

## HYDROGEN

# Turning up the heat



The UK is committed to decarbonising 80% of 1990 emissions by 2050 under the UK Climate Change Act in a move towards net zero carbon. Heat contributes about a third of the country's annual carbon dioxide (CO<sub>2</sub>) emissions and 84% of UK homes use natural gas for heating and cooking. Today, there is a strong debate about how the UK is to decarbonise heat, whether by electrification and/or conversion of the natural gas transmission network to 100% hydrogen.

H21 features a number of innovative gas engineering projects, led by Northern Gas Networks, focused on demonstrating that the UK gas grid can be re-purposed to carry 100% hydrogen, to meet the government's 2050 net zero carbon objective.

It's an ambitious goal. Though much has been done in terms of decarbonising electricity generation, decarbonising heat is very challenging because of seasonal energy demands. H21 argues that simply converting the entire heat system to electricity is not the answer.

For well over a century the UK has relied on gas and has a vast network covering about 90% of all homes and businesses. Hydrogen offers all the benefits

**A consortium of pioneering gas transmission projects, under the banner of H21, led by Northern Gas Networks, aims to demonstrate that the UK gas grid can be converted to hydrogen technically, safely and economically. Brian Davis reports.**

of natural gas, can be produced at scale and stored easily. There is no need to 'rewire' the grid and it is technically feasible to replace gas within the UK gas networks in the 30-year time-scale.

Keith Owen, Head of Systems Development and Energy Strategy at Northern Gas Networks, maintains: 'Hydrogen gives us all the benefits of natural gas without the carbon footprint. There's a lot of focus today on solving the hydrogen transmission challenge for our customers. Transitioning of the network also opens opportunities to deliver hydrogen for road and rail transport etc as well as heat.'

#### How it started

Given the UK government's initial objective as stated in the Community Energy Report 2014, to electrify heat and shut the gas networks in accordance with the

then UK Department of Energy and Climate Change (now part of the Department for Business, Energy and Industrial Strategy) policy, there was a move by the gas industry to offer an alternative solution. 'We did a lot of thinking about how we might decarbonise our natural gas transmission network. Indeed, we initially thought handling hydrogen may be a problem, not our background infrastructure,' comments Owen.

In 2015, the H21 group initiated the Leeds City Gate Project, testing the technical feasibility of provision of hydrogen in place of natural gas to Leeds, a complex gas network in Britain's fourth largest city. Two UK gas networks, Northern Gas Networks and Cadent, began designing the onshore conversion and transmission system for hydrogen. 'We demonstrated that with the right process in place it was technically feasible to decarbonise the heat infrastructure of a big city below the 7 bar system,' says Owen.

The following year, Northern Gas Networks and partners produced a more detailed H21 North of England report on the potential for deep decarbonisation of heat at major northern urban conurbations (in line with the government's Northern Powerhouse objective to spur northern developments) including Leeds, Bradford, Wakefield, Huddersfield, Hull, Liverpool, Manchester, Teesside, Tyneside and Yorkshire. This strategic modelling project was developed by Northern Gas Networks and Cadent Networks, along with Equinor's expertise on hydrogen production and technologies, seasonal production, and carbon capture and storage (CCS).

Based on the blueprint for deep decarbonisation of Leeds, the new report was published in November 2018. It concluded that it was technically possible and economically viable to decarbonise the UK's gas distribution networks by converting from natural gas to 100% hydrogen. 'We deduced that the transition would be a matter of marginal change (ie with some additional pipeline reinforcement, for example), well within our capability,' says Owen.

However, he makes the important point that: 'Before the vision of a hydrogen gas network can be realised, critical safety

Pointing to the future – background testing for Phase 1a of the H21 NIC project is being carried out at the HSE Science Research Centre in Buxton

Photo: H21

evidence for such a conversion, both upstream of the meter and downstream, must be provided. Without it, a credible government policy decision on decarbonisation of heat simply cannot be made.'

#### The next stage

Acting on behalf of UK gas networks, including Northern Gas Networks, Cadent, SGN and Wales and West Utilities, H21 successfully submitted a Network Innovation Competition (NIC) bid to Ofgem in 2017 as the first step towards providing this evidence. The project secured £9mn of Ofgem funding and a further £1mn was contributed by the UK gas networks. H21 NIC is currently working to present quantified safety evidence that the natural gas transmission network can be safely transitioned to 100% hydrogen within the existing gas distribution network.

The H21 NIC report is due to be delivered mid-2020, followed by field trials. This is a joint industry project involving Scotia Gas Networks, Cadent Gas, Wales and the West Utilities and Northern Gas Networks. Phase one of the NIC is being carried out in two parts.

Phase 1a covers background testing at the Health and Safety Executive Science Research Centre in Buxton, which was officially launched in July 2019. This claims to be the world's first 100% hydrogen gas testing facility and will carry out controlled tests to establish critical safety evidence to prove a 100% hydrogen network is as safe as the natural gas grids. 'The results will be critical in determining if it's safe to convert millions of homes across the country to hydrogen,' says Owen. Tests are being run on a large variety of network assets to analyse potential background leakage characteristics. Phase 1 (a and b) will run until 1Q2020.

Currently, about 30% of UK carbon emissions are from heating homes, businesses and industry. Owen explains: 'The large-scale conversion of the gas grid from natural gas to hydrogen is vital to meet the UK government's net zero carbon target by 2050. Re-purposing of the gas network to carry 100% hydrogen would represent a huge step towards meeting our decarbonisation targets and put the UK in a leading position in hydrogen conversion with the potential to create thousands of jobs.'

Phase 1b is tackling the 'consequence testing of leakage' at the DNV GL facility at RAF

Spadeadam in Cumbria. Tests aim to confirm any changes to safety risk under background conditions, facilities and operational repairs on a hydrogen gas network.

Following evidence found in Phase 1a and Phase 1b, the project will move forward to Phase 2, which will involve testing of operational procedures. To enable field trials to commence once Phase 1 is completed, the H21 project has secured Network Innovation Allowance funding to locate suitable test sites and develop the conceptual design.

'Currently there are certain elements of fundamental science and research that need to be carried out to establish a critical safety case,' notes Owens. A really important body of work is also being undertaken – the quantitative risk assessment, looking at all aspects of the gas transition system from a scientific, mathematical risk perspective, from initial gas transmission to the emergency control valve; how risks can be reduced and mitigation applied. The final H21 NIC report is due mid-2020.

Alongside this report there is work on the social implications of transitioning from natural gas to hydrogen; examining how and whether the customer understands climate change and the need for decarbonisation; along with the technical, cost and safety implications of conversion. The social science research is being run by the H21 NIC at Beckett University.

A further application has just been made for NIC funding to expand the transition study at Spadeadam from a network perspective. The idea is to create a microgrid of little gas networks where all processes and procedures for the hydrogen system can be tested. 'Gathering further safety evidence will help move towards the first stage of community trial,' says Owen.

'The community trial is not a safety challenge but aims to test all the processes, logistics and procedures when the natural gas network is converted to hydrogen and connected to customer appliances – along with solid social science and customer evidence,' emphasises Owen.

In line with the BEIS Hy4Heat project, once the field trials have been proven there will then be a live community trial in 2021/2022. The £25mn Hy4Heat programme aims to establish if it is technically feasible, safe and convenient to replace natural gas with hydrogen in residential and commercial

buildings and gas appliances. This will enable the UK government to determine whether to proceed to a community trial. The programme manager is Arup, working with Kiwa Gastec, Progressive Energy, Embers and Yo Energy.

The H21 North of England report underpins the safety objectives and presents a conceptual design for converting the gas networks of the North of England between 2028 and 2035. As mentioned, the report builds on the Leeds City Gate study for deep decarbonisation of northern urban conurbations that include about 12.5% of the UK population. The design incorporates a 12.15 GW hydrogen production facility, 8 TWh of inter-seasonal storage and all associated onshore infrastructure, as well as the requirement of an associated CCS scheme, scaling to 20mn t/y by 2035.

The report represents one scenario for the hydrogen gas grid conversion, following completion of the last pieces of critical safety evidence, which will be provided by the Hy4Heat and H21 NIC programmes by 2021.

Meanwhile, HyDeploy, based at Keele University, is determining if blending hydrogen of up to 20% volume with natural gas will be an easy way to reduce CO<sub>2</sub> emissions from home cooking and heating, without changing customer appliances. Approval has been given by the HSE to run a 12-month live trial (which started this summer) of blended hydrogen and natural gas, on part of the private gas network at Keele university campus. The next phase will plan similar trials on two public networks in the North of England in the early 2020s. The HyDeploy consortium is led by Cadent and Northern Gas Networks, with support by ITM Power and Progressive Energy.

Owen stresses: 'We are talking about a huge change to switch over. We know we have to decarbonise. But clearly any transition to hydrogen will be a government policy decision.' ●