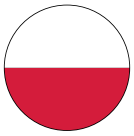

POLAND

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
Energy Technologies in the National Energy & Climate Plans
(Ref. FCH / OP / Contract 234)
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This report is based on data available up to April 2020. The information and views set out in this fiche are those of the author(s) and do not necessarily reflect the official opinion of the FCH 2 JU. The FCH 2 JU does not guarantee the accuracy of the data included. Neither the FCH 2 JU nor any person acting on the FCH 2 JU's behalf may be held responsible for the use which may be made of the information contained therein.

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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.

POLAND

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

Onshore Wind
1 130 - 2 940 MW
2 840 - 7 390 GWh/a

Offshore Wind
25 - 65 MW
100 - 250 GWh/a

Solar Photovoltaic
520 - 1 350 MW
500 - 1 300 GWh/a

Electrolysers
670 - 1 750 MW
2 150 - 5 610 GWh_{H2}/a

POWER
1 - 9 GWh/a

TRANSPORT
434 - 1 152 GWh/a

BUILDINGS
48 - 480 GWh/a

INDUSTRY
1 670 - 3 973 GWh/a

630 - 1 260 Buses

10 - 40 Trains

150 - 291 Refuelling Stations

12 140 - 24 280 Trucks

70 200 - 140 500 Cars

390 - 3 900 MWh_{H2}/a Electricity Produced

21 - 196 GWh/a into Synthetic Fuels

0 - 100 kt/a of Steel

2 200 - 9 560 Micro-CHP units in buildings

0 - 10 Commercial-scale CHP installations

1 630 - 2 130 GWh_{H2}/a in Refineries

0 - 9.1 kt/a of Aromatics

0 - 13.6 kt/a of Olefins

0 - 113.7 kt_N/a of Ammonia

340 - 870 m EUR/a

Value Added in the domestic economy

Value Added as Share of Annual Costs

New Jobs
3 600 - 8 610

Emissions avoided
0.7 - 1.8 Mt CO_2/a

EXECUTIVE SUMMARY

Poland's commitment for hydrogen deployment according to its NECP

According to its NECP, Poland is preparing a Hydrogen Technology Development Programme with the aim to deploy hydrogen applications in the power, transport and gas sectors while reducing the use of conventional fossil fuels. The programme addresses hydrogen generation, transport, storage, distribution and end-use. Hydrogen will be produced from electricity through electrolysis and from coal gasification. A hydrogen economy in Poland would increase the competitiveness of its energy companies, increase the security of energy supply and provide benefits to the Polish economy.

Poland has an enabling environment to facilitate the deployment of hydrogen, given the Polish Hydrogen and Fuel Cell Association active since 2004[1] and the Polish Hydrogen and Fuel Cell Technology Platform active since 2005[2], its commitment to decarbonise the transport sector and reduce the use of fossil fuels, the 10-years Low-Emission Transport Fund, the commitment of some oil companies to support the hydrogen deployment (like PGNiG planning to generate renewable hydrogen), its increasing share of variable electricity generation, its various activities in Research and Development, the recently planned demonstration projects, and its involvement in the Black Horse[3] project and its intention to be involved in the extension of the H2GO[4] potential IPCEI projects. Poland was also involved in the **HyLaw**[4] project, that identified and assessed major regulatory barriers, in view of prioritizing measures to address them.

Poland's NECP does not include specific objectives or targets for the production or use of hydrogen.

The scenario assessment shows substantial potential benefits of hydrogen deployment in Poland 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 Poland, a limited development of hydrogen demand is assumed in **transport**, especially for buses, trucks and trains, and also in aviation (through hydrogen-based liquid fuels or PtL) and navigation[5]. A moderate development of hydrogen demand is also assumed in the considered scenarios in **industry**, especially in refining and in ammonia production. 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 only a marginal share of electricity generation from hydrogen by 2030, coming from combined heat and power installations.

Hydrogen production

To cover the estimated hydrogen demand from new uses and from substitution of fossil-based hydrogen, 1.7 to 4.4 GW of dedicated renewable electricity sources 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 of fossil fuels.

In its NECP, Poland estimates an installed capacity in 2030 of 13.41 GW in wind and 7.27 GW in solar PV, generating over 45 TWh of renewable electricity in 2030. The technical potential for renewable electricity production in Poland seems however significantly higher[6]. 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 380 and 950 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[7], the Polish GHG emissions should be reduced by 99 Mt CO_2 in 2030, compared to 2015. In the scenarios considered, the deployment of hydrogen could contribute 0.7 – 1.8 Mt CO_2 to this goal, which is equivalent to 0.7% - 1.8% of the required emission reduction.

[1] *http://www.hydrogen.edu.pl/index_en.php?kat=en_onas*
[2] *http://en.www.ichp.pl/polish-hydrogen-and-fuel-cell-technology-platform-*
[3] *https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9b5b85f5229f74dc24608b/1570462602872/Black+Horse+poster_print.pdf*
[4] *https://www.hylaw.eu/sites/default/files/2018-10/National%20Policy%20Paper%20-%20Denmark%20%28EN%29.pdf*
[5] *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.*
[6] *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).*
[7] *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 POLAND

According to its NECP, Poland is preparing a Hydrogen Technology Development Programme with the aim to deploy hydrogen applications in the power, transport and gas sectors while reducing the use of conventional fossil fuels. The programme addresses hydrogen generation, transport, storage, distribution and end-use, taking into account the EU and Polish legal context. Owing to its properties, hydrogen can become an important area of development for the Polish economy. The Programme considers all potential hydrogen uses, from large scale plants to residential units, and the deployment of hydrogen would serve three main purposes: increase the competitiveness of energy companies; increase security of energy supply and provide benefit to the Polish economy in the frame of the energy transition. Hydrogen produced from electricity can be: injected into the natural gas network; combined with carbon dioxide to produce synthetic methane; used to improve the biogas quality. Poland explores the production of hydrogen-based liquid fuels (P2L), facilitating energy transport and storage. Poland also considers the use of fuel cells for prosumer power generation, either grid-connected or operating in island mode.

The share of renewable electricity in the total electricity consumption will increase from the current 14% to 32% by 2030. Gas-based power generation capacities will be developed to backup variable generation. These back-up plants will be supplied by imported gas and by domestic resources, among which hydrogen. Energy storage capacities will also be developed, especially to store renewable energy.

Poland acknowledges that the development of Power-to-Gas would contribute to:

- prevent electricity network congestion caused by “excess” electricity supply from variable (renewable) generation
- optimise the use of the gas network by blending hydrogen into the grid
- integrate the electricity and gas systems

However, these integrated applications are still at an early stage of market deployment. Poland plans to promote such demonstration projects, which are however not yet competitive and would hence require public support.

According to its NECP, Poland will promote the use of alternative fuels in transport, including hydrogen, starting with the Act on “electromobility and alternative fuels”. Poland plans to decrease its dependency on oil imports through the increasing use of cars powered by alternative fuels and the deployment of the required infrastructure. While electromobility highly reduces carbon emissions, additional efforts are needed to fully decarbonise the transport sector, like the promotion of other zero-emission vehicles, including hydrogen-powered ones. Hydrogen would also be considered to decarbonise the railway, aviation and maritime sectors.

Among the policies and measures to achieve a low-emission mobility, Poland foresees to promote environmental friendly transport means like the use by municipalities of fuel cell vehicles and the deployment of hydrogen refuelling stations in densely populated areas and along TEN-T corridors, if considered cost effective.

The Low-Emission Transport Fund aims to support the deployment of alternative fuels infrastructure and to start their market deployment. Poland has set up a Fund for the period 2018-2027, which supports amongst others investments to : produce renewable fuels; deploy infrastructure for the distribution and delivery of hydrogen; manufacture transport equipment related to the hydrogen value chain;; purchase vehicles and vessels powered by hydrogen.

Poland foresees to use its geological salt cavern formations as underground gas storage facilities to store hydrogen generated from Power-to-Gas installations.

According to its NECP, Poland plans to increase its energy and climate R&D budget (from 0.75% of the GDP in 2011 to 1.7% in 2020 and 2.5% in 2030) and to further cooperate with the European Institutions and other EU Member States regarding the Strategic Energy Technology (SET) Plan. One of the main research goals will be to determine the potential for production, use and development of hydrogen technologies in Poland.

Poland considers hydrogen as a key domain to explore in the frame of its RD&I activities aiming to support investments in hydrogen-related generation assets, in storage and delivery infrastructure, in end-use applications, and in developing material for energy storage (e.g. carbon cells and nanostructures).

Poland is a major beneficiary of the Modernisation Fund[8], and considers that this funding should be allocated to investments in line with the climate policy, in order to support the implementation of the NECP’s measures, among which hydrogen and fuel cell-related investments.

According to its NECP, Poland will support national research on clean coal technologies (CCT), including the production of hydrogen from coal gasification, to generate electricity using innovative IGCC (integrated Gasification Combined Cycle), or to use it in fuel cells.

In its scenario assessment, Poland recognises that additional measures might be necessary to deploy hydrogen refuelling stations and to foster the use of hydrogen powered cars. The NECP also highlights that the power system is facing increasing risks due to the increasing generation of variable electricity, and that more attention is needed for technologies, such as the use of hydrogen, enabling the integration of these variable sources.

[8] *Poland expects to consume about 43.41% of the fund financed by the EU ETS allowances*

OPPORTUNITY ASSESSMENT

Hydrogen production potential & its role in energy system flexibility

The technical variable renewable electricity production potential of Poland is more than five times as high as its expected electricity demand in 2030, which creates an important opportunity to build renewable electricity generation plants to produce hydrogen via electrolysis. According to the NECP, Poland plans to use in 2030 only 4% of its technical potential for renewable electricity generation, so there is a great margin for building up additional dedicated renewable electricity plants whose output can be converted into hydrogen via electrolysis.

There is in Poland also an opportunity to use power-to-hydrogen conversion as a flexibility provider, as the Polish energy system is expected to have substantially increasing flexibility needs; the forecasted installed capacity of variable renewable electricity generation is indeed higher than the average load in 2030. This opportunity is however to a certain extent limited by the existence of a notable capacity of pumped-storage hydroelectricity that also serves as flexibility provider to the electricity system.

Technical variable renewable electricity potential (TWh/yr)	Technical renewable electricity generation potential compared to forecasted gross electricity consumption in 2030 (Polish Energy Plan 2040[9])	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
1 085	(Polish Energy Plan 2040[9]) 539%	45.05	4%	based on NECP 109%	Low

Poland has limited readiness for wide-scale deployment of CCS. Although the possibility of using CCS technologies is being explored, there are no concrete indications that this potential will effectively be used.

[9] *Polish NECP does not provide this figure*

Energy infrastructure

Poland could assess the ability of using its existing methane infrastructure to transport and distribute hydrogen, by blending hydrogen with natural gas or by potentially converting (part of) its network to hydrogen in the long term (>2040). As the share of polyethylene in the distribution network is not known, the feasibility and cost of using existing methane infrastructure for hydrogen transport/distribution should be further assessed. In any case, conversion of the distribution networks to dedicated hydrogen pipelines would be a long (>2040) term consideration, as the hydrogen production volumes are expected to be relatively low until 2030. 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)
N.A. MS range 16%-99%	0.3	17.2	YES

There is an important existing salt cavern natural gas storage capacity in Poland, and also other large underground salt layers that could provide gas storage opportunities across the country. According to its NECP, Poland considers natural gas storage as a priority but could assess using this storage potential in the future also for hydrogen.

Current and potential gas & hydrogen demand

In Poland, opportunities for the deployment of hydrogen exist in all sectors, most notably within industry and the transport sector. 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. More generally, hydrogen deployment can contribute to the decarbonisation of the gas supply in industry and on the medium to long term, it can be deployed as a low-emission solution for the provision of high-temperature process heat. Furthermore, hydrogen can be a solution for the decarbonisation of the Polish steel industry, which is currently still dependent on a coal-based steelmaking process. In the transport sector, the largest opportunities for the deployment of hydrogen reside in Poland's road and rail sectors. In the built environment, hydrogen can contribute to the decarbonisation of existing natural gas use, but it can also be deployed as one of the low-carbon alternatives for existing coal use in this sector.

Opportunities for hydrogen demand in industry

In Poland, the opportunities for the deployment of hydrogen in industry are considerable. First of all, the Polish industry has a substantial market share in Europe's ammonia production and refinery capacity. These industries already consume fossil-based hydrogen, which could be replaced by renewable or low-carbon hydrogen. Next to this, natural gas accounts for almost a quarter of the industrial energy mix and the deployment of renewable or low-carbon hydrogen is one of the ways to decarbonise the gas supply. Furthermore, a very large share (46%) of the industrial energy consumption in Poland is used for the generation of high-temperature process heat and hydrogen is one of the low-emission energy carriers that is well-suited for the decarbonisation of this part of the energy demand. Lastly, the Polish steel sector is responsible for 6% of the primary steel production in the EU and can be decarbonised through the switch from conventional fossil-based steelmaking processes to a process where direct reduction iron is produced using hydrogen.

Presence of ammonia industry / share of ammonia production capacity in EU28 total	Presence of refineries / Share of Polish refineries in total captive hydrogen production by refineries in the EU28	Share of Poland 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)
15%	5%	6%	23%	46%
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

There are opportunities for the deployment of hydrogen in the built environment as well. Natural gas accounts for about a fifth of the energy use in households and the service sector in Poland and almost a quarter of the demand for heating. Renewable or low-carbon hydrogen can be used to replace the current use of natural gas in the built environment. Overall, almost 60% of the heating demand in the built environment is satisfied through the use of fossil fuels, with coal being the most important fuel. On the medium to long term, hydrogen could be one of the solutions to replace the use of coal in the Polish built environment.

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)
18%	76%	1%
Average: 34% MS range: 0% - 60%	Average: 74% MS range: 41% - 82%	Average: 3% MS range: 0% - 46%

Opportunities for hydrogen demand in transport

Like all EU countries, Poland has a large potential for hydrogen use in road transport. 43% of the energy use in this sector is consumed by trucks, buses and light commercial vehicles (e.g. vans). Since electrification of this segment of the road transport sector remains challenging, there is a significant opportunity for the deployment of hydrogen to decarbonise this part of road transport. The Polish rail sector is still dependent on fossil fuels for a quarter of its total energy use. Together with further electrification, deployment of renewable or low-carbon hydrogen can replace the use of diesel trains. On the medium to long term, hydrogen and derived fuels can also play a role in the decarbonisation of the aviation sector in Poland which still represents a relatively minor share of the energy demand in transport. Similarly, hydrogen and derived fuels can be deployed to decarbonise the energy use for fuelling international ships. Although international shipping and aviation are currently not yet covered by European or international climate legislation, EU countries will 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
43% (93 552 GWh)	25% (1 004 GWh)	0.0% (55 GWh)	1.2% (3 107 GWh)	4% (9 947 GWh)	97% (233 177 GWh)
Average 32% MS range 18%-48%	Average 30% MS range 0%-95%	Average 2% 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, while Poland has included hydrogen as a key decarbonisation solution for transport in its NECP with several supporting measures, there is still room to develop a comprehensive framework for the deployment and use of hydrogen in other sectors, in particular buildings and industry.

Taking into account the large overall potential for hydrogen deployment, it would be appropriate that the Hydrogen Technology Development Programme considers hydrogen within the whole Polish energy policy and addresses the decarbonisation challenges across all energy end-use sectors, preferably in coordination with the neighbouring countries and taking into account the initiatives and policies at EU level. Regulatory barriers could also be addressed in the frame of this Programme.

On the basis of the NECP, it is not clear whether Poland considers carbon capture and storage as an option to decarbonize the production of hydrogen from fossil sources (through SMR), in addition to coal gasification.

Existence of (or concrete plans for) national hydrogen roadmaps or strategies

Positive environment: Soon

According to the NECP, there is currently a draft Hydrogen Technology Development Programme, but the timeline for its adoption and implementation remains rather vague.

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

Positive environment ✓

The Polish NECP states that "The non-ETS proposed 2030 reduction target of - 7% should be considered an ambitious commitment". The plan describes qualitatively some planned climate policies and measures, mostly in the transport sector, while only limited information is provided about planned GHG emission reduction measures in the building and agriculture sectors. Hydrogen could be considered as an option to contribute filling in the gap in the non-ETS sectors.

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)

The Polish National Policy Framework (or NPF set in the context of the alternative fuel infrastructure directive (2014/94/EU)) does not contain specific commitments towards hydrogen.
The deployment of alternative fuel infrastructure is planned within the frame of the Low-Emission Transport Fund.

Inclusion of hydrogen in national plans for the deployment of alternative fuels infrastructure (2014/94/EU)	Existence of hydrogen refuelling stations (2019)	
NO	0	PL
	Total 156	EU

Existence of (investment on) hydrogen-related projects

There are currently no ongoing or operational renewable hydrogen-related projects in Poland.

Several research and demonstration projects have however been planned[10], like the replacement of the internal combustion engine of a locomotive by a hydrogen fuel cell (2021), the coupling of electrolysers with an offshore wind farm in the Baltic Sea, the separation of hydrogen from coke oven gas, a 1MW PEM electrolyser and a storage infrastructure to store renewable hydrogen. The Polish Oil and Gas Company (PGNiG) has identified the generation and storage of renewable hydrogen as an area having an important growth potential[11].

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	2.0	NO	0	PL

[10] *https://ec.europa.eu/energy/sites/ener/files/documents/3-4_poland_musial.pdf*
[11] *http://en.pgnig.pl/news/-/news-list/id/pgnig-to-invest-in-hydrogen-technologies/newsGroupId/1910852?changeYear=2018&currentPage=1*

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

Poland has set up a CO2 pricing mechanism in 1990, which is key to support the progressive shift to low carbon vehicles (including on hydrogen)

Positive environment

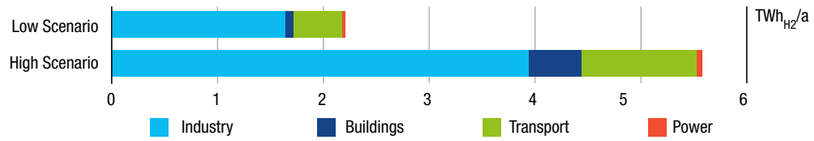
Fossil energy import bill

Like many EU Member States, Poland 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
	N.A.	**2.1%**
	Average: **0.6%** MS range: 0% - 1.5%	Average: **2%** MS range: 0% - 7%

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

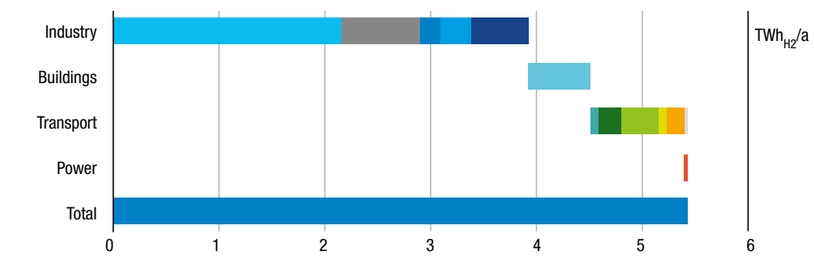
Hydrogen demand in the year 2030 has been estimated in a low and a high scenario covering the range of uncertainty. Today, conventional hydrogen mainly used in industry is produced from fossil fuels (e.g. through steam methane reforming) or is a by-product from other chemical processes. Both scenarios 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).



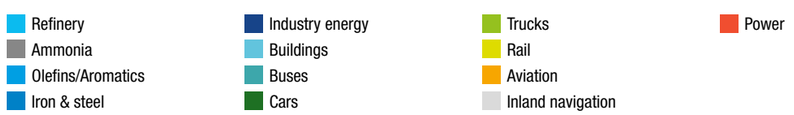
Low scenario

In the low scenario, renewable hydrogen accounts for 0.3% of final total energy demand (i.e. 2.2 out of 745 TWh/a) or 1.9% of final gas demand (115 TWh/a) according to EUCO3232.5.

High scenario



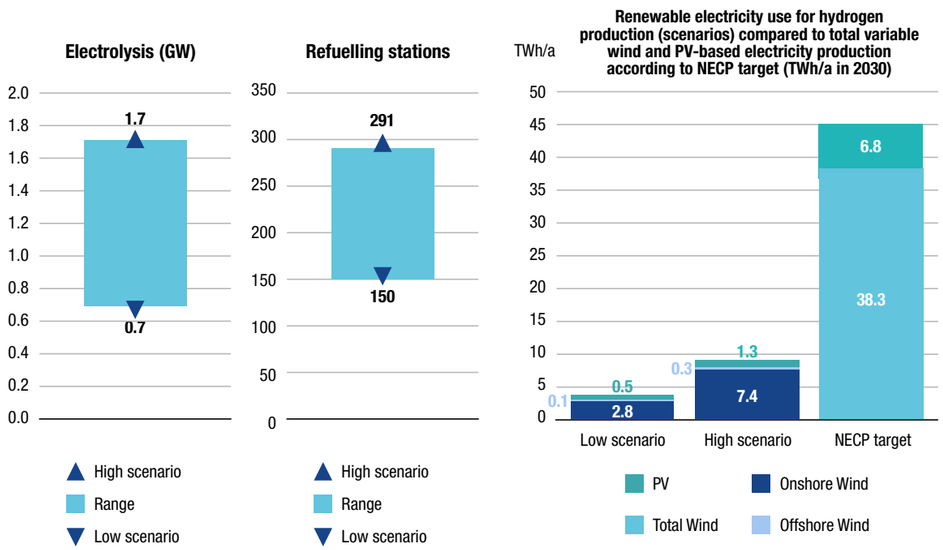
In the high scenario, renewable hydrogen accounts for 0.8% of final total energy demand (i.e. 5.6 out of 745 TWh/a) or 4.9% of final gas demand (115 TWh/a) according to EUCO3232.5.



Hydrogen generation, infrastructure and end users in Poland 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. The analysis covers only national hydrogen production to satisfy domestic demand and does not take into account any cross-border trade of hydrogen (i.e. hydrogen imports and exports are not included in this analysis).

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 1.0% in the high scenario.

End users

End user	Unit	Low scenario	High scenario
Passenger cars	Nº	70 200	140 500
Buses	Nº	630	1 260
Lorries	Nº	10 900	21 800
Heavy duty vehicles	Nº	1 240	2 480
Trains	Nº	10	42
Substituted fuel in aviation	GWh/a	21	195
Substituted fuel in navigation	GWh/a	0.1	1.1
Micro CHP	Nº	2 200	9 560
Large CHP	Nº	1	11
Iron&Steel	% of prod.	0%	1%
Methanol	% of prod.	0%	0%
Ammonia	% of prod.	0%	5%

According to the estimations, the hydrogen refuelling station network will by 2030 encompass between 150-290 stations for 83 000-166 000 fuel cell vehicles on the road.

In addition, the analysis estimates substitution of up to 1% of the conventional steel production by renewable hydrogen-based steelmaking.

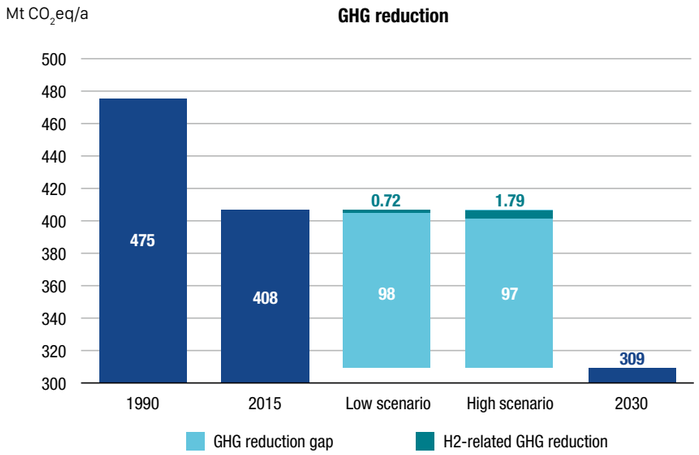
Futher use of renewable hydrogen is foreseen in ammonia production (up to 5%).

Finally, the introduction of 2 200-9 570 stationary fuel cells for combined power and heat production is estimated.

Environmental and financial impact in Poland 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.

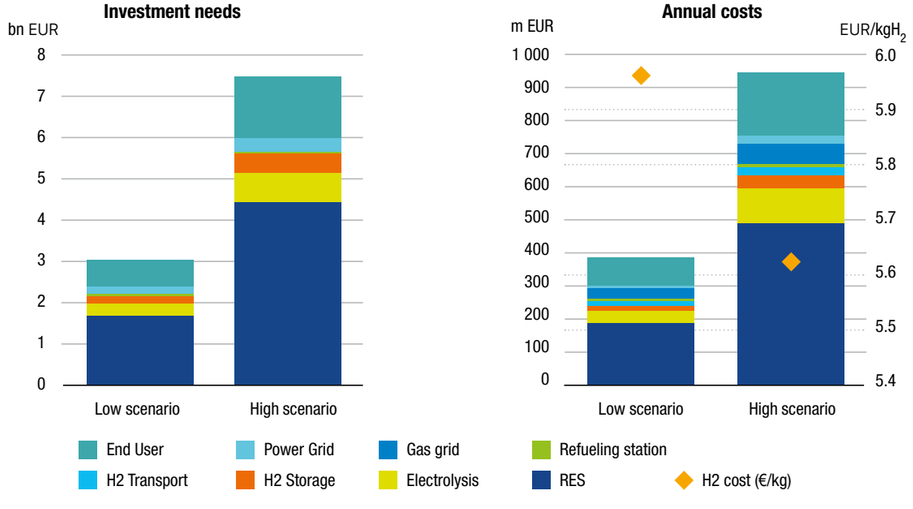
Environmental impact



An additional GHG emission reduction of 0.7-1.8 Mt CO_2 is estimated in 2030 corresponding to 0.7%-1.8% 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 3.0-7.5 billion EUR until 2030, while annual expenditure would amount to 390-950 million EUR (including end user appliances as well as power and gas grids).

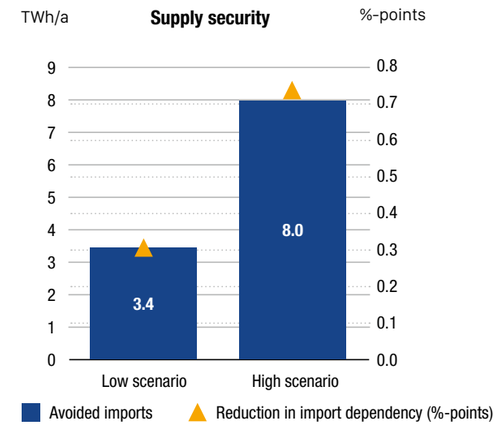


Impact on security of supply, jobs and economy in Poland by 2030

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

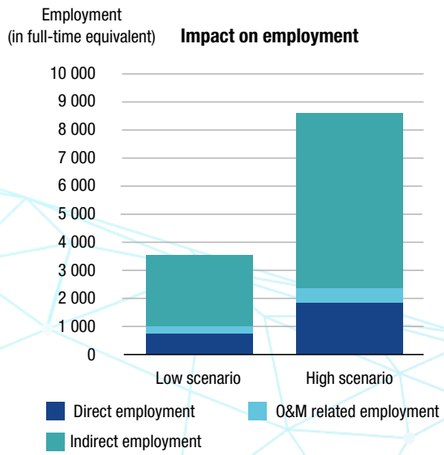
Deployment of renewable hydrogen would lead to 3.4-8.0 TWh/a of avoided imports, and thus reduce import dependency by 0.3-0.7% (in volume terms) in 2030, depending on the scenario.

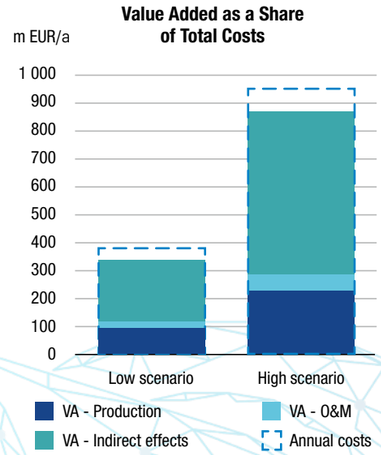


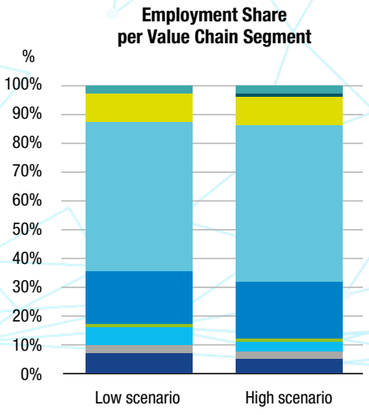
Impact on employment and value added

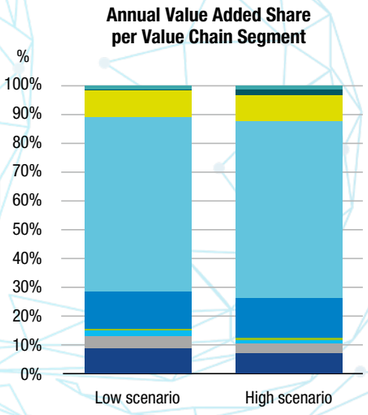
This analysis shows that in the years 2020-2030 around 120 million EUR can be retained annually in the domestic economy as value added in the low scenario, and almost 300 million EUR in the high scenario (value added is defined here as sum of wages for employees, margins for companies and taxes). If the indirect effects induced by the investment in and operation of hydrogen technologies are also taken into account, around 340 million EUR (low scenario) and almost 870 million EUR (high scenario) of value added can be created in the Polish 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 dedicated renewable electricity sources and electrolysers for hydrogen production, by investing in hydrogen storage and transport infrastructure, and in automotive industry.

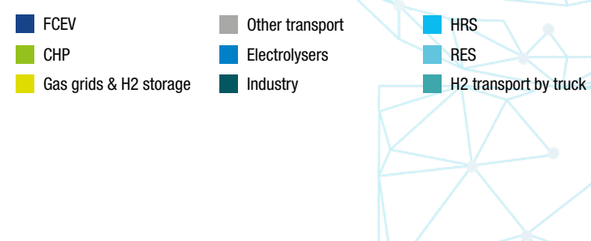
The hydrogen-related expenditures in 2020-2030 are estimated to generate employment of 1 000 – 2 400 direct jobs (in production and operations & maintenance) and contribute to a further 2 600 – 6 200 indirectly related jobs, depending on the scenario. Most of these jobs are expected to be created by building and operating renewable electricity sources, electrolysers and hydrogen transport infrastructure.











POLAND

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

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

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