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Briefing

Prioritising hydrogen use for UK transport

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Summary

Hydrogen fuel offers significant opportunities for decarbonising hard to abate parts of the UK economy as an alternative to batteries and synthetic or biofuels. It requires considerable energy and infrastructure to produce, and its availability is not unlimited, therefore its use should be focused on applications where direct electrification is not a viable option in the foreseeable future, such as for aviation and the production of virgin steel.

'Green' hydrogen, produced through electrolysis using renewable electricity, offers the largest emissions reductions compared to other forms of hydrogen energy. Scaling it up should be prioritised over 'blue' hydrogen – made using natural gas and carbon capture and storage (CCS) – which could lock us into reliance on fossil fuels in decades to come.

In spring 2022, the government published its energy security strategy, which increased the target for UK hydrogen capacity from 5GW in 2030 to 10GW, with at least half of this being 'low carbon' hydrogen (which could include hydrogen made using nuclear power). This announcement, alongside the 2021 hydrogen strategy, marks an ambitious route to hydrogen supply in the UK, however it, and related policies, do not provide a clear view on which sources of demand should be prioritised, especially when it comes to transport.

Hydrogen as a fuel

The most common production methods for hydrogen are:

- Steam reformation of natural gas, without capture of resulting carbon dioxide ('grey' hydrogen). This is already generated at scale in the UK for industrial processes.
- Steam reformation of natural gas with CO_2 captured and stored ('blue' hydrogen). Blue hydrogen's lifecycle emissions vary depending on processing, transportation, feedstocks, and the CCS technology used. Current CCS technology is not 100 per cent efficient, meaning some CO_2 emissions are produced during this process.

- Electrolysis of water using renewable energy ('green' hydrogen). Green hydrogen has considerably fewer lifecycle emissions than alternative blue and grey hydrogen. Currently, high electricity prices in the UK are preventing the rapid scaling up of green hydrogen for commercial use.

Other options are 'pink' hydrogen, produced through electrolysis using nuclear energy, and 'turquoise' hydrogen from methane pyrolysis, which produces solid carbon as opposed to carbon dioxide. Approximately 2,000TWh of hydrogen are produced globally each year, around 27TWh of that in Britain, the majority of it is grey hydrogen.

In the transport sector, hydrogen can be seen as an attractive alternative to fossil fuels in combustion engines, used in fuel cells or as the feedstock for synthetic fuels. Elsewhere in the economy, it may end up being burnt directly in power production or used as a fuel or a reductant in industrial processes, such as steel production.

It is possible to blend hydrogen with other fuels. However, when done in an internal combustion engine at high temperatures, significant volumes of nitrogen oxide emissions are produced, a major greenhouse gas, with the potential for detrimental public health effects.[1]

Policy context

Following the 2021 hydrogen strategy, the government recently announced it would be doubling hydrogen capacity from 5GW to 10GW by 2030, with at least half of this being from electrolytic sources (renewable and nuclear energy).

Ongoing consultations are determining subsidy (business) models for low carbon hydrogen producers, and new commitments from government say that, by 2025, new business models for the transportation of hydrogen will be designed.

The 2021 hydrogen strategy predicts that transport will demand 6TWh of low carbon hydrogen in 2030, mainly for HGVs, buses, rail and early stage use in shipping and aviation, raising significantly to 140TWh by 2050. The Department for Business, Energy and Industrial Strategy (BEIS) predicts that transport will demand between 20-45TWh of hydrogen in 2050, accounting for between 30-54 per cent of total hydrogen demand.[2]

Green hydrogen should be the priority

Blue hydrogen might feasibly play a role in reducing the UK's emissions in the near term to help maximise decarbonisation while renewable capacity is scaled up, but this looks less attractive while gas prices are high. And the Climate Change Committee's (CCC) recommendation, set out in its sixth carbon budget advice, is that the UK should aim to transition entirely to green hydrogen production by 2050. The low carbon hydrogen standard and hydrogen business models being developed by government should be designed to support the phasing out of blue hydrogen production by 2050 and moving to a purely green hydrogen system. The strategic use of hydrogen will also minimise the need to utilise blue hydrogen (see below).

Hydrogen in transport should be targeted at specific applications

In instances where electrification is a possibility, it should be prioritised. This will leave the supply of hydrogen – particularly green hydrogen – available for hard to abate industries. It is invariably more efficient to produce electricity and supply it directly to a vehicle or store it in a battery for later use, than to go through the multiple conversions required to turn electricity into green hydrogen, transport the hydrogen and then turn the hydrogen back into electricity or burn it.[3]

The hydrogen strategy states "Hydrogen can potentially complement electrification across modes of transport such as buses, trains and heavy goods vehicles (HGVs)"; however, each of these modes of transport could be decarbonised through either direct or battery electrification.

Cars and vans: Battery powered electric vehicles (BEVs) are already a cheaper, more efficient technology than hydrogen for cars and vans. However, to date, road transport has been leading the early hydrogen market for transport in the UK. Green Alliance's report demonstrates the need to support alternatives to individual car use, in conjunction with accelerating the UK fleet transition to electric vehicles, as opposed to switching to hydrogen vehicles to meet climate targets.

HGVs: It is becoming increasingly likely that batteries will also play an important role for HGVs, particularly for shorter journeys with investments made by automotive manufacturers such as Volvo.[4] The government is also trialling an electric road system (ERS), which supplies battery electric trucks with electricity from overhead catenary charging cables. While these technologies are being developed and trialled, hydrogen must not be locked in as the route to decarbonisation.

Rail: Nearly 40 per cent of the UK rail network is already electrified. This is faster and cheaper than using hydrogen trains.

Aviation and shipping: The picture is quite different for aviation and shipping where hydrogen is more likely to be part of the solution. The government is relying on the development of zero emission aircraft - battery or hydrogen powered - in aviation; however, both technologies are currently in their infancy. Until their development for commercial scale, sustainable aviation fuels such as power-to-liquid fuels, can be made using hydrogen and will reduce the environmental impact of flying.[5]

The shipping industry's cleanest decarbonisation options are hydrogen and ammonia. Hydrogen fuel cells are likely to be introduced to power even large ships, but storage challenges may need to be overcome.[6]

Recommendations

At present, policy makers are focusing on ensuring the supply of hydrogen; this is seen in the design of the main funding model and does not differentiate between different end uses.

Green Alliance recommends a greater focus from the government on where in the economy limited hydrogen resources are best used. Priorities should be the aviation and shipping industries over any other modes, and explicit selection criteria for projects qualifying for support should be introduced so that they target applications with few, if any, viable alternatives for decarbonisation.

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Endnotes

[1] S Wang, C Ji B Zhang and X Zhou, 2014, 'Analysis on combustion of a hydrogen-blended gasoline engine at high loads lean conditions', *Energy Procedia*, pp 323-326
[2] Gigawatt hour (GW) is the unit representing potential hydrogen capacity, whereas terawatt hour (TWh) represents the actual hydrogen output produced.
[3] D Cebon, 2020, *Hydrogen or electron economy?,* www.csrf.ac.uk/blog/hydrogen-or-electron-economy/
[4] Fleetpoint, 17 February 2022, 'Volvo Trucks leads the electric truck market in Europe'
[5] Transport & Environment, 2022, 'Planes', www.transportenvironment.org/challenges/planes/
[6] DVN, 2021, *Five lessons to learn on hydrogen as ship fuel*, www.dnv.com/expert-story/maritime-impact/Five-lessons-to-learn-on-hydrogen-as-ship-fuel.html