Written Evidence Submitted by HyDeploy

(HNZ0040)

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 the iron gas mains replacement programme and the gas distribution networks' 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 H_2 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 H_2 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 H_2 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. **We 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. We 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.

The consortium 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, we 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.

The consortium 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.**

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.

The **HyDeploy trial at the University of Keele**, a UK-first, will provide a hydrogen blend (up to 20% H_2) 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% H_2 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 H_2 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-curser to wide-scale blending.

Trials, such as HyDeploy, 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.

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.

Bright Blue's recent report, '*Going Greener: Public attitudes to net zero'*, highlighted a number of key concerns for the public with regards to decarbonising heat – consumers 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. We 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, the consortium **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 H_2 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 RIIO GD2 plan. The expectation is that funding for build out would form part of the existing Gas RAB.

The gas distribution networks 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. The gas distribution networks are already helping low-carbon gas producers connect to the grid and trialling new ways to help decarbonise. The HyDeploy and HyNet projects are already laying the foundations for the delivery of the UK's hydrogen economy, and there continues to be investment to support 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. The 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. GDNs 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;***

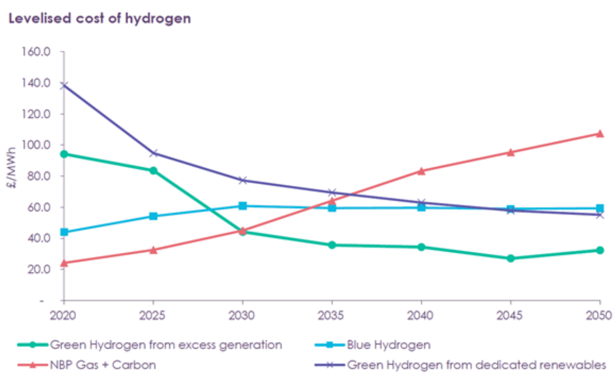
The ENA's recent 'Pathways to Net Zero' report concluded that a balanced combination of low-carbon gases (including blue and green hydrogen) and electricity would cost £13 billion per year less to deliver than full electrification. This is seen as a relatively conservative estimate due to the complexity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

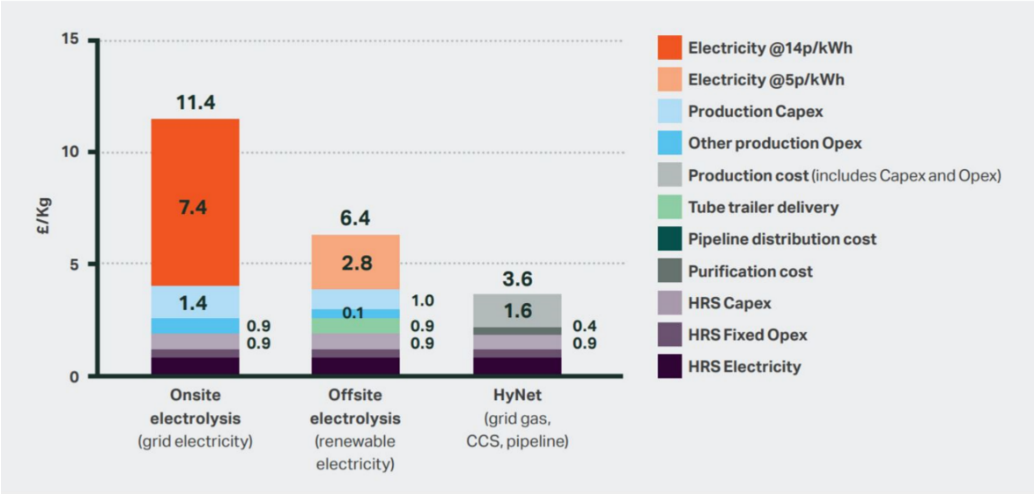


Cost of hydrogen production: ENA: Gas Goes Green, Hydrogen: Cost to customer, May 2020

(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.

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.[1][2][3]

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

[1] Institution of Engineering and Technology (IET) and Nottingham Trent University, October 2018
[2] https://d2e1qxpsswcpgz.cloudfront.net/uploads/2020/03/ukerc_bn_decarbonisation_heat_local_gas_demand_vs_electical_supply_web.pdf

[3] https://www.green-alliance.org.uk/reinventing_retrofit.php

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 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 2050[4].

About HyDeploy

HyDeploy is a pioneering hydrogen energy project designed to help reduce UK CO2 emissions and reach the Government's net zero target for 2050.

As the first ever live demonstration of hydrogen in homes, HyDeploy aims to prove that blending up to 20% volume of hydrogen with natural gas is a safe and greener alternative to the gas we use now. It is providing evidence on how customers don't have to change their cooking or heating appliances to take the blend, which means less disruption and cost for them. It is also confirming initial findings that customers don't notice any difference when using the hydrogen blend.

HyDeploy @ Keele is the first stage of this three-stage programme. In November 2019, the UK Health & Safety Executive gave permission to run a live test of blended hydrogen and natural gas on part of the private gas network at Keele University campus in Staffordshire. HyDeploy is the first project in the UK to inject hydrogen into a natural gas network.

HyDeploy is being delivered by the HyDeploy consortium, led by Cadent. The partners include Northern Gas Networks, Progressive Energy Ltd, Keele University, HSE – Science Division and ITM Power. The first HyDeploy live demonstration is being hosted on the Keele University campus in Staffordshire. It is a great example of networks and partners working together to achieve a common goal – the reduction of carbon emissions and improved air quality for the near future.

(January 2021)

[4] H21 North of England, November 2018 pp23