FOCUS ON CHANGE

Hydrogen - a hero for zero?

Watching the UK government grapple with energy policy, we've seen U-turns and varying views on how to tackle the UK's future energy security and short-term energy crisis. On the one hand, we saw the rather controversial decision to lift the ban on fracking, since reversed. On the other, as Jacob Rees-Mog puts it, the hydrogen 'silver bullet'. Speaking to the House of Commons, he remarked that "with some adjustments [hydrogen could be] piped through to people's houses to heat them during the winter."

The sheer scope of potential applications puts hydrogen firmly in the picture as a long-term solution to the energy transition challenge. But can hydrogen take us from hero (fuel) to zero (emissions)? In this article, we explore the arguments for and against hydrogen as a fossil fuel alternative.

The hydrogen spectrum

The source and industrial processes to manufacture hydrogen for use as a fuel are integral to its credentials as a low-carbon, environmentally friendly fuel. There are many 'colours' of hydrogen, which we explain below.

- **White hydrogen:** Naturally occurring in the earth's crust, white hydrogen is extracted by drilling. This can be the most environmentally friendly source.
- **Green hydrogen:** Electricity generated from renewable sources, eg wind and solar, is passed through water. The process (electrolysis) separates the hydrogen and the oxygen. However, this process directs renewable power away from the grid.
- **Blue hydrogen:** Natural gas is split into hydrogen and CO_2. The CO_2 is captured and stored to mitigate its effect on the climate. This supports the ongoing production of natural gas.
- **Grey hydrogen:** Like blue hydrogen, natural gas is split into hydrogen and CO_2, but instead of being stored, the CO_2 is released. This is the most common form of hydrogen production at the moment.
- **Pink hydrogen:** Like green hydrogen, the same process of electrolysis is used but the source is nuclear energy.
- **Brown hydrogen:** Likely the most environmentally damaging, brown hydrogen is created by burning coal.

The opportunity

Hydrogen is not a new idea – it has been around as a fuel for over a hundred years, but producing it cost-effectively, at scale and safely has been the challenge. However, the versatility of hydrogen as a fuel puts it firmly in the mix for the future of energy. There are many potential applications in the 'hard to abate' sectors (meaning those facing significant barriers to de-carbonise) such as shipping, other heavy transport, and in blast furnaces in the steel industry. It could be used as a replacement for natural gas in the heating sector, displace diesel in maritime and heavy truck use, and even in power generation. Flexible power stations could be powered by hydrogen, working alongside intermittent renewables and replacing industrial applications, for industrial heat. As things stand, hydrogen is also being put to work in domestic transport, including cars and trains. But to make a real difference to our collective goal of decarbonisation, the cleaner colours of hydrogen production would need to be scaled up significantly – and there are ambitious plans afoot to achieve that.

For example, Norwegian energy company Equinor has received UK government approval for its H2H Saltend plant, to produce blue hydrogen[1]. The site chosen is the Humber in Northern England, because it is the most carbon-intensive industrial region in the UK. The plan aims to capture 95% of the CO_2 emissions in the production of blue hydrogen. The project should prevent one million tonnes of CO_2 from reaching the atmosphere per year (the equivalent of removing 45,000 cars).

Meanwhile, the H21 North of England project[2] supports the transition from natural gas to hydrogen to heat 3.7 million homes and 40,000 businesses in the North of England. The report suggests that the gas network and infrastructure in place, currently used for 95% of consumers and businesses, could be converted to support hydrogen. Initial testing has been completed, including odourising hydrogen with the smell of natural gas.

Further afield in Germany (Lower Saxony), 14 hydrogen-powered trains produced by Alstom are being used on a regional passenger train, heralded as a world first[3]. The trains have a range of 100km, are entirely free of carbon emissions, and were developed to operate on non-electrified lines. Spurred on by this success, the company has also received contracts to provide its hydrogen model to Frankfurt, Lombardy, and four regions in France[4].

That all sounds positive. What are the drawbacks?

Expense and efficiency

In our journey to reach net zero, we have a finite amount of time left for us to make a difference. Moreover, a just transition needs to include affordable energy for less wealthy people in both developed and developing economies. The cheapness of the solutions is important – and there's a strong argument that we won't be able to use hydrogen, cheaply and effectively, for some of the applications that have been proposed.

Let's consider Mr. Rees-Mogg's 'silver bullet' argument for hydrogen in domestic heating settings, for example. Recent research[5], informed by 32 studies, found that hydrogen, relative to alternatives such as heat pumps, is expensive and not that efficient. Specifically, it noted that "hydrogen for heating results in higher consumer heating costs (including the upfront and running costs of heating systems". This is largely down to the amount of electricity required to produce green hydrogen, relative to heat pumps. In terms of inefficiencies, the report found that "five times more" electricity would be required to heat a home with hydrogen than a heat pump. When blue hydrogen is used, there is still a cost inherent in the current process that makes it uneconomical relative to natural gas[6]. With that in mind, we're unlikely to be warmed by hydrogen-powered homes any time soon.

Cost is also an issue with hydrogen-fuelled cars. To date, there are just 300[7] of these cars in the UK, with the cheapest model retailing at nearly £50,000[8]. From 2017 to 2019, oil giant Shell opened hydrogen refuelling stations in services stations in Cobham, Gatwick and Beaconsfield, with a view to capitalising on consumer demand for hydrogen cars. But earlier this year, Shell opted to close these stations due to a lack of use[9]; for drivers wishing to reduce their emissions, electric cars are the preferred choice.

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[1] https://www.equinor.com/energy/h2h-saltend

[2] https://h21.green/

[3] https://www.railway-technology.com/news/alstom-hydrogen-trains-germany/

[4] https://www.alstom.com/press-releases-news/2022/8/world-premiere-14-coradia-ilint-start-passenger-service-first-100

[5] https://www.bbc.co.uk/news/science-environment-63050910 and http://www.janrosenow.com/uploads/4/7/1/2/4712328/is_heating_homes_with_hydrogen_all_but_a_pipe_dream_final.pdf

[6] https://podcasts.apple.com/gb/podcast/everything-about-hydrogen/id1475783473

[7] https://greenfleet.net/features/08112021/uks-hydrogen-strategy

[8] https://www.carwow.co.uk/guides/choosing/hydrogen-cars#gref

[9] https://www.thetimes.co.uk/article/shell-shuts-hydrogen-car-fuel-stops-as-the-low-carbon-technology-stalls-t7hrpm2nw

Transportation and geography

Transportation costs are another barrier. Hydrogen's very low density means that it's tricky to transport – over longer distances, it is commonly cooled to very low temperatures, liquified and carried in cryogenic liquid tankers. The cost of transporting hydrogen, and the energy efficiencies inherent in doing so, diminish the appeal and practicality of using it. A report by the International Renewable Energy Agency (IRENA) on how the global energy trade could help meet the 1.5°C target stated the importance of innovation to reduce the energy used in the liquefaction process[10]. That is not a quick fix. To be widely adopted and scalable, we need a smoother journey from the production site to the point of use (producing hydrogen locally is an obvious alternative too).

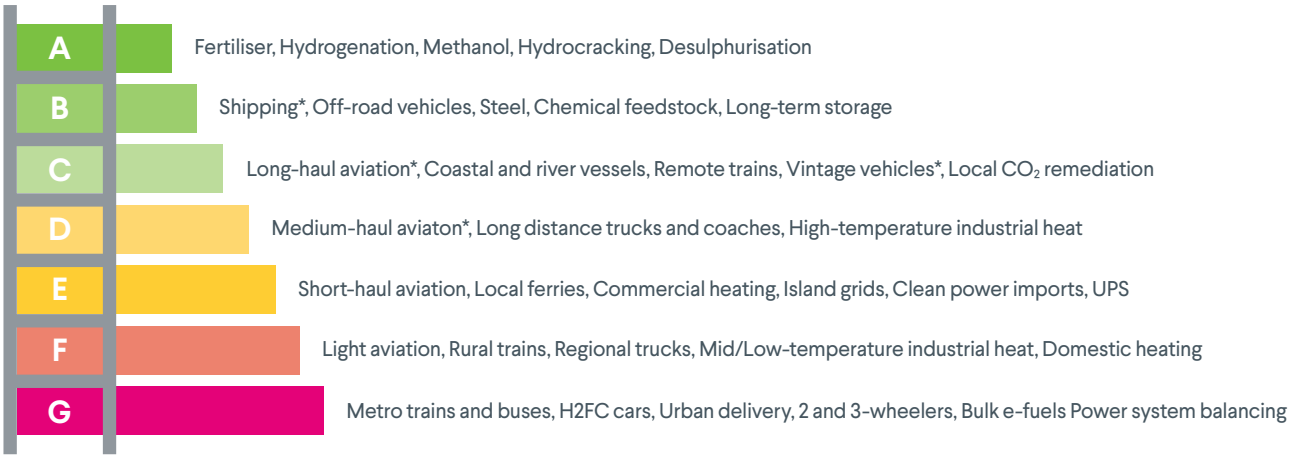
Focusing on the right types of change

For hydrogen to make a meaningful difference in our transition from fossil fuels, there's a conversation to be had around priorities and pragmatism – pinpointing areas in which hydrogen is the best choice. Conversely, we also need to recognise that alternative technologies or solutions may be more appropriate in some settings.

The hydrogen ladder, below, is an attempt to prioritise the use of hydrogen by focusing on the demand side of the equation. It's a starting point for conversations in the hydrogen community to ascertain when and where hydrogen is the best solution, or if a clean alternative – say electrification or batteries – would be more effective. In the lower rungs of the ladder, electrification and batteries are big competing technologies and are arguably more viable. You'll notice that domestic heating sits on the second-to-last rung alongside rural trains, while hydrogen cars are on the bottom.

The Hydrogen Ladder

Unavoidable



Uncompetitive

* Via ammonia or e-fuel rather than H2 gas or liquid
The Clean Hydrogen ladder, Version 4.0 Source: Liebrech Associates (concept credit: Adrian Hiel/Energy Cities)

[10] https://www.irena.org/publications/2022/Apr/Global-hydrogen-trade-Part-II

The right change, in the right places

Another consideration is geography. The countries producing natural gas seem like good candidates to produce blue hydrogen, for example. But for blue hydrogen to be 'done right', there needs to be a very high capture of the CO_2 and vanishingly low emissions of methane. We need to be confident both in the integrity of this process and its overall safety, meaning we should turn to well-regulated, transparent countries when sourcing blue hydrogen.

How can we harness the investment opportunities in hydrogen?

The International Energy Agency estimates that worldwide investment in clean energy needs to triple to around $4 trillion by 2030[11]. Within that, there is a huge scope for investors to contribute to, and benefit from, hydrogen as a fossil fuel alternative.

As we've seen, hydrogen can be put to work in a variety of applications, but not all of these are feasible, or even desirable. For that reason, investors need to be fully apprised of the context in which a prospective investment in hydrogen is taking place, to ascertain if it effects real-world change and aligns with their investment beliefs. It's also important to note that some hydrogen-focused investment opportunities are quite speculative/risky in nature. The flipside of innovative technologies is that they are, by nature, new and untested, thereby exposing investors to the risk they don't succeed as planned. Because it is at a relatively early stage of development, the sector is also very niche at the present time.

In our view, the more likely route to access hydrogen is via the companies already held in portfolios, ie by investing in their transition. Companies in 'hard to abate' sectors will be the more likely users of hydrogen in the near term. Those that are able to evolve their business to accommodate hydrogen, and importantly invest and be part of creating hydrogen solutions within their sectors, will likely have a competitive advantage.

There is also potential in cross-sector opportunities, in the form of developments in technology or infrastructure that make hydrogen more cost competitive. For example, a key target in the global steel industry's journey to net zero is the planned construction of 70 new near-zero carbon plants this decade. These could include hydrogen furnaces, and would have the dual benefit of tackling the growing demand for steel as well as driving emissions down.

Finally, we've also seen the emergence of hydrogen infrastructure funds, which purport to invest across the hydrogen value chain, tackling issues of production, transportation, and supply. In October 2022, a large LGPS pooled fund invested €100m into a Clean Hydrogen Infrastructure Fund[12] – the fund in question has attracted 1.3bn in investments and is now closed to new investors. Hydrogen infrastructure is an area we'll be monitoring for emerging opportunities.

Ultimately, an investment in hydrogen – directly or indirectly – should be weighed up against the demand profile. If you're interested in other ways in which investors can play a part in decarbonisation, check out the sister articles in our Focus on Change series.

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[11] https://www.iea.org/reports/net-zero-by-2050

[12] https://www.netzeroinvestor.net/news-and-views/briefs/uk-local-government-pension-pool-to-invest-100m-in-clean-hydrogen?refresh=truehttps://www.netzeroinvestor.net/news-and-views/briefs/uk-local-government-pension-pool-to-invest-100m-in-clean-hydrogen?refresh=true