UK energy security: the benefits of diversification

February 2025

green alliance...

Methodology and assumptions

The core aims of this analysis are to build on existing academic and policy literature, informed by interviews with a broad range of stakeholders, and incorporate new calculations.

This methodology explains how we estimated hydrogen demand in 2035 and the costs of domestic and imported hydrogen.

Estimated hydrogen demand in 2035

These predictions were made using Green Alliance's institutional knowledge, stakeholder interviews, government projections (based on the Net Zero Industrial Pathways (NZIP) model), as well as additional research and projections made by other bodies, in particular, the Climate Change Committee's (CCC) sixth carbon budget and the National Energy System Operator's (NESO) *Future energy scenarios*.[1, 2, 3]

We estimated the following levels of demand per sector:

Industry – 30TWh

Our estimate is on the low end of the government's 25-55TWh range. The assumptions for the low end of the government range were based on a 'cluster network' scenario where hydrogen is predominantly used within 25km of industrial clusters, with minimal use for industrial non-road mobile machinery. We believe this is the likely scenario, at least at this early stage of hydrogen infrastructure, given the shifting focus to widespread industrial electrification over hydrogen use. Our estimate is also similar to that made by the CCC (30TWh) and NESO in its 'holistic' scenario (26TWh).[2, 3]

Power – 20TWh

Our estimate for the power sector falls around the middle of the government's 5-30TWh range, which was largely based on NESO's *Future* *energy scenarios*, which were between 2-19TWh.[3] The other major source of our estimate was Regen's 'A day in the life 2035', done in conjunction with NESO, which estimated 10-30TWh.[4]

Domestic heat – 0TWh

Our prediction is that hydrogen is not used for domestic heat, which is the bottom of the government 0-60TWh range. While there is ongoing debate in this area, the consensus within Green Alliance, our interviews and among most hydrogen experts, is that domestic heating is an expensive and impractical use of hydrogen, especially given that heat pumps are such an effective alternative.[5] Within government, the final decision on hydrogen's role is due in 2026, but the cancellation of the 'hydrogen village' trials last year is likely to indicate a diminishing role for hydrogen in domestic heating.[6]

Transport – 20TWh

Our estimate for hydrogen use in transport is at the lower end of the government's 20-30TWh range but still substantial. With approximately 15TWh for shipping and 5TWh to be used between heavy goods vehicles, buses and aviation. While there seems to be a growing consensus on the use of hydrogen derivatives as shipping fuel, hydrogen use in these latter sectors, particularly aviation, is very uncertain. As a result, we have used the middle of government estimates.

Estimated cost breakdown for domestic green hydrogen production

The European hydrogen observatory 'Levelised cost of hydrogen calculator' was used to calculate the costs of different domestic production approaches.[7] The values for capital expenditure (capex), operating hours, average electricity costs, grid feed and electricity taxes were adjusted based on our own estimations, otherwise default values were used (which include a 20MW electrolyser and a six per cent cost of capital).

Capital expenditure

Estimates for cost per kW vary considerably, from approximately £750 – 1,500 per kW. We therefore used the average of four sources, £1,130.[7,8,9,10]

Operating hours

A load factor of 45 per cent was used for all modes of production, equivalent to 3,942 hours per year. For modes including grid connection with a renewable power purchase agreement (PPA) and direct connection to renewables, this was based on offshore wind load factors and assumptions made by other studies which typically use load factors of 40-50 per cent.[7, 8, 11] This is notably lower than the 57 per cent assumed in the Department for Business, Energy and Industrial Strategy's (BEIS) *Hydrogen production costs 2021* report.[12]

For the mode using otherwise curtailed electricity, the same load factor of 45 per cent was used, assumed to be made up of 22.5 per cent curtailed electricity and another 22.5 per cent of top up electricity from the grid at cheap times. Estimates for curtailment load factors are typically in the range of 15-25 per cent, and it was widely recognised in our interviews, and many of the sources making these estimates, that using curtailed energy alone was too unpredictable to make an investible business case.[11, 12, 13] An arrangement like this, using grid electricity to increase the load factor and reliability of production is one potential method.

Average electricity costs

For grid PPAs and co-located renewable energy modes, the price of £82.42 per MWh from the latest contract for difference (CfD) auction round six for offshore wind was used (£58.87 in 2012 prices adjusted using an inflation rate of 1.4 per cent).[14, 15]

For otherwise curtailed energy, the curtailed energy cost was assumed to be £15 per MWh. This was based on information from interviews suggesting that taking part in the National Grid's balancing mechanism is unlikely to be free, as assumed in *Hydrogen production costs 2021*, but rather somewhere in the region of £10-20 per MWh.[12] The top up portion from the grid price was taken to be £41.20 per MWh. This was based on half-hourly market index prices between November 2023-24, taking the cheapest 45 per cent of times.[16] This approach assumes some correlation between times of curtailment and times of cheap electricity.

Electricity system charges and levies

These included:

- Balancing Services Use of System (BSUoS) charge, based on 2024 data released by NESO, resulting in a cost of £7.63 per MWh.[17]
- Demand Transmission Network Use of System (TNUoS) charges, again based on 2024 NESO data, resulting in a cost of £3,755 per day.[18]
- Policy levies, which include CfD, feed-in tariffs and renewable obligation schemes. Energy intensive industries currently have an 85 per cent

reduction in these levies resulting in a cost of approximately £4 per MWh.[11, 19]

The British Energy Supercharger acts to reduce electricity system fees to qualifying energy intensive users. If eligible, BSUoS and TNUoS charges would be reduced by 60 per cent and policy levies from 85 per cent to a 100 per cent reduction.[11, 20]

Projecting the costs of domestic and imported ammonia and hydrogen to 2035

Domestic costs

The two factors that are likely to have the largest impact on future cost of production is the future price of electricity and electrolyser capex.

For the electricity prices the latest projections from Cornwall Insight were used.[21] Its estimate was for an approximately 30 per cent drop between 2024 and 2030, before a 'levelling of prices' until the late 2030s. This was corroborated by similar projections made in other studies.[8, 12]

For capex projections we used the average of the same latter sources which estimated a drop of 20 per cent by either 2030 or 2035.[8, 12]

Imported costs

Projections for the cost of imported green ammonia to 2035 are not readily available, however sources estimated the price in 2030 to be in the range of £93-119 per MWh.[22, 23]

Assuming a price drop between 2030 and 2035, we therefore took the bottom of this range as the estimate for the 2035 price, £90 per MWh.

Endnotes

[1] Department for Energy Security and Net Zero (DESNZ), 2023, 'Hydrogen transport and storage networks pathway', analytical annex

[2] Climate Change Committee (CCC), 2020, *Sixth carbon budget*

[3] National Energy System Operator (NESO), 2024, *Future energy scenarios*

[4] Regen and National Energy System Operator (NESO), 2022, *A day in the life of 2035*, second edition. Note that figures from these sources are given in TWh of final energy from sources, not the energy contained. Assuming a 50 per cent efficiency, we have therefore multiplied the figures from the original sources by two to give the corresponding TWh of hydrogen fuel.

[5] T Weidner, G Guillén-Gosálbez, 2023, 'Planetary boundaries assessment of deep decarbonisation options for building heating in the European Union', *Energy conversion and management*

[6] Government correspondence, December 2023 update, 'Hydrogen village trail: open letter to gas distribution networks and further information'

[7] European Hydrogen Observatory, 2023, 'Levelised cost of hydrogen calculator'

[8] A Giampieri, J Ling-Chin and A Roskilly, 2024, 'Techno-economic assessment of offshore wind-to-hydrogen scenarios: a UK case study', *International journal of hydrogen energy*

[9] ITM Neptune V, www.itm-power.com, (last accessed 1 December 2024)

[10] McKinsey & Company, 2023, 'Hydrogen trade outlook: 2023 update'

[11] S Gill, 2024, *Green hydrogen in Scotland*, Scottish Futures Trust

[12] Department for Business, Energy and Industrial Strategy (BEIS), 2021, *Hydrogen production costs 2021*

[13] A Simkov, 2023, *Turning wasted wind into clean hydrogen*, Policy Exchange

[14] DESNZ, 2024, 'Contracts for difference allocation round 6'

[15] Bank of England, 'Inflation calculator', www.bankofengland.co.uk

[16] Elexon BSC, 'Market index prices', www.bmrs.elexon.co.uk, (last accessed 1 December 2024)

[17] NESO, 2024, 'BSUoS fixed tariff'

[18] NESO, 2024, 'Final TNUoS tariffs for 2024/25'

[19] BEIS, 2022, government consultation: 'Exemption scheme for energy intensive industries'

[20] DESNZ, 2023, government consultation: 'British industry supercharger network charging compensation scheme'

[21] Cornwall Insight, Q4 2023, 'Power market outlook to 2030'

[22] Zero-Emission Shipping, RMI and Global Maritime Forum, 2024, *Oceans of opportunity – supplying green methanol and ammonia at ports*. Note that the price for green ammonia from the United States was omitted due to high levels of uncertainty over Inflation Reduction Act subsidies

[23] J Egerer, V Grimm, K Niazmand and P Runge, 2023, 'The economics of global green ammonia trade – "Shipping Australian wind and sunshine to Germany"', *Applied energy*