DENMARK

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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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.

DENMARK

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

Onshore Wind
190 - 900 MW
450 - 2 130 GWh/a

Offshore Wind
40 - 200 MW
170 - 790 GWh/a

Solar Photovoltaic
35 - 170 MW
30 - 130 GWh/a

Electrolysers
120 - 580 MW
400 - 1 910 GWh_{H2}/a

POWER
3 - 392 GWh/a

TRANSPORT
337 - 1 061 GWh/a

BUILDINGS
23 - 230 GWh/a

INDUSTRY
38 - 230 GWh/a

150 - 310
Buses

30 - 91
Trains

63 - 128
Refuelling Stations

2890 - 5680
Trucks

30 000 - 59 900
Cars

1 - 169 GWh/a
Electricity Produced

28 - 266 GWh/a
into Synthetic Fuels

1 050 - 4 580
Micro-CHP units
in buildings

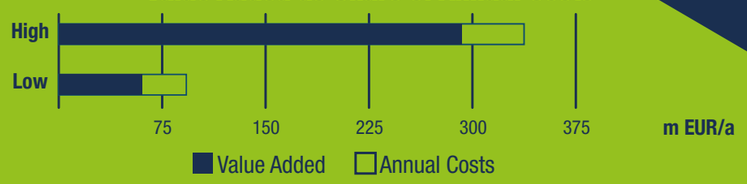
10 - 70
Commercial-scale
CHP installations

20 - 30 GWh_{H2}/a
in Refineries

66 - 290
m EUR/a

Value Added
in the domestic economy

Value Added as Share of Annual Costs



New Jobs
560 - 1 440

Emissions avoided
0.2 - 0.6 Mt CO_2/a

EXECUTIVE SUMMARY

Denmark's commitment for hydrogen deployment according to its NECP

According to its NECP, Denmark has the ambition to reduce its greenhouse gas emissions by 70% by 2030, relative to 1990 levels (aiming for net-zero emissions by 2050). To reach this target, new solutions will have to be developed in the power and gas sectors, in road transport, aviation and navigation as well as in the agricultural sector. Power-to-X is one of the technologies that can contribute to fully decarbonizing the Danish economy.

Hydrogen Denmark, the national Association, highlights that "Nearly 67 million" private and public funding in total will be directed at industrial hydrogen production in Denmark. This is unprecedented in a Danish context and marks the beginning of a new era for the utilization of renewable energy in Denmark".[1]

Denmark is in a favourable starting position given its current extensive investments in hydrogen research and the important number of pilot and demonstration projects (e.g. hydrogen refuelling stations, transport and delivery infrastructure with, among others, the Hydrogen Mobility flagship project[2], greening the gas sector with the FutureGas project[3], producing hydrogen from renewable electricity sources, enabling the storage of renewable electricity from wind turbines[4], guiding the creation of hydrogen ecosystems with the Hydrogen Valley[5], etc.). Denmark is currently involved in the Green Flamingo[6], the Green Octopus and the Silver Frog IPCEI projects, and was also involved in the HyLaw[7] project, that identified and assessed major regulatory barriers, in view of prioritizing measures to address them. Hydrogen Denmark[8] cooperates with neighbouring countries keeping an international outlook to endorse the use of hydrogen solutions in future technologies.

Denmark'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 Denmark 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 Denmark, 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 inland navigation[9]. The development of hydrogen demand is also assumed in the scenarios in industry, in particular in refining. This industry uses fossil-based hydrogen for several processes including desulphurisation, 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 that Denmark will be one of the early adopters of using hydrogen for power generation (back-up), although the produced electricity volumes will be still low.

Hydrogen production

To cover the estimated hydrogen demand from new uses and from substitution of fossil-based hydrogen, 0.3 to 1.3 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 renewable electricity plants. 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, Denmark estimates an installed capacity in 2030 of 9.67 GW in wind and 4.92 GW in solar PV, generating over 44 TWh of renewable electricity in 2030. The technical potential for renewable electricity production in Denmark seems however significantly higher[10]. 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 90 and 340 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[11], the Danish GHG emissions should be reduced by 17 Mt CO_2 in 2030, compared to 2015. In the scenarios considered, the deployment of hydrogen could contribute 0.2 – 0.6 Mt CO_2 to this goal, which is equivalent to 1% - 4% of the required emission reduction.

[1] *https://www.hydrogeneurope.eu/sites/default/files/Press%20release%20-%20Hydrogen%20and%20P2X%20on%20the%20rise%20in%20Denmark.pdf*
[2] *https://h2me.eu/*
[3] *https://futuregas.dk/*
[4] *http://hybalance.eu/*
[5] *http://hydrogenvalley.dk/frontpage-en/*
[6] *https://static1.squarespace.com/static/5d3f03877280260001 21b2a2/t/5e208b85ba1b7664a1933b7d/1579191174296/Green%2BHH2%2BGreen%2BFlamingo%2Bposter_print.pdf*
[7] *https://www.hylaw.eu/sites/default/files/2018-10/National%20Policy%20Paper%20-%20Denmark%20%28EN%29.pdf*
[8] *https://brintbranchen.dk/english/*
[9] *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*
[10] *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).*
[11] *C, 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*

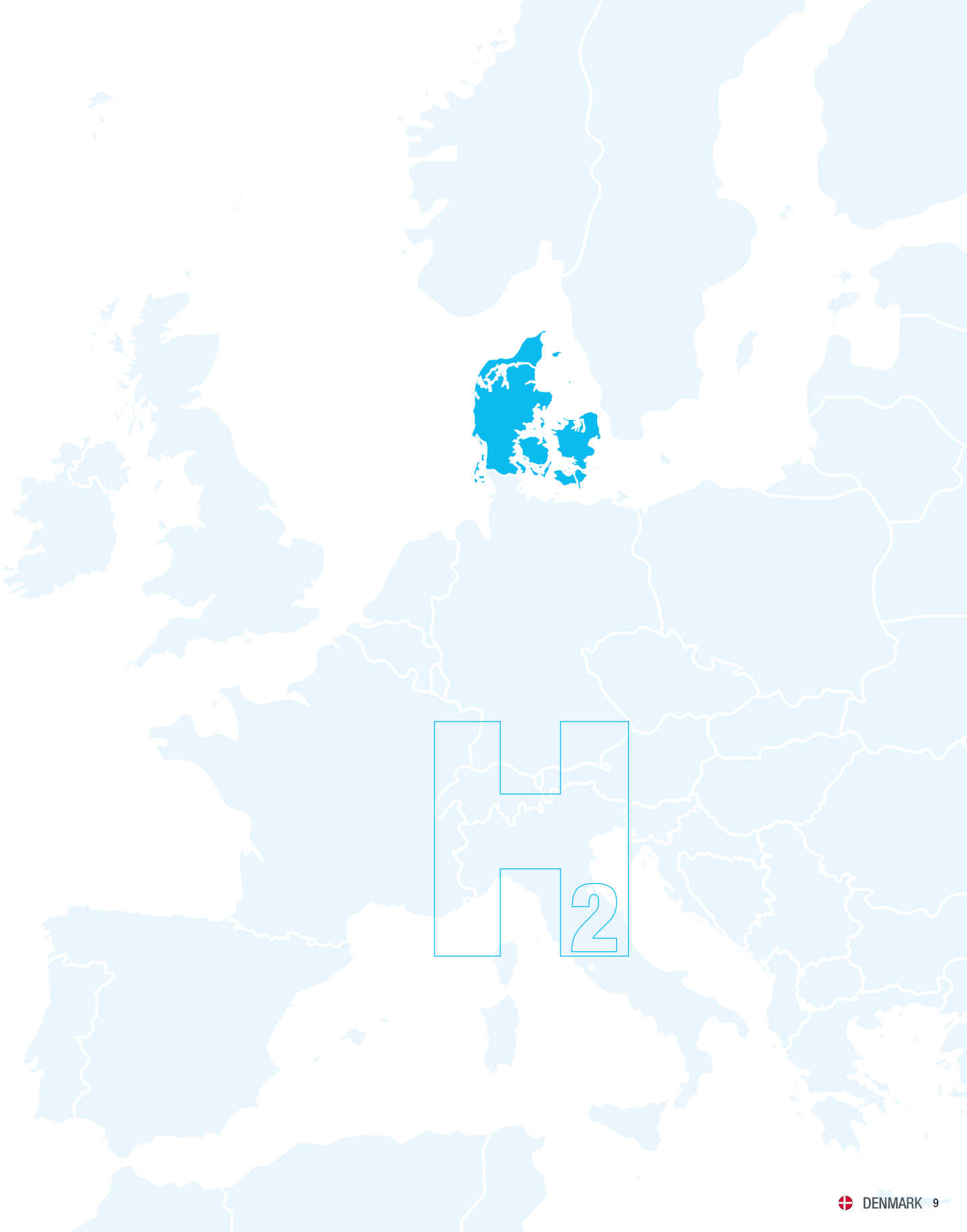
HYDROGEN IN THE DANISH NECP

As Denmark has committed to reduce its greenhouse gas emissions by 70% by 2030, relative to 1990 levels (aiming for net-zero emissions by 2050), it is essential that funding is in place for research, development and demonstration as well as deployment of climate neutral technologies. New solutions will have to be developed in the energy sector, in road transport and aviation as well as in the agricultural sector. Power-to-X is one of the applications that potentially can contribute to fully decarbonizing the energy sector, road transport and aviation as well as the agricultural and industrial sectors. For this reason, research on power-to-X development and upscaling will be supported and developed.

According to the NECP, energy storage could be a useful tool to ensure system stability and security of energy supply, by levelling out demand peaks and by storing surplus wind energy after its conversion into hydrogen for later use in times of energy supply shortage. Today, the technologies available for storing electricity are rather limited and expensive. However, these technologies will continue to be developed and may become more competitive, as current trends in costs of storage technologies are indicating. Therefore, it is likely that in the future batteries will become more prominent in energy markets, while power-to-gas and hydrogen could also play a large role in ensuring energy supply security.

The Danish Government has in 2017 allocated a budget of 5.1 million EUR for R&D and demonstration programmes on new renewable energy technologies, including hydrogen and fuel cells. In order to accommodate future needs, the Danish Government has established a fund of 128 million DKK to support development and demonstration projects on energy storage. The fund was granted end of 2019. Two power-to-X projects have received grants and will establish large scale production and storage of green hydrogen. Both projects have the ambition to demonstrate production and consumption of green hydrogen on near market-based conditions.

In December 2019, the Government reached an agreement with the concerned political parties on the Finance Act 2020. The parties agreed, among other things, to allocate funds to support large-scale power-to-X technologies and to initiate a preliminary study on “energy islands”.



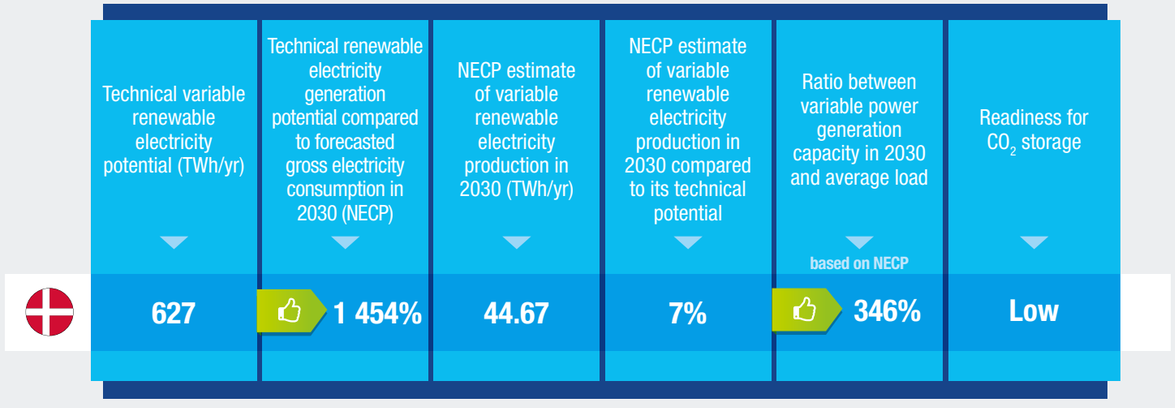
OPPORTUNITY ASSESSMENT

Hydrogen production potential & its role in energy system flexibility

The technical potential of renewable electricity production in Denmark is more than ten times higher than its forecasted electricity demand in 2030, creating a strong opportunity to use this abundant potential to produce renewable hydrogen via electrolysis. According to the NECP, Denmark would only use 7% of its technical potential in renewable electricity generation by 2030, so there is a great margin for building up dedicated renewable electricity sources for hydrogen production via electrolysis.

There is also an opportunity to develop power-to-hydrogen production and storage as a flexibility provider, especially since the intermittent electricity generation capacity is projected to be twice as high as the average load in 2030. This opportunity is however influenced by the high electricity interconnection rate, with forecasted net transfer capacity of interconnectors exceeding the projected installed capacity of intermittent renewable electricity.

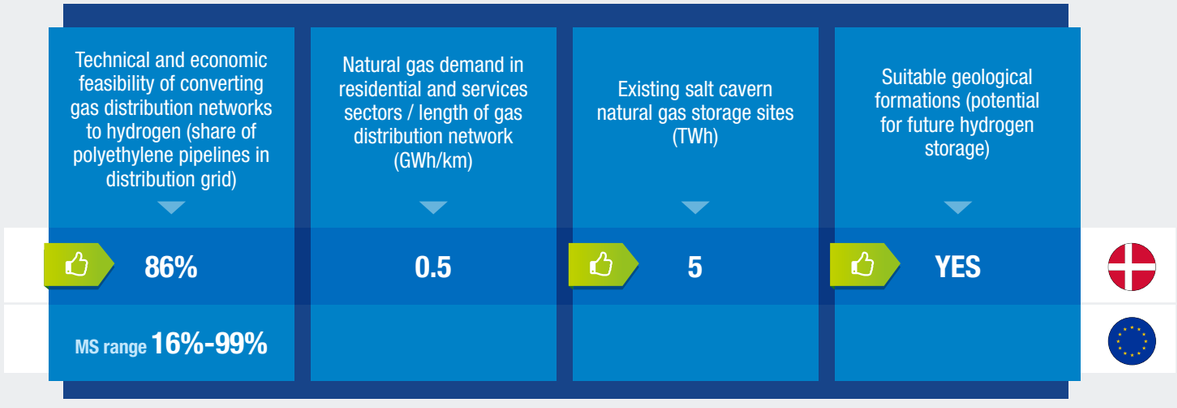
With respect to the production of low-carbon hydrogen via steam reforming of natural gas combined with CCUS, the short-term potential is rather limited. Even though there are some potential CO_2 storage sites, there is only limited indication of progress towards effectively utilizing these capacities.



Denmark has limited readiness for wide-scale deployment of CCS. Although it has potentially suitable sites for CO_2 storage and there are plans in place to use CCS technologies by 2030, there is only limited indication of progress towards using captured CO_2 in industrial processes and/or utilizing the potential storage capacities.

Energy infrastructure

Denmark 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 distribution network is mainly made up of polyethylene, it can 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. 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, distribution and end-use infrastructure.



Denmark has currently 2 underground storage facilities at Lille Torup (salt cavern facility) and at Stenlille in the central part of Zealand (aquifer storage facility). In addition, there is Palaeozoic salt deposit that covers a large part of Denmark territory and which might be suitable for the construction of dedicated hydrogen storage facilities. Denmark could take the opportunity to explore further the possibility to use this deposit for hydrogen storage.

Current and potential gas & hydrogen demand

In Denmark, the largest opportunities for the deployment of hydrogen are in the transport sector. Renewable or low-carbon hydrogen can contribute to the decarbonisation of road transport, especially freight transport by road. On the long term, hydrogen and derived fuels can also contribute to the decarbonisation of shipping and aviation. The short-term opportunities for hydrogen demand in industry are relatively limited, as industries with existing hydrogen use are rather scarce in Denmark. However, on the medium- and long-term hydrogen can definitely play a useful role in the decarbonisation of industry, to replace existing natural gas use and as a renewable or low-carbon alternative to generate high-temperature process heat. In the built environment, the direct use of fossil fuels for heating is relatively low. Renewable and low carbon hydrogen can be deployed to replace the remaining use of fossil fuels in buildings and in CHP plants that supply heat to heating networks.

Opportunities for hydrogen demand in industry

On the short-term, the opportunities for using hydrogen in industry in Denmark are, on the basis of the assessed indicators, relatively limited due to the rather low levels of existing hydrogen use in industry. However, on the medium and long term, hydrogen is an interesting decarbonisation solution for Denmark's industry, since around a third of the industrial energy demand currently comes from natural gas. Furthermore, a quarter of the Danish industrial energy demand is used for high-temperature heat processes, which are currently strongly dependent on fossil fuels. Renewable or low-carbon hydrogen is one of the energy carriers that provide a means to decarbonise this part of the energy demand.

	Presence of ammonia industry / share of ammonia production capacity in EU28 total	Presence of refineries / Share of Danish refineries in total captive hydrogen production by refineries in the EU28	Share of Denmark 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)
DK	0%	0.4%	0%	30%	26%
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 Denmark, only 12% of the energy demand in households and services is satisfied through the direct use of natural gas. Next to electrification and renewable energy-based district heating grids, hydrogen is one of the potential solutions to decarbonise heating, which accounts at present for three-quarters of the final energy demand in the built environment in Denmark. Especially in neighbourhoods that are currently connected to gas distribution grids, a switch from natural gas to hydrogen is expected to be among the most cost-efficient options to decarbonise the energy use for heating. Next to this, almost a quarter of the heat in Danish district heating networks still comes from fossil fuels. Hydrogen can be one of the solutions to replace this fossil fuel use.

	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)
DK	12%	76%	3%
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

According to the indicators, Denmark holds a large potential for deployment of hydrogen in the transport sector. Over two thirds of the energy use in the Danish rail sector is coming from fossil fuels. Next to electrification, hydrogen trains and the use of hydrogen derived fuels can be a suitable alternative for the current diesel trains to reduce the GHG emissions from rail transport. Like in all countries, there is also a large opportunity to deploy hydrogen in road transport in order to reduce GHG emissions. Lastly, on the long term, there is an opportunity for the use of hydrogen and derived fuels for bunkering of international ships, as well as in the aviation sector and to a more limited extent also in the domestic shipping sector.

	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
DK	35% (14 793 GWh)	69% (916 GWh)	3.5% (1 726 GWh)	13% (6 219 GWh)	18% (13 115 GWh)	94% (42 391 GWh)
EU	Average 32% MS range 18%-48%	Average 30% MS range 0%-95%	Average 2% MS range 0%-10%	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 assessed indicators show that Denmark is in a favourable position for the large-scale deployment of renewable hydrogen in this decade and beyond, with concrete targets already set and investments being made towards the deployment of hydrogen. Substitution of fossil fuel use with renewable or low-carbon hydrogen can be one of the options to reach the additional GHG emission reductions required in the non-ETS sectors. Hydrogen can also be considered in the ETS sectors, in particular in the energy intensive industries. However, hydrogen applications are in general not yet fully competitive. Mass production of equipment and scaling up of installations is expected to further bring down the cost on the middle term. In the meantime, it is expected that Denmark will continue to provide support for hydrogen related research and facilitate the implementation of pilot and demonstration projects.

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

Denmark is currently focusing on supporting hydrogen demonstration and flagship projects (e.g. by providing funding for two large-scale hydrogen projects on the Jutland Peninsula[12]), deploying hydrogen infrastructure and stimulating its end-use demand. Hydrogen Denmark[13] works on improving the framework conditions for hydrogen and fuel cells deployment. But there is currently no comprehensive national plan that specifically addresses hydrogen.

[12] https://www.pv-magazine.com/2019/12/20/denmark-bets-on-green-hydrogen/
[13] https://hydrogeneurope.eu/member/hydrogen-denmark-brintbranchen

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

Denmark's 2030 target for greenhouse gas (GHG) emissions not covered by the EU Emissions Trading System (non-ETS), is -39% compared to 2005, as set in the Effort Sharing Regulation (ESR). With the existing measures, the European Commission estimates that Denmark would miss this target by 16% and would have a cumulative deficit of 35.6 million tons of CO_2 equivalent over the period 2021-2030. A higher deployment of hydrogen could hence be considered to fill in this gap.

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)), Denmark foresees a limited market uptake for hydrogen vehicles before 2025. The support measures defined in the Danish NPF are unlikely to have a significant impact on removing the market barriers for hydrogen deployment in the transport sector.

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
NO	9	281 116

Existence of (investment on) hydrogen-related projects

Denmark already has 9 hydrogen refuelling stations, ranking first at EU level in terms of number of refuelling stations compared to the number of cars. Denmark has already spent important RD&D budget on hydrogen (top MS in EU, about 28 M EUR in 2014 as example), focusing amongst others on hydrogen transport and refuelling infrastructure, hydrogen use and power-to-gas projects. There are currently 15 hydrogen projects under construction and 32 in operation, which indicates that Denmark is one of the frontrunners.
Denmark is involved in the Green Flamingo, the Green Octopus and the Silver Frog potential IPCEI projects[14]. Hydrogen Denmark Brintbranchen is involved in several projects[15] like Hydrogen Mobility Europe, HyLaw, Biocat Roslev, FutureGas, and has been partner in many projects in the past.

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)
YES	15.0	NO	47

[14] https://www.hydrogen4climateaction.eu/projects
[15] https://brintbranchen.dk/projects/

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

Hydrogen fuelled cars are exempted from levies, similar to electrical cars. Electrolysis plants are considered as industrial processes and are also exempted.

Positive environment

Fossil energy import bill

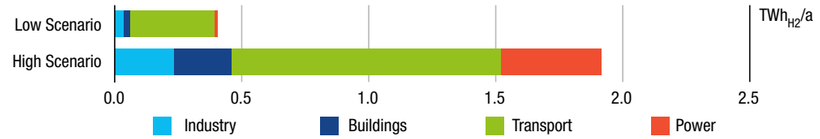
While Denmark remains a natural gas exporting country, it has recently become a net oil importer[16], due to declining production levels and increasing needs for domestic consumption. Switching from (imported) fossil fuel to domestically produced hydrogen (for use in transport, heating and industry sectors) would reduce the fossil energy bill and have a positive impact on Denmark's trade balance.

	Import bill for natural gas as share of national Gross Value Added	Import bill for all fossil fuels
	0.03%	**0.2%**
	Average: **0.6%** MS range: 0% - 1.5%	Average: **2%** MS range: 0% - 7%

[16] *https://www.reuters.com/article/denmark-oil/denmark-swings-to-net-oil-importer-after-north-sea-production-decline-idUSL8N1VL1Y6*

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

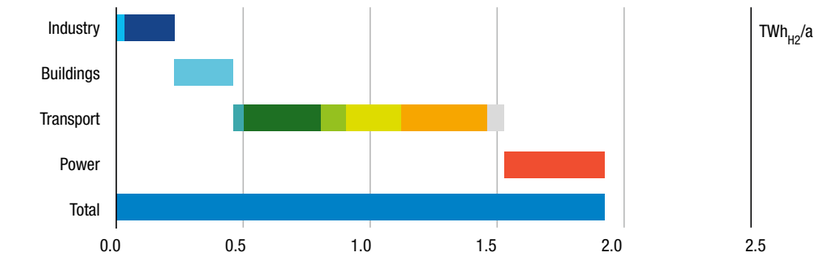
Hydrogen demand in the year 2030 has been estimated in a low and a high scenario covering the range of uncertainty. Today, conventional hydrogen mainly used in industry is produced from fossil fuels (e.g. through steam methane reforming) or is a by-product from other chemical processes. Both scenarios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



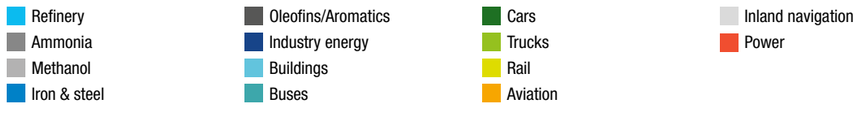
Low scenario

In the low scenario, renewable hydrogen accounts for 0.3% of final total energy demand (i.e. 0.4 out of 148 TWh/a) or 2.5% of final gas demand (16 TWh/a) according to EUCO3232.5.

High scenario



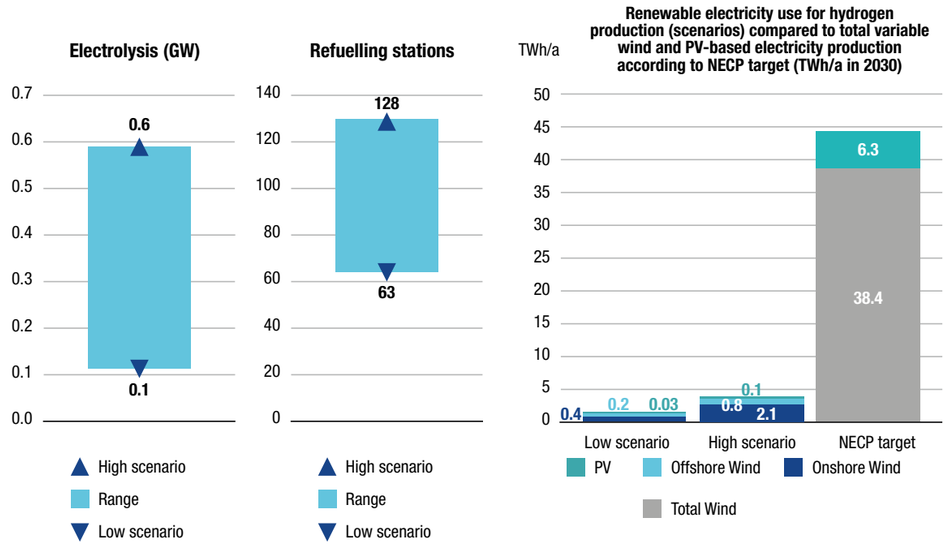
In the high scenario, renewable hydrogen accounts for 1.3% of final total energy demand (i.e. 1.9 out of 148 TWh/a) or 12.1% of final gas demand (16 TWh/a) according to EUCO3232.5.



Hydrogen generation, infrastructure and end users in Denmark 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 0.3% of the overall technical renewable power potential in the low scenario and for 1.4% in the high scenario.

End users

End user	Unit	Low scenario	High scenario
Passenger cars	Nº	30 000	59 900
Buses	Nº	150	310
Lorries	Nº	2 800	5 500
Heavy duty vehicles	Nº	90	180
Trains	Nº	30	91
Substituted fuel in aviation	GWh/a	24	225
Substituted fuel in navigation	GWh/a	4.3	41.1
Micro CHP	Nº	1 050	4 580
Large CHP	Nº	10	70
Iron&Steel	% of prod.	0%	0%
Methanol	% of prod.	0%	0%
Ammonia	% of prod.	0%	0%

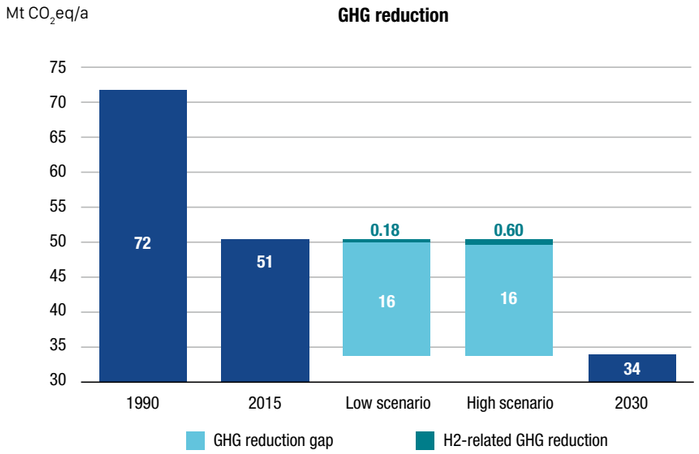
According to the estimations, the hydrogen refuelling station network will by 2030 encompass between 60-130 stations for 33 000-66 000 fuel cell vehicles on the road.

Finally, the introduction of 1 060-4 650 stationary fuel cells for combined power and heat production is estimated.

Environmental and financial impact in Denmark 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.

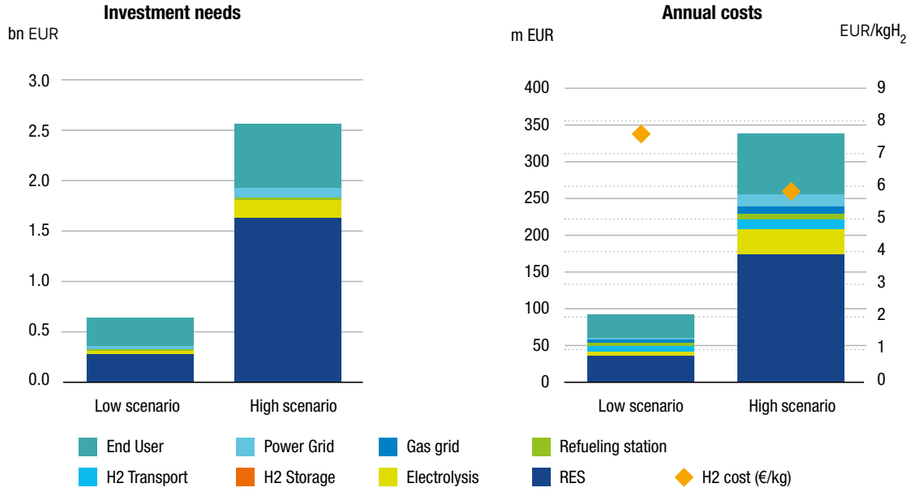
Environmental impact



An additional GHG emission reduction of 0.2-0.6 Mt CO_2 is estimated in 2030 corresponding to 1.1%-3.6% 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 0.7-2.6 billion EUR until 2030, while annual expenditure would amount to 90-340 million EUR (including end user appliances as well as power and gas grids).

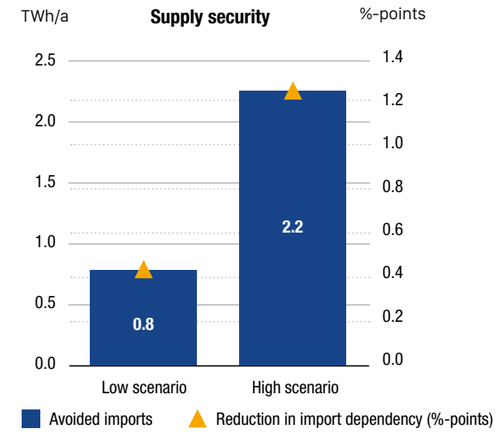


Impact on security of supply, jobs and economy in Denmark by 2030

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

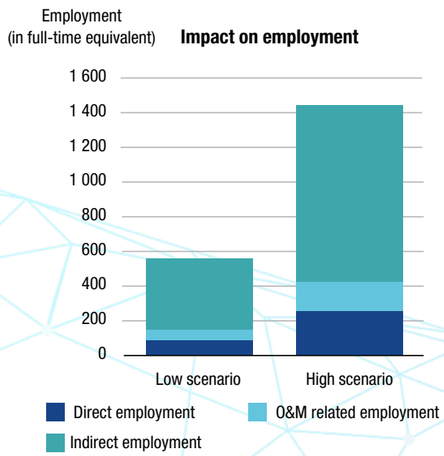
Deployment of renewable hydrogen would lead to 0.8-2.2 TWh/a of avoided imports, and thus reduce import dependency by 0.4-1.2% (in volume terms) in 2030, depending on the scenario.

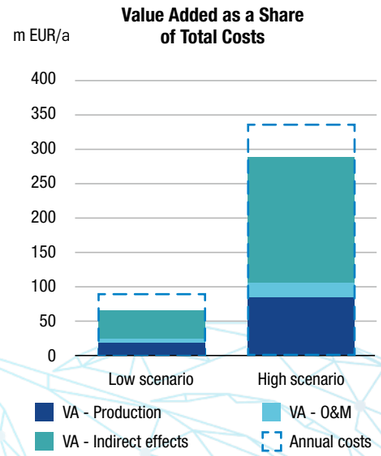


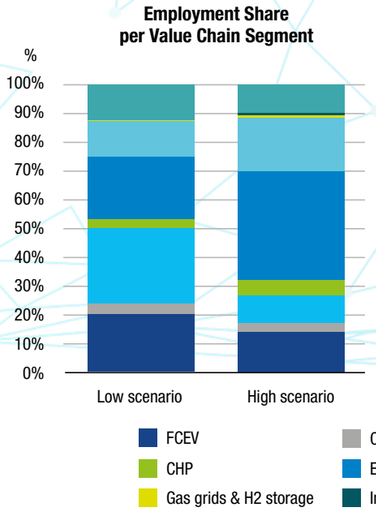
Impact on employment and value added

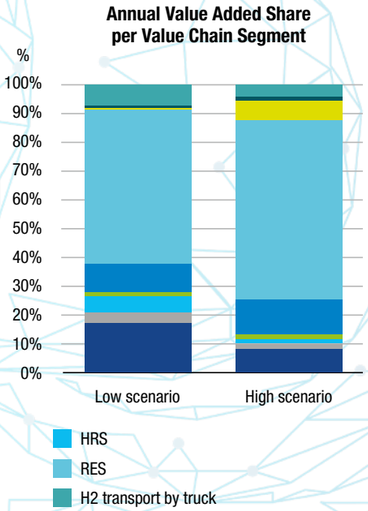
This analysis shows that in the years 2020-2030 around 30 million EUR can be retained annually in the domestic economy as value added in the low scenario, and almost 110 million EUR in the high scenario (value added is defined here as sum of wages for employees, margins for companies and taxes). If the indirect effects induced by the investment in and operation of hydrogen technologies are also taken into account, around 65 million EUR (low scenario) and almost 300 million EUR (high scenario) of value added can be created in the Danish 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, and in automotive industry. In the high scenario, a more significant share of value added is expected to be created by building and operating hydrogen transport networks and storage facilities.

The hydrogen-related expenditures in 2020-2030 are estimated to generate employment of 150 - 400 direct jobs (in production and operations & maintenance) and contribute to a further 400 – 1 000 indirectly related jobs, depending on the scenario. Most of these jobs are expected to be created in the automotive industry and by building and operating electrolysers and hydrogen refuelling stations.









FCEV
CHP
Gas grids & H2 storage
Other transport
Electrolysers
Industry
HRS
RES
H2 transport by truck

DENMARK

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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