWh/a of avoided imports, and thus reduce import dependency by 0.6-1.5% (in volume terms) in 2030, depending on the scenario.

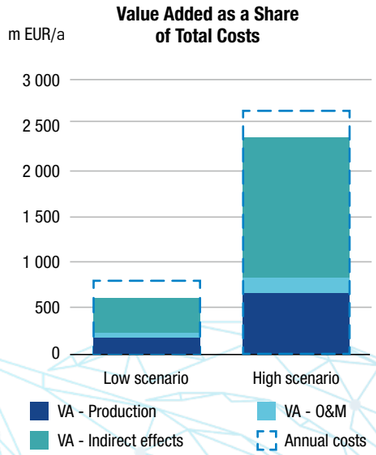


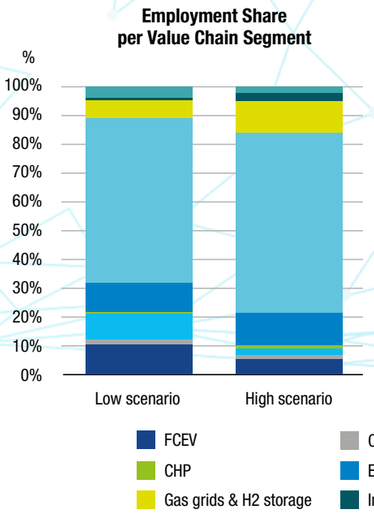
Impact on employment and value added

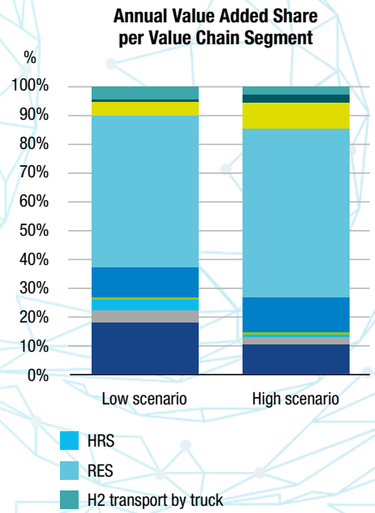
This analysis shows that in the years 2020-2030 around 230 million EUR can be retained annually in the domestic economy as value added in the low scenario, and almost 830 million EUR in the high scenario (value added is defined here as sum of wages for employees, margins for companies and taxes). If the indirect effects induced by the investment in and operation of hydrogen technologies are also taken into account, around 600 million EUR (low scenario) and over 2 350 million EUR (high scenario) of value added can be created in the Spanish economy annually, which is almost equivalent to the amount of annual investment needed. Most of this value added is expected to be created by building and operating dedicated renewable electricity sources and electrolysers for hydrogen production, and in the automotive industry.

The hydrogen-related expenditures in 2020-2030 are estimated to generate employment of 2 740 – 10 200 direct jobs (in production and operations & maintenance) and contribute to a further 7 780 – 25 600 indirectly related jobs, depending on the scenario. Most of these jobs are expected to be created by building and operating renewable electricity sources, electrolysers and hydrogen transport infrastructure.









SPAIN

Opportunities arising from the inclusion of **Hydrogen Energy Technologies** in the National Energy & Climate Plans

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

2