

Insights

LOW CARBON HYDROGEN IN THE UK – A UNIVERSAL SOLUTION?

Jan 17, 2025

SUMMARY

The scaling up of low carbon hydrogen technologies will be crucial for achieving the UK's Net Zero target by 2050 and a sustainable energy future. Historically, hydrogen has been produced from fossil fuels and utilised across heavy industry processes (whether as feedstock in fertiliser production, steel manufacturing or petrochemicals). Low carbon hydrogen, produced with significantly reduced greenhouse gas emissions, can facilitate the decarbonisation of hard to abate industrial sectors. However, it is not without its challenges. Production costs currently exceed certain national Net Zero targets more than two-fold (e.g. in Australia the target green hydrogen production cost is US\$2/kg but the actual cost is US\$9/kg and similarly in Canada the figures are just under US\$3/kg (target) but US\$8/kg (actual)) with more than half the production cost attributable to the cost of the power required for electrolysis.

TYPES OF LOW CARBON HYDROGEN

For hydrogen to be as integral to achieving Net Zero as the UK Government (the “**Government**”) intends for it to be, almost all current and future hydrogen production must be low carbon. The primary types of low carbon hydrogen are as follows:

BLUE HYDROGEN

This form of hydrogen is derived from natural gas as a feedstock source, and steam reforming or ‘gasification’ used as the production process. Natural gas is the most abundant source of hydrogen, but its chemical composition means that carbon emissions are generated (as a by-product) which need to be captured and either stored or reused. Therefore, blue hydrogen production operates hand-in-hand with carbon capture, usage and storage projects. Grey hydrogen follows the same process, but does not include the capture of the carbon emissions.

GREEN HYDROGEN

Green hydrogen electrolyses water as a feedstock (thereby splitting the hydrogen and oxygen atoms) using electricity generated by renewable energy sources, such as wind and solar power projects. The predominant advantage is that green hydrogen produces no carbon emissions. However, its reliance on renewable power makes it expensive, meaning it is generally regarded as a less attractive long-term feedstock for industrial end-users.

UK GOVERNMENT COMMITMENTS

The Government has committed to producing 10GW of low carbon hydrogen by 2030, including green and blue hydrogen production. By 2050, it is anticipated that around 60% of low carbon hydrogen would take the form of green hydrogen.

The Energy Act 2023, passed under the previous Conservative Government addresses many regulatory areas around hydrogen production. In December 2023, the Hydrogen Strategy Delivery Update confirmed further support for hydrogen production and storage and the creation of an end-user marketplace. However, market commitment is insufficient as developers do not have the revenue certainty to commit to these projects. Currently, the only viable offtakers are localised heavy industrial players which is why hydrogen (and carbon capture) in the UK has developed around regional clusters in industrial heartlands. In the Update, the Government states that revenue support will be provided to ease the development of hydrogen solutions, with the first step being the publication of its Low Carbon Hydrogen Agreement (“**CHA**”). The CHA essentially acted not dissimilarly to the Contracts for Difference scheme (“**CfD**”) for renewable projects, with a strike price and a government top up to guarantee the offtake price (termed the “**Difference Amount**”). The CHA includes a floor price equal to the reference price for natural gas (i.e. where the offtake price is less than the strike price but is more than the floor price, the Difference Amount is equal to the strike price less the offtake price but where the offtake price is less than both the strike price and the floor price, the Difference Amount is only equal to the strike price less the floor price). Whilst this offers price certainty, it does not guarantee the long-term cash flow which underpins the bankability of any project. The agreement also introduced a Price Discovery Incentive Ratio, whereby hydrogen producers would receive a percentage portion of the sales value to incentivise hydrogen sales at a price above the price of natural gas (essentially giving hydrogen producers 10% of the difference between the hydrogen sales price achieved less the price of natural gas). Further, the UK’s low carbon hydrogen scheme, the Hydrogen Production Business Model (“**HPBM**”), was introduced under the Energy Act 2023 with the aim of providing revenue support to successful projects.

As part of the new Labour Government’s Clean Power by 2050 targets, the Labour manifesto has committed £500 million in investments from the National Wealth Fund in the production of green hydrogen, specifically in ports and industrial clusters across the UK. Beyond the manifesto, there have been no significant announcements for the new Government’s commitments.

THE EXISTING UK MARKET

The UK's geology, geography and existing infrastructure means we are well placed to develop, produce, store and utilise hydrogen in our energy economy. The predominant end-users of hydrogen at this stage appear to be agriculture, transport and the oil and gas industry, and case studies for each are discussed below. There is a potential use case for industrial heating, however domestic use in residential heat networks looks like a more remote possibility.

The UK is actively developing five key hydrogen corridors to lead on-land hydrogen infrastructure development. It is thought these corridors will increase the mobility and robustness of an effective hydrogen network. However, significant coordination between these corridors is essential. A co-location of multiple industrial clusters (by way of natural gas import hubs) is a preferred method to pool resources. There is a significant increase in the development of green shipping corridors, which is primarily government-led, to globalise the hydrogen industry. Despite efforts, the main barriers to the UK achieving a successful low carbon hydrogen market include the following:

BANKABILITY

Big hydrogen infrastructure is commonly financed by equity investors sponsoring the project and secured investors lending high proportions of debt (and subsequently being repaid out of project cash flows). The main barrier therefore is lenders trusting the reliability of predicted cash flows generated from hydrogen projects and investing on that basis. There are currently few offtake opportunities and industrial end users are not yet prepared to commit to take hydrogen in bulk and on a long-term basis.

Whilst HPBM has introduced the Difference Amount in offtake agreements, the UK currently does not have a liquid market for hydrogen meaning the base reference price is unpredictable and cannot offer long-term reliability for offtakers and investors (hence the reliance on the natural gas price as a base reference floor price). Similarly, negotiating a strike price may be commercially difficult for developers as any cost calculation (which may at the time be hard to price due to market volatility) will be heavily scrutinised by the Department of Energy Security and Net Zero under their "value for money" criteria.

RESOURCE AVAILABILITY

The production of green hydrogen through electrolysis requires substantial volumes of water and access to large pools of freshwater can be an issue (especially in areas with water scarcity and where there are competing demands for water supply). Additionally, the vast amounts of land usage required for green hydrogen is problematic. Hydrogen plants generating the electricity required for electrolysis can take up considerable space, hence why offshore plants using seawater are often viewed as a valued option.

However, seawater requires further energy consumption from the desalination, filtration, softening and demineralisation process. It can take more than three times as much seawater to produce one litre of ultra-pure water for electrolysis. Seawater can also lead to high corrosion. However there is

significant investment in research and development to produce green hydrogen from seawater, exemplifying companies' investment in the alternative resource.

For green hydrogen to become a universal solution: (1) the manufacture of electrolyzers needs to be rapidly accelerated as there simply are not enough electrolyzers in the world to generate the green hydrogen volumes needed; and (2) renewable energy costs need to be reduced (or subsidised specifically for green hydrogen production) – as the latter renders green hydrogen unmarketable and without the former green hydrogen simply cannot be produced. China has significantly enhanced its manufacturing capabilities for electrolyzers (and accounted for 60% of global electrolyser manufacturing capacity in 2023).

TRANSPORTATION AND STORAGE

Uncertainty remains around how hydrogen is to be transported to and stored at the point of use in sufficiently large quantities. Infrastructure for transportation via existing natural gas pipelines is, however, ready to use, meaning that hydrogen can be blended with natural gas and transported using existing infrastructure. As hydrogen is a smaller molecule than natural gas, it may leak, meaning more investment in leak detection and prevention systems will be required.

Above the ground, transportation by trucks is preferential where there are low distances to offtakers, but trucks have a natural boundary on volume capacity, meaning there are limits to scalability, alongside issues of traffic disruption and road degradation (which occurred in the US shale boom when delivery of fracking proppant materials and chemicals to shale drilling sites were scaled up).

Whilst storage is essential in ensuring the fluctuation in hydrogen production is levelled out, the storage is significantly hindered due to the low density of the gas. As the lightest chemical in the universe, hydrogen is always looking to escape and its pressurised state can place additional stress on any storage infrastructure's resilience.

Trading of hydrogen is relatively limited and mostly occurs in small-scale, regionalised locations between neighbouring countries (e.g. small pipelines between the Benelux countries and France). Ammonia is favoured in the market for maritime hydrogen transport due to established routes, industry expertise and its favourable properties (ammonia's higher energy density means a larger volume of energy can be traded). However converting ammonia back into hydrogen poses challenges relating to safety, cost, energy efficiency and environmental compliance.

Case study 1: Agricultural Sector

The initial growth of low carbon hydrogen has been concentrated around its use as a feedstock in the production of ammonia and methanol for fertiliser and petrochemicals. This could displace current demand for hydrogen feedstock from unabated fossil fuels. However, whilst fertiliser prices have eased since 2022/23, the additional costs of green hydrogen complicate widespread use, given that the adoption of green hydrogen currently adds a price premium to ammonia. Over the

last 18 months, green hydrogen-based ammonia projects have commenced production in Norway and achieved FID in India. However, for wide spread scalability, green hydrogen-based ammonia must achieve price parity with traditional ammonia. Accordingly, government incentives and policies are crucial to encourage the adoption of green hydrogen in agriculture, using a combination of incentives and regulations to drive change.

Case study 2: Transport Sector

The use of hydrogen in fuel cell electric vehicles (“FCEVs”) has been identified as key to the low carbon solution. However, the current uptake of FCEVs in the UK market is minimal, with the sale of only around 100,000 units. Global adoption of FCEVs has been dominated by the Asia-Pacific market, with significant contributions from China, South Korea and Japan by the likes of Toyota’s pioneering hydrogen fuel cell technology ‘Toyota Mirai’ and Honda’s Clarity Fuel Cell CR-V e:FCEV. China has also invested heavily in FCEV technology for trucks, buses and hydrogen refuelling stations and a number of cities across Europe (e.g. Barcelona, Bologna, Paris, Cologne, Frankfurt, Odenburg, Cottbus and Walbrzych) are trialling hydrogen fuelled bus routes.

FCEV infrastructure is still in the early stages of development due to the Government’s preference for battery-electric or ‘plug-in’ vehicles. There are also significant concerns around the availability of hydrogen on a large enough scale to supply the consumer market, high production costs and limited refuelling infrastructure. Despite the slow adoption of FCEVs, the vehicles have faster refuelling times than electric batteries (in minutes not hours) and, whilst batteries are more energy efficient using 80% to 90% of the electrical energy stored (as compared with hydrogen fuel cells which only use 40% to 60% of the energy potential), in cold weather hydrogen fuel cells are more efficient as electric batteries can use up to 40% of their electrical energy just for heating. Within Europe, Germany is the leader in terms of FCEV deployment.

Alternatively, hydrogen-derived fuels for long-distance marine transportation have been identified as another viable use in the transport sector, which can reduce air pollution and carbon emissions from shipping. Ports are becoming central for the development of ‘hydrogen hubs’ which can facilitate the production, storage and distribution of hydrogen. For example, the Port of Rotterdam is developing the first major hydrogen hub in Europe, supporting its international maritime applications.

Case Study 3: Oil and Gas

The refining sector is the largest single user of hydrogen, primarily for hydro-cracking and hydro-treatment processes. Most hydrogen used in refineries is self-derived as a by-product, with only about one-third being blue or green hydrogen. Essar’s refinery in Stanlow produces 16% of all UK road transport fuels comprising 4.4 billion tonnes of diesel and 3 billion tonnes of petrol annually and, accordingly produces 2 million tonnes of carbon emissions a year. Essar is seeking to be the first decarbonised refinery in the world and has invested in a new furnace capable of using

hydrogen as a combustion feedstock fuel. Essar is also developing a 350 MW blue hydrogen production plant on site (with the carbon being captured and stored offshore in Liverpool Bay). Idemitsu has also demonstrated the use of ammonia as a combustion fuel in a cracking furnace at its Tokuyama complex, thereby abating 20% of fossil fuel consumption in the combustion furnace.

WHERE CAN WE GO FROM HERE?

Whilst the UK has identified the wide spread adoption of low carbon hydrogen as essential to achieving its Net Zero commitments, the Government must incentivise hydrogen and create an effective hydrogen-based marketplace for demand to increase. The Government could provide R&D allowances for developments in green hydrogen. Further R&D is also necessary to test and commercialise the models of projects discussed above, which may in turn create allowances or grant funding. Alternatively, tax credits for institutions to switch to green hydrogen would further incentivise companies to embrace hydrogen as an energy solution. This would in turn increase bankability. With respect to the Government implementing policies, timeliness is important. Ultimately, to effectively develop an efficient UK hydrogen economy, focus, clarity and consistency will be integral to instilling confidence in investors.

This article was written with trainee solicitor, Emily Hewitt.

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