HyDeploy2 Project

Gas Network Innovation Competition // Cadent
3rd Project Progress Report (PPR) // December 2021

HyDeploy2

The HyDeploy2 project seeks to address a key issue for UK customers: how to reduce the carbon they emit in heating their homes. The UK has a world class gas grid delivering heat conveniently and safely to over 83% of homes.

Emissions can be reduced by lowering the carbon content of gas through blending with hydrogen. This delivers carbon savings, without customers requiring disruptive and expensive changes in their homes. It also provides the platform for deeper carbon savings by enabling wider adoption of hydrogen across the energy system.

This Network Innovation Competition (NIC) funded project seeks to develop the evidence base to allow roll-out of a 20 mol% blend of hydrogen within the UK local distribution network by running trials on the public network.

Before any hydrogen can be blended with natural gas in the network, the percentage of hydrogen to be delivered must be approved by the Health and Safety Executive (HSE). It must be satisfied that the approved blended gas will be as safe to use as natural gas.

Such approval is provided as an Exemption to the current hydrogen limit of 0.1 mol% within Schedule 3 of the Gas Safety (Management) Regulations (GS(M)R), 1996. These regulations ensure the safe use and management of gas through the gas network in the UK. Following such approval, hydrogen production and grid injection units are to be operated, and an extensive trial programme undertaken.

Blending hydrogen at 20 mol% with natural gas across the UK, would save around 6 million tonnes of carbon dioxide emissions every year, the equivalent of removing 2.5 million cars from the road.

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1.0 Executive summary

HyDeploy achieved another landmark success with the injection of hydrogen blended gas into the Winlaton trial gas network, the first time that a blend of hydrogen and natural gas has been transported and efficiently utilised on a public gas distribution network encompassing a supportive customer base with diverse appliances and energy suppliers.

This year the focus has been primarily on securing an Exemption for deployment of the UK's first hydrogen blend on a public gas network as well as demonstrations to show the viability of using hydrogen blends in industrial processes. In conjunction to the trials, further evidence has continued to be developed to support the ultimate objective of HyDeploy, which is to unlock national roll-out of hydrogen blends to the wider gas distribution networks across the UK.

The project has been in communication with local residents, industry stakeholders and policy makers. These activities have helped build momentum around hydrogen blending - which is now a key element of the UK Government's hydrogen strategy.

The Exemption application was originally submitted on 1st June 2020 along with a comprehensive set of technical reports and documents comprising the evidence base to justify the injection of blended hydrogen into the Winlaton trial network. The HSE undertook an extensive review of the evidence leading to development of further supporting analysis, particularly in the area of materials. The successful conclusion of the evidence assessment culminated with the project being awarded an Exemption to blend up to 20% hydrogen into the Winlaton trial network on 14th July 2021.

Following the successful attainment of the Exemption, the first molecules of hydrogen blended gas were injected into the Winlaton trial network on 4th August 2021. Swift operational mobilisation was achieved, with injection of blended hydrogen commencing within 21 days of the Exemption being awarded, due to the successful site development and engineering physical works that were delivered simultaneously with evidence development and review, throughout the year.

Operations have been successful since injection commencement in the summer, with rapid ramping up to maximum blend level and the site continues to operate at this level into the Winlaton trial network and will continue to do so for the full trial period.

The successful site operations have been mirrored by the successful roll-out of the billing process which was designed, developed and reviewed with multilateral engagement between the billing experts at NGN, officials at Ofgem and the key stakeholders from Xoserve and the shipper/supplier community. This process ensures customers will not pay for any of the hydrogen gas they receive during the trial and hence safeguards customers from any detrimental financial implications during the demonstration.

To enable national roll-out of hydrogen blended gas across the UK gas distribution networks, as well as understanding the impact and compatibility of using hydrogen blends for domestic users, it is critical to attain this understanding for industrial and commercial users too. Therefore, a programme of work to achieve this was developed which includes a number of industrial trials.

The first of these trials was successfully delivered in September 2021 where sheet glass was manufactured at Pilkington's manufacturing facility on blended hydrogen for the first time in the UK's history of glass manufacturing, with no implications to the quality of product or the combustion assets involved. A similar industrial trial will be undertaken in early 2022 on a large scale industrial boiler at Unilever. Large scale burner trials were undertaken this year to underpin the work.

The project has been in communication with local residents, industry stakeholders and policy makers. These activities have helped build momentum around hydrogen blending – which is now a key element of the UK Government's hydrogen strategy – with hydrogen blending playing a central enabling role of the hydrogen economy. The significance of which has been seen in the Government's ten-point plan which sees a policy decision to be made on hydrogen blending within the UK in 2023.

The project continues to contend with the impacts of Covid-19 which has manifested in delays to certain tasks and milestones within the project. However, the project has benefited from being a well-established team with all key participants highly experienced and with good working relationships with one another. This meant the transition to online working was well managed reducing the amount of delay originally anticipated to the trial start date.

Overall, 2021 has been a very successful and productive year for HyDeploy2. The public trial has already been a huge success both from an engineering perspective, but also public perception through the social science work that has been carried out. Now the project is fully focussed on addressing all remaining evidence gaps to build a comprehensive evidence base to justify the safe transportation and utilisation of hydrogen blended gas across the entire UK national gas distribution networks.

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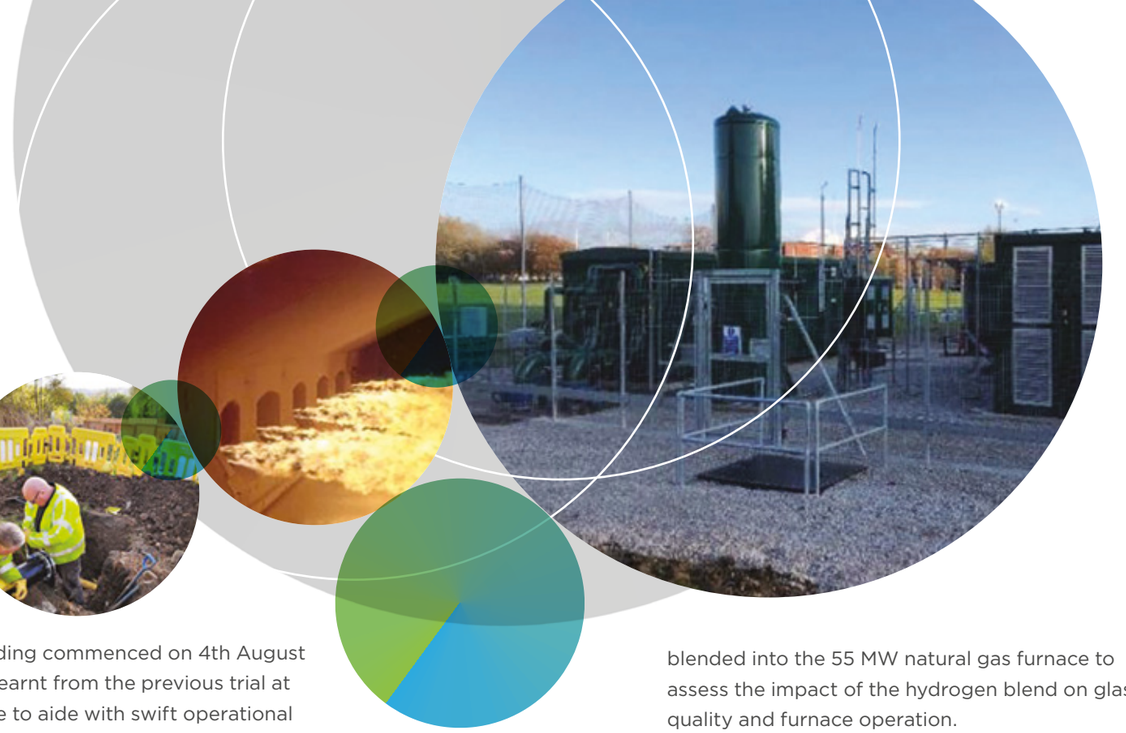


2.0 Project manager's report

The HyDeploy2 project has had a successful year, driving forward progress towards deployment of blending hydrogen into the gas distribution grid.

Key achievements

The key achievement of 2021 has been the successful award of an Exemption to the hydrogen limit within Schedule 3 of GS(M)R, to permit hydrogen blended gas to be injected into a public gas distribution network for the very first time.

The Exemption was awarded on 14th July 2021 following an extensive period of challenge and review by the HSE which culminated in over 200 clarification questions. The review led to the development of further analysis to support the originally submitted evidence, particularly for the demonstration of showing the compatibility of transporting hydrogen blended gas through existing cast iron mains and services.

This was a key difference to the previous trial at Keele, which was a predominantly Polyethylene pipeline network, however the national roll-out of hydrogen blending would not be possible without the demonstration that hydrogen blends are compatible with existing metallic pipelines. This was achieved predominantly through rigorous physical experimentation and materials science to produce mechanical property test data from coupons taken from the in-situ cast iron pipelines.

To complete the risk assessment of the cast iron compatibility assessment the lab based test data was supported by computational modelling of cracks and critical flaws/defects to understanding the consequences of hydrogen exposure to cast iron pipelines.

After demonstrating that it was safe to transport hydrogen blends within the existing cast iron pipelines at Winlaton for the duration of the proposed trial, the challenge and review process was complete and the Exemption granted. Upon being awarded the Exemption to blend hydrogen into the Winlaton trial network, hydrogen blending commenced on 4th August 2021. Lessons learnt from the previous trial at Keele were able to aide with swift operational mobilisation and the project were able to quickly ramp up the hydrogen blend rate to its maximum in a short period of time.

The commencement of the trial initiated the utilisation of the agreed billing process which was designed to ensure no customers on the Winlaton trial network were financially implicated by the hydrogen blended gas by ensuring customers received the hydrogen element of their gas for free.

Stakeholders from NGN's Market Services and Regulatory Compliance team, Xoserve, the Shipper and Supplier community and officials from Ofgem worked together to design, develop and deliver a billing process which enables network trial type activities using non-conventional gas (e.g. blended hydrogen) whilst safeguarding the customers from any detrimental financial implications due to the change of gas.

The industrial trials are a key element of the HyDeploy2 programme which will provide the evidence to demonstrate that hydrogen blended gas can be utilised in industrial and commercial sectors. A key achievement during this year has been the successful trial which has taken place at NSG Pilkington's glass manufacturing facility in St Helens.

An extensive programme was undertaken to develop the trial engineering and logistics to achieve the five-day trial where hydrogen was blended into the 55 MW natural gas furnace to assess the impact of the hydrogen blend on glass quality and furnace operation.

The results showed that neither the glass quality nor the furnace operation were negatively impacted by the hydrogen blended gas. Prior to this, a large scale trial programme had been developed leveraging a series of 100% hydrogen industrial trials under the BEIS funded Industrial Fuel Switching (IFS) programme benefiting from cost efficiencies across the programmes.

The trial was conducted in partnership with Dunphy, a UK manufacturer of industrial burners, and the trial was able to successfully demonstrate compatibility of supplying a 1.2 MW test boiler representative of the majority of commercial/ small scale industrial heating units. The results from the Dunphy trial underpins the basis for a second trial at Unilever to run blended hydrogen through a 7 MW steam-raising boiler in Q1 2022.

Fiscal metering has been another area of success this year with the conclusion of the fiscal accuracy test programme led by the National Engineering Laboratory (NEL) which tested a representative sample of meters (both fiscal and process control) to understand any measurement accuracy implications of operating with a hydrogen blend.

Communication and dissemination

Following the successful awarding of the Exemption, the project team embarked to share the developed evidence with the wider gas industry focussing on technical stakeholders by running a 'Myth Buster' themed technical webinar towards the end of July 2021. The webinar attracted over 70 participants (including international attendees) who could engage directly with the project team on a technical platform.

The recording of the webinar was published on the HyDeploy website. Strong outreach continued thereafter with the creation of two HyDeploy podcasts; the first discussing the macro opportunity of hydrogen blending within the wider energy system and the second focussing on the trials. Both of the podcasts have been published on the HyDeploy website and received over 800 views online.

Local residents on the Winlaton trial network have been front and centre of the project. Regular engagement has been achieved with these customers informing them about updates, and progressing as well as providing a line of communication for customers to raise any queries with the project team.

Energy Minister visit

This line of engagement has proved to be of benefit as customers regularly get in touch with the project team throughout the year to seek clarifications, provide feedback and discuss their appliances. To reinforce these lines of engagement, following the appropriate Covid guidelines at the time, the project team held a customer drop-in surgery day in the Autumn at the Winlaton Church/Community Centre where customers were able to discuss face-to-face with members of the project team their experiences and raise any questions whilst sharing a warm cup of tea.

The public perception of hydrogen is paramount to achieving the support required to unlock hydrogen blended networks and so HyDeploy continued with its social science aspect of evidence generation by conducting a survey for the Winlaton trial network residents to partake in, building on the social science work that was performed during the Keele trial. There were over 140 respondents engaged via a combination of the survey's and follow-up interviews. The detailed analysis and results are currently being written up and should be completed in Q1 2022.

Dedicated efforts continue to be made with policy makers and key industrial stakeholders to ensure that the full potential of blended hydrogen is realised in helping to achieve the Committee on Climate Change's carbon budgets whilst the UK strives to achieve the Net-Zero 2050 target.

To drive this, NGN's Low Thornley site (the location of the hydrogen blend compound and injection units) had opened its gates in 2021 for site visits. These visits were well attended - seeing a number of local residents from the Winlaton trial network attend.

This increased engagement with the trial as well as the wider UK decarbonisation challenge, on one occasion this was combined with a site visit by officials from Ofgem providing a direct platform for local residents to engage with Ofgem officials and the project team. The site also hosted the Energy Minister at the time and other Government officials to continue to showcase the potential of hydrogen blended gas networks.

The collective efforts of communication and dissemination enhanced the previously generated momentum for hydrogen blending as a critical step to unlock hydrogen deployment within the UK energy system. These efforts led to large interest from the media as the wider public becomes more engaged with the challenge of decarbonising energy such that reporters from ITV, the Financial Times and the New York Times have all visited site and engaged with the project team and local residents, further enhancing the successful outreach of the project.

Outlook for next period

The original expectation of the HyDeploy2 programme was that there would be a requirement for two public network trials to develop and demonstrate the evidence to unlock blending on the lower and medium pressure networks. However, the evidence generated in the gas characteristics and operational procedures elements of the programme for the below 2 barg networks was beyond expectation and as such a second small scale domestic-focused trial similar to the scale and make-up of the Winlaton trial would not offer best value of resources.

Therefore, a material change to the programme was requested to re-focus the resources to cover all remaining evidence gaps to unlock hydrogen blending for the wider gas distribution networks; specifically, elements such as Gas Characteristics, Assets, Materials & Procedures and Industrial and Commercial users for the above 2 barg distribution networks i.e., intermediate and high pressure tiers.

Being able to blend into different pressure tiers of the distribution network will build resilience and flexibility for customers to receive hydrogen blended gas. Proposals were drawn up and shared with Ofgem and following bilateral engagement Ofgem sanctioned this change in Project Direction.

Hydrogen blending technology is being recognised as a vital enabling technology for the UK to reach Net-Zero.

This means that the HyDeploy2 programme has since increased focus on addressing all remaining areas and barriers to rolling out hydrogen blends across the UK. This will be instrumental in defining the approach and scope of the final phase of the programme – which seeks to maximise the evidence that can be locked in to enable deployment.

Key challenges

The global pandemic caused by coronavirus continues to be the biggest challenge for the project which has caused some delays to a few elements of the programme driven by an inability to access resources, labs, offices and individuals. However, the project team has remained resilient and flexible and adjusted to remote ways of working. Despite this, the project remains on track with relatively limited delay.

A number of clarifications enquiries were received during the early period of the trial, primarily due to the differences in information provided by energy suppliers.

Overall, it has been a successful year for the project: achieving the UK's first hydrogen blends to be transported within a public gas network; increasing knowledge to address gaps for blending hydrogen gas in to higher pressure networks, and demonstrating the compatibility of using hydrogen blends within industrial and commercial processes. Hydrogen blending technology is being recognised as a vital enabling technology for the UK to reach Net-Zero.
The successes of the last year are due to a competent, dedicated and engaged project team working collaboratively towards collective goals.

3.0 Business case update

Under the Climate Change Act, as modified in 2019, the UK is committed to achieving Net Zero emissions by 2050. This requires decarbonisation of all aspects of the energy sector.

The role of hydrogen in achieving this has received increased attention over the last few years. This culminated in the Hydrogen Strategy[1] released during 2021. This built upon the recommendations from the Committee on Climate Change (CCC)[2] in its Net Zero report, as well as the Prime Minister's 'Ten Point Plan for a Green Industrial Revolution' released in Autumn 2020 and subsequent Energy White Paper.

Delivering low carbon heat via gas capitalises on existing network assets cost effectively and means that customers do not require disruptive and expensive changes in their homes.

The Hydrogen Strategy is clear that *"developing a thriving low carbon hydrogen sector in the UK is a key plank of the government's plan to build back better with a cleaner, greener energy system."* *It also notes that "low carbon hydrogen has a critical role to play in our transition to net zero."*

The Strategy sets out the roadmap to deliver the ambition of 5 GW of production capacity by 2030 and the role hydrogen plays in meeting our Sixth Carbon Budget and net zero commitments. This recognises that there are a range of applications where hydrogen has a key role, in Industry, Power, transport and heat in buildings. The importance of blending is identified, as shown in the Strategy's Figure 2: The hydrogen value chain[1] (right).

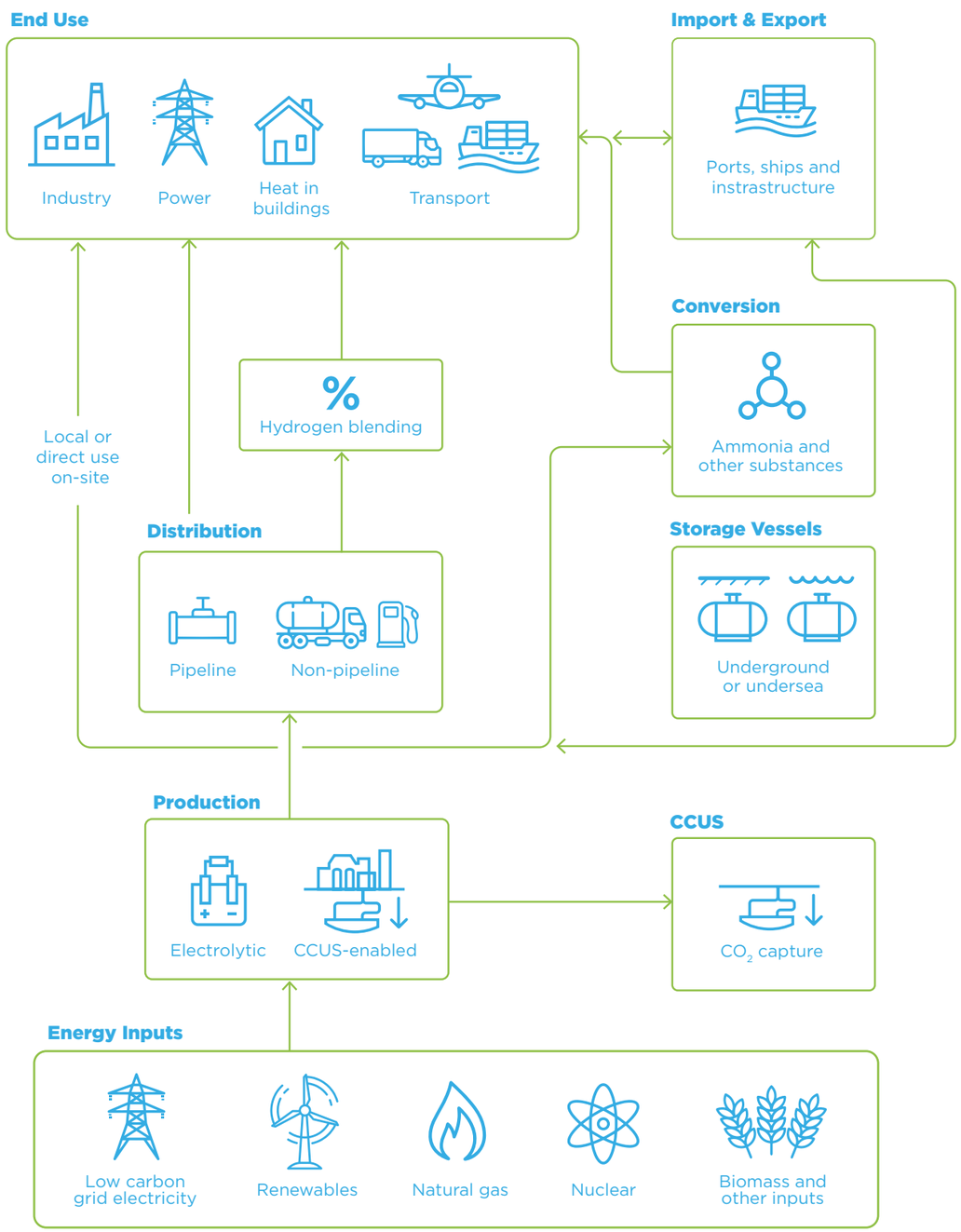
As previously announced in the 10 Point Plan, government has laid out that by 2023 it wishes to work with industry to complete testing necessary to allow up to 20% blending of hydrogen into the gas distribution grid for all homes on the gas grid. This is supported by a Value for Money assessment being undertaken by BEIS in 2022.

Blending provides the basis to establish and build out hydrogen production capacity, address regulatory hurdles, build the wider hydrogen supply chain and importantly provide an opportunity for customers to become accustomed to hydrogen being part of the energy mix. Over time, building on this platform, it is expected that parts of the gas system could migrate to full hydrogen. This will require resilient hydrogen supplies, the next level of regulatory and operational changes as well as suitable appliances.

Programmes such as H21, H100 and Hy4Heat are designed to progress these network and appliance issues. Manufacturers such as Worcester Bosch and Baxi have both developed "hydrogen ready" boilers to facilitate that transition, as well as other appliance manufacturers developing hydrogen cookers and fires. These have been visibly demonstrated at the Hydrogen Home[3] established by Cadent, BEIS and NGN during 2021. Plans for 100% hydrogen trials are advancing in line with the Ten Point Plan with objectives for a hydrogen neighbourhood by 2023, village by 2025 and town by 2030.

Delivering low carbon heat via gas capitalises on existing network assets cost effectively and means that customers do not require disruptive and expensive changes in their homes. Alternatives such as electrification using heat pumps will make a contribution; in reality, to deliver Net Zero, will require a combination of both. However, this approach requires substantial consumer capital outlay and disruption, as well as reinforcement of the electricity grid and additional generation capacity – recognising the combined implications of electrification on passenger vehicles.

The hydrogen value chain



The Hynet project provides a platform for early roll out of blending into the local distribution zone to decarbonise domestic heat in combination with full hydrogen to industry to deliver deeper decarbonisation.

Hydrogen blending exploits the existing gas network by reducing the carbon intensity of heat delivered, requiring no changes to appliances and the gas network which provides a non-disruptive solution for customers. It can operate seamlessly with a range of future heat scenarios, and provides a deliverable pathway and early carbon reductions in the built environment.

The HyNet project[4] provides a platform for early roll out of blending into the local distribution zone to decarbonise domestic heat in combination with full hydrogen to industry to deliver deeper decarbonisation. It also provides a platform for flexible hydrogen fuelled power generation to balance intermittent renewables, as well as facilitating complementary zero carbon solutions for transport.

The HyNet infrastructure has been deliberately designed to interface with key distribution offtakes from the National Transmission System, allowing early deployment of blending by Cadent. During 2021, the project was selected as one of two industrial decarbonisation clusters, as was the East Coast Cluster[5] which also encompasses the NGN distribution region.

During 2021 HyNet completed FEED on the UK's first large scale low carbon hydrogen facility, which will produce initially 3 TWh per annum of low carbon hydrogen production rising to over 30 TWh by 2030.

To deliver hydrogen will require an appropriate policy regime. BEIS is undertaking work on business models to achieve this. Alongside the Hydrogen Strategy, BEIS issued a 'minded-to' consultation on hydrogen business models which is being developed into a model contract during 2022. This provides the basis for low carbon hydrogen production for all end uses, including hydrogen blending, as one of the expected early applications of hydrogen.

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1011283/UK-Hydrogen-Strategy_web.pdf

[2] Net Zero - The UK's contribution to stopping global warming, CCC May 2019

[3] https://www.energylivenews.com/2021/07/16/fuel-of-the-future-uks-first-hydrogen-powered-homes-open-to-the-public/

[4] www.hynet.co.uk

[5] https://eastcoastcluster.co.uk/

[6] https://www.northerngasnetworks.co.uk/ngn-you/the-future/integrel/

4.0 Progress against plan

The project has proceeded well against the original plan up to the commencement of the Winlaton trial, after which the change in Project Direction has led to the development of an updated project plan with progress against each programme elements summarised below.

Much of the effort and resource used this year was focussed on the HSE challenge and review of the evidence base to support the first public trial exemption which led to the successful awarding of the Exemption. Further supporting analysis for repurposing cast iron was generated during the challenge and review phase to provide the level of demonstration deemed necessary. Hydrogen blend injection mobilised soon after the awarding of the Exemption and resources have focussed on maintaining the continuous operation of the hydrogen blend trial.

In parallel, collation of evidence required to support national roll-out began in the area of industrial gas users. Following the project re-direction this has been ramped up to cover all existing barriers to hydrogen blends roll-out on the wider gas distribution networks (specifically the intermediate and high pressure tier networks).

Programme element	Progress
1. Evidence for Wider Roll-out - Materials	A materials test programme was developed to assess materials that would be exposed to pressure tiers above that which the Winlaton trial network operates. This information will be necessary to support the roll-out of hydrogen blending on assets and materials operating at higher pressures. The University of Manchester and University of Sheffield have spent this year completing their data generation of impacts of hydrogen exposure to the mechanical properties of materials. The experimental work has been completed comprising hydrogen exposure conditions equivalent to 50 barg at a 20% hydrogen blend ratio. Samples were exposed to hydrogen under pressure, then stored in liquid nitrogen before being mechanically tested in air. The results are being written up and are due for completion in Q1 2022. The mechanical test data produced by the Universities will now aid the asset suitability assessment work which is being led by DNV. Throughout this period international relationships have been fostered, such as with the US Department of Energy, and has led to some collaboration on developing mechanical test data on cast iron.

Programme element	Progress
1. Evidence for Wider Roll-out - Materials (Continued)	A network asset register has been compiled in collaboration with NGN's H21 NIA project to ensure duplication is avoided. DNV has since developed the assessment criteria based on design standards and identified data gaps. This will inform a final materials test programme which will commence in Q2 2022. The ability for existing assets (and therefore materials) to be compatible with hydrogen blends is critical to achieving national roll-out and any materials data generation test programme can be resource intense. Therefore, HyDeploy is actively seeking to collaborate with all other UK based hydrogen asset materials research and development programmes to gain value from any existing synergies and to avoid duplication of work and effort, this has resulted in a successful collaboration kick-off meeting between Cadent's HyDeploy, NGN's H21, SGN's LTSFutures and National Grid's FutureGrid.
2. Evidence for Wider Roll-out – Domestic Appliances	During 2021 the primary focus of the HyDeploy2 programme was engaging with the HSE to review the submitted evidence in support of the Exemption application submitted for the Winlaton trial. This set the context of all of the technical workstreams, including the domestic appliances workstream. The domestic appliance evidence base submitted was based on a representative sample of 13 appliances, which collectively encompassed the design variability of natural gas domestic appliances since the first tier of appliances were introduced in 1976 – following the conversion from towns gas. This technical structure allowed the results of the testing to be nationally applicable, instead of limited to the Winlaton geography. The most notable results within the domestic appliance workstream were those relating to understanding the impact of introducing a hydrogen blend within hazardous appliances i.e., those producing dangerous levels of carbon monoxide.

Programme element	Progress
2. Evidence for Wider Roll-out – Domestic Appliances (Continued)	A significant safety credit was observed following the introduction of a hydrogen blend, as carbon monoxide levels were seen to reduce by between 80-90%, often reducing back to a tolerable level. A key focus area for the domestic appliance workstream through 2021 was the further analysis necessary to explore the effect of a hydrogen blend on existing Oxygen Depletion Sensors (ODSs), which are a flame protection device that exist within some gas fires. From the HyDeploy1 evidence base, ODSs were known to be a potentially sensitive component of gas fires. A rigorous analysis technique was employed using performance data from laboratory test conditions to explore the expected performance of ODSs within real world conditions. This modelling exercise, supported by physical experimentation, demonstrated that the actual performance implications were marginal and did not compromise the ability of gas fires to safely shutdown. This evidence was reviewed and approved by the HSE as part of the Winlaton submission. Overall, the domestic appliance workstream has demonstrated that existing natural gas domestic appliances are compatible with hydrogen blends from both a performance and safety perspective. The evidence generated to date has led to Worcester Bosch, Baxi and Ideal Boilers all publicly stating their product ranges are compatible with hydrogen blends.

Programme element	Progress
3. Evidence for Wider Roll-out – Gas Characteristics	The focal areas of the gas characteristics workstream through 2021 were two-fold: progressing fundamental analytical programmes such as consequences testing, and providing supporting analysis for the review of procedures e.g., hazardous area assessments. The laboratory access constraints imposed by the Covid-19 pandemic led to a derivation from the original technical strategy with respect to assessing the marginal consequences of explosions. Instead of utilising experimental results, a desk-based assessment was submitted. This assessment was based on the prevailing explosion models used for vent sizing design. The modelling work was submitted, reviewed and accepted as part of the overall Winlaton evidence submission. The construction of a UK first experimental facility at the HSE Buxton site continued through 2021, leading to experimental programme consisting of over 60 controlled explosions. This allowed real world data to be gathered, at representative conditions based on an assessment of historical gas incidents. The physical experimentation provided supporting validation of the desk-based assessment, as the comparative test conditions yielded similar results as those predicted. The focus of the gas characteristic workstream over 2021 increasingly transitioned from fundamental research to procedures review support, particularly following the issue of review questions from the HSE. Such work included an assessment of hazardous areas around governor stations, leakage behaviour expected from metallic pipework and ignition potential analysis from operational equipment. The gas characteristics workstream continued to be a foundational pillar of the evidence base submitted in support of a hydrogen blend Exemption – as was observed following the Keele University Exemption process.

Programme element	Progress
4. Evidence for Wider Roll-out – Industrial & Commercial Gas Users	The Industrial & Commercial (I&C) workstream undertook two key trials during 2021: testing of a 1.2 MW boiler at the Dunphy manufacturing facility in February, and a five-day trial on the 55 MW operational glass furnace at Pilkington Glass in September. Preparation continued for the third trial, which is due to take place on the 7 MW steam-raising boiler at the Unilever manufacturing complex in Port Sunlight. Both of the trials undertaken were in collaboration with the BEIS funded Industrial Fuel Switching (IFS) programme. This enabled engineering synergies to be captured, leading to a more efficient delivery of the work programme. The 1.2 MW boiler testing demonstrated the operational soundness of fuelling a boiler with a hydrogen blend. The testing characterised the thermal and process performance of the boiler to provide robust evidence of performance integrity. The results of this formed a confidence building exercise in the development of the Unilever trial. A five-day trial was undertaken at Pilkington Glass in St. Helens. Each day during the trial 2 tonnes of hydrogen were consumed by the 55 MW furnace. This rate of hydrogen consumption could have provided an equivalent blend to 30,000 typical domestic homes – demonstrating the importance of decarbonising heavy industry. The ground breaking trial produced a batch of sheet glass, which passed all product quality testing. This was the first use of a hydrogen-natural gas blend within the UK to produce glass and demonstrated the potential to decarbonise heavy industry without major disruption. An 18-month engineering and logistics programme was required in preparation for the trial, which involved hiring 20 additional hydrogen trailers from the continent as the rate of consumption was greater than the available UK fleet of hydrogen trailers. Following the accepted material change request of the HyDeploy2 programme, the I&C workstream has become a central workstream in closing evidence gaps to unlock hydrogen blending across the gas distribution network.

Programme element	Progress
5. Evidence for Wider Roll-out – Procedures	A critical aspect of safe management of the gas network and installations is the correct application of operational procedures. The assessment of appropriate operational procedures formed a critical part of the Exemption, but this was limited to those procedures utilised on the medium and low pressure networks. The assessment now will be extended to the intermediate and high pressure networks to ensure all network procedures have been assessed for suitability and any recommendations or changed required captured accordingly within the evidence base. This work will continue into 2022 where the approach has been taken to assess the full suite of a single GDN's procedures since the majority of GDN procedures are technically similar. In this case NGN's suite of procedures have been selected to build upon the assessment already carried out on the medium and low pressure procedures adopted for the Winlaton trial - there are a total of circa. 660 procedures and the Energy Network Association's 74 GIS documents (Gas Industry Standards) which are applicable to all GDNs. This method should provide a practical way to demonstrate that a suitable set of GDN network procedures across all pressure tiers for hydrogen blended operations is practical and feasible. The technical questions will then be addressed by an expert forum of key stakeholders from the gas industry including Cadent, NGN, Progressive Energy, HSE-SD, DNV, SGN and IGEM. Any changes to procedures will be captured in supplement documents which can be used to inform hydrogen blend standards.
6. Extension of evidence base required for wider deployment	See sections 1-5

Programme element	Progress
7. Generic activities applicable to all sites	Following the accepted material change request, only one Exemption-based network trial will be undertaken as part of the HyDeploy2 programme. Therefore, please see section 9 and 10 of this table.
8. Local engagement and evidence gathering	The project has been in communication with local residents, industry stakeholders and policy makers. These activities have helped build momentum around hydrogen blending – which is now a key element of the UK Government's hydrogen strategy – with hydrogen blending playing a central enabling role of the hydrogen economy. The significance of which has been seen in the Government's ten-point plan which sees a policy decision to be made on hydrogen blending within the UK in 2023. Significant emphasis continues to be put on the social science element of the project as such a survey was conducted with the residents on the Winlaton trial network as well as interviews to capture evidence associated with public perception of hydrogen and hydrogen blended gas. The results of this work will be published in 2022.
9. Develop and submit site specific exemption	The Exemption application to blend up to 20% hydrogen into the Winlaton trial network was submitted in June 2020 and reached a successful conclusion with the award of the Exemption being granted in July 2021.

Programme element	Progress
10. Site preparation, installation and commissioning	Site preparations at the Low Thornley site included the design, build, installation and commissioning of hydrogen grid entry unit (GEU), supplied by Thyson Technology. The GEU design was principally based on the Keele University GEU, however incorporated lessons learnt to improved expected performance. The hydrogen supply for the Winlaton trial was via a gas supply contract with Air Products. This selection was due to this being the lowest cost and risk option of hydrogen supply. Air Products safely installed a storage facility and docking station for hydrogen trailers, and the Air Products and Thyson facilities were integrated to provide a single hydrogen supply and blending installation. The integrated system was commissioned and isolated during the exemption evidence review process, to minimise the lead time between the awarding of the exemption and the commencement of the trial.
11. Live trial	The Winlaton trial safely commenced on the 4th August 2021. Since then, all committed-to undertakings and processes have been enacted, including the blend progression schedule to sanction blend level increases. Over the course of 6 weeks the blend level was carefully increased, and has been at 20 vol% with a control tolerance since. No appliance or network issues have been identified which were attributable to the hydrogen content of the supplied gas. This operational experience further enhances the evidence base demonstrating the viability of safely transporting and utilising hydrogen blends within the existing gas distribution infrastructure.
12. Site reinstatement and engagement close out	Was not due to commence in 2021
13. Network models for deployment	Was not due to commence in 2021

Programme element	Progress
14. Regulatory and commercial basis for deployment	This aspect of the project is truly unique from the previous trial, since at Keele there was only one permanent shipper/supplier involved, unlike at Winlaton where there are many and of course customers have the freedom to change their suppliers during the trial so the billing process needed to be developed to be flexible and broad to allow for the fluidity of supplier changes, but robust enough to ensure that the customers are not financially impacted and that the hydrogen element of the customer's bill remains free of charge. Scoping work is underway to consider the most appropriate approaches for billing regimes for roll out. This is interfacing with other programmes, including the Future Billing Methodology project as well as work undertaken by Frontier into this area. BEIS's gas blending group will provide a focal point to consider these issues. NGN, Cadent and Progressive Energy are members of this group, and the project team is actively engaged and contributing to this.
15. Skills and training	Training for the Winlaton operatives was completed in 2020 and was refreshed in 2021. Wider engagement was conducted with the Gas Safe Community in the form of a webinar and published articles with over 700 Gas Safe engineers in attendance.

Programme element	Progress
16. Communications and dissemination	The communications strategy for 2021 has been largely focused on supporting delivery of the first public trial, along with national engagement with regard to the role for hydrogen blending. Due to Covid-19, face to face engagement with the local community has been more limited, but the project team has made the most of social media and the website to reach out where is required. There has been considerable engagement with key officials within BEIS regarding the role of gas blending. This has been recognised, with blending explicitly referred to in the 10 point plan, and BEIS forming an expert blending group to inform the transition to roll out. With the Exemption granted, the plan is to lodge key evidence in the IGEM Hydrogen Knowledge Centre library such that this becomes a resource which can be drawn on by the wider industry. Three papers were accepted for presentation and publishing at the International Conference on Hydrogen Safety. This included: an overarching paper of the evidence base; a paper on the consequence experimental testing, and a paper on the appliance test work. This allowed for international dissemination of the generated evidence. All presented papers will be published in the International Journal of Hydrogen Energy over 2022.
17. Project management	Effective project management is necessary to deliver a project with 6 partners and multiple work streams. The governance structure is provided by the Steering group which meets quarterly. A well-managed system of monthly project meetings with associated programme and budget reporting is in place, and a comprehensive project risk register being used to manage the programme. Subsidiary working groups monitor and progress individual work streams.

5.0 Progress against budget

The table to the right shows the progress against budget to the end of November 2021. The programme is being managed for overall delivery within budget.

Progress this year has been delivered as per the original budget. The majority of spend has been focused on securing the exemption through the development of further analysis, trial initiation and management and project management accounting for the remainder.

Due to a collaborative working approach with manufacturers and other hydrogen-related projects, budgeted spend for certain programme elements has been sufficient to cover actual spend with forecast funds remaining to allow further focus in other programme elements. Inevitably individual programme elements will vary compared with the original budget, especially following the project re-direction in Q4 of 2021, but this is being actively managed with a process of monthly reporting and review, enabling proactive decisions to be made to deliver the project to plan.

Overall, the delivery of the programme has been stewarded in such a way to ensure cost effective progress towards programme objectives.

Programme element	Spend to date (£)	Budget to date (£)	Total budget (£)
1. Exemption evidence - Materials	706,722	811,825	934,031
2. Exemption evidence – Appliances	521,367	418,248	497,965
3. Exemption evidence – Gas Characteristics	1,656,405	1,396,563	1,486,829
4. Exemption evidence – Gas Detection	56,784	209,885	223,292
5. Exemption evidence – Procedures	219,814	226,450	299,170
6. Extension of evidence base required for wider deployment	770,646	1,213,834	2,191,524
7. Generic activities applicable to all sites	380,138	955,505	1,016,544
8. Local engagement and evidence gathering	254,499	1,127,795	1,428,912
9. Develop and submit site specific exemption	628,422	383,761	757,072
10. Site preparation, installation and commissioning	2,078,718	1,533,605	2,279,219
11. Live trial	110,286	412,955	1,771,399
12. Site reinstatement and engagement close out	6,000	10,500	168,403
13. Network models for deployment	4,070	32,450	34,523
14. Regulatory and commercial basis for deployment	28,128	95,720	205,244
15. Skills and training	7,863	24,300	68,940
16. Communications and dissemination	43,309	69,380	312,068
17. Project management	788,364	837,598	1,293,606
Total	**£8,261,535**	**£9,760,374**	**£14,968,741**

6.0 Project bank account

Bank statements have been provided to Ofgem. Due to the confidential nature of the project bank statements, they have not been included in this report.

7.0 Successful delivery reward criteria

All scheduled Successful Delivery Reward Criteria were completed in full during this period, as tabulated below and as evidenced to OFGEM.

SDRC1: Communications plan
25th October 2019

SDRC2: Evidence Base for First Trial
30th June 2020

SDRC3: Exemption Submission
22nd September 2020

SDRC4: Winlaton Trial Commencement
4th August 2021

Due to the change in project direction following the success of the evidence base generated for the Winlaton Trial, Ofgem have resigned Project Deliverables for the remainder of the project all of which are scheduled for delivery in 2022/2023.

8.0 Data access details

No public network or consumption data has been collected on this project to date.

9.0 Learning outcomes

The following key learning points have been identified during this period, and provided the foundation for delivery of the ongoing programme, as well as informing national roll-out.

Face-to-face Meetings

Due to the global pandemic all engagements were transitioned to remote interactions, which for most engagements led to an immaterial impact. However, more technically focused engagements were affected to a greater extent due to the interactive and creative nature of such discussions.

This constraint was eventually overcome by holding socially distanced meetings in line with government guidelines, but led to a more nuanced appreciation of meetings that require face-to-face interaction and those which can be managed remotely.

Customer Engagement

Customers are at the heart of the HyDeploy2 project – delivering low carbon heat without disruption. The work undertaken by the social sciences department reinforced how important it is to maintain contact with the customers, even during 'quiet' periods of the project.

The team is planning a 'behind the scenes' session for the local customers alongside the wider dissemination programme, to ensure that they are valued and have the opportunity to see the contribution they are making to delivering low carbon solutions.

Adaptability

With the global pandemic continuing to impact different businesses and organisations in different ways, everyone involved in the project has needed to adapt to sustained new ways of working.

Supply Chain Management

As well as the direct impacts of the global pandemic, there have been many indirect impacts, specifically on supply chain delivery.

The knowledge and experience of supply chains cannot be underestimated, and leveraging that expertise through dedicated engagement has been found to be immensely valuable to the delivery of the project by thinking about the broader risks to the supply chain at the early stages of engagement and agreeing appropriate contracts which provide mitigations.

10.0 Intellectual property rights

No registerable IPR has arisen during the period.

11.0 Risk management

Effective risk management is critical for successful project delivery. A risk register is being used as a project management tool.

Going into 2021 the key project delivery risks were associated with securing the Exemption and commencing the Winlaton trial.

Covid-19

This continues to be an element that cannot be omitted from the Risk Register, but with experience most individuals have adapted to new ways of working.

Exemption

There were some impacts on the timeline of the Exemption, fundamentally driven by Covid implications and the development of further analysis. This was successfully navigated resulting in the awarding of the Exemption in July 2021.

Physical works

Covid secure ways of working were identified. There were some impacts on timelines, particularly relating to site access.

More generally contingent plans had to be put in place to manage budget and schedule, which resulted in an alternative delivery plan for installation using framework contractors which has been put in place.

Going forward the key risks being managed relate to:

Contract Management

The final aspects of evidence is being developed with a number of expert contractors supporting and providing the work. This is being addressed by tight management of contractors by NGN.

Operations

Resilient hydrogen supplies continue to be secured, designed to provide reliable hydrogen availability during the trials.

Industrial trials

The next trial is scheduled in Q1 2022 and costs and risks associated with this programme are being managed and mitigated through collaboration with 100% hydrogen Industrial Fuel Switching trials.

12.0 Accuracy assurance statement

This report has been prepared in accordance with the Gas Network Innovation Competition Governance Document published by Ofgem.

The project has been subject to review and challenge by the Cadent Project Manager and signed off by Damien Hawke, Cadent Safety & Network Strategy, who is Project Sponsor for this NIC project.

Damien Hawke has confirmed that the processes in place and steps taken to prepare this Project Progress Report are sufficiently robust, and that the information provided is accurate and complete.

13.0 The project team

HyDeploy2 is being delivered by the HyDeploy consortium, which has technical expertise and practical experience. The partners are:

Cadent Gas (formerly National Grid Gas Distribution) is leading HyDeploy2. They own and operate four of the eight gas distribution networks in the UK, including the West Midlands.

Northern Gas Networks is partnered with Cadent to deliver HyDeploy2. They own and operate the gas network in the North East, Northern Cumbria and much of Yorkshire.

Keele University is providing learning from the first HyDeploy trial and providing continuity of consortia through the HyDeploy2 trials.

HSE Bespoke Research and Consultancy is the consulting arm of the Health & Safety Executive. They will be providing the scientific evidence which will support the safety case for the public trials.

ITM Power manufacture integrated hydrogen energy solutions.

Progressive Energy is an independent UK clean energy company. It will be supporting the management of HyDeploy2 through development and implementation.

In addition to the core project partners the project is supported by a number of key companies:

Kiwa specialise in gas testing. It is carrying out offsite testing on a range of common household appliances to inform the project, and will lead the gas safety appliance checks on the campus.

Dave Lander is an internationally recognised expert in gas quality and safety and co-ordinated the Exemption application to the HSE.

HyDeploy

Visit **www.hydeploy.co.uk**
Send **info@hydeploy.co.uk**