



UNITED KINGDOM

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



2

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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.

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

Onshore Wind
1 400 - 7 340 MW
4 450 - 22 800 GWh/a

Offshore Wind
390 - 1 980 MW
1 460 - 7 470 GWh/a

Solar Photovoltaic
830 - 4 240 MW
660 - 3 360 GWh/a

Electrolysers
1 100 - 5 630 MW
4 120 - 21 090 GWh_{H₂}/a

POWER
30 - 301 GWh/a

TRANSPORT
2 937 - 9 763 GWh/a

BUILDINGS
762 - 7 620 GWh/a

INDUSTRY
389 - 3 404 GWh/a

13 - 130 GWh/a Electricity Produced

624 - 1 120 Refuelling Stations

1 760 - 3 520 Buses

210 - 630 Trains

24 850 - 49 700 Trucks

353 300 - 706 500 Cars

301 - 2 857 GWh/a into Synthetic Fuels

0 - 150 kt/a of Steel

34 980 - 152 170 Micro-CHP units in buildings

0 - 2.0 kt/a of Aromatics

200 - 530 GWh_{H₂}/a in Refineries

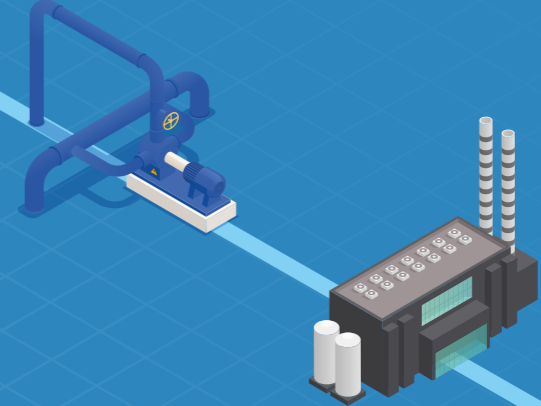
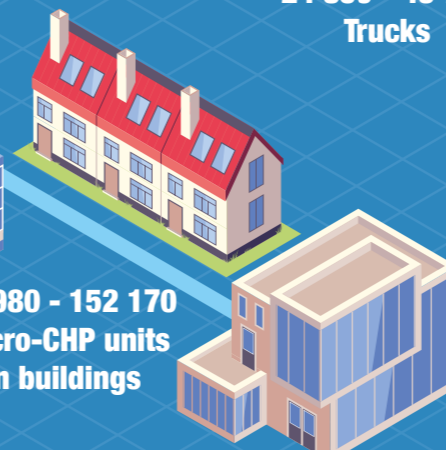
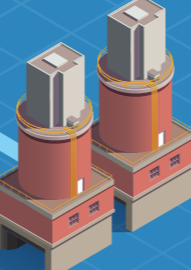
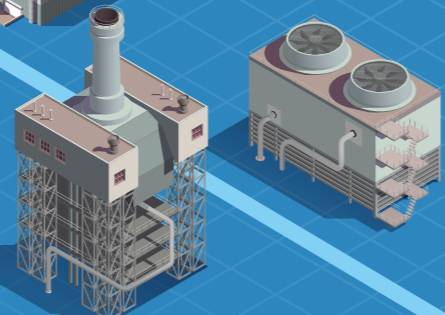
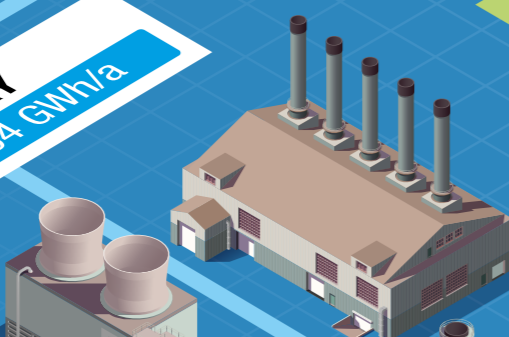
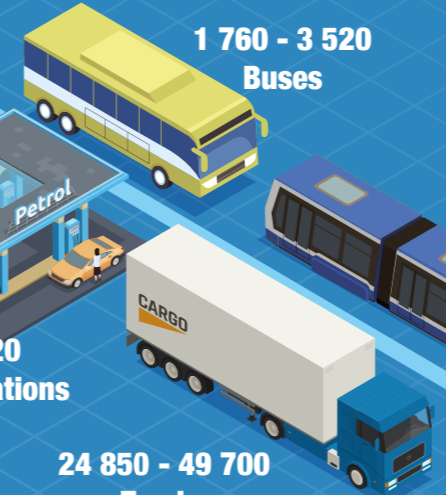
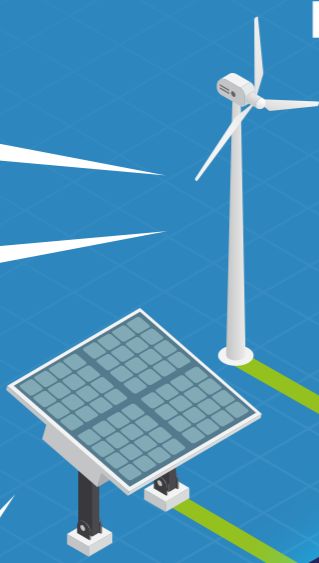
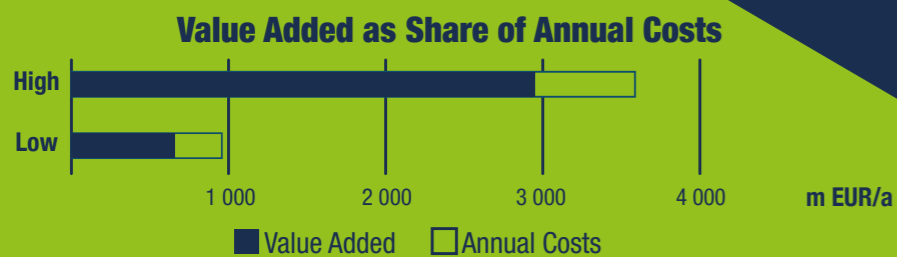
0 - 23.2 kt/a of Olefins

0 - 41.3 kt/a of Ammonia

660 - 2 940 m EUR/a | **Value Added** in the domestic economy

New Jobs
12 530 - 45 970

Emissions avoided
1.7 - 6.3 Mt CO₂/a



EXECUTIVE SUMMARY

The United Kingdom's commitment for hydrogen deployment according to its draft NECP

"The UK government, and many UK companies, believe hydrogen and fuel cells are an essential part of the energy future. Today these technologies have limited availability and high costs, but by 2025 they could bring hundreds of millions of pounds of economic benefits".¹

The UK has an active Hydrogen and Fuel Cell Association which aims "to make the UK the best place for hydrogen and fuel cells across all applications and opportunities"². In 2016, a Roadmap for the UK "Hydrogen and Fuel Cells: Opportunities for Growth" was published³, highlighting the high interest and commitment of the industry.

The UK is in a favourable starting position for hydrogen deployment given its active Hydrogen and Fuel Cell Association, its companies with relevant expertise across the supply chain as well as its research groups highly active in fuel cells and hydrogen, its flagship projects such as BigHit aiming to create a hydrogen territory in the Orkney Islands of Scotland⁴, its hydrogen projects to decarbonize the heating/transport/industry sectors in the Tees Valley and Leeds City Region⁵, the ambition of the City of London to become a world leader in hydrogen and fuel cell activity⁶ (world's first hydrogen double deck buses⁷), and several other ongoing investments in hydrogen research and demonstration projects. The UK is not involved in IPCEI projects but has participated in the HyLaw⁸ project, that identified and assessed major regulatory barriers, in view of prioritizing measures to address them.

In its draft NECP, the UK seems to consider hydrogen applications as a long-term option. Its draft NECP for 2021-2030 does not include specific objectives or targets for the production or use of hydrogen, nor hydrogen specific policies and measures.

The impact assessment shows substantial potential benefits of hydrogen deployment in the United Kingdom 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 the United Kingdom, 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 navigation⁹. A significant development of hydrogen demand is also assumed in the scenarios in **industry**, especially in refining and the iron and steel sector. 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, 2.6 to 13.6 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 the European EUCO 3232.5 scenario¹⁰, the installed capacity of variable renewable electricity sources in 2030 is estimated at 50.5 GW in wind and 29.5 GW in solar PV, generating about 180.5 TWh of electricity. The technical potential for renewable electricity production in the UK seems however significantly higher¹¹. 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 964 and 3 583 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 EUCO3232.5 scenario¹², the British GHG emissions should be reduced by 275 Mt CO₂ in 2030, compared to 2015. In the scenarios considered, the deployment of hydrogen could contribute 1.7 – 6.3 Mt CO₂ to this goal, which is equivalent to 0.6% - 2.3% of the required emission reduction.

¹ <https://www.tdworld.com/grid-innovations/generation-and-renewables/article/21120970/insights-from-producing-a-uk-hydrogen-roadmap>

² <http://www.ukhfca.co.uk/>

³ <http://www.ukhfca.co.uk/resources-2/>

⁴ <https://www.bighit.eu/>

⁵ <http://www.leeds.ac.uk/info/130564/energy/767/hydrogen>

⁶ <https://www.london.gov.uk/what-we-do/environment/pollution-and-air-quality/cleaner-buses>

⁷ <http://www.ukh2mobility.co.uk/stations/>

⁸ <https://www.hylaw.eu/>

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 draft NECP of the United Kingdom does not present any concrete relevant figures, so the EUCO scenario figures were thus selected instead.

¹¹ 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).

¹² 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 THE UNITED KINGDOM

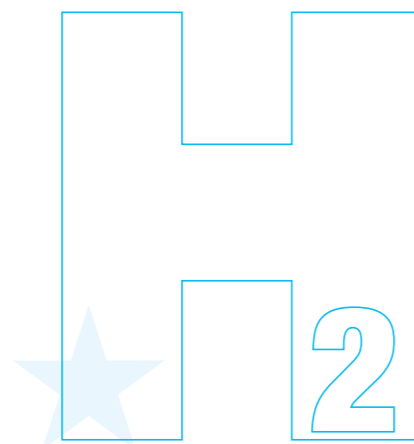
The UK Government is promoting the transition to bi-mode (modern diesel / electric) trains, as well as trains using alternative technologies such as power from batteries or hydrogen fuel cells, through the inclusion of environmental criteria in the tenders for rail franchises, thereby encouraging the market to investigate alternative fuels and drive trains that reduce emissions. In this context, hydrogen is expected to play a role in the British railway sector.

According to the UK's NECP, hydrogen is also considered in the Energy Innovation Needs Assessment project, which is a two-phased effort to develop a set of reports to provide evidence for the innovation needs. It will assess themes such as power generation, carbon capture and storage, hydrogen, energy demand and supply for heating and transport.

According to its NECP, the UK foresees a budget of up to £25 million to investigate the potential uses of hydrogen for heating and to test the possibility of using existing gas pipes and end-user appliances for hydrogen.

Scotland's energy sector has benefited from EU funding for energy infrastructure projects and research and development, particularly to investigate new, low carbon technologies and enabling infrastructure, such as offshore wind, marine renewables and integrated hydrogen solutions. Orkney, for example, is home to the UK's first smart grid, connecting renewable energy generation to Orkney's distribution network at a considerably lower cost than conventional network connection. The 'Surf 'n' Turf' project demonstrates a fully integrated energy model, with hydrogen produced by electrolyzers using electricity from tidal and onshore wind turbines. The produced hydrogen is stored, and then used in a fuel cell to provide low carbon heat, power or energy for transport purposes. A European-funded project called 'BIG HIT'¹³ will build on the Surf 'n' Turf project¹⁴ in Orkney to further develop the technologies for producing, storing and transporting hydrogen from renewable sources for heating, power and mobility purposes.

The British Clean Growth Strategy (CGS) includes three illustrative pathways to meeting the UK's long-term target of reducing its greenhouse gas emissions in 2050 by at least 80% relative to 1990 levels. These pathways show that the 2032 pathway would leave open a wide range of options for 2050 - different pathways within this range, and beyond it, are also possible. One of the pathways studied is based on the assumption that by 2050 all cars and vans would be fuelled by hydrogen, the majority of buildings would use hydrogen and that CCUS would be used at large scale.



¹³ <https://www.bighit.eu/>

¹⁴ <http://www.surfnurf.org.uk/>

OPPORTUNITY ASSESSMENT

Hydrogen production potential & its role in energy system flexibility

The estimated technical variable renewable electricity production potential in the UK is more than ten times higher than its expected electricity demand in 2030 (according to the EUCO 3232.5 scenario). This creates a significant opportunity to utilize part of this potential renewable electricity generation to produce hydrogen via electrolysis. According to the EUCO 3232.5 scenario, the UK would by 2030 use only 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.

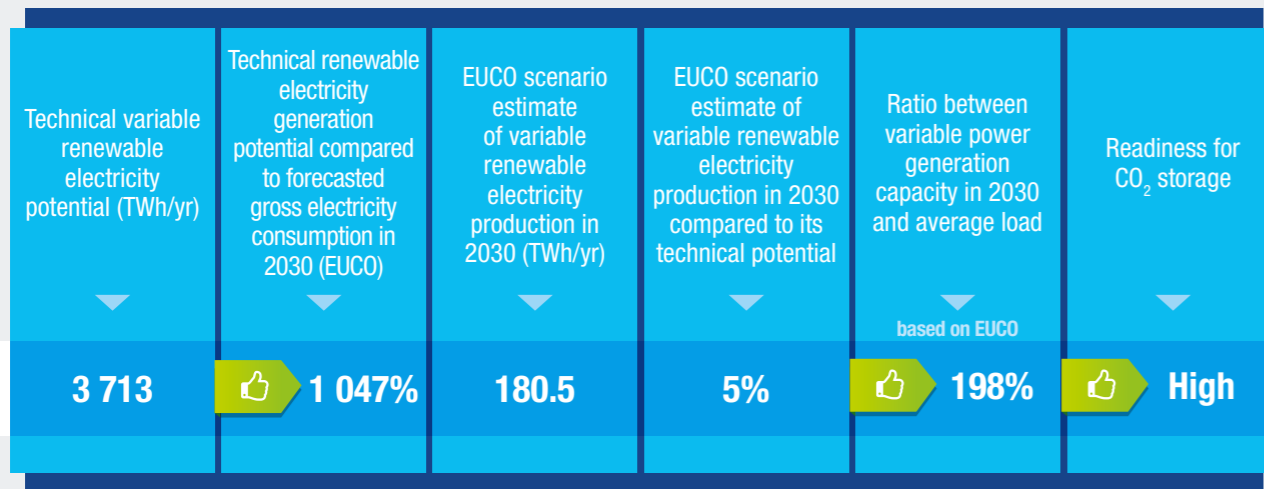
There is also an opportunity to use power-to-hydrogen conversion and hydrogen storage as a flexibility provider, as the British energy system is forecasted to have in 2030 higher installed capacity of variable renewable electricity generation than the average load. This opportunity is further reinforced by the fact that the available electricity interconnection capacity level is forecasted to remain rather limited, especially when compared to the forecasted installed variable renewable generation capacity in 2030.



Energy infrastructure

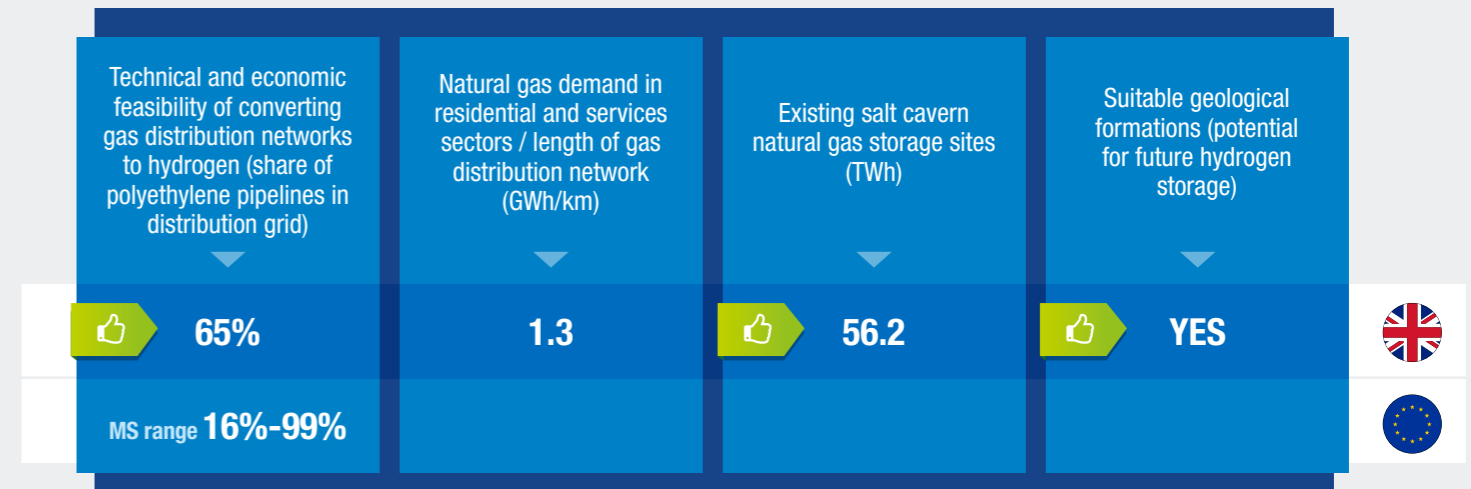
The UK can consider using its existing methane infrastructure for hydrogen transport and distribution, by blending hydrogen in the public grid in the short (2020-2030) and medium term (2030-2040) and potentially converting (part of) its network to hydrogen in the long term (>2040). As the share of polyethylene in the distribution network is relatively high, it could be converted to hydrogen at a relatively low cost. However, conversion of the networks to dedicated

hydrogen pipelines would in general be a longer-term consideration, as the hydrogen production volumes are expected to remain relatively low until 2030, except in a few pilot projects such as Leeds. In the short and medium term, hydrogen could in other regions be blended with methane in the existing grid, without the need for physical adjustments to the transport and end-use infrastructure.



The readiness for wide-scale deployment of CCS in the UK can be considered as an important opportunity for low-carbon hydrogen production using CCS, as the UK is one of the most advanced countries in Europe

regarding carbon capture and storage, with a high geological CO₂ storage potential and well advanced research programmes.



There is an important salt cavern natural gas storage capacity in the UK, that could be used for hydrogen storage, and also large underground salt layers that could provide additional hydrogen storage opportunities.

The availability of suitable formations to develop storage sites for seasonal hydrogen storage represents an opportunity for the UK and offers it a competitive advantage for hydrogen deployment.



Current and potential gas & hydrogen demand

In the UK, a considerable potential for the deployment of hydrogen exists 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 fossil-based hydrogen use, and in the medium to long term it can replace conventional fossil-based production processes in the 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 replace the existing natural gas use, which is the dominant fuel for heating; such a switch could significantly reduce the GHG emissions in this sector. 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

In the UK, the opportunities for the deployment of hydrogen in industry are considerable. First of all, the British industry has a substantial market share in Europe's ammonia production and refinery capacity. These industries currently consume fossil-based hydrogen, which could be replaced by renewable or low-carbon hydrogen. Next to this, natural gas accounts for around one third of the industrial energy mix and the deployment of decarbonised hydrogen is one of the ways to decarbonise this part of the energy use.

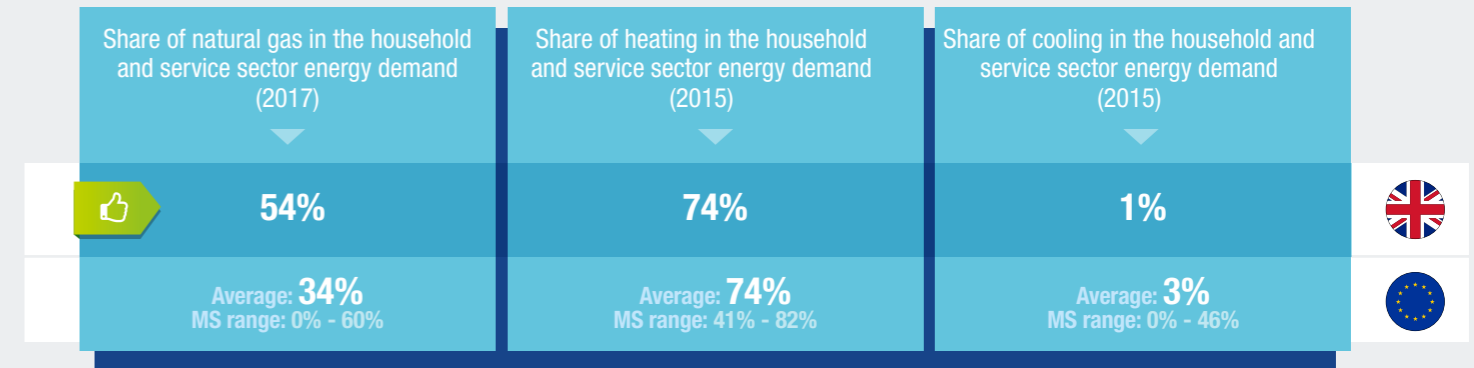
Furthermore, a significant share (36%) of the industrial energy consumption is used for the generation of high-temperature process heat. Hydrogen is one of the low-emission energy carriers that is well-suited for the generation of high-temperature heat. Lastly, the British steel sector, which is responsible for 6% of the primary steel production in the EU, can be decarbonised through the switch from conventional fossil-based steelmaking processes to a process where direct reduction iron is produced using hydrogen.



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

In the built environment in the UK, natural gas accounts for more than half of the final energy demand and almost three quarters of the heating demand. Therefore, hydrogen could play a substantial role in the decarbonisation of heating in the built environment, by gradually replacing natural gas. Hydrogen is an attractive alternative as it can be transported through the existing methane transmission and distribution

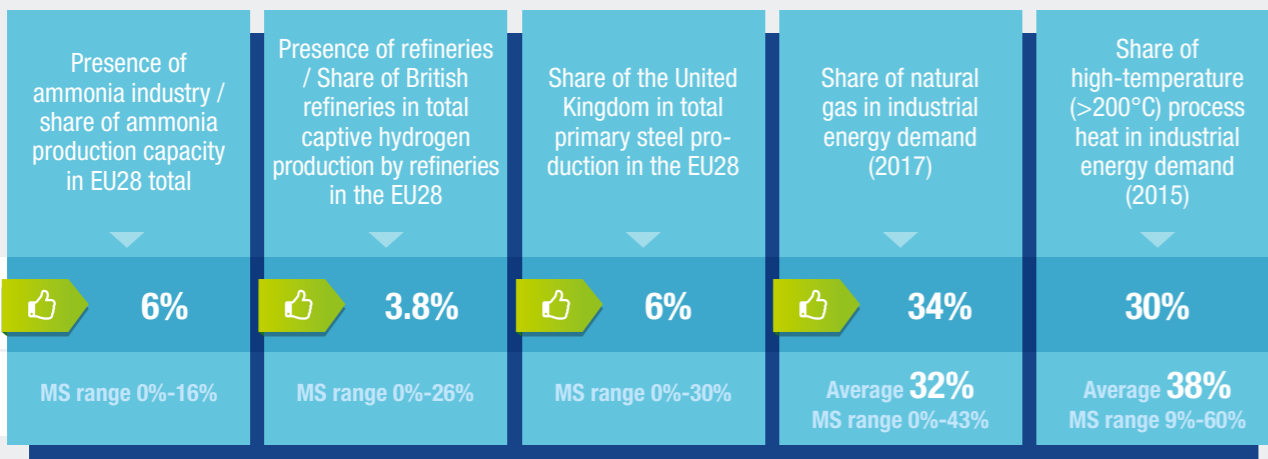
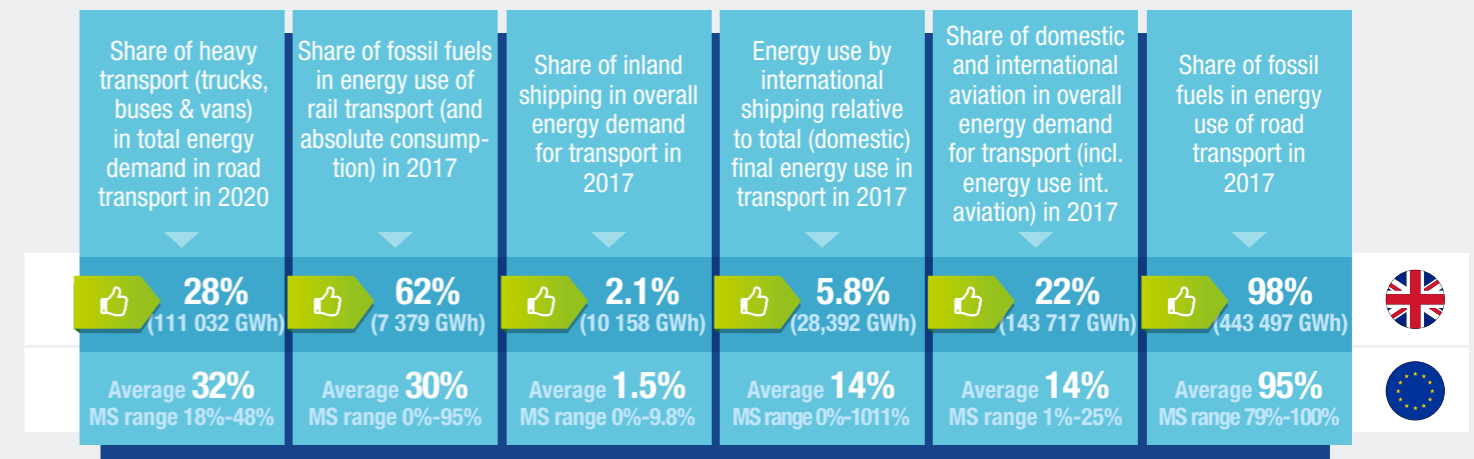
system. Only when hydrogen concentrations exceed certain limits, investments in adjustments of the gas infrastructure and end-use appliances will be needed. There are already large-scale plans for turning the gas grid in the north of England into hydrogen grids. This conversion is currently planned to start in 2028 and by 2035 3.7 million properties would switch to hydrogen, which would increase to 12 million by 2050.



Opportunities for hydrogen demand in transport

Like most European countries, the UK has a large potential for hydrogen use in road transport. Around 28% 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 hydrogen to decarbonise this part of road transport. Next to this, fossil-fuelled trains account for over 60% of the energy use in the British rail sector. A switch to hydrogen trains is one of the low-carbon solutions that can help to reduce the GHG emissions from rail transport. The UK government has set the target to phase out all diesel trains by 2040. As part of this effort, the rail sector is

planning to convert 321 existing diesel trains into hydrogen trains and the first of these should be running by 2022. The energy use of the aviation sector in the UK is equivalent to 20% of the total energy use in domestic 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. Although international aviation and shipping are currently not yet covered by European or international climate legislation, European countries with large shipping activities need to make a collective effort to support the decarbonisation of this sector.





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

The UK has ambitious plans and projects to deploy a hydrogen economy and has in general a very positive environment for such a development. Taking into account its large potential for hydrogen deployment based on renewable electricity using electrolysers, it would be appropriate that the UK comprehensively considers the potential contribution of hydrogen to address the decarbonisation challenges in all energy end-use sectors.



To facilitate hydrogen development, the UK has the intention to further invest in hydrogen related research and in (large-scale) pilot and demonstration projects and in the deployment of hydrogen refuelling stations, which can contribute to paving the way for the use of low-carbon hydrogen as a means to achieve deep decarbonisation.


Positive environment
Existence of (or concrete plans for) national hydrogen roadmaps or strategies
✗
<p>An overarching hydrogen roadmap has not yet been developed in the UK; such a comprehensive roadmap would support the country in mainstreaming hydrogen within the energy system. The UK Hydrogen and Fuel Cell Association could provide support in structuring such a roadmap, which could be based on the "Hydrogen and Fuel Cells: Opportunities for Growth - A Roadmap for the UK".¹⁵</p>

¹⁵ https://www.e4tech.com/uploads/files/e4tech/resources/126/UKHFC-Roadmap-Final-Main-Report-171116_1_.pdf

GHG mitigation gap in non-ETS sectors (need for additional GHG reduction measures)	Positive environment
✗	✗
<p>Achieving the UK's domestic target set in the fifth carbon budget, would likely also allow to achieve the 2030 target of -37 % greenhouse gas emissions compared to 2005 for sectors outside the EU Emissions Trading System (non-ETS) set under the Effort Sharing Regulation (ESR). However, it is unclear whether the existing and planned policies set out for the transport and buildings sectors, are sufficient to achieve the ESR target. Anyhow, the UK could consider integrating hydrogen to strengthen its set of measures.</p>	

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 UK's National Policy Framework (or NPF set in the context of the alternative fuel infrastructure directive (2014/94/EU)) shows a commitment towards developing an early market for hydrogen in the 2025 timeframe, targeting the availability of 65 publicly accessible refuelling points.		
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	17	1 835 305
Total 156		Average 1 677 543
		

Existence of (investment on) hydrogen-related projects			
There were in 2019 17 refuelling stations operating in the UK, which are paving the way for the deployment of a hydrogen network (e.g. "establishing the UK Hydrogen Corridor" ¹⁶ project led by Tees Valley).			
The UK has substantial dedicated R&D budgets to support research and innovation in the field of hydrogen. There were in 2019 3 projects in operation and 5 projects under construction; this development shows that the UK is acquiring a strong 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)
N.A	17.2	N.A	8
			

¹⁶ <https://www.ukri.org/funding/funding-opportunities/strength-in-places-fund/wave-1-seedcorn-funded-proposals/#pagecontentid-11>

Positive environment

Existence of national tax incentives (CO₂ pricing mechanisms & car taxation)

The UK has set up a CO₂ pricing mechanism in 2013 and introduced a carbon related taxation for vehicles; both measures are key to support the progressive shift to low carbon vehicles (including on hydrogen).



Fossil energy import bill

The UK depends partly on imports for its consumption of natural gas and oil products. As the import dependence is expected to further increase due to decreasing domestic production, switching from imported fossil fuels to nationally produced hydrogen will have a positive impact on the security of supply, as well on the energy import dependence and bill.

Import bill for natural gas as share of national Gross Value Added

0.4%

Average: 0.6%
MS range: 0% - 1.5%

Import bill for all fossil fuels

0.7%

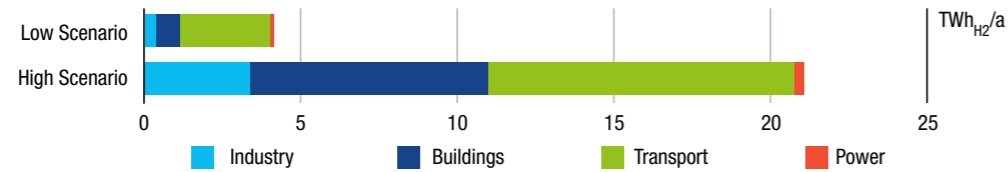
Average: 2%
MS range: 0% - 7%



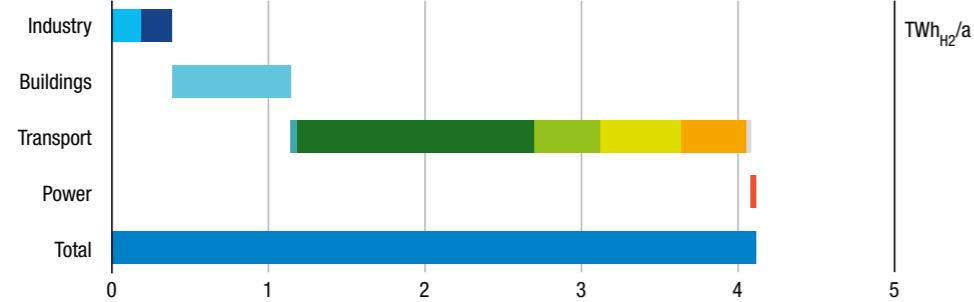
SCENARIO ASSESSMENT

Estimated renewable/low carbon hydrogen demand for UK 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).

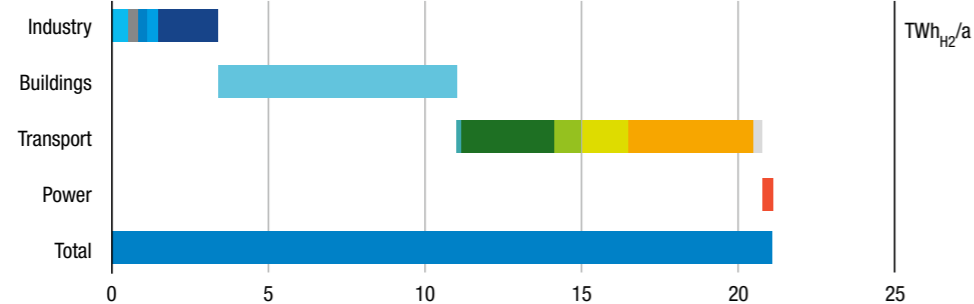


Low scenario

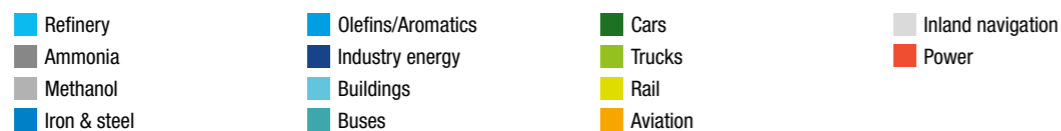


In the low scenario, renewable hydrogen accounts for 0.3% of final total energy demand (i.e. 4.1 out of 1 306 TWh/a) or 1.3% of final gas demand (327 TWh/a) according to EUCO3232.5.

High scenario



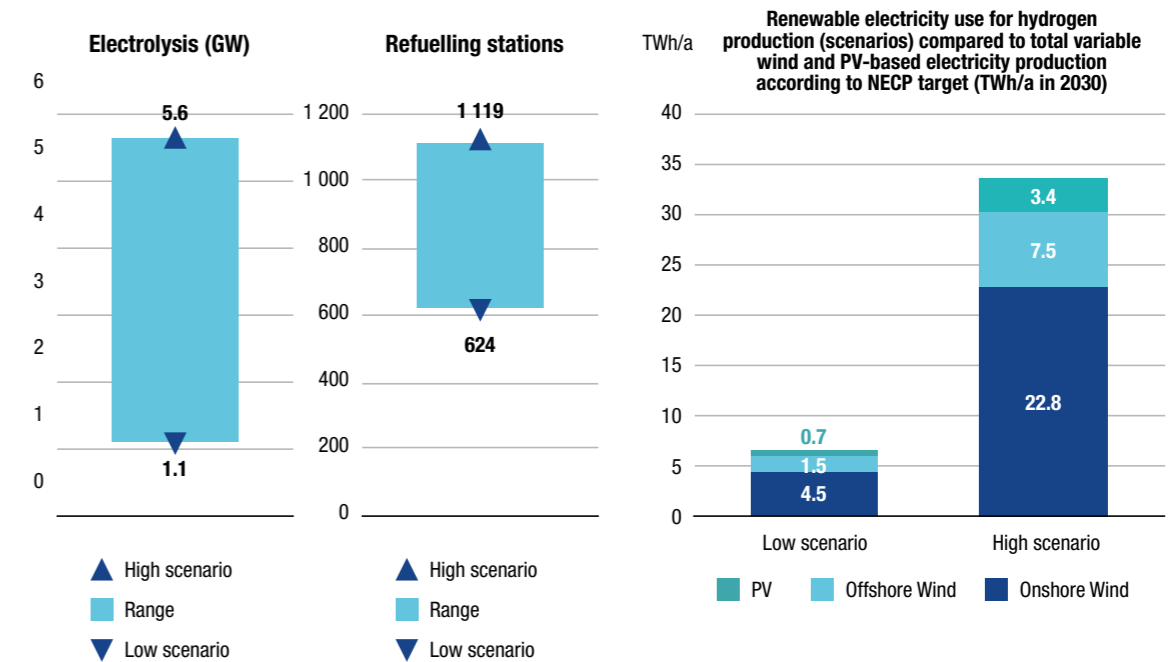
In the high scenario, renewable hydrogen accounts for 1.6% of final total energy demand (i.e. 21.1 out of 1 306 TWh/a) or 6.4% of final gas demand (327 TWh/a) according to EUCO3232.5.



Hydrogen generation, infrastructure and end users in UK 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 0.5% of the overall technical renewable power potential in the low scenario and for 2.4% in the high scenario. Alternatively hydrogen produced from SMR + CCS would require 6 -30.6 TWh/a of natural gas at a SMR+CCS capacity of 0.5 - 2.5 GW for the low and high scenarios, respectively.

End users

End user	Unit	Low scenario	High scenario
Passenger cars	N°	353 300	706 500
Buses	N°	1 760	3 520
Lorries	N°	24 100	48 200
Heavy duty vehicles	N°	750	1 500
Trains	N°	210	631
Substituted fuel in aviation	GWh/a	277	2 636
Substituted fuel in navigation	GWh/a	23.3	221.2
Micro CHP	N°	34 980	152 170
Large CHP	N°	0	0
Iron&Steel	% of prod.	0%	2%
Methanol	% of prod.	0%	0%
Ammonia	% of prod.	0%	5%

According to the estimations, the hydrogen refuelling station network will by 2030 encompass between 620-1 120 stations for 380 000-760 000 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.

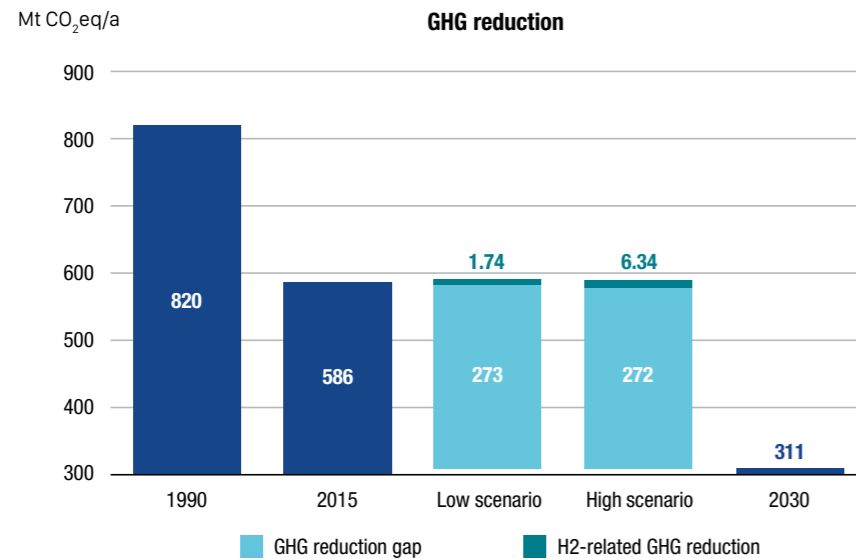
Further use of renewable hydrogen is foreseen in ammonia production (up to 5%).

Finally, the introduction of 34 980-152 170 stationary fuel cells for combined power and heat production is estimated.

Environmental and financial impact in UK 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.

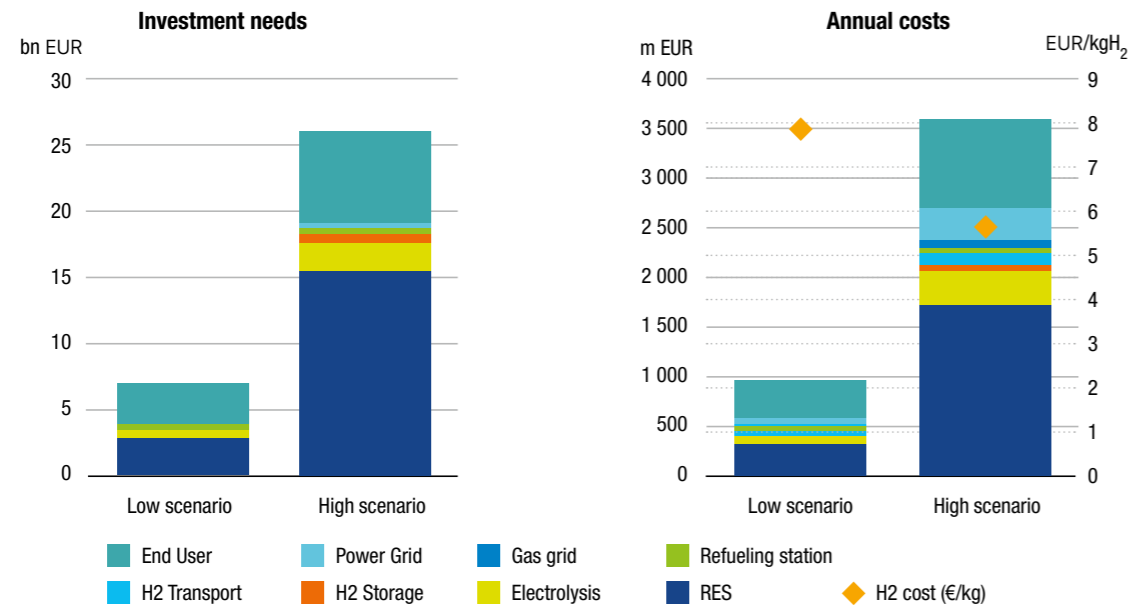
Environmental impact



An additional GHG emission reduction of 1.7-6.3 Mt CO₂ is estimated in 2030 corresponding to 0.6%-2.3% 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 7.0-26.0 billion EUR until 2030, while annual expenditure would amount to 960-3 580 million EUR (including end user appliances as well as power and gas grids).



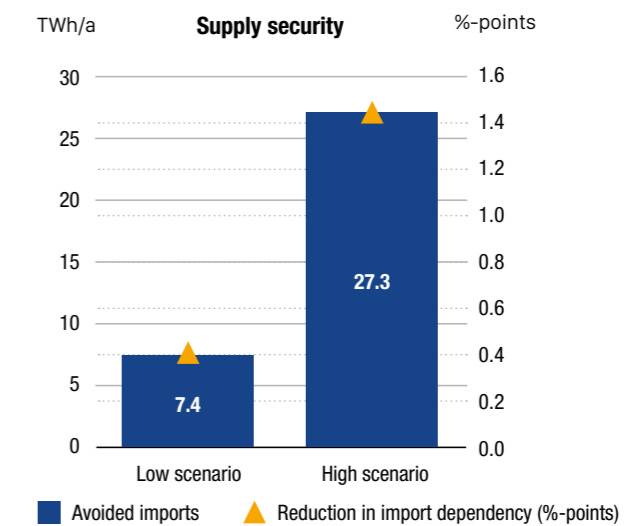
Alternatively hydrogen produced from SMR + CCS would require 4.0-10.3 billion EUR of investments or annual costs of 758-2 453 million EUR.

Impact on security of supply, jobs and economy in UK 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 7.4-27.3 TWh/a of avoided imports, and thus reduce import dependency by 0.4-1.5% (in volume terms) in 2030, depending on the scenario.



Impact on employment and value added

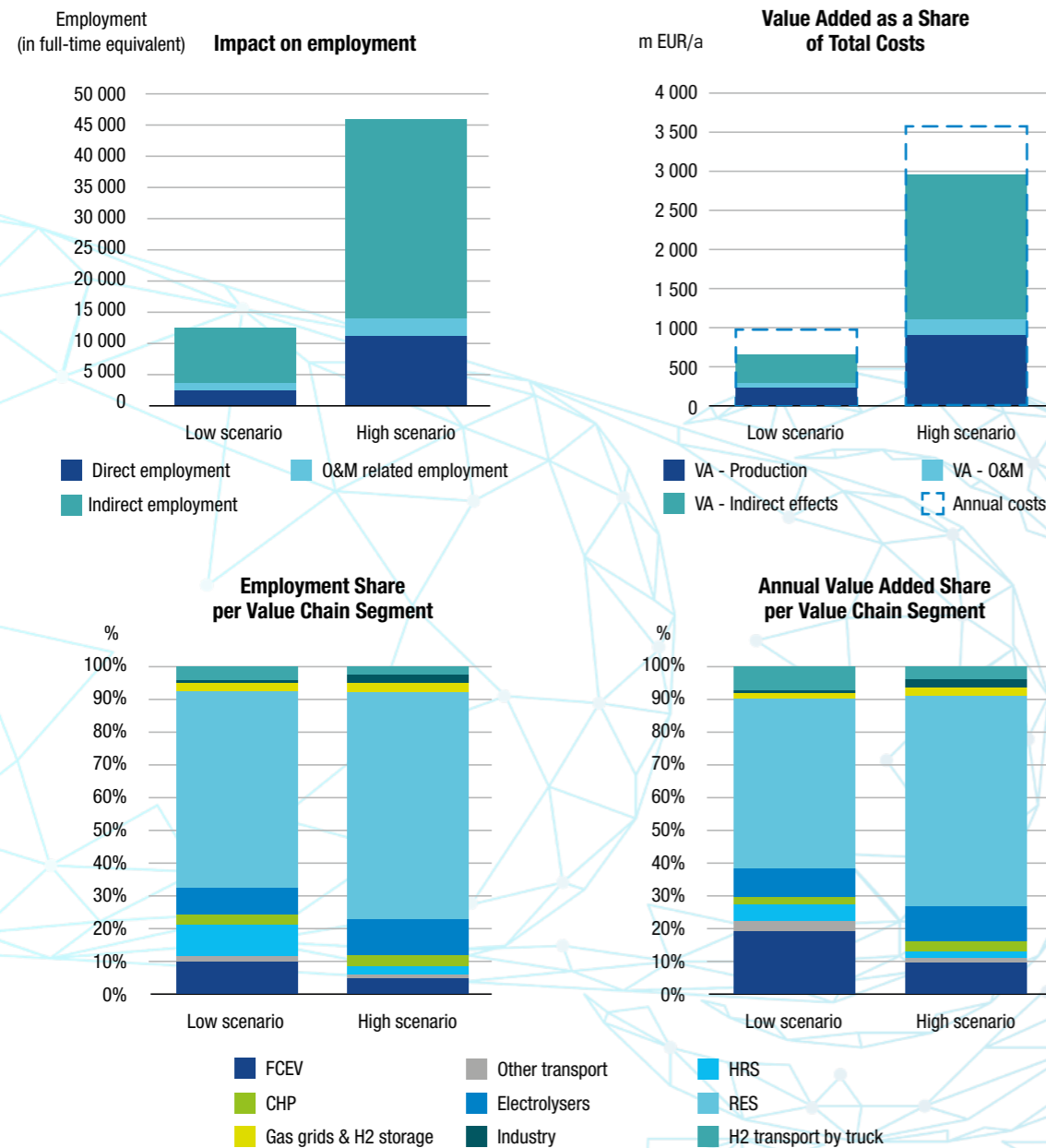
This analysis shows that in the years 2020-2030 around 280 million EUR can be retained annually in the domestic economy as value added in the low scenario, and almost 1 110 million EUR in the high scenario (value added is defined here as sum of wages for employees, margins for companies and taxes). If the indirect effects induced by the investment in and operation of hydrogen technologies are also taken into account, around 665 million EUR (low scenario) and almost 2 950 million EUR (high scenario) of value added can be created in the British 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 electrolyzers for hydrogen production, and in the automotive industry.

The hydrogen-related expenditures in 2020-2030 are estimated to generate employment of 3 550 – 13 900 direct jobs (in production and operations & maintenance) and contribute to a further 8 980 – 32 100 indirectly related jobs, depending on the scenario. Most of these jobs are expected to be created by building and operating renewable electricity sources, electrolyzers and hydrogen refuelling stations, and in the automotive industry.



UNITED KINGDOM

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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