HYDROGEN

Netherlands lays foundations for the world's first hydrogen economy

Dutch lawmakers know they need to move faster when it comes to the decarbonisation of heat and transport – and they're getting serious about hydrogen. *Robert Stokes* explores some of the country's most innovative projects.

E urope's first large-scale green hydrogen plant moved closer to reality in January this year when a proposed electrolysis project in the Netherlands won €11mn in financing from the Fuel Cells and Hydrogen Joint Undertaking (FCH-JU) – a European Commission/industry partnership supporting hydrogen technology innovation.

Amsterdam-based chemicals maker Nouryon and Dutch gas infrastructure operator Gasunie expect to make a final decision this year on whether to build the hydrogen plant in Delfzijl, on the northern Netherlands coast. The facility would come equipped with 20 MW of electrolyser power and would be capable of producing 3 kilotonnes of hydrogen per annum (ktpa).

Among the uses for hydrogen produced by solar-powered electrolysis, Dutch firm BioMCN, another partner in the project, will combine the gas with carbon dioxide (CO2) from other processes to produce renewable methanol. Meanwhile, Nouryon and Gasunie are considering increasing the capacity at Delfzijl to 60 MW and 9 ktpa to produce hydrogen for use in sustainable jet fuels.

The project is just one of several



scaled-up hydrogen initiatives in the Netherlands, which is developing a greater focus on renewable gas amid declining domestic production from its own natural gas reserves. There remains an intense debate over hydrogen's role in the country's future energy system – but there appears to be broad agreement that capacity must be developed rapidly within a decade.

Hydrogen hub

In a report: *Time is Running Out for Green Hydrogen*, the Dutch Hydrogen Coalition called for green hydrogen production capacity to rise from a modest 1 MW now to 500 MW by 2025, and 3.4 GW by 2030. The coalition includes 27 organisations – from Boilers powered by green hydrogen are heating homes in Rotterdam in Stedin's Power2Gas study Photo: Stedin gas and power network operators to government bodies and environmental groups.

The Netherlands government's National Climate Agreement includes significant encouragement for large-scale deployment of green hydrogen, with a goal of electrolysis capacity reaching 3 to 4 GW in 2030, supported by adequate hydrogen infrastructure. Regions and cities are already developing and progressing ambitious plans to create hydrogen economies.

Most notably, Groningen, Drenthe and Friesland provinces are collaborating around the €2.8bn HEAVENN project, which aims to develop a complete green hydrogen value chain in the northern Netherlands. HEAVENN began its five-year development plan in January 2020. The scheme includes building small and large capacity electrolysers, converting natural gas pipes for transporting hydrogen and creating giant storage caverns for hydrogen to serve as batteries for the power system.

Demand-side elements include new and improved infrastructure to get the hydrogen to transport, industrial and domestic users. In an indication of its significance within Europe, HEAVENN is receiving a €20mn grant from the FCH-JU, one of the largest such grants ever made to a single project, bringing its initial development funding to €90mn.

There is talk of the region and, indeed, perhaps the entire country becoming a European 'hydrogen hub' and piping the gas beyond its borders. In February, Gasunie's 2019 annual report stated that, as an independent network company and connector, it can connect and transport hydrogen from different providers to the large industrial clusters in the Netherlands. It predicted that this network could have a capacity of approximately 10–15 GW by 2030.

Parts of the Dutch national gas transport and storage network can be adapted to transport hydrogen quite easily, it added, and this could also facilitate movements of the gas to Germany's Hamburg and the Ruhr area.

As well as declining natural gas production, other key drivers for hydrogen include the country's offshore wind potential (estimated to reach 11.5 GW by 2030 and 60 GW by 2050) which can power green hydrogen production. Its extensive onshore and offshore gas infrastructure, and experience in the sector, have also been cited as important precursors to the hydrogen economy.

More Dutch projects

While the Delfzijl electrolyser would be the first technology of its kind to be implemented in Europe on this scale, it's not the only green hydrogen project in the Netherlands, nor is it the largest. Other industry-led green hydrogen initiatives expecting to reach final investment decisions in 2021 include a 1 GW electrolysis plant in Zeeland, which is being assessed by Danish energy company Ørsted, in partnership with chemicals companies Dow and Yara.

A consortium made up of Gasunie, Groningen Seaports and Shell Nederland announced in late February that it intends to launch a project known as NortH2, in which

King Willem-Alexander of the Netherlands opening Gasunie's HyStock green hydrogen plant near Groningen in June 2019 Photo: Gasunie

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The Netherlands

electrolysis will be powered by a massive offshore wind farm to produce green hydrogen from 2027. The group is also considering placing electrolysers offshore. It is seeking additional partners and could launch the feasibility study in 2020. See also news story on page 4.

For context, all these plans represent a large upscaling of hydrogen production capacity compared with HyStock - Gasunie and partner EnergyStock's 1 MW green hydrogen plant, which opened last June as the first power-to-gas facility in the Netherlands. Co-funded by the EU Connecting Europe Facility, HyStock represents an important step in upscaling power-to-gas technology. It involves taking power from thousands of nearby solar panels to electrolyse water to make green hydrogen for transport and industry.

Significantly, it is co-located with an EnergyStock underground gas storage facility with adequate buffering capacity and connections to the main gas and electricity infrastructure.

Going blue

Carbon neutral 'blue' hydrogen, made through the steam reforming of natural and gas, with bolt-on carbon capture and storage (CCS) capabilities, is the focus of another four industry-led projects. One, called 'H-vision', aims to decarbonise natural gas and refinery gases to produce hydrogen for use as a fuel and feedstock. The project consortium includes BP, Gasunie, Port of Rotterdam Authority, Power Plant, Shell, Germany energy company Uniper and Dutch gas storage company Koninklijke Vopak.

H-vision appointed a new project director in January to oversee the next phase of the estimated €2bn project, which is progressing towards an expected final investment decision as early as 2021. H-vision is doing further work on the business case, choosing a location for the hydrogen installations and compiling an inventory of required infrastructure and storage needs.

As currently envisaged, the hydrogen systems would have a total capacity of 700 ktpa and would supply hydrogen to industrial customers in Rotterdam in early 2026. Feasibility studies suggest it could reduce industrial CO2 emissions by 2.2mn tonnes in 2026, rising to as much as 4.3mn tonnes in 2031.

Another blue hydrogen project, Hydrogen to Magnum (H2M), aims to generate zero emission dispatchable power from a combined cycle gas turbine power plant in Eemshaven converted for hydrogen fuelling, with the CO2 from hydrogen production to be stored in aquifers in Norway. Swedish energy company Vattenfall, Dutch energy firm Nuon, Norwegian energy company Equinor and Gasunie are the stakeholders.

A third initiative proposing to use hydrogen with carbon from waste gasification to make bio-methanol would be Europe's first plant to make valuable chemicals and biofuels out of non-recyclable waste materials. The companies involved are Enerkem, Nouryon, Air Liquide, Shell and Port of Rotterdam, which would host the plant. The project has financial backing from Netherlands government and the European Union. The plans envisage a capacity to convert 360mn tonnes of waste into 220mn tonnes of bio-methanol.

Domestic and academic interest

While many of the Netherlands planned and operational hydrogen facilities focus on industrial and transport applications, utility firm Stedin is approaching the middle of its five-year Power2Gas study to prove the feasibility and safety of heating Dutch homes with green hydrogen.

In spring 2020, it was assessing the first winter's results from apartments in the Rozenburg area being heated by hydrogen-fuelled boilers in a residential block's central heating unit. The hydrogen is being produced by eight stackable anion exchange membrane electrolyser units supplied by Germany's Enapter. They are in a nearby portable structure and supply the boilers via a short pipeline that previously carried natural gas.

The electrolysers are monitored and controlled remotely, which allows them to be run optimally for demand patterns. In 2025, Stedin intends to scale-up its study by supplying 550 existing homes in Stad aan 't Haringvliet, South Holland with hydrogen via the existing natural gas grid.

The development of hydrogen projects in the Netherlands is also being supported and, conversely, catalysing industrial and academic research in the country. DNV GL, the energy consultant and certification body, is managing a recently established multi-year, multi-client global joint industry project to see how hydrogen could decarbonise the energy-intensive manufacture of ceramics, glass and steel.

The project aims to develop and demonstrate a burner system capable of running on 100% hydrogen, 100% natural gas, or mixtures of the two to offer fuel flexibility at only limited capital cost. The Netherlands government is among 25 international partners funding the project, which is being supported by natural gas and hydrogen expertise at DNV GL's Groningen laboratories and test facilities.

Meanwhile, DNV GL is among organisations attracted to the University of Groningen's Zernike Campus, where a 'Hydrohub MegaWatt Test Centre' is also being planned. It will be an openinnovation infrastructure for research, and for performing stress testing at MW scale with both alkaline and proton exchange membrane (PEM) electrolysis of water, to point the way towards GW-scale production of sustainable hydrogen by process industries.

The plan is to let material and component suppliers test how their products perform in a MW-scale electrolyser. Electrolyser makers do not themselves provide the same access to suppliers of anodes, electrodes, membranes and pumps.

The Hydrohub MegaWatt Test Centre is part of a wider Hydrohub Innovation Programme being coordinated by the Netherlandsbased Institute for Sustainable Process Technology to help scale up green hydrogen production. This institute is an intermediary between industry, SMEs, knowledge institutions and the government. The programme includes two other projects: a Hydrohub GigaWatt Scale Electrolyser (2018–2021), investigating what will be needed to build a GW-scale electrolysis plant in the Netherlands around 2025 or 2030, and HyChain, analysing the future value chain in hydrogen production.

Not overnight

As the title of the Hydrogen Coalition's November report hinted, no one is under any illusion that a sustainable hydrogen economy will develop in the Netherlands overnight. The report also asked for policy changes, claiming that current subsidy schemes and resources are insufficient for scaling-up hydrogen. For instance, Dutch gas distribution system operators cannot currently pipe 100% hydrogen through the existing natural gas grid.

In addition, the supply of green hydrogen from renewablespowered electrolysis will initially be limited and relatively high cost. But with the Netherlands supreme court ruling in December 2019 that the government must move faster to cut carbon emissions, the hydrogen lobby is knocking loudly on a door that is opening wider.

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