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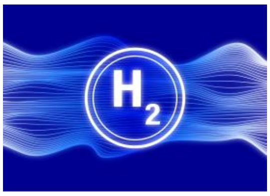
Edison Explains

Low-carbon hydrogen: Blue or green



Hydrogen and the energy transition

Hydrogen is expected to play a key role in the decarbonisation of the energy system, particularly in hard-to-abate sectors such as industry, road freight, shipping and aviation. It can also be used for long-duration storage to manage demand fluctuations in the power sector (the Hydrogen Economy – Decarbonising the final 20% report). The demand for hydrogen is likely to be met through the production of both blue and green hydrogen, which together are referred to as low-carbon hydrogen

Why is hydrogen described in different colours?

Hydrogen is a colourless gas, but the colour codes refer to the source or process used to generate the hydrogen. Black and brown hydrogen are generated from different types of coal, while grey hydrogen is created when natural gas is split into hydrogen and CO_2, usually through steam methane reformation (SMR). Blue hydrogen is also derived from natural gas, but in this case the CO_2 emissions are captured to be eitherused in industrial processes or stored underground using carbon capture, utilisation and storage (CCUS). Green hydrogen is produced by splitting water using electrolysis that has been powered by renewable energy sources such as wind or solar and is the cleanest option, since CO_2 is not produced as a by-product.

Edison Insight

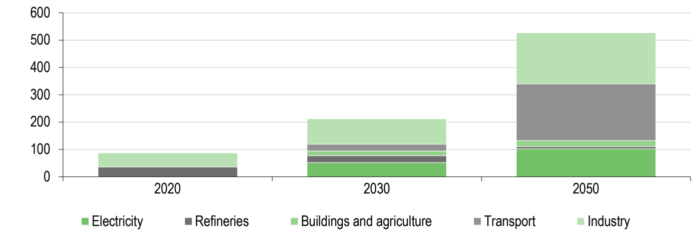
'Faster adoption of low-carbon hydrogen will be needed with contributions from both blue and green hydrogen in order to meet 2050 net zero targets.'

Elaine Reynolds, energy analyst

What is the demand for hydrogen by sector?

In 2020, the demand for hydrogen was 87Mt (source: IEA), and this was produced mainly from fossil fuels. Industry sector demand for hydrogen was c 51Mt, mostly for chemical production, particularly ammonia, and c 10% was consumed in steel making. The remaining 36Mt was used in refining. By 2050, the IEA estimates that total demand will grow to 528Mt, with use in refineries declining and growth seen particularly in the industry, electricity and transport sectors During this time, the share of blue hydrogen as part of low-carbon hydrogen production is expected to fall from 95% to 38%, while green hydrogen's share will increase from 5% in 2020 to 62%.

Total consumption of hydrogen-based fuels: hydrogen, ammonia and synthetic fuels (Mt)



Source: IEA – Net Zero by 2050 – A Roadmap for the Global Energy Sector

What is the current scale of blue and green hydrogen production?

The development of green and blue hydrogen projects remains at a low level, with the IEA estimating that less than 0.1% (c 300MW) of worldwide hydrogen production came from electrolysis (green hydrogen) in 2019, 40% of which was located in Europe, while there are only c 16 blue hydrogen projects in operation around the world, with 80% of these in North America. Close to 60 blue hydrogen projects are planned or in development worldwide and, if realised, would produce almost 9Mt of hydrogen by 2030. Project sizes for green hydrogen have been increasing from the 1MW to 5MW range pre 2020 to projects in the hundreds of megawatts range announced in 2020 that are expected to become operational in the coming years. The IEA estimates that there are 350 projects under development (equating to c 54GW) and a further 40 projects (or 35GW) in the early stages of development, which could provide equivalent to 4.9–8.3Mt of hydrogen production by 2030.

How is this likely to scale up?

Since 2020, 14 countries, including the UK, have adopted hydrogen strategies to meet climate change ambitions. In countries with established oil and gas industries, such as the UK and Norway, CCUS is expected to play a larger role, at least in the short to medium term. The UK Hydrogen Strategy sets out a roadmap that takes a twin track approach envisaging two large-scale CCUS (blue hydrogen) clusters in operation by 2025, growing to four by 2030, while several large-scale electrolysis (green

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hydrogen) projects are expected to be in operation by the end of the decade, with the ambition of reaching a low-carbon hydrogen (green + blue) production capacity of 5GW by 2030. The EU strategy is to prioritise green hydrogen with a goal of installing 6GW of renewable electrolysers by 2024 and at least 40GW by 2030. In addition, there are 40GW of projects planned in neighbouring countries outside the EU. This alone equates to 80GW, which is close to the upper end of the IEA's global green hydrogen projection for 2030. We have not identified any significant green hydrogen project pipeline beyond Europe, except in Australia, where Global Energy Ventures is seeking to ramp up production and ship green hydrogen to Asia.

What are the challenges?

The key challenge will be to continue to scale up the production of both blue and green hydrogen capacity to meet the pathway to net zero emissions by 2050. Current 2030 projections of 9Mt of hydrogen from CCUS and up to c 8Mt from electrolysis are still significantly below the 58Mt from CCUS projects and 80Mt from electrolysis required to meet the Net Zero Emissions by 2050 Scenario.

It is currently easier to deploy CCUS projects at a large scale and so blue hydrogen can be seen as a way to establish supply and demand through existing natural gas infrastructure. This could then be phased out with green hydrogen. Critics see this twin track approach as risking locking in higher carbon emissions, and that infrastructure should be developed around hydrogen demand and supply and not on keeping existing gas assets running. CCUS is also only able to capture between 75% and 90% of the CO_2 produced and a small percentage of the more potent greenhouse gas methane is known to leak during the SMR process. CCUS is nevertheless expected to maintain a role in the energy transition for industry sectors where CO_2 emissions are difficult to eliminate and the IEA estimates that CCUS will contribute to 4% of overall emissions reductions to 2030 and 12% to 2050.

The cost of green hydrogen is currently higher than for blue hydrogen, although it is expected that, as the green industry develops, and with the right incentives, the cost of this technology will drop. The IEA estimates that the levelised cost of green hydrogen will fall from current levels of US$3–8 per kg, to US$1.3–3.5 per kg in 2030, making it comparable with the cost of blue hydrogen at $1–2 per kg.

Major UK projects

Electrolysis

Gigastack is a multi-phase programme to prove economically viable renewable hydrogen at scale, using offshore wind. The project is led by a consortium consisting of ITM Power, Ørsted, Phillips 66 and Element Energy, and has received funding from the Department of Business, Energy & Industrial Strategy (BEIS). The project is to develop a 100MW scale electrolyser system to use power from Hornsea Two, the world's largest offshore windfarm, to provide renewable hydrogen to Phillips 66's Humber Refinery. The consortium expects a final investment decision by Q223 and a commercial operating date by the end of 2025, subject to a supportive policy environment. ITM Power currently operates the world's largest electrolyser facility at its 1GW pa gigafactory in Sheffield and has announced that it will open a second gigafactory nearby with a capacity of 1.5GW pa by the end of 2023.

The Dolphyn project also received funding from BEIS and is a floating wind turbine project to produce hydrogen offshore Aberdeen, aiming for an operational start-up in 2024/25 for a 10MW facility, growing to 100–300MW by the late 2020s. The project is being led by Environmental Resources Management (ERM), a global sustainability consultancy.

CCUS

In October 2021, the UK government announced that it had selected the East Coast and HyNet CCUS projects in northern England as initial beneficiaries of a £1bn pot of state funding, with the Scottish Cluster as a back-up option. The East Coast cluster is led by BP, in partnership with Eni, Equinor, National Grid, Shell and Total, and aims to capture up to 27Mt CO_2 pa in Teesside and the Humber and supply up to 10GW of hydrogen for power and industry by the mid-2030s. HyNet is backed by Eni, Essar, Progressive Energy, Cadent and InterGen and plans to produce over 30TWh per year from hydrogen from the Stanlow Refinery and other sites by 2030, and capture and store over 2Mt of CO_2 in Liverpool Bay.

The Acorn Project, led by Pale Blue Dot Energy, a subsidiary of Storegga Geotechnologies, together with Shell, Harbour Energy, ExxonMobil, Macquarie, Petrofac and Wood, sits at the heart of the Scottish Cluster. Phase 1 of the project aims to capture and store 300,000 tonnes/year of CO_2 from the St Fergus gas terminal in north-east Scotland, using existing pipelines to transport the CO_2 to an offshore storage site. Phase 2 of the project, planned to come online by the mid-2020s, aims to blend hydrogen with natural gas into the National Transmission System, initially at 2%, cutting around 400,000 tonnes a year of carbon emissions, and with the ability to grow to a blend of 20%.