

Written Evidence Submitted by Cadent (HNZ0042)

Cadent welcome the Government's focus on hydrogen as a route to achieving net-zero. In particular, recent announcements, including the Prime Minister's '10-point plan for a Green Industrial Revolution' and the Energy White Paper, provide much needed clarity on Government support for hydrogen as a future fuel. We are clear that if the UK is to reach net-zero by 2050, then there is a critical role for hydrogen to play, and we welcome this recognition from Government.

Building further momentum now requires a step-up in policy and regulatory support along the whole hydrogen value chain, from upstream (to support hydrogen production and drive cost reduction) through the midstream (to create a hydrogen-ready distribution networks) to the downstream (to stimulate end-user demand and support for hydrogen).

At the highest level, and in line with other countries (e.g. Germany, Netherlands, Japan) where hydrogen development is further progressed, support for a hydrogen economy starts with the UK Government commitment to the need for significant levels of hydrogen in the energy system. This could take an initial form of a target for hydrogen production in the short to medium term, and does not necessarily need to be linked to specific end use. The policy levers could then follow.

The following table summarises the areas where policy and/or regulatory support is most needed. They should sit within a coherent hydrogen strategy, which should itself sit within the UK's overall Net Zero strategy.

Value chain element	Goal	Key policy/regulatory options
Upstream (production)	Incentivise investment in hydrogen production (and associated infrastructure) and accelerate cost reduction	<ul style="list-style-type: none"> Develop regulated asset base (RAB) models for hydrogen infrastructure investments (including CCUS facilities, storage facilities and dedicated hydrogen and CO2 pipelines), with ownership competed through a 'direct procurement' model Establish new contracts for difference (CfDs) for hydrogen production (with separate arrangements for blue and green hydrogen, given current cost disparity and the desire to incentivise both blue and green hydrogen production). Blue will deliver cost effectively at scale and at speed, providing the basis to develop infrastructure Ensure that the support for green hydrogen enables programme to acceleration of cost reduction in electrolysis
Midstream (distribution)	Create hydrogen-ready distribution network	<ul style="list-style-type: none"> Align RIIO-GD2 settlements to enable gas distribution networks (GDNs) to make 100% of the network hydrogen-ready, starting with regions close to planned hydrogen industrial clusters Update Gas Grid Code and safety regulations to enable both the blending of hydrogen (and other low-carbon gases) and discrete 100% hydrogen networks
Downstream (use)	Stimulate and support end-user demand and support for hydrogen	<ul style="list-style-type: none"> Establish region-specific, technology-agnostic Low Carbon Obligations defining heat decarbonisation goals and trajectories – placing the onus on Local/City Authorities to establish their preferred heat decarbonisation strategy Mandate hydrogen-ready for boiler sales by 2025

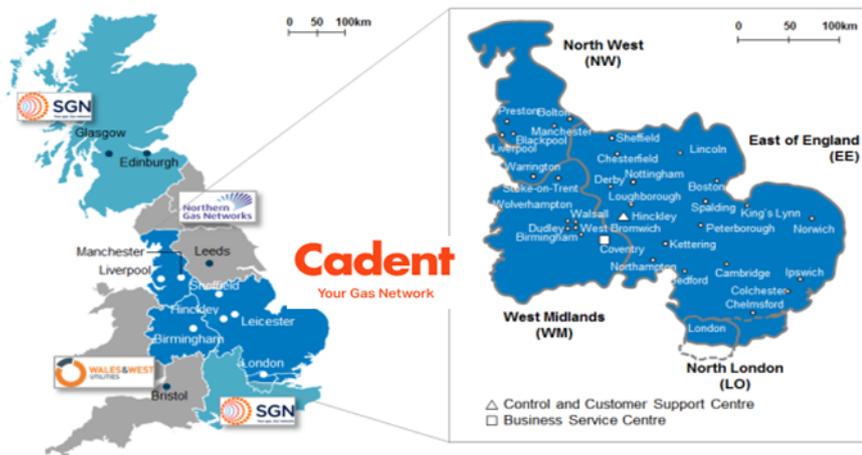
		<p>(with the flexibility to run on 100% hydrogen, 100% natural gas or blends)</p> <ul style="list-style-type: none"> • Add hydrogen to existing policy such as the Renewable Transport Fuel Obligation • Enhance public narratives around hydrogen to address known areas of concern and misconceptions
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Some of the options presented above are essentially ready to be implemented, such as updating the Gas Grid Code and safety regulations and mandating hydrogen-ready boilers. In parallel there is a real urgency to delivering the hydrogen business models to support production and use. It is imperative that the promised hydrogen business model consultation is issued early in 2021 with a strong “minded-to” position on the preferred option, such that projects are able to progress to financial close rapidly. In parallel demand side policies such as a Low Carbon Obligation must be developed to build the customer base.

Attached are our formal responses to the call for evidence, however, we would be more than happy to expand on any of these points further or to answer any specific queries the Committee may have. In addition, we would be delighted to provide evidence to the Committee at one of its hearings, if this would be helpful.

About Cadent

Cadent owns and operates four gas distribution networks in the UK, providing a safe, reliable and efficient network that transports gas to homes, schools, businesses. We serve 11m customers across this footprint and are the largest gas distribution company in the country. We own and operate the gas distribution network for the North West, West Midlands, East of England and North London.



1. The suitability of the Government’s announced plans for “Driving the Growth of Low Carbon Hydrogen”, including:

- the focus, scale and timescales of the proposed measures;
- how the proposed measures—and any other recommended measures—could best be co-ordinated;
- the dependency of the Government’s proposed plans on carbon capture and storage, any risks associated with this and how any risks should be mitigated; and
- potential business models that could attract private investment and stimulate widespread adoption of hydrogen as a Net Zero fuel;

Recent policy announcements have provided much-needed near-term targets and timescales, such as for the mandating of hydrogen-ready boilers and for at-scale hydrogen for heat trials including a 'hydrogen village'. These targets are particularly welcomed given many of them will be delivered during this Parliament.

The proposals for at-scale hydrogen trials, starting with a 'neighbourhood' and then working up to a 'hydrogen town' are both aspirational and achievable. The dates set for these strike the right balance between practicality and ambition. Indeed, these hydrogen for heat trials fit with Cadent's own ambitions to deliver hydrogen through our gas network, as well as with the iron gas mains replacement programme and our own plans to enable local areas to decarbonise heat, industry and transport.

Hydrogen production will also be critical to the successful establishment of a hydrogen economy here in the UK, and if we are to reach our net-zero by 2050 goal. **The Government's proposed 1GW of H₂ production by 2025 is a very powerful signal to markets, both in terms of scale and timescales.** However, we note that this is a 'hope' rather than a target, something which we would like to see solidified. **The Government's proposed target of 5GW of H₂ production by 2030 is, however, not sufficiently aspirational.** In order to provide the necessary stimulus to the market and to begin to achieve scalability and the economic advantages that come with it, **the 2030 target should be at least 10GW of H₂ production, with a role for both Blue and Green hydrogen.**

We welcome Government's recognition of the important role that Carbon Capture & Storage (CCS) will play, and believe it has a key role if we are to reach the levels of hydrogen production required within the timeframes. **CCS will be necessary for low cost, bulk hydrogen production. It is imperative that the Government deliver on its commitment to multiple CCS clusters.** As a minimum, all of the currently proposed clusters must progress through the FEED stage under IDC, and ideally the four main clusters should progress in tandem, without delay or pushed into a second tranche of funding.

Furthermore, **a finalisation of hydrogen business models is critical if we are to drive the growth of low carbon hydrogen.** The focus has to be on a financeable business model for production, as this unlocks the sector. If the business model enables early hydrogen to be sold at the equivalent price to natural gas, giving early adopters a carbon benefit, this would create demand. **Cadent strongly advocate a Contracts for Difference (CfD) regime,** which is familiar with the financing sector, and which has a track record in driving down support over time. In parallel, demand-side policies will play a role, particularly for wider use such as blend in the grid (noting that currently there are no carbon penalties here). It will also be important to consider the interface between H₂ and CCS business models, as financing projects will depend on both managing the risk allocation appropriately and be delivered on the same timeframe. Cadent would very much like to see these future business-models outlined in the upcoming Hydrogen Strategy, but believe Government should commit to delivering a consultation on these proposals in Q1 2021 not just 'in 2021'. Indeed, **the Government's proposed Hydrogen Strategy must be delivered as quickly as possible, no later than Q1 2021** in order that the ambitions outlined in other policy and announcements can be realised.

Cadent welcomes the strengthening of the business model team at BEIS. However, there remain multiple pockets of BEIS working on hydrogen - this needs co-ordination within the department and across other departments, including HM Treasury and the Department for Transport.

Given their scale, expertise and existing regulatory frameworks, Cadent believe that the **gas distribution networks have a key role to play in coordinating both the individual demonstration projects, but also the wider transition to a hydrogen economy.** However, this cannot be done in isolation and will require input and commitment from Government, regulators (primarily Ofgem and HSE), as well as industry grouping, such as the Energy Networks Association.

Cadent strongly welcomes the Government's recent recognition of the importance of hydrogen blending, and believe that this is not only a quick and easy way to reduce carbon emissions, but that it is a necessary step to the creation of a hydrogen economy here in the UK and the further roll-out of hydrogen. **Blending hydrogen into the gas network provides an immediate means to reduce the carbon intensity of gas without requiring the users to make changes.** The HyDeploy project is demonstrating that levels of 20% by volume (7% by energy) can be achieved in the gas distribution network without requiring changes to appliances. If expanded across the UK, this equates to 29TWh of hydrogen. The National Grid Transmission is also commencing work on assessing the feasibility of blending into the transmission network. The HyNet industrial cluster plans to deliver blends of hydrogen and natural gas to around 2 million households as well as commercial and industrial users from the early phases of the project with potential for further expansion to other nodes on the gas distribution network. It is recognised that blending is just part of this pathway towards decarbonisation because the end-point is a shift to 100% hydrogen. However, **enabling blending would give confidence to producers that there is demand and create early bulk hydrogen production, develop hydrogen infrastructure, and building associated supply chains.** Critically it allows customers to become accustomed to hydrogen being part of the energy mix without disruption. **To support blending, a regulatory regime would need to be established that also allows retailers to sell this additional hydrogen.**

Cadent's view on specific Government investment programmes:

The Government has made several recent investments in hydrogen projects. The structure of the **Hydrogen Supply Competition** has enabled rapid progress because the programmes are entirely grant funded. This is important in the early stages of innovation and is critical in an environment with policy uncertainty. The fund has been adequate to support both Pre-FEED and FEED (Front End Engineering Design) studies across all aspects of hydrogen production technology. Whilst the programme is yet to complete, the outputs will result in final Investment Decisions (FID) to be made, on the proviso sufficient policy is in place, by 2021/22. By this stage a clear policy framework is required to obtain private sector funding. The precedent of the offshore wind sector shows how policy certainty from Government can deliver strong commitments from the private sector. A long-term commitment to hydrogen supported by evolving and effective policy would be expected to deliver the same benefits for a hydrogen economy.

The **Hydrogen Transport Programme** (HTP), launched in August 2017, supported by the Government's Office for Low Emission vehicles (OLEV), has allocated £23m of grant funding to develop the UK's hydrogen vehicle market. During the second phase, £14m was allocated to 5 projects including 5 hydrogen refuelling stations, 73 Fuel Cell Electric Vehicles (FCEVs), and 33 fuel cell buses. Whilst the programme is ambitious, not all funding has been spent or allocated due to project delays. In the main the delays have been associated with obtaining planning consent for refuelling infrastructure and/or the delivery of hydrogen vehicles from Original Equipment Manufacturers (OEMs). The programme has delivered the first round of UK deployment and proved the operational viability of hydrogen as a transport fuel. It has also exposed challenges which need to be addressed in any expansion phase e.g. role of hydrogen in decarbonising key sectors like rail and heavy goods vehicles (HGVs).

The **UK Hydrogen Mobility Programme** (UKH2 Mobility), a 100% industry initiative, reports that as of May 2020, there are 14 publicly accessible hydrogen refuelling stations, servicing c.280 vehicles. UKH2 Mobility (and industry) are encouraging a significant increase in the level of ambition over the next 5 years, promoting a vision of >6,000 H₂ vehicles by 2025, available to all transport modes with ownership costs that are competitive with equivalent zero-emission alternatives, and a public network of 80 hydrogen refuelling stations. This is broadly consistent with the **Hydrogen Taskforce's** report¹ which includes a policy recommendation to establish 100 hydrogen refuelling stations by 2025 to support the roll-out of hydrogen transport in the UK.

¹ https://www.hydrogentaskforce.co.uk/wp-content/uploads/2020/04/FINAL_Hydrogen-Taskforce-Report-Feb2020_Lores.pdf

The **Hy4Heat** programme has made significant inroads into exploring compatibility of hydrogen in homes and businesses. Both establishing the critical safety evidence for any transition and the development of both domestic, industrial and commercial hydrogen appliances. In comparison to other low carbon technology developments within the BEIS Energy Innovation Programme such as small modular nuclear reactors, for which there is £180m² allocated, the investment of £25m in Hy4Heat has been relatively small for a sector that represents a third of the UK's emissions. Whilst the programme has been effective the Government has lacked the ambition to plan for large scale customer trials and the natural progression to roll-out as would be expected. The necessary technical and engineering understanding has now been delivered and the regulatory and public support which enable the findings to be exploited at scale needs to quickly catch up. Investment at a scale comparable with other low carbon technologies is now needed along with a much more closely integrated approach with Ofgem. Immediate clarity is required regarding which infrastructure, such as new pipelines, should be funded by gas consumers and therefore regulated by Ofgem and which should be funded by other means.

2. The progress of recent and ongoing trials of hydrogen in the UK and abroad, and the next steps to most effectively build on this progress;

The UK is currently a world-leader in at-scale hydrogen trials, but it is imperative that **Government continue to support, and expand on its support to date, for projects such as HyDeploy and HyNet, if the UK is to keep its competitive advantage and to become a world-leader in hydrogen.**

Australia, Netherlands, Germany, and China amongst others have all published hydrogen strategies with supportive government policy. The Netherlands and Germany have adopted strategies to commit to large scale levels of hydrogen utilisation in the next decade. They have announced budgets for initial direct funding via investments/grants and are considering other measures e.g. tax breaks to encourage hydrogen. Mobility and industry are seen as the vanguard, with an increasingly strong consensus that hydrogen at scale is a necessity. The UK could still take the lead in the next 5 years with well-placed funding, the development of enabling policy, and high proliferation of renewables which gives us an advantage in the production of green hydrogen. If we don't our renewable energy could end up being exported into the European market place, potentially supporting the creation of hydrogen economies abroad and giving other nations a competitive advantage over the UK. **The UK should consider exploring and implementing policy initiatives to create a supportive ecosystem for hydrogen, building on the HyNet and HyDeploy pilot initiatives,** and leverage hydrogen and green technology as a tool of economic recovery post-COVID-19.

Cadent is pleased to be leading the **HyDeploy trial at the University of Keele**. This UK-first will provide a hydrogen blend (up to 20% H₂) to around 100 domestic properties and 30 university buildings. The HyDeploy project has built a strong evidence base for domestic appliances, proving that they can operate safely with a blend of up to 20% H₂ without any modifications. The next trial planned in the North East will be the first on a public network and will be another leap forward in demonstrating that H₂ blended gas can be transported through our existing gas networks. The project is also focussing on the evidence base for Industrial & Commercial settings, has commenced live Industrial trials and planning a third public demonstration in the North West as a pre-cursor to wide-scale blending.

Trials, such as the HyDeploy trial at the University of Keele, are establishing the safety case for safely transporting and utilising hydrogen blends initially on a closed network, and subsequently on a public network. The HyDeploy project is ultimately looking to establish the basis for long term use of hydrogen blends across the entire distribution network.

Public trust will be crucial to the longer-term roll-out and use of hydrogen. Pilot projects, such as Hy4Heat and HyDeploy, are valuable and necessary to demonstrate feasibility and build public trust, and these pilots should be continued and expanded.

² <https://www.gov.uk/guidance/energy-innovation#beis-energy-innovation-programme>

Research by Keele University into the perceptions of customers receiving blended hydrogen in their homes as part of the HyDeploy trial at Keele University has demonstrated that strong support for blended hydrogen is possible from the public, because of the combination of environmental benefits with no disruption to the customer. However, this and other research demonstrates that there are a number of public concerns about hydrogen relating to safety and cost implications. These concerns are not insurmountable, but highlight the need for continued social science research alongside technical hydrogen feasibility projects, as well as the importance of effective communication with the public, with lessons from the best practice operated in the HyDeploy projects that can be adopted in future rollouts of blended hydrogen gas.

Cadent were delighted to sponsor Bright Blue's report, Going Greener: Public attitudes to net zero. We strongly believe that whatever solutions we decide on to reach net-zero, they must work for our customers. The report highlighted a number of key concerns for the public with regards to decarbonising heat – they want to own and have control over their heating system, they want their heating system to be able to heat the home quickly and when they want, they want their heating system to be cheap, and they do not want to have to make considerable changes to the home in order to decarbonise heat. Cadent are clear that hydrogen will have an important role to play in the decarbonisation of heat, and believe that it presents a solution which addresses many of these consumer concerns.

In order to support further trials, **Cadent would like to see Government addressing the wider regulatory barriers to the use of hydrogen** – the commercial and regulatory framework, specifically those which relate to billing. In addition, it would be helpful if Government were to **amend the Gas Safety (Management) Regulations (1996)** to a standard which can allow changes to the H₂ specification rather than multiple exemptions

3. The engineering and commercial challenges associated with using hydrogen as a fuel, including production, storage, distribution and metrology, and how the Government could best address these;

On production, the existing hydrogen supply programme has provided valuable support. The **Net Zero hydrogen fund** will also be critical, particularly to drive projects forward and to maintain momentum. This should be usable for development funding (i.e. beyond 'innovation') to bridge the gap to deployment.

Hydrogen provides a means for significant energy storage. Hydrogen can provide energy system flexibility in the form of storage (including inter-seasonal storage), peak generation dispatchable power and sector coupling. In addition, salt cavern storage of hydrogen has been in use for decades in the UK. Cadent's HyNet project is planning 1TWh of storage in the North West - this compares with Tesla's Australian world leading Mega battery which is 0.00045TWh, 4 orders of magnitude smaller. **Finalising business models for hydrogen storage will be important to realising the full potential that hydrogen storage has to offer.**

The existing gas networks will have a critical role to play in the future distribution of hydrogen. Given the fact that 23.5m homes are currently heated by gas boilers and homeowners are notoriously resistant to change, the relative ease and low up-front cost of converting to hydrogen is a fundamentally important point. **A future mandated switch from natural gas to hydrogen for gas users as part of future regulation will be important so customers can not delay the switching of the network to a carbon neutral solution.** Cadent is already developing such a network for HyNet. Funding for this has been allocated in its RII0 GD2 plan. The expectation is that funding for build out would form part of the existing Gas RAB.

Cadent are already working on a number of programmes to confirm metering accuracy for hydrogen and blends. Further work may be required in this area to support changes to gas billing methodologies.

4. The infrastructure that hydrogen as a Net Zero fuel will require in the short- and longer-term, and any associated risks and opportunities;

The national gas network is a hugely valuable asset that is already supporting the delivery of low carbon gases for heat, power and transport. Cadent is making its network fit for the future - helping low-carbon gas producers connect to the grid and trialling new ways to help decarbonise. Our HyDeploy and HyNet projects are already laying the foundations for the delivery of the UK's hydrogen economy, and we continue to invest in supporting other means to decarbonise the gas grid, such as through connecting bio-fuel producers. All of this will help the 23.5million households currently connected to the gas grid to decarbonise without further intervention.

Indeed, Cadent and the other gas distribution networks (GDNs) are already preparing the ground for the transition to hydrogen. Our mains replacement programme, something which has been supported by the Health & Safety Executive and Ofgem, is replacing iron gas pipes with modern polyethylene pipes, which are capable of transporting hydrogen safely. Based on work to date, the UK is approaching circa 70% plastic piping across the different GDN footprints. If this programme were to be continued into the next regulatory periods, we would be on target to see over 90% of pipes replaced and capable of transporting hydrogen by 2032. By proactively focusing on mains replacement in areas which will get hydrogen first this will be a cost-effective way of readying the network for hydrogen.

Further infrastructure detail on the costs of hydrogen conversion is inextricably linked with heat and energy policy and therefore difficult to predict given the range of scenarios at play. Cadent are currently focusing on working through this and planning for future scenarios.

Utilising the existing gas network to transport hydrogen also has the added benefit of enabling large-scale storage of hydrogen at no additional cost. Indeed, the gas network already provides considerable storage for natural gas, enabling the electricity distribution network to cope with peaks and troughs. With more renewable power generation coming online, converting excess power to hydrogen and then storing this in the gas network offers a low-cost solution to energy storage and would result in far lower costs than relying on battery storage. A mixed approach to decarbonisation, which includes roles for both electrification and hydrogen conversion, will result in far lower costs than an electric only solution.

5. Cost-benefit analysis of using hydrogen to meet Net Zero as well as the potential environmental impact of technologies required for its widespread use;

The ENA's recent 'Pathways to Net Zero' report concluded that a balanced combination of low-carbon gases (including blue and green hydrogen) and electricity would cost £13 billion per year less to deliver than full electrification. This is seen as a relatively conservative estimate due to the complexity of the energy system. The key drivers of the relative economics include:

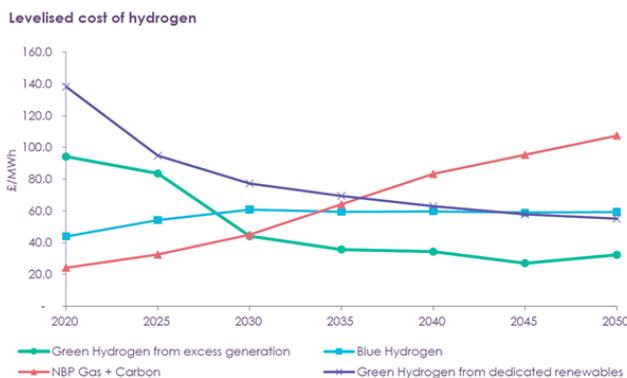
- the fact that a **comprehensive gas distribution network already exists, serving 83% of UK householders** (a theme shared with other countries prioritising hydrogen), and is already largely hydrogen-ready;
- the **high cost to reinforce the electricity distribution network** to meet peak heating demand in a full electrification scenario.
- the **high cost of retrofitting buildings with entirely new heating systems** in a full electrification scenario (especially given the low renewal rate and relative energy inefficiency of building stock in the UK); and
- the **need for a flexible system to meet seasonal energy demand** at times of low renewable power output but high demand for energy and heat.

It should be noted also that even in high electrification scenarios, there remains a high demand for gas for flexible, reliable, dispatchable power generation to secure the

increasingly intermittent power grid. Hydrogen, particularly with its cost effective storage at scale provides a low carbon fuel for such dispatchable generation, for which there are few if any alternatives.

Decarbonising the gas network and establishing a hydrogen economy is expected to bring broader economic benefits including job creation and export potential. The Global Hydrogen Council estimates the hydrogen economy will be worth \$2.5 trillion by 2050, with 30 million new jobs. In the near-term, preparing for a hydrogen economy can also play a valuable role in stimulating a green recovery from Covid-19. Specifically, there are opportunities to accelerate the gas mains replacement programme; and to accelerate the development of the UK’s first hydrogen hubs from industrial clusters such as HyNet in the North West.

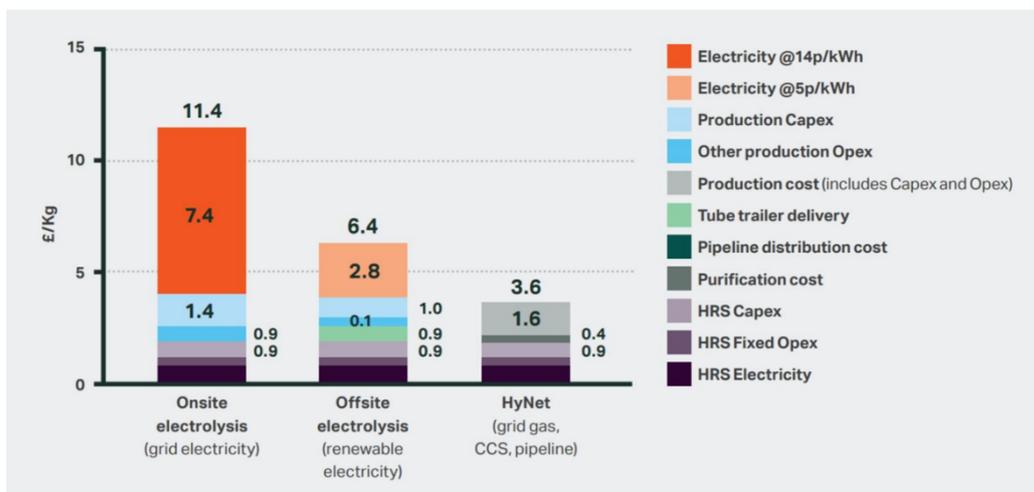
Recently completed work by the ENA, under the Gas Goes Green initiative (which covers a view across all Gas Distribution companies, including Cadent), estimates the relative costs of blue and green hydrogen over time as production is scaled. The analysis shows that blue hydrogen would initially be the lowest cost form of hydrogen production at £43/MWh. This is still 79% more expensive than the National Balancing Point (NBP) price for natural gas plus the carbon price. Green hydrogen from renewables rapidly reaches cost parity with natural gas by c.2030 at £44/MWh as carbon prices increase and the cost of green hydrogen falls due to falling capex prices for renewables and lower electricity wholesale prices. The cost reduction trajectory for green hydrogen is expected to be like that experienced by renewables over the past decade.



Cost of hydrogen production: ENA: Gas Goes Green, Hydrogen: Cost to customer, May 2020 (NBP = National Balancing Point)

This perspective is confirmed by the Hydrogen Council report by McKinsey, Path to Hydrogen Competitiveness – A Cost Perspective. The report looks at the breakeven production costs for hydrogen across key segments and shows that hydrogen becomes competitive across a range of applications at between \$2-3/kg (equivalent to £40 to 58/MWh). This is particularly applicable for industry, heat and commercial transport applications.

Our own work called HyMotion, (Cadent, 2019) demonstrates for a new, dedicated 100% hydrogen pipeline (part of the HyNet regional cluster consortium), that competitive hydrogen



pump prices are attainable and can deliver hydrogen at a significantly lower cost than alternative supply options.

Comparative costs of hydrogen production and distribution. Cadent, HyMotion 2019.

6. The relative advantages and disadvantages of hydrogen compared to other low-carbon options (such as electrification or heat networks), the applications for which hydrogen should be prioritised and why, and how any uncertainty in the optimal technology should be managed.

Hydrogen for Industry

The scaled use of hydrogen at industrial clusters is likely to be one of the first and major users of hydrogen. For many applications there are limited alternative choices to deliver low carbon solutions, particularly for high heat industrial requirements such as steel production and chemical processing. Various reports show a need to deliver industrial fuel switching to hydrogen of between 100-135TWh/yr by 2050.³⁴⁵

For example, HyNet industrial cluster (name for North West Industrial cluster consortium) is engaged with over 30 industrial users with an interest in using hydrogen to reduce carbon intensity of their processes. Several existing facilities across the UK produce hydrogen or hydrogen-rich fuels as a by-product and use this fuel onsite, examples are INOVYN's chlor-alkaline process, Sabic's processing plant, and refineries and steelworks. In terms of timescales to deployment, the Hy4Heat programme indicates that many applications will be commercially ready for deployment during the early 2020s, with boilers, indirect users, heaters, kilns and many furnaces all able to be deployed between 2023-2025. The third phase of the BEIS Industrial Fuel Switching programme sets out to provide the necessary demonstration across a range of applications to expedite deployment.

In addition to the Government competitions that have made the industrial pre-FEED and FEED work possible, there needs to be confirmation of the business models and regulation that will underpin the schemes. This includes hydrogen production, CCUS, storage, and distribution. Without certainty of the regulatory model that will support these assets (e.g. RAB based models, production incentives etc), attracting private sector investment will be difficult.

Hydrogen for Domestic Heat

Over 23.5m homes (83%) in the UK are connected to the gas network. Gas boilers are currently low cost and well suited to the fabric of the UK's Housing stock. They deliver high heat rapidly and efficiently for the periods of time that users require it. It is projected that 80% of the 2050 homes have already been built with their inherent fabric of construction. Plus, the existing gas network provides high levels of resilience, capacity and flexibility (meeting 20-year peak 6-minute demand as well as summer lows).

Heating for buildings can be decarbonised in several ways, including hydrogen, electrification/heat pumps and district heating networks. All three technologies will play a role, although there is currently no clear consensus on the optimum mix. Hydrogen has two key advantages over the other options that will make it particularly attractive to some homeowners. First, existing gas central heating systems can be very easily converted to hydrogen. Currently 23.5m homes are currently heated by gas boilers. There are significant

³ Institution of Engineering and Technology (IET) and Nottingham Trent University, October 2018

⁴ https://d2e1qxpsswcpqz.cloudfront.net/uploads/2020/03/ukerc_bn_decarbonisation_heat_local_gas_demand_vs_electrical_supply_web.pdf

⁵ https://www.green-alliance.org.uk/reinventing_retrofit.php

barriers to change for householders including available space, suitability of the property, need to change out the whole heating system, access to capital, as well as simple inertia to change. The relative ease and low up-front cost of converting to hydrogen is therefore a fundamentally important benefit. A future mandated switch from natural gas to hydrogen for gas users as part of future regulation will be important so customers can not delay the switching of the network to a carbon neutral solution.

By contrast, converting to electric heat pumps could require higher upfront costs than a hydrogen boiler (an air source heat pump costs £9-11k to install, versus c.£2k for a new boiler) and is more disruptive. Electrifying heat would also require a massive and disruptive expansion of the UK's electricity infrastructure as the gas network currently supplies six times more energy at peak in the coldest winters than the electricity network. This issue of peak demand is then further compounded as the performance of air source heat pumps declines in cold, peak demand conditions, often requiring the use of further electric resistive heating. Hydrogen boilers can generate significantly higher temperatures than heat pumps, which makes them better suited to heating poorly insulated buildings (which are also often hard and costly to retrofit to higher energy efficiency standards). 70% of homes in the UK are still below EPC – C, equivalent to 19 million homes.

Blending hydrogen as a first step

Blending hydrogen into the gas network provides an immediate means to reduce the carbon intensity of gas without requiring the users to make changes. The HyDeploy project is demonstrating that levels of 20% by volume (7% by energy) can be achieved in the gas distribution network without requiring changes to appliances. If expanded across the UK, this equates to 29TWh of hydrogen. The National Grid Transmission is also commencing work on assessing the feasibility of blending into the transmission network.

The HyNet industrial cluster plans to deliver blends of hydrogen and natural gas to around 2 million households as well as commercial and industrial users from the early phases of the project with potential for further expansion to other nodes on the gas distribution network.

Blending will only be a temporary first-step towards decarbonisation because the end-point is a shift to 100% hydrogen. However, enabling blending would give confidence to producers that there is sufficient demand and enable early bulk hydrogen production, developing hydrogen infrastructure, and building associated supply chains. To support blending, a regulatory regime will need to be established that supports blending also allows retailers to sell the hydrogen to consumers.

Conversion to 100% hydrogen

Due to the merits of using a molecular-based vector for consumer heating, including the opportunity provided by the mature gas network, consideration is being given to the conversion of the gas network to full hydrogen. This was initiated by the original H21 Leeds City Gate Project (NGN, WWU 2016), the H21 North England project (NGN, Cadent, Equinor 2018) and is developing further through the H21 NIC programme and BEIS's HyHeat project. This programme is establishing the developments required for gas users to use 100% hydrogen. Boiler manufacturers such as Worcester Bosch are actively developing 'hydrogen-ready' appliances. The H21 North of England programme predicts an increase of hydrogen demand through 100% conversion to 194TWh by 2050⁶.

(January 2021)

⁶ H21 North of England, November 2018 pp23