East Coast Hydrogen

Paper 2:

The Needs Case

Contents

1 Problem Statement

The UK Government Policy and Net Zero legislation are driving the need to reduce CO2 emissions and further decarbonise the Industrial &Commercial (I&C) and Power sectors by 2035. Hydrogen production is planned in the Teesside and Humber regions, but I&C and Power users are spread throughout the northeast of the UK. Northern Gas Networks (NGN) owns 36,000 km of natural gas distribution pipework and is therefore in a prime position to repurpose its assets from natural gas to hydrogen usage with the aim of contributing to the Government's Net Zero Strategy.

To meet net zero by 2050, NGN proposes to link hydrogen production with I&C users via a hydrogen pipeline network including access to hydrogen storage to ensure demand can be met during peaks and troughs of energy usage. The network must be developed in line with the Network Pathway policy and meet the hydrogen strategy timescales to decarbonise electrical production and hard to decarbonise sectors.

The East Coast Hydrogen (ECH_2) Feasibility and Pre-FEED studies have identified that the most cost-effective solution to transport hydrogen at scale is to repurpose existing natural gas assets. The requirement for a FEED study is fundamental to define a final route for the network, connecting supply with demand and storage, and determine a more specific project cost estimate to inform a final investment decision.

Therefore, this section of the submission will focus on the need for a 100% hydrogen network, which was identified through engagement with numerous stakeholders.

2 Strategic fit and alignment with government policy objectives

The east coast region is home to UK's largest industrial emission clusters (Tees Valley, Humber) as well as West Yorkshire hosting concentrated industrial energy demand, significant gas storage, and abundant offshore wind power.

The ECH_2 project is a first of its kind, 15-year collaborative energy infrastructure programme established by NGN, Cadent and National Gas (NG), along with a supporting consortium group comprising of over 120 partners across the full hydrogen value chain. The project's primary goal is to build a 100% hydrogen transmission and distribution network to decarbonise the industrial, commercial, and power sectors in the east coast region, aligning to the government's clean energy policy.

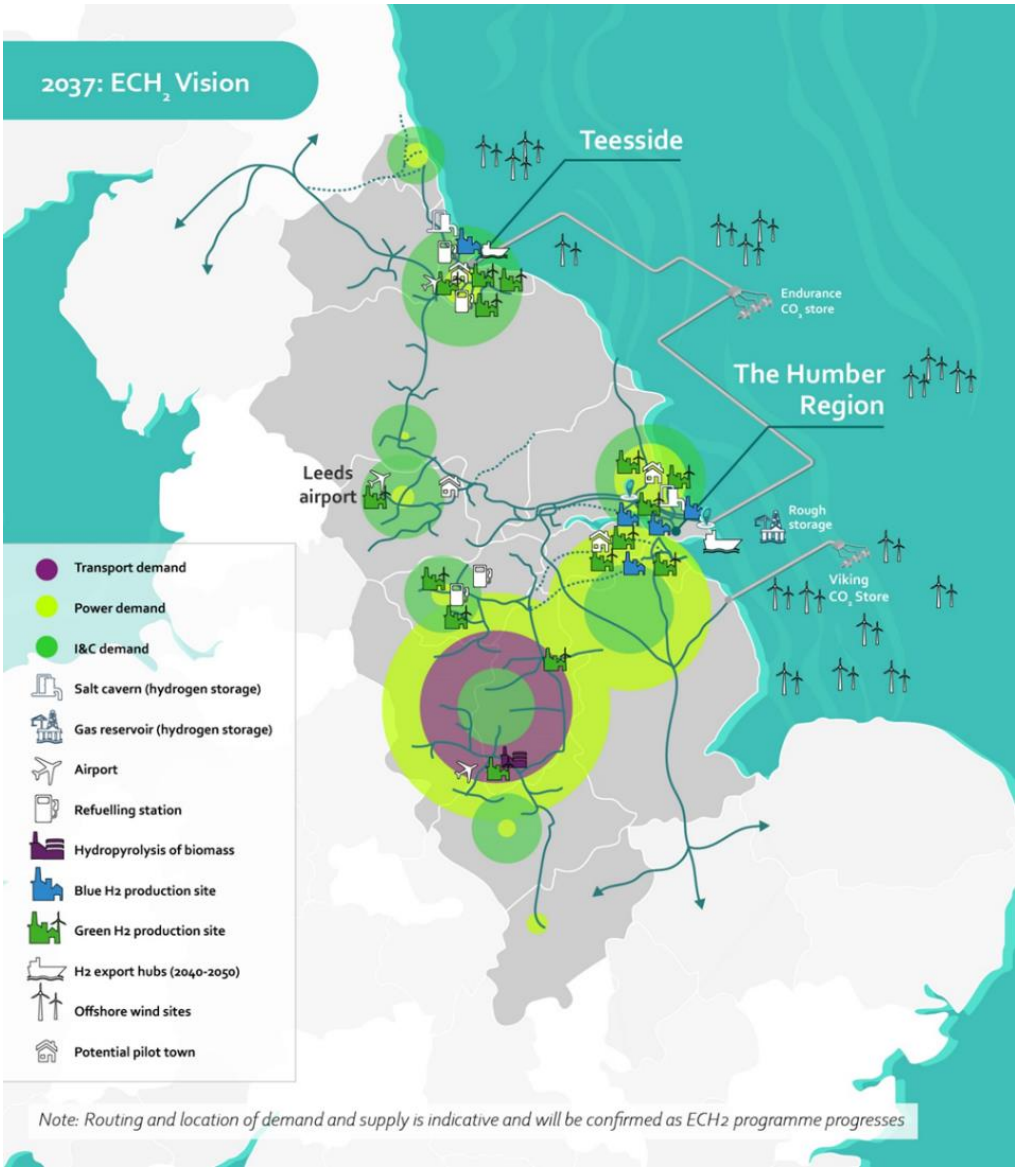


Figure 1. The East Coast Hydrogen programme will build a 100% hydrogen transmission and distribution network to decarbonise the industrial, commercial, and power sectors in the east coast region.

Given the scale of industrial energy consumption within the east coast region, the ECH_2 network is crucial in the race to net zero. ECH_2 aims to connect hydrogen supply, demand, and storage through a mixture of repurposed and new pipelines. With many industries in the region reliant on the use of gas, and unable to decarbonise with electricity, the introduction of hydrogen is vital to the future economic prosperity of the region.

ECH_2 supports government policy and net zero legislation whilst enabling green job creation, reducing emissions, and boosting resilience across the energy system. The ECH_2 programme has identified approximately 88 terawatt hours (TWh) of annual hydrogen production in the region, and over 58 TWh of annual industrial, commercial, and power energy demand materialising up to 2037[1].

ECH_2 will enable decarbonisation of industrial, commercial, and power customers located within industrial clusters as well as those that are located outside of the clusters, representing 50% of UK's

[1] East Coast Hydrogen Delivery Plan. East Coast Hydrogen. November 2023.

Industrial and Commercial (I&C) emissions[1]. It will also offer future optionality to decarbonise transport and heating sectors through effective utilisation of large-scale hydrogen infrastructure, thereby delivering investment value.

The ECH_2 programme will enable the Government to attain the hydrogen production target of 10 gigawatts (GW) of low carbon hydrogen production by 2030, described in the Hydrogen Strategy (2021), with at least one GW of production capacity by 2025, potentially supporting over 9000 UK jobs and over £4 billion investment[2]. It also supports development of eight projects selected through the government's Net Zero Hydrogen Fund (NZHF) and Hydrogen Allocation Round 1 (HAR1), and the carbon capture usage and Storage (CCUS) cluster competition within the region to facilitate blue hydrogen generation.

Hydrogen is the most credible decarbonisation pathway for high temperature (>400°C) industrial processes where electrification is unsuitable or uneconomic, and where carbon capture is not feasible. Consequently, hydrogen infrastructure will need to be rapidly deployed to economically achieve the UK's net zero target. According to the Climate Change Committee (CCC)[3] and National Grid's Future Energy Scenarios[4], low-carbon hydrogen is expected to play an essential role in achieving net zero across the commercial, power, transport, and heating sectors.

Since indicating the ambition to develop a world leading low-carbon hydrogen economy in its Ten Point Plan for a Green Industrial Revolution (2020), the UK Government has continued to develop its vision for developing industrial 'Super Places' as hubs for renewable development.

The Teesside and Humber Industrial Cluster Plans (2022) articulate the vision to establish the UK's first net zero industrial cluster by 2040, with hydrogen fuel switching playing a critical role in decarbonising industries such as steel and refining, because alternate fuel switching options such as electrification are not viable.

The government's Industrial Decarbonisation Strategy (2021) clearly highlights the ambition to reduce industrial emissions by at least two thirds by 2035 and 90% by 2050. The ECH_2 programme facilitates decarbonisation of I&C and power sites within and outside of the clusters through a phased and customer driven pipeline routing strategy. This also involves connecting blue hydrogen facilities within the East Coast Cluster and Viking CCUS clusters, enabling 8.9 TWh of I&C demand to fuel switch from natural gas to hydrogen in the 2030s. The ECH_2 programme can help deliver the benefits of switching 15.7 TWh of natural gas usage to low-carbon hydrogen by 2032, abating up to 7% of all UK I&C emissions[5].

[2] Hydrogen Strategy. Department of Business Energy and Industrial Strategy. August 2021.
[3] 6th Carbon Budget. Committee for Climate Change. December 2020.
[4] Future Energy Scenarios 2023. Electricity System Operator. July 2023.
[5] East Coast Hydrogen Delivery Plan. East Coast Hydrogen. November 2023.

Figure 2. UK hydrogen strategy and policy timeline.

3 Future government policy horizon

Low carbon hydrogen will play a crucial role in the future of the UK's energy system, and according to the UK Hydrogen Strategy potentially becoming comparable in scale to existing electricity use by 2050. The recently published Hydrogen Net Zero Investment Roadmap (2024) highlights that the UK is entering into a period of unprecedented growth for the hydrogen economy. The ECH_2 programme supports this trajectory by enabling significant decarbonisation of key UK sectors and helping build a competitive hydrogen market.

In December 2023, the government awarded support to electrolytic hydrogen production projects representing 125 MW of production capacity through the first Hydrogen Allocation Round (HAR1)[6]. The second Hydrogen Allocation Round (HAR2), with a capacity aim of up to 875 MW closes for applications in April 2024[7]. The government has set a further ambition to allocate up to 1.5 GW across HARs 3&4, launching in 2025 and 2026 respectively. Also in December 2023, the government announced a positive strategic decision to support the blending of up to 20% hydrogen by volume into the gas distribution networks, stimulating the development of the UK hydrogen market.

In alignment with the British Energy Security Strategy (2022), ECH_2 will enable the UK to diversify its energy supply by harnessing the large-scale offshore wind industry and help the power sector reach net zero by 2035. To support the expansion of strong, home-grown, clean energy supply chains, the government announced the £960 m Green Industries Growth Accelerator (GIGA) fund for UK projects including hydrogen and CCUS in November 2023[8]. Excess renewable electricity can be used to produce hydrogen, which can be stored as strategic reserves and used to generate electricity when there is insufficient renewable energy generation to power the grid. In December 2023, the government published a consultation seeking views on its minded-to position on the market interventions that could be required to mitigate barriers to hydrogen to power (H2P) deployment[9]. ECH_2 can facilitate decarbonisation of 12% of the UK's electricity from natural gas, helping to abate over 6 $MtCO_2$ per year within the east coast region. In addition, ECH_2 can help fuel-switch up to 58 TWh of power sector natural gas demand by 2037[10].

The National Infrastructure Commission (NIC)[11] recommends the development of a core hydrogen pipeline network by 2035, for which the UK government has announced its support in principle[12]. The ECH_2 programme facilitates this ambition by creating a core hydrogen backbone that connects the industrial heartland of the North-East with Humber, Yorkshire, and the Midlands, with the potential for wider rollout across the UK.

The update to Hydrogen Transport Business Model (HTBM) published in December 2023 clearly articulates the government's strategic objectives for the first allocation round which are fully supported by the ECH_2 programme:

[6] Notice: Hydrogen Production Business Model / Net Zero Hydrogen Fund: HAR1 successful projects. Department for Energy Security & Net Zero. December 2023.
[7] Hydrogen Net Zero Investment Roadmap. Department for Energy Security & Net Zero. February 2024.
[8] Press Release: Huge boost for UK green industries with £960 million government investment and major reform of power network. Department for Energy Security & Net Zero. November 2023.
[9] Consultation: Hydrogen to Power: Market Intervention Need and Design. Department for Energy Security & Net Zero. December 2023.
[10] East Coast Hydrogen Delivery Plan. East Coast Hydrogen. November 2023.
[11] Second National Infrastructure Assessment. National Infrastructure Commission. October 2023.
[12] Hydrogen Net Zero Investment Roadmap. Department for Energy Security & Net Zero. February 2024.

- ECH_2 promotes attainment of **net zero** by supporting decarbonisation at pace.
- ECH_2 enables **whole energy system** benefits, including security of supply and helping manage environmental impacts.
- ECH_2 helps unlock the development of an economic and efficient **hydrogen market** that supports wider growth.

ECH_2 can help the government achieve its ambition of supporting up to two geological storage projects at scale and associated regional pipeline infrastructure, with construction or operation underway by 2030.

Figure 3. Strategic objectives of the Hydrogen Transport Business Model (HTBM) first allocation round are fully supported by the ECH_2 programme[13].

The energy transition landscape in the UK is evolving rapidly and becoming increasingly integrated and complex. The Hydrogen Transport and Storage (T&S) Networks Pathway published in December 2023 highlights that strategic planning will guide the first allocation round, ensuring that the successful infrastructure projects can contribute to the overarching T&S strategic objectives. The strategic planning approach can provide a greater certainty on network requirements both in the short and longer term[14]. It can give clarity and confidence to potential consumers, producers, and infrastructure projects, fuelling the growth of the hydrogen economy which the ECH_2 programme supports.

Large scale central planning needs to be balanced with an understanding of local and regional needs, as recognised in Ofgem's recent consultation on the Future of Local Energy Institutions and Governance. The Energy Act's passage enabled the establishment of a National Energy System Operator (NESO). This will happen in the summer of 2024. The NESO will be an independent, public organisation at the heart of the UK energy transition[15]. The NESO will take on strategic planning activities for hydrogen T&S from 2026. In the interim, the government will be responsible for strategic planning, and the Networks Pathway is the first stage of this process. The NESO will have responsibilities around delivering a net zero energy system that balances sustainability with affordability and security. In addition to strategic planning, the NESO will also add value through

[13] Hydrogen Transport Business Model Market Engagement on the First Allocation Round. Department for Energy Security & Net Zero. December 2023
[14] Hydrogen Transport and Storage Networks Pathway. Department for Energy Security & Net Zero. December 2023.
[15] Policy Paper: Draft: Strategy and policy statement for energy policy in Great Britain. Department for Energy Security & Net Zero. February 2024.

supporting development of whole energy market and helping create a resilient and secure energy system.

Figure 4. The NESO will deliver value through strategic planning, market development and creation of a resilient and secure whole energy system[16].

The government published a draft of the Strategy and Policy Statement for Energy Policy in Great Britain in February 2024, which confirms NESO's core responsibilities. The ECH_2 programme supports the fulfilment of these responsibilities by:

1. Enabling clean energy and net zero infrastructure through creation of a core hydrogen network connecting multiple industrial, commercial, and power consumers across multiple regions.
2. Ensuring energy security and protecting consumers through supporting generation of home-grown energy and creating a cost-effective energy system that ensures a just transition.
3. Ensuring the energy system is fit for the future through helping the UK achieve its decarbonisation targets.

The NESO will be supported by a network of Regional Energy Strategic Planners (RESPs). Ofgem is currently undergoing extensive consultation with stakeholders to design in detail the RESP's functions, governance mechanisms, and boundaries. There will be 10 to 13 RESP regions across the UK which will facilitate long-term investment based on a trusted, local, holistic strategic plan[17].

The RESPs will work with organisations at a local level including combined authorities, local government, and the gas and electricity industries, to plan and build the infrastructure needed in different parts of the country and attract investment for projects. In alignment with the government's Energy Bill (2023), the ECH_2 programme will inform the RESP and ultimately the NESO on how to strategically build out hydrogen assets in the UK, utilising networks' consumer relationships and insights on volume and timing of demand and production.

Funding the ECH_2 FEED study represents a low regret opportunity to achieve regional and national decarbonisation ambitions and establishing a resilient and self-sufficient energy system. It is

[16] NESO Introduction Webinar, Electricity System Operator, December 2023
[17] RESP Design Workshops, Ofgem, January 2024

essential that a clear plan for transportation and storage of hydrogen is developed to provide certainty for those across the hydrogen value chain and stimulate investments. Progressing to FEED stage now is critical to ensure deployment in time to unlock whole system decarbonisation benefits and achieve the UK's 2030 and 2050 net zero target.

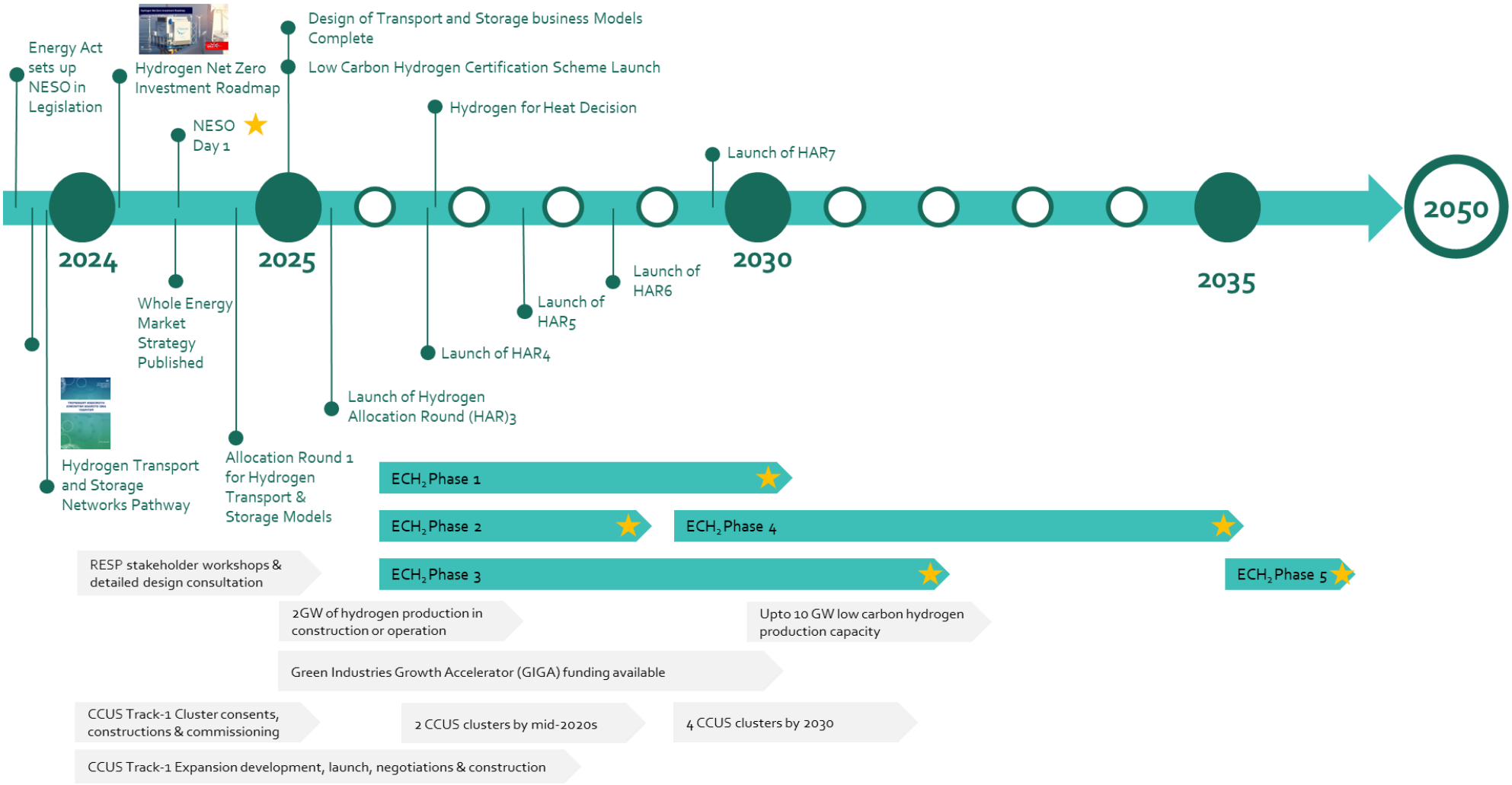


Figure 5. Illustration of future energy policy horizon and interaction with ECH_2 plans.

4 Externally supported evidence

Further to the alignment of ECH_2 with current and future government policy, evidence can be found for the need for a core hydrogen network to transport 100% hydrogen in wider industry papers.

One such report is the Second National Infrastructure Assessment prepared by the NIC, which included consultation with the public, industry, academics, and local and national government to inform a proposed roadmap for the future of infrastructure in the UK[18].

Referring to energy and net zero, the assessment indicates that in those cases where industry cannot decarbonise through electricity, new infrastructure to supply clean hydrogen must be provided to meet the UK net zero target.

As demand for low-carbon products increase, it is critical that the UK protects its industrial activity and provides the infrastructure for industry to decarbonise. To this end, the NIC proposes a core network is created by 2035, to transmit and store hydrogen that can connect multiple producers, users, and stores of hydrogen. ECH_2 would facilitate delivery of this goal.

Furthermore, the NIC report calls for this network to support existing industries and encourage new industry into areas which have seen decline, such as the northeast of England, as well as connecting the industrial clusters in Grangemouth, the northeast of Scotland, Teesside, Humber, Merseyside, and South Wales. ECH_2 encourages industry to the northeast and aims to connect Teesside and the Humber.

According to the NIC, a hydrogen network, such as ECH_2, would:

- Provide resilience by enabling industrial clusters to access other sources of hydrogen supply or demand.
- Help achieve a single price for access and use of the network. Having a network means customers on the network could buy hydrogen from multiple sellers, facilitating a more competitive market for hydrogen and thereby reducing costs.
- Increase optionality of locations on the network. For example, hydrogen production sites would not need to be based near users, allowing them to be located on sites with a preferable water and electricity supply.
- Provide access to more underground prominent storage locations, such as the line running along the coast to Scarborough.
- Create more opportunities to switch existing unabated gas-fired generation sites outside industrial hubs to hydrogen. These sites have access to electricity networks and cooling water, making switching feasible.

Finally, the NIC recommends such a network is designed based on the following principles:

- Focus on providing access to hydrogen for the most likely large users, some of which are situated in industrial hubs. ECH_2 can connect two of the most significant industrial clusters in the UK, Teesside, and the Humber, and pick up large glass and construction products manufacturers in West Yorkshire.

[18] Second National Infrastructure Assessment. The National Infrastructure Commission. October 2023.

- Connect these users to likely sites for electrolytic-enabled hydrogen production. ECH_2 has aligned with the various green hydrogen producers in the clusters to ensure a connection to the network.
- Ensure that networks pass through areas where it is most feasible to locate storage, particularly those sites that look most promising to develop first. With this in mind, the ECH_2 network was developed to align where future storage projects may be situated. An example of this is the repurposed East Riding line along to Scarborough, designed to allow future regional storage projects developed in the area to connect to the ECH_2 network.

Comparing the proposed NIC core network below with ECH_2, it is clear that ECH_2 aligns with the proposed design and the benefits identified by NIC for a 100% hydrogen network.

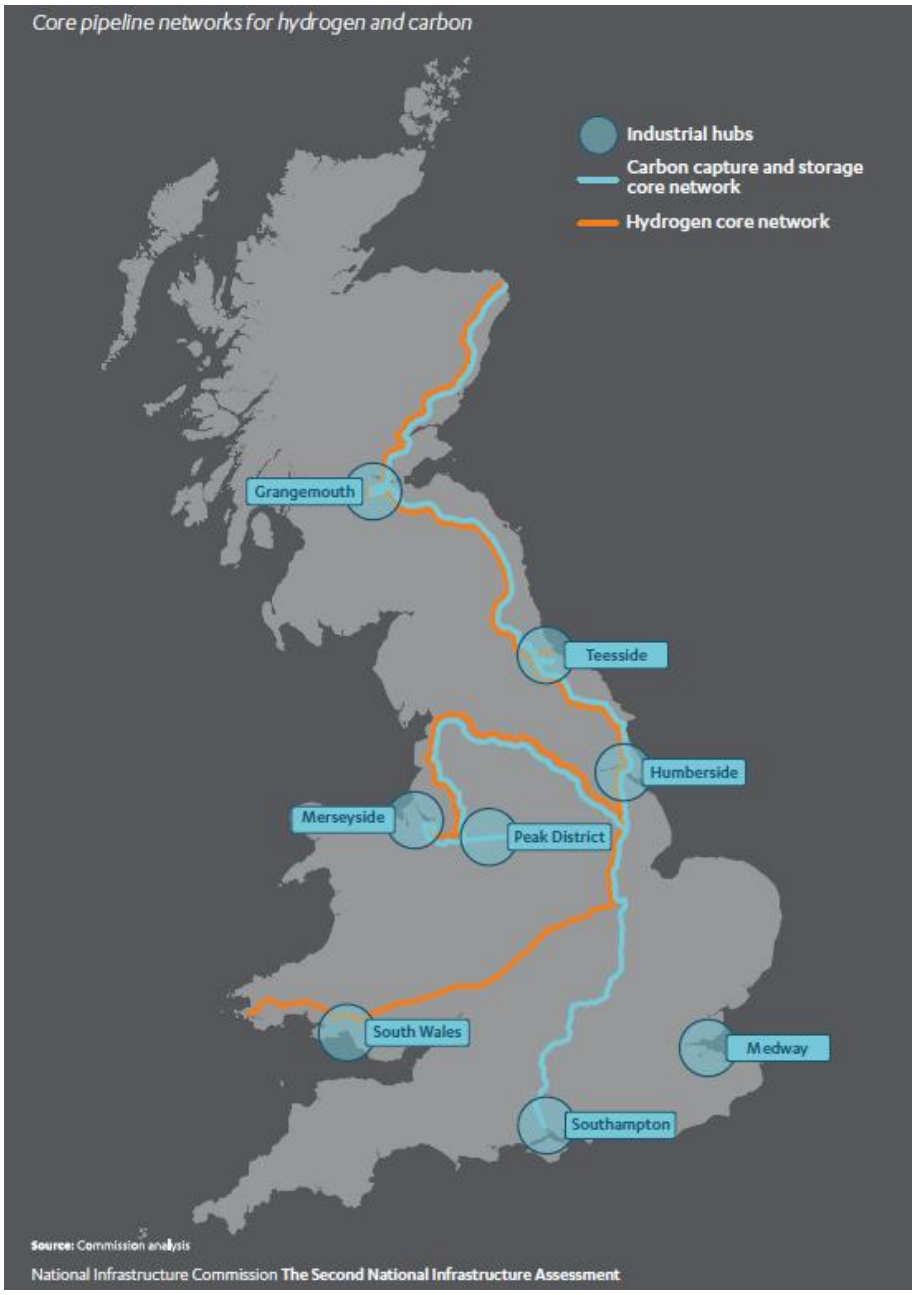


Figure 6. NIC proposed core hydrogen network. (Source: Second National Infrastructure Assessment).

A further report supporting the need for a 100% hydrogen network is the Hydrogen Champion Report by Jane Toogood[19]. As an independent expert advisor, her role was to make recommendations to the Secretary of State on the actions needed by industry and government to accelerate investment in the hydrogen economy. As part of this report, evidence provided by AFRY, a European leader in engineering, design, and advisory services, estimates that long-duration energy storage enabled by a hydrogen network could save the electricity system £13-24bn between 2030 and 2035 by reducing electrical network constraints and seasonal imbalances. Furthermore, transport infrastructure is critical to deliver hydrogen from curtailed wind to the demand centres.

Fuel switching to hydrogen has the potential to reduce annual industrial emissions between 7 and 18 MtCO2e (million tonnes of carbon dioxide equivalent) by 2050. For feedstock users, hydrogen is a unique decarbonisation route; for some others with large-scale high heat combustion requirements, it is the only viable commercial alternative. ECH_2 can connect to these users and provide investment certainty for users and producers, acting as a crucial enabler for deploying decarbonisation measures.

As part of their Large-Scale Electricity Storage Report, The Royal Society[20], an independent scientific academy in the UK, reported that pipelines would be crucial in transporting hydrogen to and from stores, as trains or tankers would be too expensive. This is further supported by the CCC report, Delivering a Reliable Decarbonised Power System[21], which states that pipelines are the only transport mode suited to transporting significant volumes of hydrogen.

This report further expands on the need for a hydrogen network. The CCC describes that the insufficient build of this network can potentially drive inefficiencies (e.g., in the location of assets or the volume of production and storage infrastructure required) and, in turn, system costs. Government research suggests that between 100 kilometres (km) and 1,000 km of pipeline could be needed by 2030, with 700-26,000 km required by 2035. NGN alone is looking to create a network of around 940 km of new and reused infrastructure as part of ECH_2, contributing significantly to this goal. Finally, the CCC claims that the late delivery of this network has the potential to act as a blocker to the storage and production infrastructure needed.

It is evident from the reports referred to above, that independent bodies advising the Government to propose a hydrogen network, such as ECH_2, as a key enabler to decarbonise industry and support the broader hydrogen economy.

[19] Hydrogen Champion Report. Jane Toogood. March 2023.
[20] Large-Scale Electricity Storage. The Royal Society. September 2023.
[21] Delivering a Reliable Decarbonised Power System. Climate Change Committee. March 2023.

5 Alignment with NGN's future strategy

What are NGN's strategic objectives?

NGN has the following strategic aims that are relevant to the ECH_2 Project:

1. To be a net zero transporter of energy by 2050
2. To play a leading role in the transition to net zero
3. To ensure the sustainable use of existing assets
4. To work towards the development of a hydrogen economy and identify opportunities for long-term investment
5. To develop the evidence that demonstrates the safe and economical use of hydrogen in gas networks to meet net zero UK energy needs at least cost
6. To work collaboratively with government, regulators, industrial partners and other energy networks in the development and implementation of strategies and policies that facilitate a future hydrogen network

How do they align with the East Coast Hydrogen Network?

1. **To be a net zero transporter of energy by 2050**

ECH_2 provides a clear pathway for NGN to become a transporter of net zero energy by 2050. It aligns with government strategies and policy and meets the requirements of the Hydrogen Transport and Storage Business Model providing a mechanism for a new hydrogen network to be created at least cost with minimal disruption.

2. **To play a leading role in the transition to net zero**

ECH_2 economically facilitates the decarbonisation of industrial clusters in the NGN region, that together are a significant percentage of the UK industrial emissions. Heavy industry is one of the most difficult and costly parts of the economy to decarbonise. ECH_2 allows NGN to play a leading role in securing the economic future of the North of England and continue with the industry-leading work it started on hydrogen in 2016 with the H21 Leeds City Gate study.

3. **To ensure the sustainable use of existing assets**

If the UK is to achieve its net zero targets, it will eventually cease to utilise methane as a source of energy, and NGN's methane network assets could become redundant and require costly decommissioning if an alternative use isn't found for them, which would likely require funding through electricity customer bills and taxation. During the transition, the risk of asset stranding could push up financing costs and investability of the sector, leading to ever-increasing bills for gas customers remaining on the network until they are able to switch to an alternative. ECH_2 provides an opportunity for a significant amount of these assets to have a sustainable future transporting hydrogen to industrial, power generation and storage facilities. This will give greater confidence to investors that NGN'S assets have a long-term future and help ensure net zero at least cost.

4. **To work towards the development of a hydrogen economy and identify opportunities for long-term investment**.

NGN wants to continue its investment in its existing and new energy distribution assets. ECH_2 provides a clear route for realising this investment and this FEED study is a key step in enabling an investible hydrogen network.

5. **Develop the evidence that demonstrates the safe and economical use of hydrogen in gas networks to meet the net zero UK energy needs at least cost**

NGN has taken a leading role in developing the evidence base for hydrogen as a solution to the Net zero challenge since the H21 Leeds city gate report in 2016[22]. As the gas distribution network in the North of England, NGN has taken a proactive role in supporting the Energy Transition, as it recognises that all parts of the energy system need to work together to deliver net zero at the least cost. Gas is a key part of the solution. This has been enthusiastically supported by NGN's Board and senior leadership team and investing in hydrogen projects has been a key pillar of our Energy Futures Strategy since RIIO-GD1. NGN considers that repurposing the existing network for hydrogen is much cheaper, less disruptive, and more sustainable than building new network infrastructure for the transport of hydrogen and large-scale electrification, particularly for difficult-to-electrify heavy industries. It recognises that all solutions need to be part of the mix and applied where they are most efficient and impactful.

A large amount of the strategic investment by NGN to date has been related to the domestic use of hydrogen, however, ECH_2, as an industrial hydrogen network, is not dependent on the government decision in 2026 in relation to hydrogen for domestic heating. Even so, ECH_2 would enable the efficient rollout of domestic hydrogen use as well, if it is approved.

6. **To work collaboratively with government, regulators, industrial partners and other energy networks in the development and implementation of strategies and policies that facilitate a future hydrogen network.**

NGN understands that to achieve all the other strategic objectives above it will need to work collaboratively with a range of partners. ECH_2 has been a successful collaborative project since its inception. This proposed FEED study provides an opportunity to continue this collaborative approach with these partners and achieve a hydrogen pipeline network that will benefit all partners and the UK as a whole.

[22] https://www.northerngasnetworks.co.uk/wp-content/uploads/2017/04/H21-Executive-Summary-Interactive-PDF-July-2016-V2.pdf

6 Hydrogen demand

In this section we summarise the needs case that has been previously presented in our joint engagement sessions and detailed in the ECH_2 delivery plan. Within this document we focus more closely on the needs case related to the NGN area.

While there are multiple routes to decarbonisation in different sectors of the economy, the availability of low-carbon hydrogen is essential for hard-to-abate industrial, power, and large commercial operations.

Reasons why industrial and commercial entities will take up low-carbon hydrogen as a decarbonisation medium include:

- **Technical feasibility of available alternatives** such as space constraints, technology maturity, readiness, and scalability (which often vary on a specific site level basis).
- **Industrial dependency on natural gas as a feedstock** or for high-temperature thermal processes makes it hard to abate.
- **Cost-effectiveness of using alternative fuels** or capital investment cycles to refit/convert industrial equipment.
- **Lack of electricity capacity** to electrify industrial processes.

6.1 Determining the potential hydrogen demand in NGN's region

To calculate the potential hydrogen demand, NGN set out to determine the following through the Pre-FEED:

- What proportion of industrial and large commercial gas users within the network need hydrogen to decarbonise their industrial processes?
- What would the uptake of low-carbon hydrogen be over time for these users?
- What is the demand profile for hydrogen uptake and natural gas decline for 2028, 2032 and 2037, assuming a hydrogen pipeline is available?

Gas usage trends were plotted to determine the number of users connected to NGN's network likely to use hydrogen to decarbonise. This trend for the top 1000 users can be seen in Figure 7.

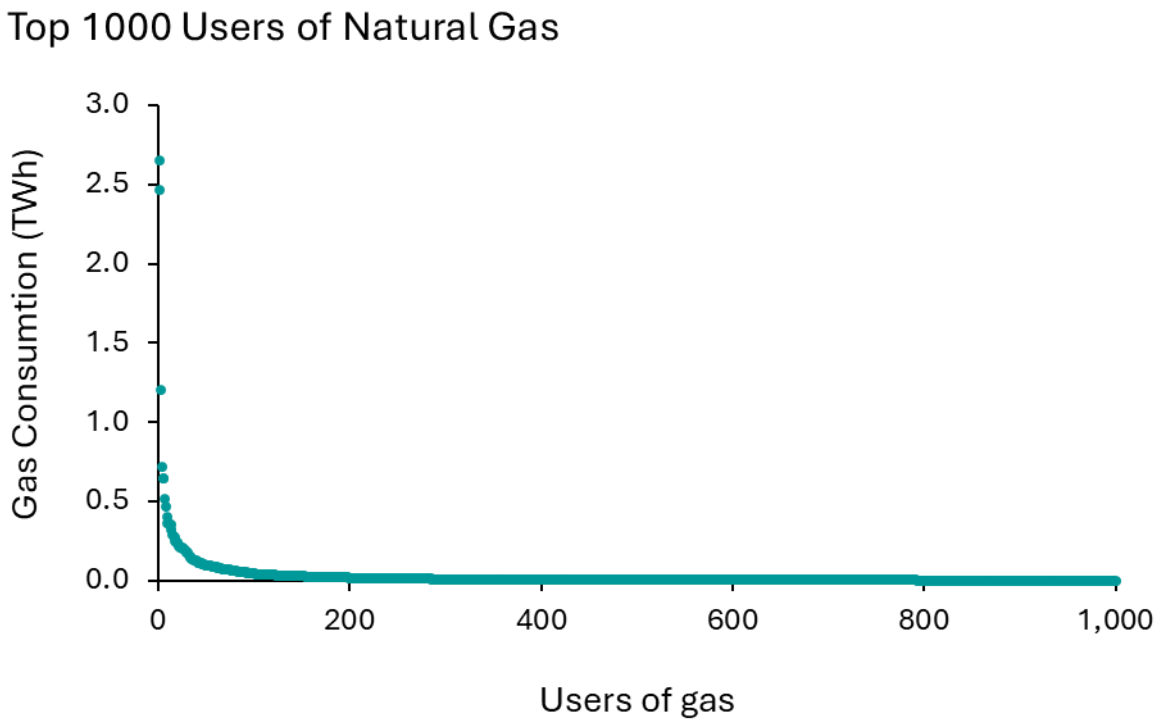


Figure 7. Top 1000 users of gas in NGN's network.

Figure 8 demonstrates that the top 250 users account for the majority of consumption on the NGN network, and they are most likely to rely on low-carbon hydrogen for decarbonisation.

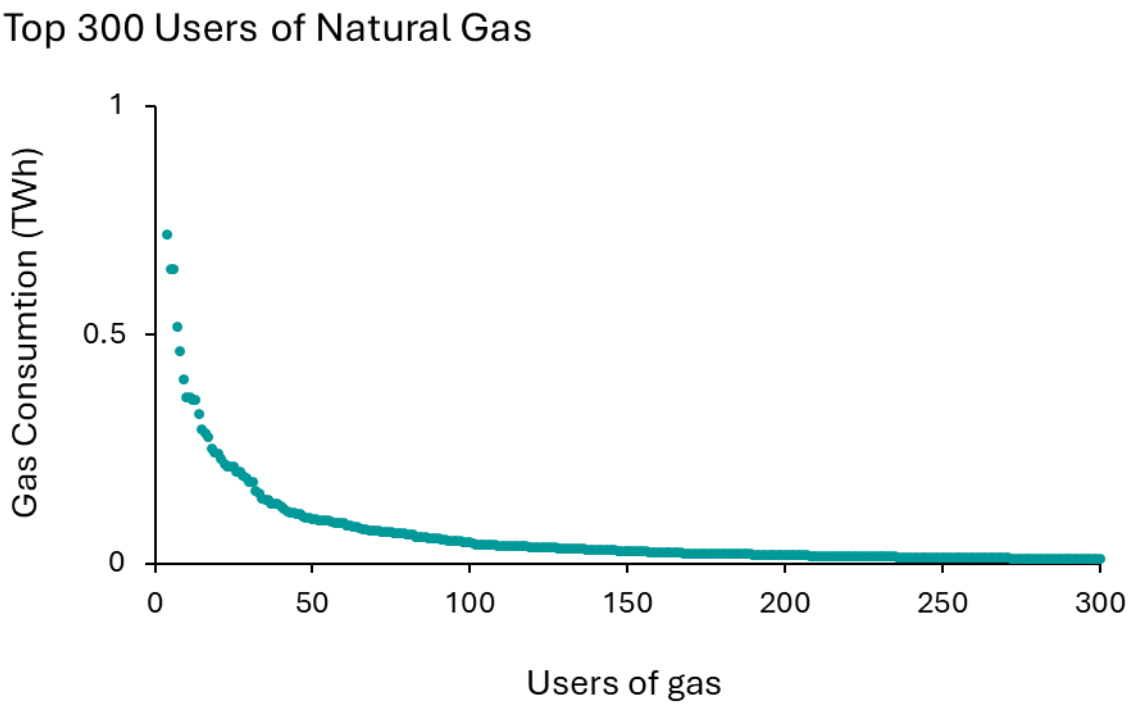


Figure 8. Top 300 users of gas in NGN's network.

To determine the potential reliance of these top 250 users on hydrogen, today's availability and cost of technology were modelled, along with:

- Sector decarbonisation commitments from industry associations or government reports.

- Industrial dependency on natural gas, e.g., feasibility and cost-effectiveness of implementing alternative technology.
- Users' strategic priorities for decarbonising, collected through primary data from the top 250 gas users and secondary resources.

A detailed account of how this information was used to create demand profiles for 2028, 2032 and 2037 can be found in Appendix A1 – Demand Study Report.

6.2 Data gathering

To determine the viability of fuel switching and understand the appetite for hydrogen from the top 250 users, detailed engagement with these users took place over 18 months. As part of this engagement the following stakeholder plan was followed:

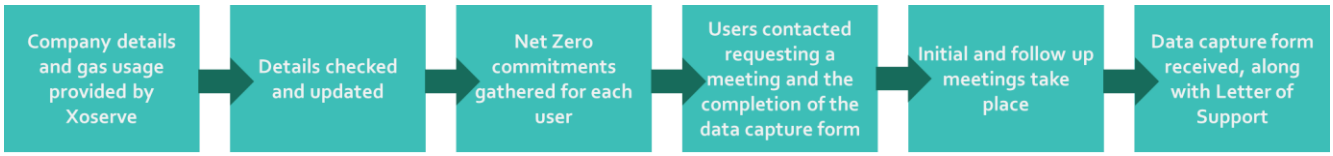


Figure 9. Data gathering process carried out with each of the Top 250 users of gas in NGN's network.

6.2.1 Collating company details and gas usage

The site addresses were requested from Xoserve for each user, along with the Annual Quantity (AQ), which signifies the actual annual consumption from a user in the previous year. These were matched to internal NGN records on contact details for each site.

6.2.2 Corroboration and update of details

In some cases, where sites had, for example, closed or companies changed ownership in recent years, the details were updated, and the correct contact sought.

6.2.3 Gathering of net zero commitments and categorisation

Net zero plans for each of the users were then collated to inform and modify the potential usage profile generated during the Pre-FEED stage.

Furthermore, each user was categorised into industry classifications they and N-ZIP (Net Zero Industry Pathway) categories, enabling usage to inform the cost-benefit analysis. All this data was collated in a tracker. An excerpt of this tracker can be found in Appendix A2 – Top 250 Tracker.

6.2.4 Contacting users

Using the details provided by Xoserve or researched by the team, the users were contacted by phone or email and an introductory meeting was requested, along with the completion of a data capture form. A template of the email used to contact users of gas can be found in Appendix A30 – Template Stakeholder Contact Email.

The data capture form was designed to allow users to record data on expected natural gas and hydrogen usage up to 2035. This was completed to question and inform the assumptions made when modelling the demand between natural gas and hydrogen over the next ten years. Data capture forms completed by three of our users, [redacted] can be found in Appendix A28 – Demand Capture Forms.

6.2.5 Initial and follow up meetings

These introductory meetings aimed to:

- Introduce ECH_2 and explain its aims along with the network routing for each of the phases and the timelines to achieve these.
- Discuss the users net zero plan and their timelines.
- Understand what the natural gas is currently being used for, i.e., a CHP plant, and how their natural gas usage may change over the next five years.
- Understand if they had started considering fuel switching to hydrogen and if they had started engaging with their equipment manufacturers.
- Understand if they would be interested in connecting to the ECH_2 network and by when.

Follow-up meetings were then scheduled on an ad-hoc basis to answer questions or provide updates.

Meeting minutes for all these meetings were then collated in a business development tracker and used to inform the design of the network. The business development tracker can be found in Appendix A3 – Business Development Tracker.

6.2.6 Collation of data and letters of support

Follow-up emails were then sent to request the completion of the data capture forms, letters of support, Non-Disclosure Agreements (NDA) and consortium membership where appropriate.

The letters of support from our users have been collated and can be found in Appendix A27 – Letters of Support.

6.3 Stakeholder engagement findings

As part of the engagement process, NGN held meetings with 111 I&C and Power users to discuss their Net Zero plans, of which **95% have stated they want to use hydrogen**. In the NGN area, 94 have become ECH_2 consortium members and 37 have provided detailed data on their forecasted natural gas and hydrogen usage.

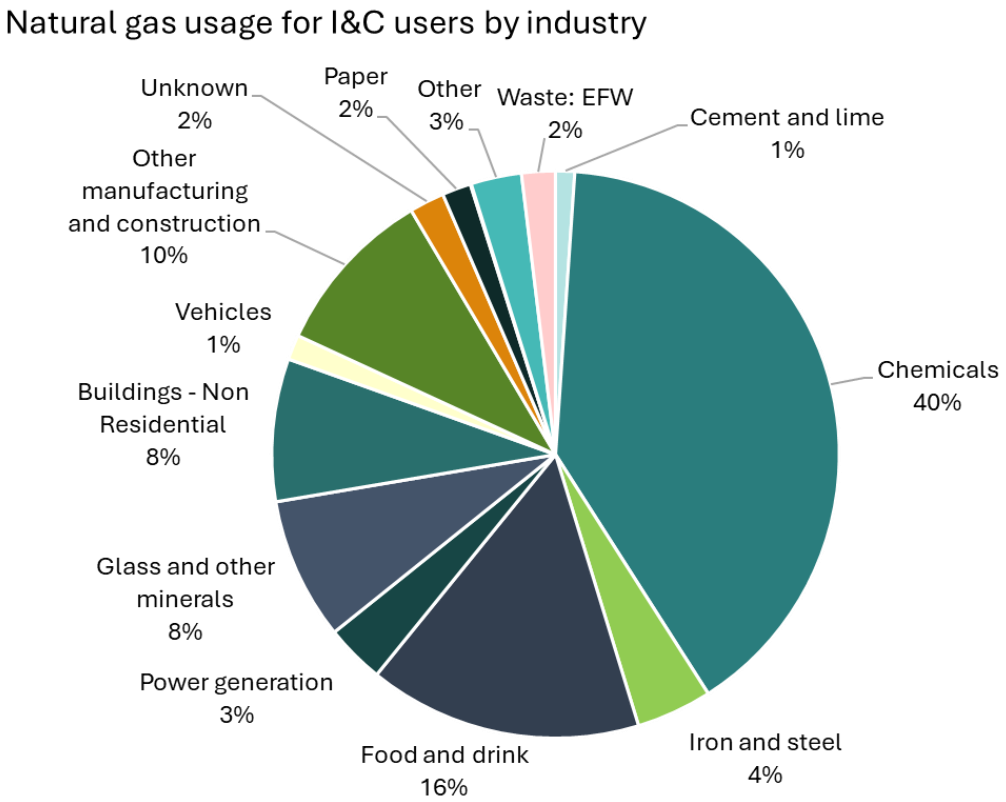


Figure 10. Natural Gas consumption of the Top 250 users of gas per industry.

From these top 250 users, the most significant consumption by far is from the Chemicals sector (40%), followed by food and drink (16%), construction materials (10%) and glass manufacturing (8%). All these sectors have been identified as prime examples of industries that can only, or more easily decarbonise through fuel switching to hydrogen, either due to the technical feasibilities of alternatives, industrial dependency on natural gas as a feedstock, the cost-effectiveness of alternative fuels or the lack of a grid connection.

The demand and commitment to fuel switching from these gas users can be seen in the letters of support provided by the users.

*Of the 111 users NGN met with, **30 provided letters of support**.*

These have been collated and included in Appendix A14 – Letters of Support.

As part of the engagement with all stakeholders, **94 have now become consortium members**. A summary of these can be seen below. The consortium group is central to the delivery of ECH_2. It allows the programme to be tailored to the needs of the region's energy users.

Figure 11. Consortium members.

6.4 Modelled hydrogen and natural gas demand

Modelling from the Pre-FEED stage shows a demand of hydrogen in NGN's region (NGN and National Gas network demand) of 5 TWh of low-carbon hydrogen by 2028, exponentially growing to 42.7 TWh by 2037, of which, NGN's ECH_2 network would connect 10 TWh by 2037. This would equate to **1.9 Mt/CO2** emissions being avoided a year by 2037 through fuel switching in NGN's network alone.

*This is the equivalent of **CO_2 avoided** by decarbonising all the homes in the cities of **Manchester, Sheffield and Leeds**.*

All these figures exclude any potential demand for hydrogen from aviation fuel, road transport, domestic heating, and additional direct production connections.

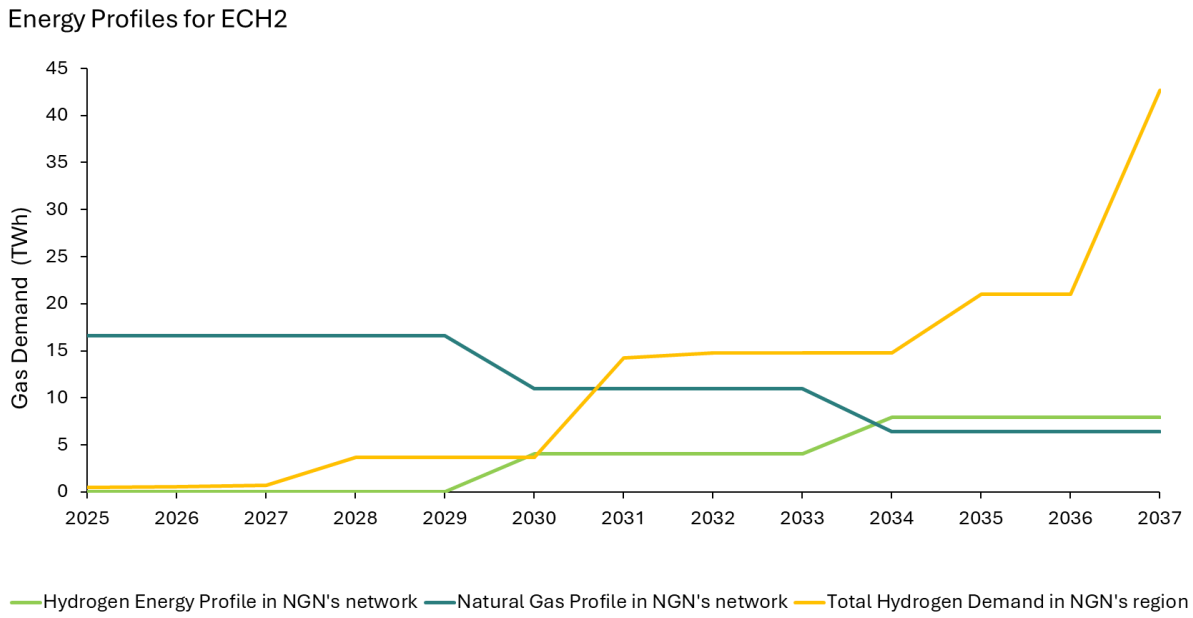


Figure 122. Change in natural gas and hydrogen in NGN's network and region.

Uptake in glass production, power generation and food and drink industries provide the bulk of the demand in the early phases, whilst uptake in the harder to convert sectors, such as chemical production, can be seen to increase in the later phases.

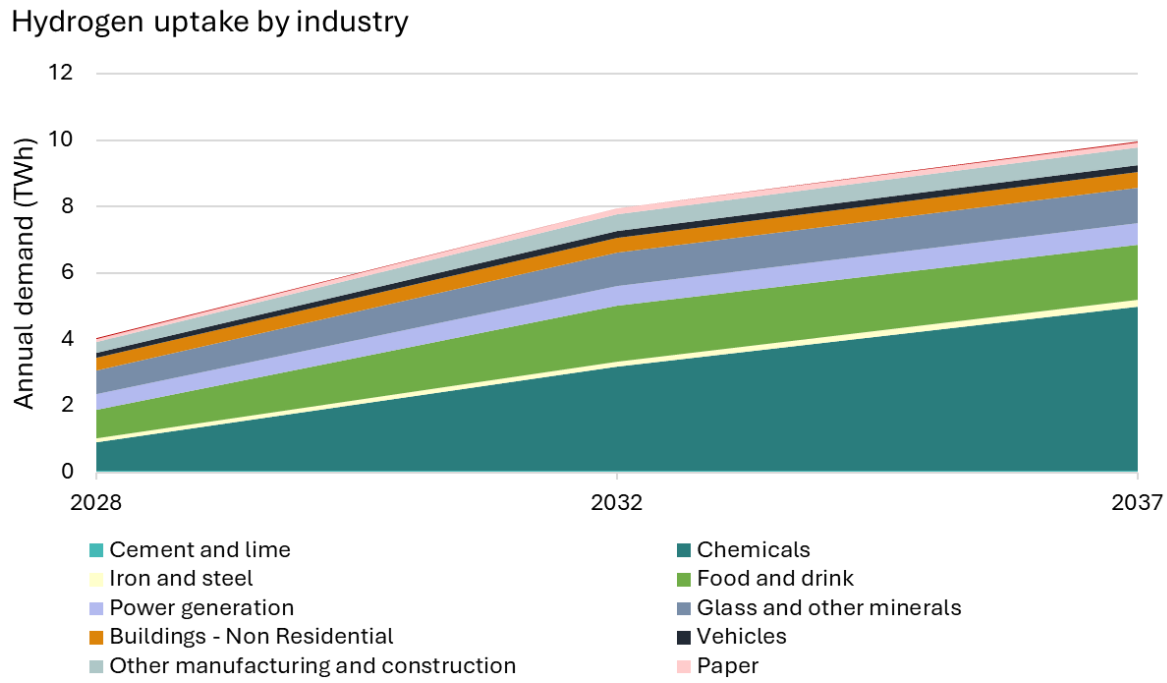


Figure 13. Uptake of hydrogen per industry.

Looking at the spread of this demand over the NGN region, critical centres of natural gas consumption are present in the hydrogen production clusters, such as the Humber (22%) and Teesside (16%). However, significant demand for hydrogen is geographically dispersed throughout the region in North Yorkshire (10%), West Yorkshire (34%), Tyneside (10%) and Cumbria (8%).

While pipeline infrastructure is required to connect assets within clusters, networks are crucial in transporting hydrogen from the clusters to the gas users in the broader region and allowing them to decarbonise.

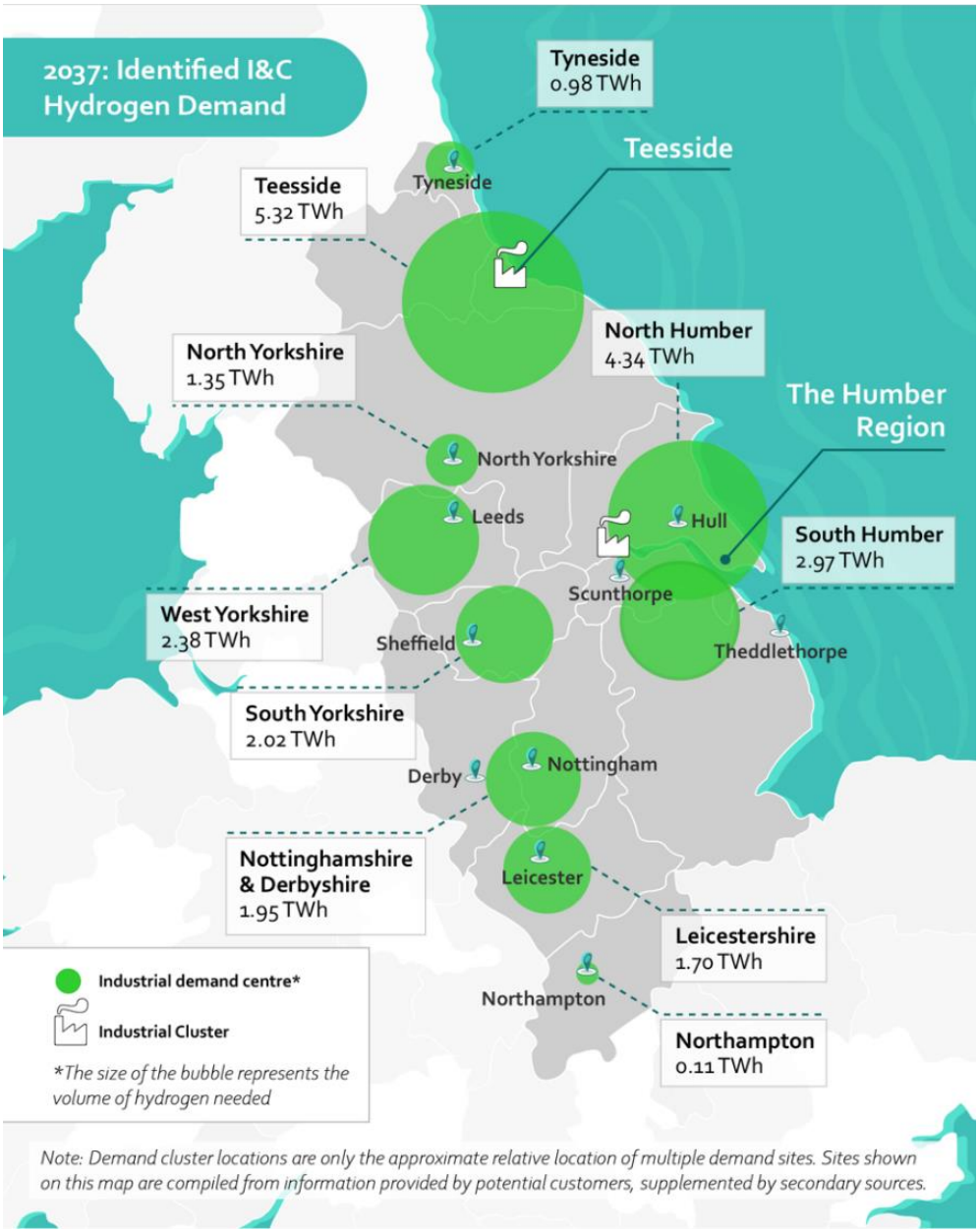


Figure 14. Hydrogen demand clusters in the ECH$_2$ region.

Details on the modelled hydrogen demand and how it was calculated can be found in Appendix A1 – Demand Study Report.

6.5 Case studies

To demonstrate the varied requirement for hydrogen in NGN's region the commitment of users to switch fuels, the following case studies have been provided by each of the below companies.

6.5.1 Syngenta

Syngenta is one of the [redacted] of gas on the network, consuming upwards of [redacted] a year. As can be seen in the map below, their site is in Huddersfield. The ECH$_2$ network would be the only practical solution to providing them with the large quantities of hydrogen they would require to decarbonise their operations.

Current Gas Usage: [redacted]

Syngenta is a global, science-based, ag-tech company, leading innovation in crop protection and seeds to benefit growers worldwide. The Group has global sales of £33.4bn (2022). The Huddersfield site is one of seven active ingredient manufacturing sites in Syngenta. The site is one of the largest within the company, with over 250 acres, and is landlord to other international companies (Arxada & Lubrizol). The site is seen as strategic and has opportunities to grow operations as Syngenta seeks to bring its innovation pipeline to fruition and invest in new technology.

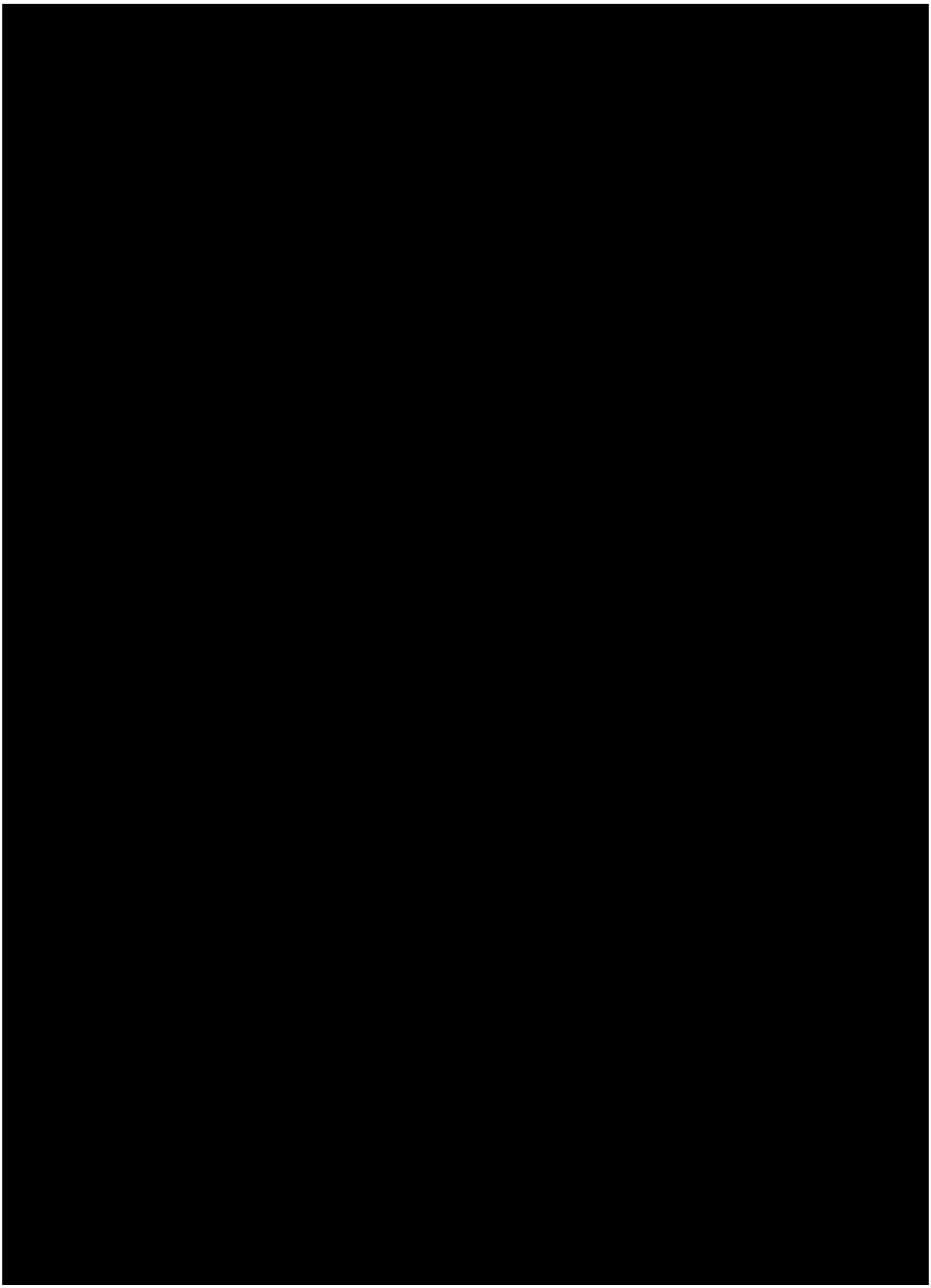
The Good Growth Plan is our commitment to help farmers meet the challenge of sustainably feeding a fast-growing world population. It is central to our strategy to ensure the Syngenta business has a sustainable long-term future. Within the plan, there is a desire to reduce the carbon intensity of our operations by 50% by 2030.

The site is one of the largest within Syngenta and is powered by a natural gas combined heat and power plant. Given the size of the site, we contribute significantly to scope 1 emissions, and we are committed to reducing them by implementing and constantly developing our sustainability roadmap to achieve our 2030 sustainability targets. We have a programme of ongoing carbon reduction projects, but these projects will not be quick fixes and will take time to evaluate and implement. They are very complex and involve everything from improving our infrastructure to changing the process chemistry of making active ingredients. Moving away from burning fossil fuels to new forms of energy and related technology is going to be essential to achieving our goals.

"Hydrogen provides a breakthrough technology, and we are very excited about the East Coast Hydrogen project as this creates the conditions for our operations to access low or zero-carbon energy (electrical and thermal).

The East Coast Hydrogen project will enable Syngenta to support farmers in producing healthy nutritious food and help lead the transition into more sustainable manufacturing in support of agriculture".

[redacted] **Strategic Projects Manager at Syngenta.**



6.5.3 Inspired Pet Nutrition

Inspired Pet Nutrition are one of the companies on our network that lie at the end of a new spur in the Topcliffe area of North Yorkshire.

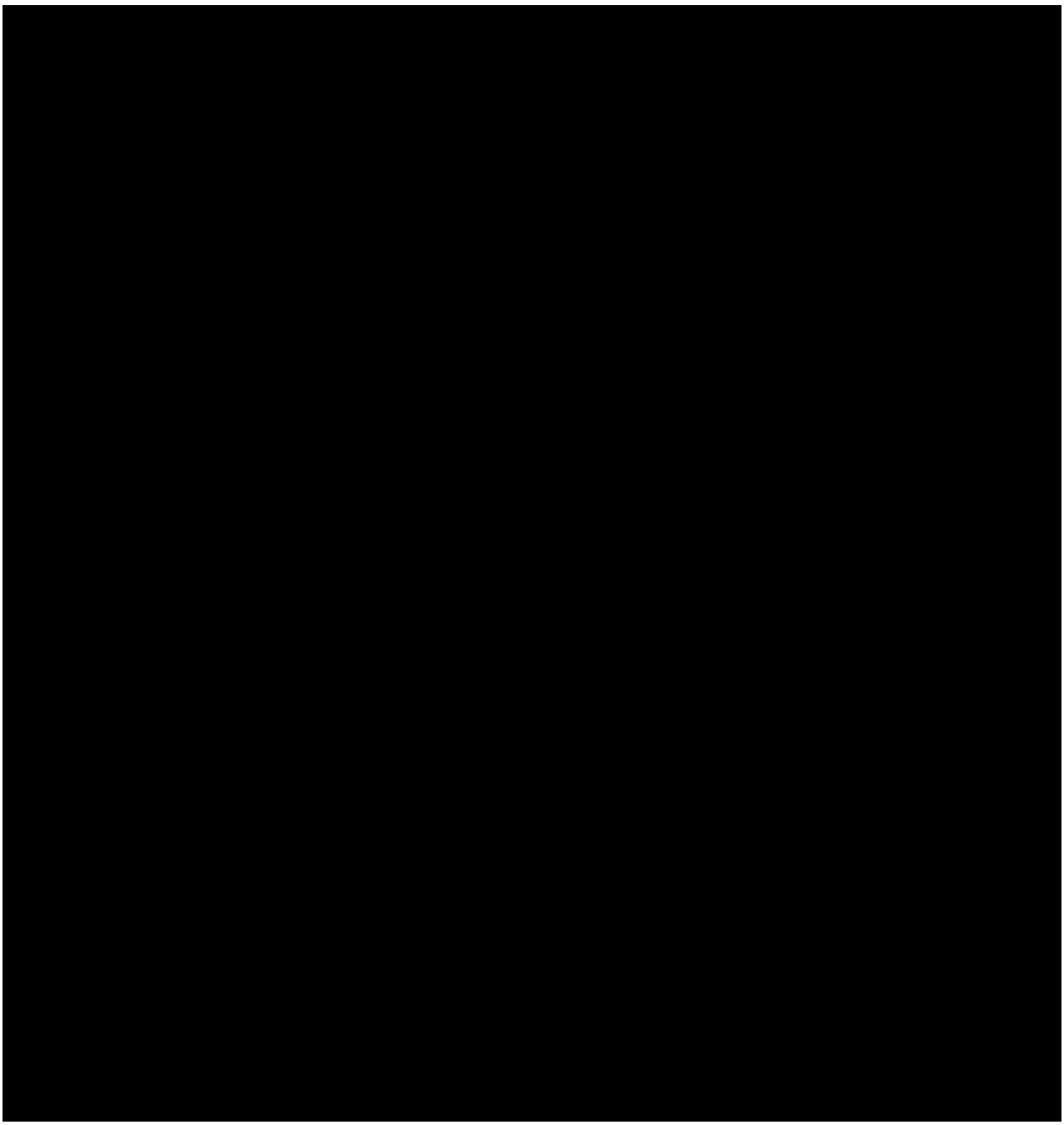
Current Gas Usage: [redacted]

Inspired Pet Nutrition is the largest dry pet food manufacturer in the UK and the first major pet food manufacturer to be certified carbon negative. We continue to focus hard on reducing our overall carbon footprint and hydrogen use forms a large part of that strategy.

We currently use the gas supply to gently cook our products in the ovens and dryers, which have been developed to accept a hydrogen supply when available. We also plan on upgrading our 1.1MW combined heat and power plant to be hydrogen-ready, to make up the shortfall from the green electricity supply to the site.

"Our electricity is already secured from renewable resources, but the lack of a green gas solution is very frustrating for us. Being able to make the switch to hydrogen is a huge step forward for us in reducing our environmental impact even further".

[redacted] **Head of Technical and Engineering at Inspired Pet Nutrition.**



6.5.5 Quorn

Quorn have two sites near Middlesborough. The Belasis site has been identified by Quorn as one of their sites where hydrogen would be better suited to decarbonise their combined heat and power plant and boilers.

Quorn™

Current Gas Usage: [redacted]

Quorn Foods is the number one meat alternative producer in the UK, with headquarters in Stokesley, North Yorkshire and a fermentation plant within the Teesside industrial cluster. With over 40 years of history, we have led the way in encouraging people to more healthy and sustainable diets.

We aim to both achieve Net Zero and reduce scope three emissions by 30% by 2030. In our Belasis site we have a combined heat and power plant, which uses 70% of our gas intake. We also have gas boilers that provide steam for our steamers to cook food and hot water for clean downs. We are very keen to pursue any avenue that will help us towards our Net Zero by 2030 goal. The retailers we sell to are very invested in decarbonising their supply chains and so reducing our emissions will help with competitive advantage in this area.

"Quorn Foods are keen to decarbonise our processes in line with our net zero ambitions. We are supportive of expanding the pipeline infrastructure to potentially benefit not only ourselves but other users in the area, for the good of all of us". [redacted] **Group Electrical Engineer at Quorn.**

7 Low carbon hydrogen production

7.1 Determining the amount of hydrogen produced in NGN's region

To determine the amount of hydrogen production in NGN's area, ECH_2 collected primary and secondary quantitative and qualitative data from all announced production projects in the region. Throughout the Pre-FEED process, NGN has engaged regularly with all producers to ensure that the latest information on production capacity is available and to align and connect the network to these producers. Twenty-three hydrogen producers in the ECH_2 region are consortium members and have committed to exploring opportunities with NGN. Many have indicated they would depend on connecting into a network to provide flexibility and resilience of supply to their customers. These include, [redacted] to name a few.

All identified projects have been broken down into phases, where applicable, to enable a more granular forecast of potential hydrogen production to be developed and informed by regular updates from the producers. Forecasts have been considered in the greater context of the UK government's targets to produce 10GW of low-carbon hydrogen by 2030. A detailed account of how production in the region was modelled can be found in Appendix A12 – Production Study Report.

7.2 Modelling hydrogen production

ECH_2 has the potential to connect over 8GW of hydrogen production by 2030. This means NGN's area alone could significantly contribute to the 10GW hydrogen production target set out by the UK Government.

There are two major production hubs within NGN's region (Teesside and the Humber), adding up to 8.27 GW of announced hydrogen capacity by 2037.

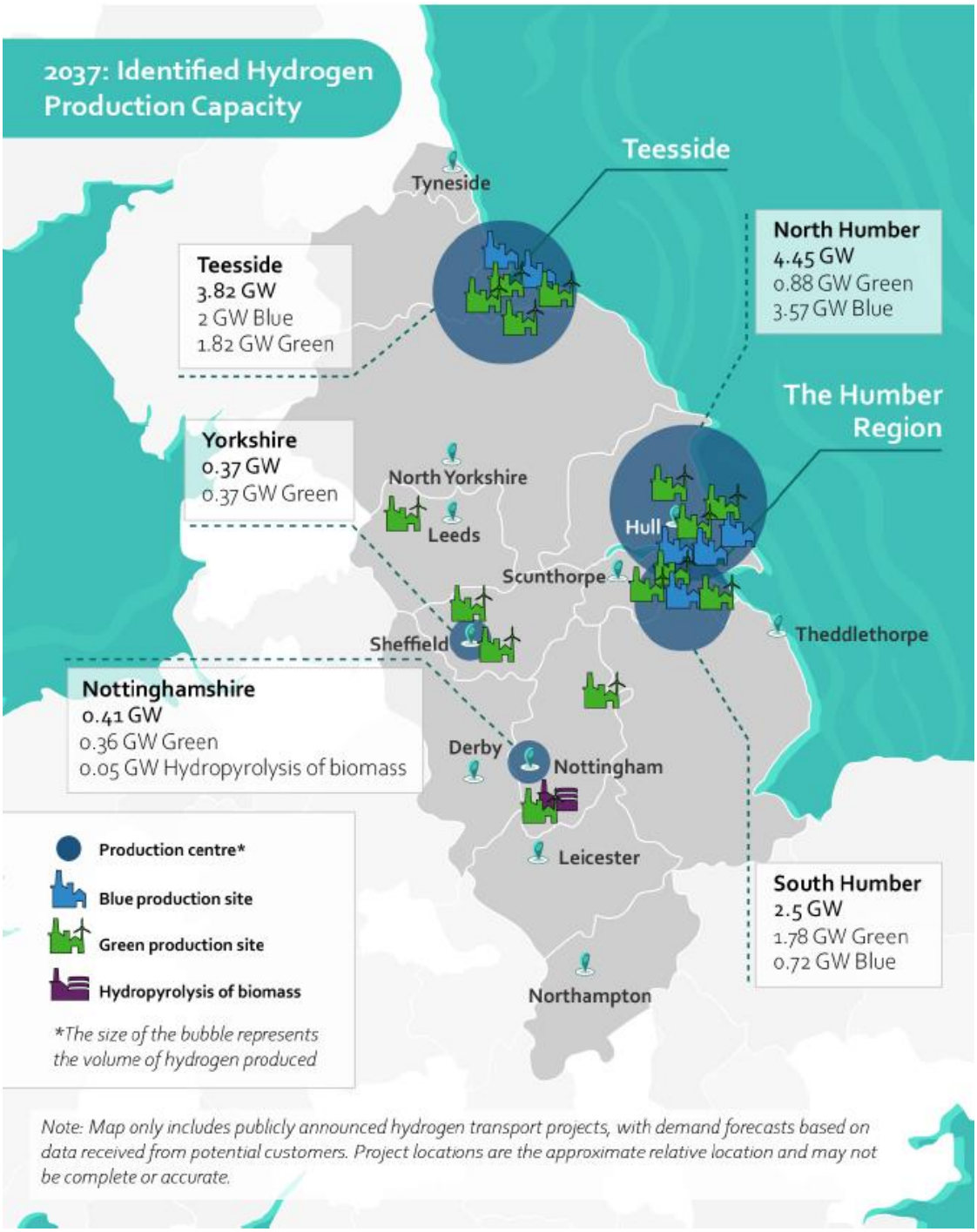


Figure 15. Identified hydrogen production hubs in the ECH_2 region.

Furthermore, as shown in the graph below, there is more than sufficient announced low carbon hydrogen production to satisfy the area's industrial and large commercial hydrogen demand, unlocking the route for many high CO2 emitters to decarbonise before 2037, even if we assume no further hydrogen production becomes online past 2032. This is even the case when considering further I&C demand identified in the whole ECH_2 NGN region.

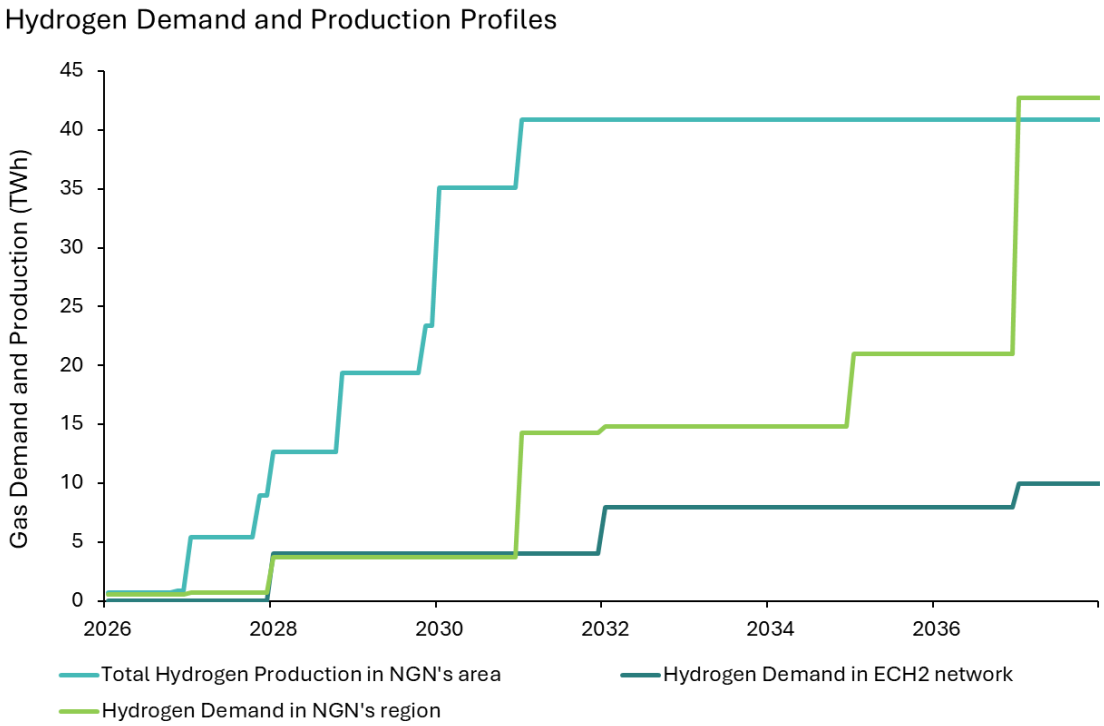


Figure 16. Hydrogen production and demand in NGN's region from 2025 to 2035

By providing further routes for low-carbon hydrogen producers to connect and deliver hydrogen to additional customers, ECH_2 can enable the early development of hydrogen transport and storage infrastructure, thereby consolidating and aggregating demand and accelerating the development of the hydrogen economy.

7.3 Case studies

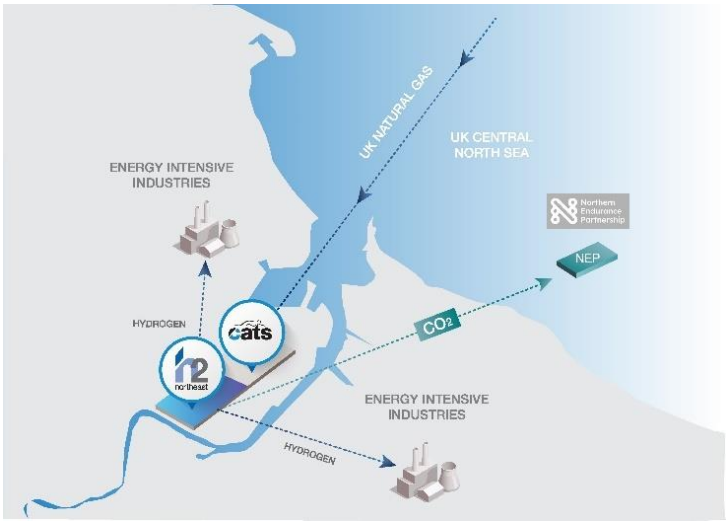
The following companies have provided case studies to showcase how ECH$_2$ would support their blue and green hydrogen projects.

7.3.1 Kellas Midstream - H2NorthEast

Project: H2NorthEast (Blue Hydrogen)

H2NorthEast is committed to bringing new low carbon hydrogen production projects to Teesside that will support industry decarbonisation in the region. Nearly half of all carbon emissions from UK industrial cluster CO2 emissions come from Teesside and the Humber, and Teesside aims to become one of the world's first decarbonised industrial clusters, helping to accelerate the UK's overarching 2050 net zero goal.

H2NorthEast



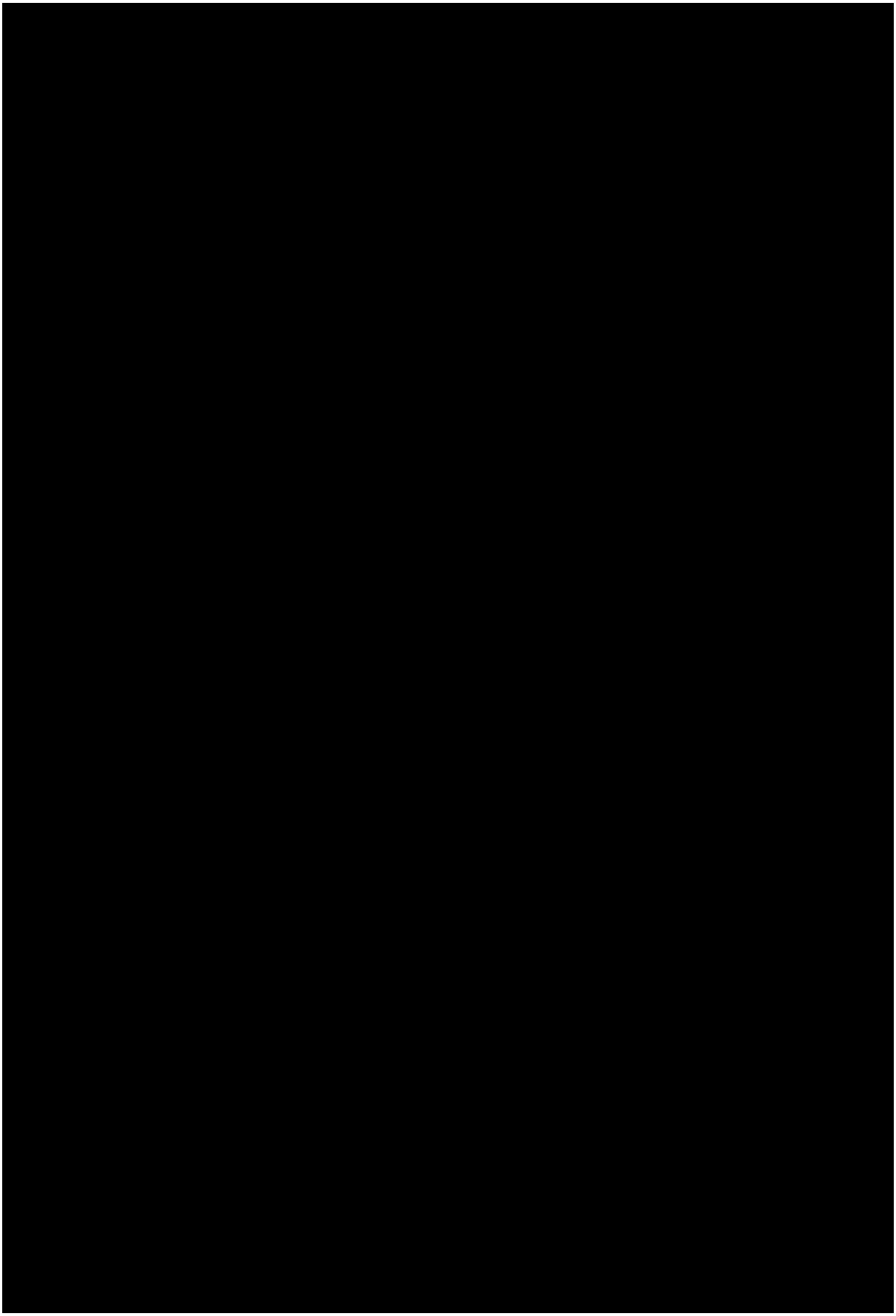
H2NorthEast is a major project that will deliver over **1 GW** of low carbon hydrogen to industrial users across Teesside. A partnership between Kellas Midstream and SSE Thermal, the project has the potential to contribute as much as 10% of the government's ambition for 10GW of low carbon hydrogen production, supporting the UK to become a global leader in the production and use of low carbon hydrogen and a net zero nation by 2050.

Teesside is the perfect location for the H2NorthEast project. Together with the Humber region, it represents one of the highest carbon-emitting industrial clusters. H2NorthEast will be located close to industry that needs to decarbonise and close to developing hydrogen infrastructure.

H2NorthEast will boost the local economy by bringing high-quality jobs to the region, creating opportunities for skills development, supporting the local supply chain and developing the next generation of engineers, safeguarding existing industry and attracting inward investment to the region.

By utilising synergies with Kellas' existing Central Area Transmission System (CATS) gas transportation and processing terminal and connection to the Northern Endurance Partnership CO_2 pipeline and store, H2NorthEast will deliver hydrogen at lower cost, cutting emissions whilst also promoting regional growth – contributing an additional £200-300m to the local economy and creating hundreds of new jobs. **The ability to connect across the East Coast would enable H2NorthEast to expand those benefits outside of Teesside and further support UK industrial decarbonisation.**

"The East Coast Hydrogen network would enable H2NorthEast to provide low carbon hydrogen to customers outside the Teesside area, helping them to decarbonise and minimise infrastructure cost".
[redacted] **CEO – Kellas Midstream.**



7.3.3 Meld Energy – Saltend Chemicals Park Green Hydrogen

meld.energy

Project: Saltend Chemicals Park (Green Hydrogen)

Meld Energy is a UK-based green hydrogen developer with international backing from World Kinect Sustainability Ventures. The partnership between Meld and WKC demonstrates both the commitment and assurance of the commercial credibility and market access to attract the investment suppliers, and partners necessary to delivery electrolytic hydrogen at scale in the UK. We have set ourselves the goal of producing at least 10% of the UK's green hydrogen and are determined to play a significant role in helping the UK reach Net Zero.

Our mission is to develop an international portfolio of green hydrogen production to supply low and zero carbon fuels for industry, road transport, shipping and aviation and our project in Saltend Chemicals Park is just the start of this.

Saltend Chemicals Park Green Hydrogen

Meld's flagship 100MW project located at Saltend Chemicals Park, Hull seeks to reduce carbon emissions at the park by 20% by replacing natural gas currently used on site with green hydrogen. Work on the facility is due to begin in 2026 with it becoming operational towards the close of 2028.

Why East Coast Hydrogen

Meld Energy, as a green hydrogen project developer, recognise the potential benefit from access to a hydrogen network in order for us to reach a wider number of off takers, maximising impact of a new green hydrogen production plant. In terms of CAPEX considerations, this limits our infrastructure investments. It also provides us with an opportunity to investigate the gas network as an off taker of last resort, allowing us to operate the electrolyser plant at higher utilisation rates which in turn promotes greater plant efficiency and allows us to optimise the electrolyser stacks use to manage degradation. In summary, there are a number of CAPEX and OPEX benefits.

"We support the development of hydrogen networks as a cost-effective way of delivering hydrogen to customers. We see the investment in hydrogen and hydrogen-ready infrastructure as essential to ensure industry can decarbonise in line with Government targets. We therefore support the progression of the ECH_2 programme".

[redacted] **Founder & CEO at Meld Energy.**

8 Hydrogen storage

Hydrogen storage is required in almost every independent third-party net zero scenario for the UK.

Hydrogen storage capacity will be necessary to:

- Balance the grid by storing excess electricity as hydrogen for later use in peak energy periods.
- Improve energy security through the ability to store energy as hydrogen at scale and across seasons.
- Support the development of an efficient tradable hydrogen market.
- Provide sufficient resilience to customers with multiple direct connections to give off-takers confidence in switching.

8.1 Determining the storage capacity in NGN's region

ECH_2 has collected primary quantitative and qualitative data from various announced storage projects. This includes offshore and onshore facilities, some of which have collocated low-carbon hydrogen production. These projects are at various stages of development and are looking to secure funding or obtain planning. Public data on these projects, as well as engagement with storage providers, was used to model the potential for hydrogen storage in NGN's region.

To demonstrate the resilience of the future hydrogen transmission and distribution system, an assessment of the potential storage capacity utilising linepack of the National Transmission System's (NTS) feeder pipeline, Feeder 7, for conversion into 100% hydrogen transmission was also carried out.

The detailed assessment carried out as part of the Pre-FEED can be found in Appendix A13 – Storage Study Report.

8.2 Modelling hydrogen storage

The east coast region is well placed geologically for hydrogen storage, with high availability of existing natural gas reservoirs and salt caverns.

As part of the Pre-FEED, it was found that there are plans for up to 0.7 TWh of announced salt cavern storage by 2037, with 3.3 TWh expected from Rough by 2030 and a further 10 TWh by 2050. ECH_2 will, therefore, be able to address and connect, up to 19% of the UK's 2050 storage requirements to regional producers and demand centres.

With the planned hydrogen storage being localised close to the coast on the Teesside and Humber clusters, the ECH_2 network is not only able to connect these two centres of storage to provide reliability of supply to the network, but it also allows potential users of gas located outside these clusters to benefit from the security of supply that hydrogen storage would provide.

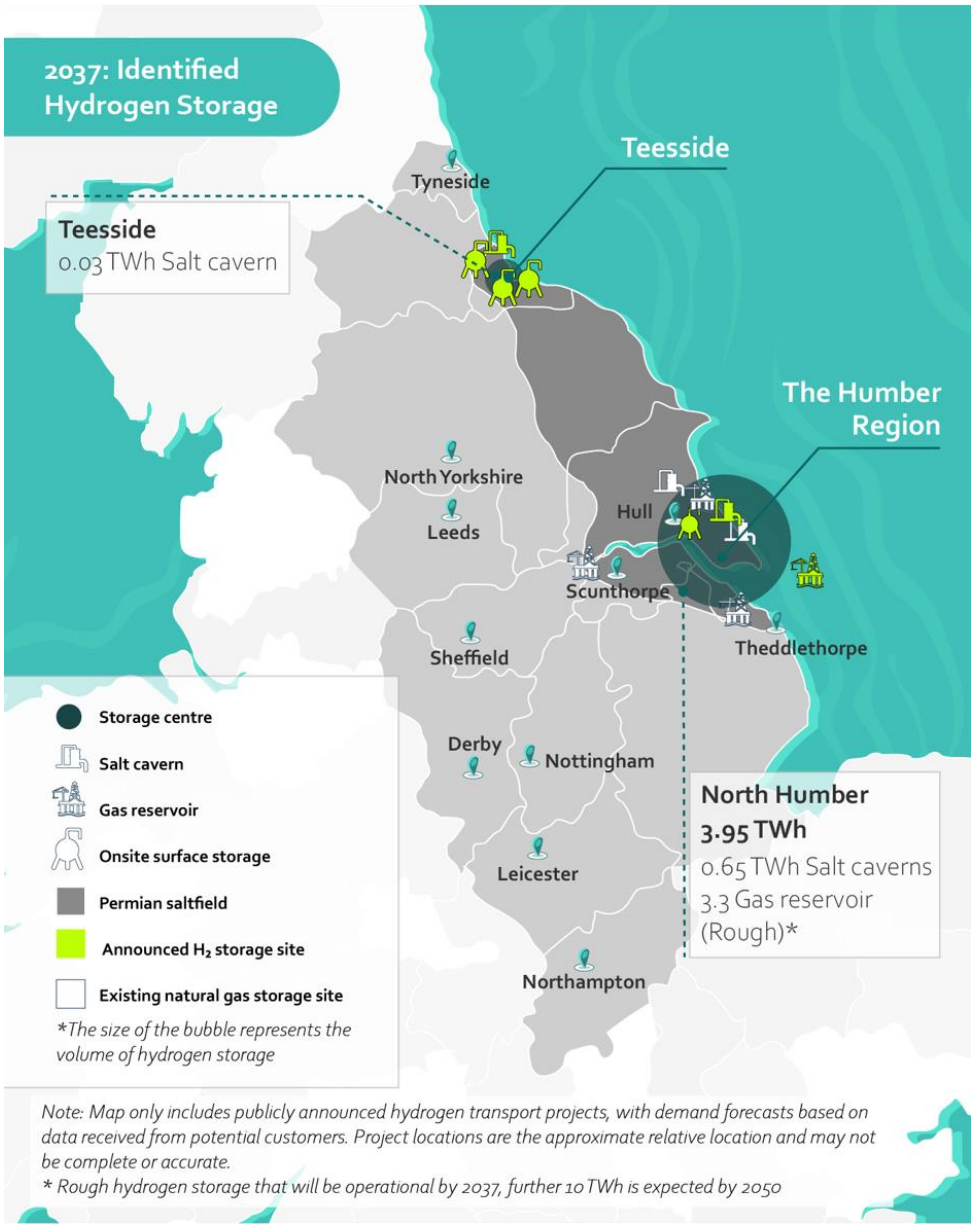


Figure 17. Identified hydrogen storage hubs in the ECH$_2$ region.

Furthermore, clarity on where hydrogen transport infrastructure will be available can give certainty to hydrogen storage providers to bring their storage sites online. The Industrial Decarbonisation Research and Innovation Centre (IDRIC), in conjunction with the British Geological Survey, were able to determine that in the east coast region there is a "resource potential" for hydrogen storage in salt caverns of between 22 TWh to 48 TWh[23]. These salt caverns are generally located in the coastal region between the Humber and Teesside due to the geological suitability of the area. The green boxes in the figure below represent feasible locations for new hydrogen salt cavern storage.

[23] Assessing the Regional Demand for Geological Hydrogen Storage. IDRIC. February 2024.

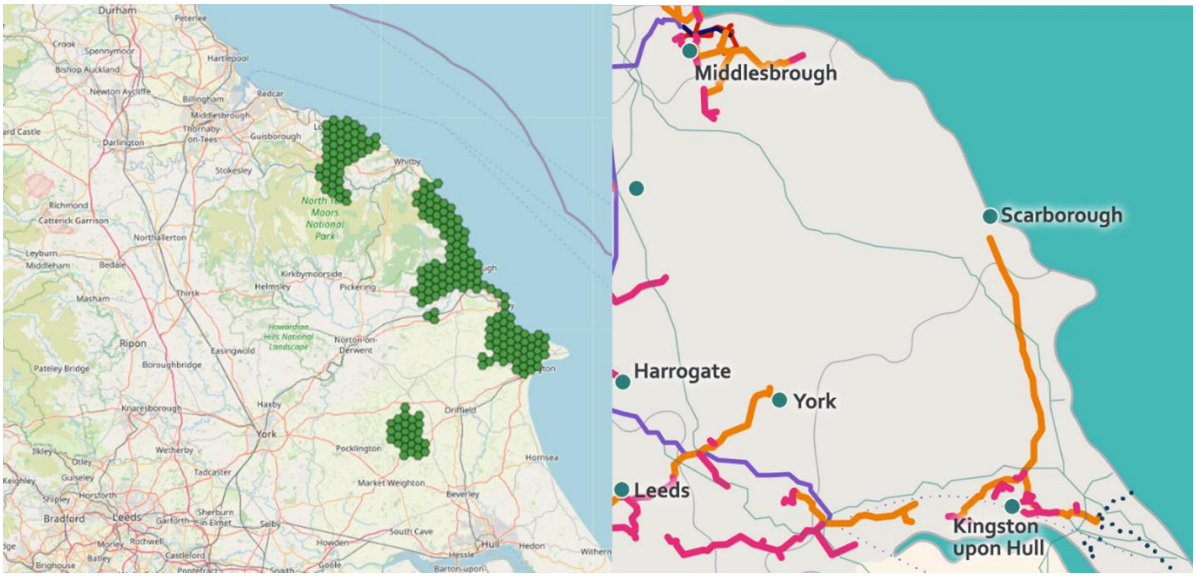


Figure 18 . Left: Map showing the location of feasible sites for geological hydrogen storage (Source: Assessing the Regional Demand for Geological Hydrogen Storage. IDRIC. February 2024.) Right: Map showing the Scarborough line designed to connect to hydrogen storage.

With this in mind, the ECH_2 network was developed to align with the location of future storage projects. An example of this is the repurposed East Riding line connecting to Scarborough (shown in Figure 18 above), designed to allow future regional storage projects developed in the area to connect to the ECH_2 network. Only 5-10% of 2035 storage demand in the east coast can be met by current planned projects[24]. Providing clarity and certainty on where transport infrastructure will be available can act as a key to unlocking future hydrogen storage projects.

The national and local transmission system pipelines have also been identified as critical for diurnal storage, as the need for storage will increase due to the volumetric energy content of hydrogen being about one third of that of natural gas. Based on the assessment carried out as part of the Pre-FEED, the linepack flexibility of feeder seven, will be able to provide in the range of 4 to 14 GWh of storage depending on initial system pressure and resultant linepack pressure. By acting as the backbone to the network, feeder seven will be critical in providing the storage required for within-day fluctuations in demand.

[24] Assessing the Regional Demand for Geological Hydrogen Storage. IDRIC. February 2024.

8.3 Case studies

The following case studies were provided by hydrogen storage providers for announced and unannounced hydrogen storage projects.

8.3.1 Centrica – Rough Gas Field

centrica
energy storage+

Project: Rough Gas Field

Centrica has a 200-year history in the energy industry alongside a long pedigree of acquiring, structuring, developing, and building assets across the energy value chain. In July 2023, Centrica committed publicly to a material investment programme of £600m-800m/year. These investments will help us pivot existing assets towards their decarbonisation journeys, give us exposure to new kinds of low carbon assets, and allow us to maintain balance in our portfolio. We believe that hydrogen will play a role in all three of these areas.

Rough Gas Field

Centrica Energy Storage + has owned and operated the Rough gas storage facility and gas processing infrastructure at the Easington Terminal since 2002. The asset has historically offered 150 billion cubic feet (bcf) of seasonal storage, approximately 75% of total UK gas storage volume. Centrica plans to redevelop the Rough Gas Field to provide a highly responsive, market-led methane gas storage solution with 120 billion cubic feet (Bcf) capacity, which could be operational by early 2028.

New facilities will be designed to be hydrogen-ready, capable of storing between 10-16TWh of hydrogen when the developing market requires large-scale hydrogen storage.
Centrica also has ambitions to develop complementary infrastructure around the existing Easington Terminal with the construction of large-scale green and blue hydrogen production, with the potential to deploy in other industrial clusters. Developing hydrogen production capability at Easington will enable Centrica to fuel switch to decarbonise site operations, equivalent to up to c.140,000 tonnes of CO_2 saving / year.

Why East Coast Hydrogen

Centrica Energy Storage is located in the key strategic location of Easington on the east Yorkshire coast. ECH2 benefits us by providing the critical transportation infrastructure required to enable large-scale hydrogen production to supply areas of demand. It will also ensure that hydrogen storage can be utilised to maximise the hydrogen production efficiency of producers and will ensure the security of supply for end-users with connection to large-scale hydrogen storage sites such as Rough.

Hydrogen will be a key energy vector to drive the decarbonisation of the Humber industrial cluster local to Centrica Energy Storage assets. ECH2 will then enable clusters to be connected, thus enabling the growth of the hydrogen economy beyond a regional and national level to support the UK's transition to Net Zero.

"Combined with an interconnected hydrogen backbone, large-scale hydrogen storage at Rough would provide levers to improve the efficiency of using renewable and hydrogen assets, whilst ensuring hydrogen can be used during periods where it is of greatest value. Transport infrastructure projects such as ECH_2 are essential to ensure the system maximises the benefits of low-cost hydrogen production and allows hydrogen to be produced where it is c

Energy Transition Interface Manager at Centrica Energy Storage+.

9 Local government and regional engagement

As part of the Pre-FEED stage, it was critical that the planned network aligned with net zero and decarbonisation plans being developed by local government. The below describes the engagement that has taken place and how ECH_2 aligns with local plans.

9.1 North-East & Yorkshire (NEY) Net Zero Hub

The Northeast and Yorkshire Net Zero Hub collaborate with six Combined Authorities and Local Enterprise Partnerships, accelerating the transition to 'Net Zero' and a clean growth future through local energy delivery.

It includes:

- Hull and East Yorkshire Local Enterprise Partnership
- West Yorkshire Combined Authority
- Tess Valley Combined Authority
- York and North Yorkshire Local Enterprise Partnership
- South Yorkshire Mayoral Combined Authority

As part of their decarbonisation strategy, ECH_2 has advised on the chosen routes for hydrogen transport to align with the hydrogen strategies in the hub areas that lie in NGN's area.

The Net Zero Hub is collectively reviewing its Hydrogen Strategy and has asked Arup to carry out a study on how hydrogen will play a role in the region. This study is expected to be published in Spring 2024, with the report indicating that ECH_2 will play a major role in growing the hydrogen economy in the regions that the network reaches and has become a core aspect of its strategy.

9.2 West Yorkshire Combined Authority (WYCA)

As part of its targets, WYCA has pledged to achieve net zero by 2038, with significant progress against this by 2030.

One of the ways to reach this goal is through hydrogen; as a result, WYCA has commissioned the creation of a hydrogen roadmap for the region.

ECH_2 joined a WYCA stakeholder workshop in January 2024 to share information on demand and production data gathered as part of ECH_2 with the purpose of informing their modelling methodology and application to the WYCA area. Further to this, ECH_2 has held regular meetings with [redacted] to provide data that may inform the WYCA's roadmap.

As part of the FEED study, NGN will engage further with WYCA to understand how ECH_2 can support the decarbonisation of the heat network planned for the centre of Leeds, reaching large consumers such as hospitals and universities.

9.3 Tees Valley Combined Authority (TVCA)

The TVCA is committed to becoming a significant player in the hydrogen sphere, with ambitious targets including:

1. Delivering the UK's first decarbonised heavy industrial cluster by 2040.
2. Delivering large-scale carbon capture, utilisation and storage and over 4GW of hydrogen production by 2030.
3. Creating a National Hydrogen Transport Hub, supporting the transition to zero-emission transport.
4. Supporting Teesside International Airport to be Net Zero in its operations by 2030 and supporting the development of Sustainable Aviation Fuels to pursue Net Zero flights by 2035 – making it the UK's first Net Zero Airport.

With so much hydrogen production centred around Teesside, ECH_2 has closely aligned with TVCA plans through regular engagement with [redacted] They have provided the following case study:

[redacted]

9.4 [redacted] - Humber hydrogen round table

On November 9, 2023, NGN hosted a Hydrogen Round Table for key stakeholders in the Humber to discuss the potential for industrial decarbonisation in the region and the steps needed to maximise the future benefits from a transition to hydrogen.

The attendees included hydrogen producers, such as [redacted], supported by local councillors and NGN's Energy Futures Director and ECH_2 Senior Project Manager.

As part of the roundtable, political attendees and their representatives were keen to demonstrate their support for the emerging hydrogen industry in the Humber and extended an offer to engage with businesses if they required help or faced specific challenges. Furthermore, industrial representatives agreed to collaborate more closely in the future, including how hydrogen production and usage development would align with ECH_2.

10 Wider benefits

10.1 Project Union enabler

National Gas' flagship conversion project, Project Union, aims to repurpose the transmission feeders that supply Local Distribution Zones (LDZs) from natural gas to hydrogen. Within NGN's region, Feeder seven will be the first transmission pipeline to be repurposed. For this to happen, NGN must modify the existing Off-Takes and AGIs that connect to Feeder seven. The first phase of ECH_2 will support this phase of Project Union and then connect the first spurs of NGN's hydrogen network to this feeder. ECH_2 is, therefore, a key enabler for Project Union.

10.2 Facilitating transport decarbonisation

Transport is the UK's largest carbon emitting sector, accounting for 27% of the UK's total Green House Gas (GHG) emissions. Transitioning away from fossil fuels would see a saving of between 1,300-1,800 $MtCO_2e$ between 2020 and 2050[25].

NGN's region is home to multiple pilots and research projects to demonstrate the potential of decarbonising transport, with the first multi-modal hydrogen transport hub and various announced Sustainable Aviation Fuel (SAF) production projects in Teesside.

10.2.1 Road transport and trains

NGN and Transport for the North (TfN) partnered with ERM as part of a Network Innovation Allowance (NIA) project to produce a dynamic tool that takes a cross-sectoral approach to visualise the potential for hydrogen refuelling in the Northern Powerhouse 11 regions. The Hydrogen Mobility Visualiser models the future hydrogen demand for heavy-duty transport and the gas network infrastructure. This focuses on heavy goods vehicles, buses, and trains, as these are the likely forms of transport that could transition to hydrogen. NGN provided the background data for the current gas infrastructure and the planned ECH_2 pipelines. TfN used their future demand predictions for heavy-duty transport hydrogen demand alongside the anticipated adoption periods. The visualiser is intended to help build partnerships between potential hydrogen users within the transport sector in the North of England and relate those local potential demand clusters to strategic infrastructure.

The yellow circles on the map below, taken from the tool created by this project, identify the approximate areas and volumes with realistic potential for hydrogen refuelling in NGN's region. Focusing specifically on this region, the period for Phase three and Phase five of ECH_2 (2030 – 2035) and assuming a certainty minimum of 50%, it can be seen below that there will be a transport demand of 6143 kg/day of hydrogen, the equivalent to 205 MWh.

[25] Hydrogen Transportation and Storage Infrastructure Assessment of Requirements up to 2035. HMG.2022.

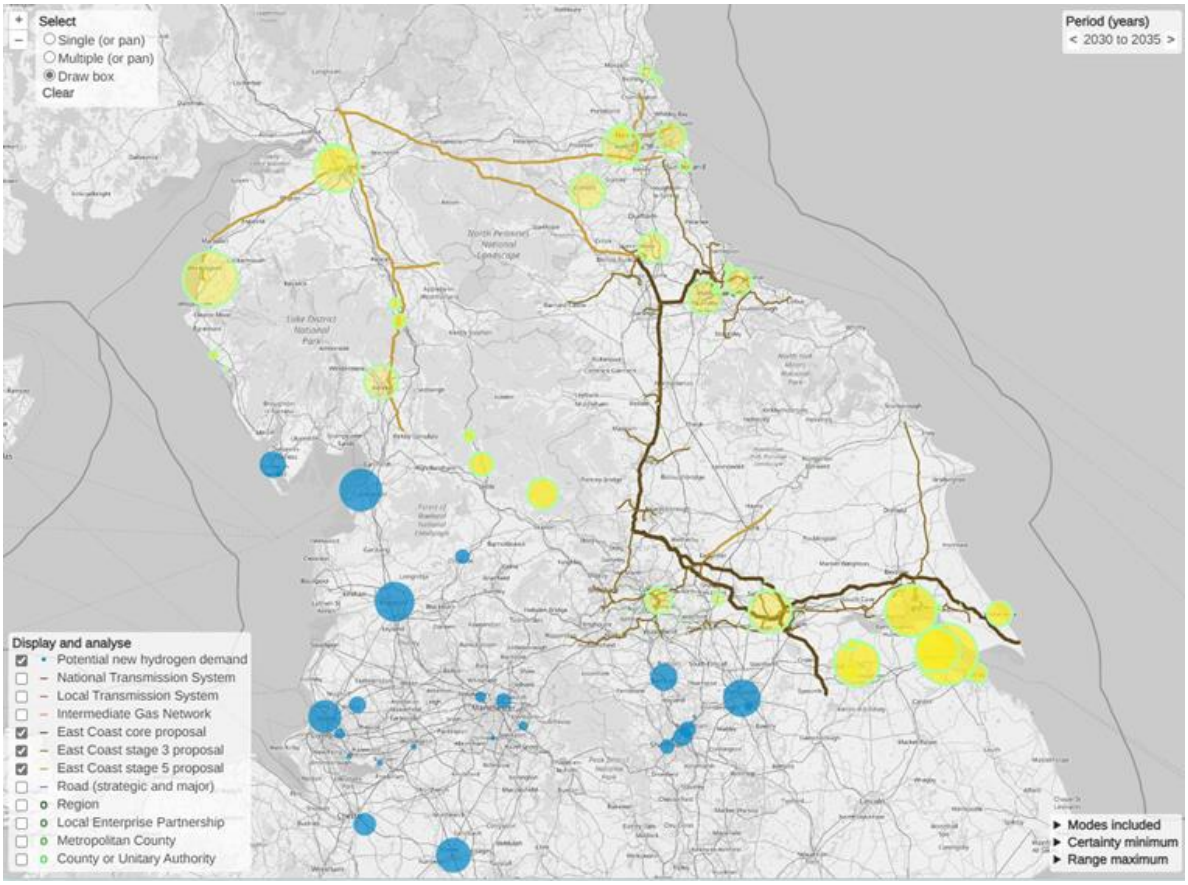


Figure 19. Hydrogen for transport demand map for the period 2030-2035. The yellow circles on the map identify the approximate areas and volumes with realistic potential for hydrogen refuelling in NGN's region

This demand rises to 21,260 kg/day (708 MWh) by 2050. This growth is visible in the map below.

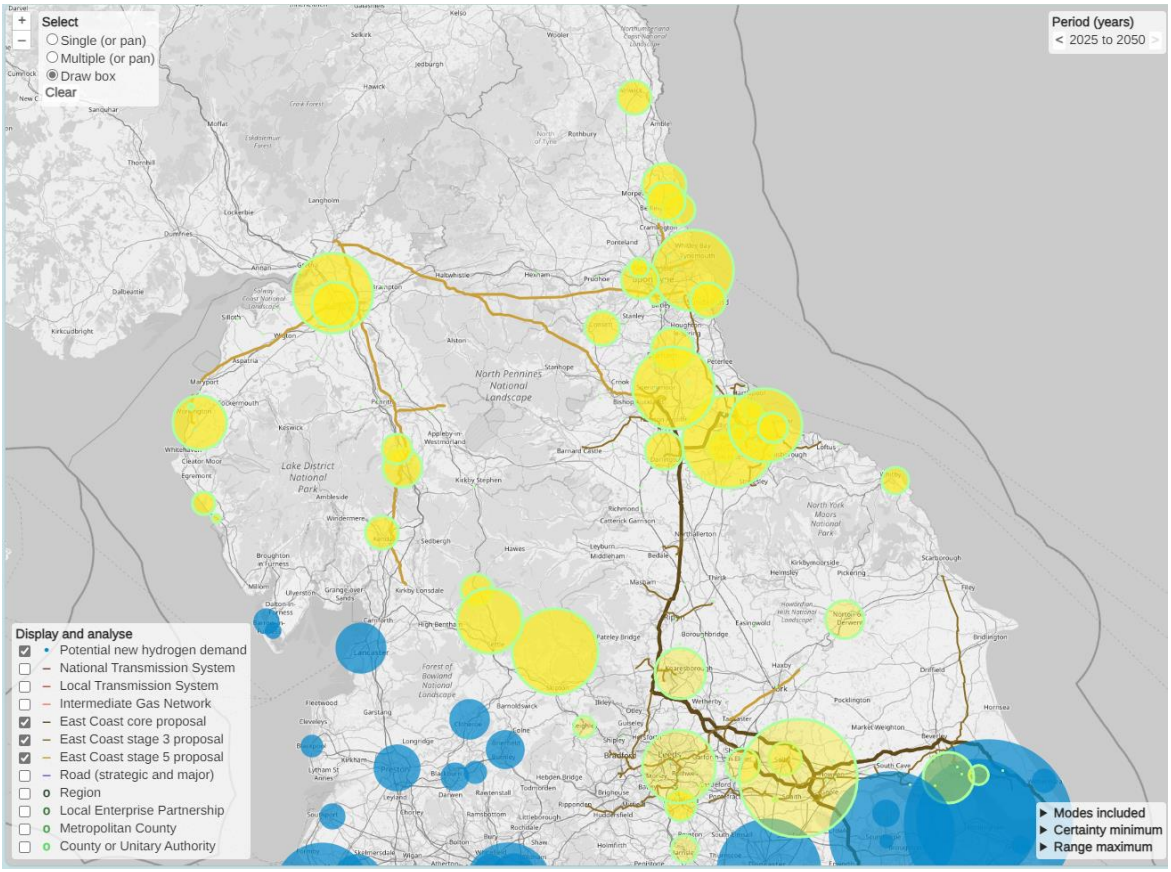


Figure 20. Hydrogen for transport demand map for the period 2025-2050. The yellow circles on the map identify the approximate areas and volumes with realistic potential for hydrogen refuelling in NGN's region.

As seen on the maps, the planned ECH_2 network is well placed regarding the hydrogen for transport demand clusters and would be able to support the hydrogen supply to these demand centres.

10.2.2 Sustainable aviation fuel (SAF)

SAF production could require 0.6-3 TWh of low-carbon hydrogen, increasing to 5-20 TWh depending on the final mandate[26]. With five SAF projects announced in Teesside alone, ECH_2 would be the key to enabling large scale SAF production in the Northeast.

10.3 Conversion blueprint

ECH_2 would act as a blueprint for regional network conversion to hydrogen, supporting the broader ambitions to create a UK-wide hydrogen network and a UK hydrogen economy.

It would also inform the UK National Energy System Operator (NESO) and Regional Energy Strategic Planning (RESP) on how to build hydrogen assets to develop a mature, well-functioning hydrogen market through the lessons learned in the strategic network planning of the east coast region.

ECH_2 would also enable discussions between the gas transmission and distribution industry ahead of the NESO and RESP being put in place to allow for network development to start.

[26] Pathway to Net-Zero aviation: Developing the sustainable aviation fuel mandate. HMG. 2023.

10.4 Economic growth

A transition to low-carbon hydrogen via ECH$_2$ would support the continued growth of local and regional economies and support retention of the current skilled, manufacturing workforce.

Manufacturing is the largest sector within the east coast region, generating £48.5bn for the UK in 2021. Food, beverages and metal products are the highest earning sectors, producing £13.6bn[27], up to 14% of the manufacturing sector, and aligning to industries forecasting the need for 6.1 TWh of low-carbon hydrogen by 2037[28]. It is vital for manufacturing companies to smoothly transition to a low-carbon alternative, while maintaining market competitiveness. Within the top 250 users of gas in the NGN area, 69% of the gas usage is from companies that are owned by non-UK entities.

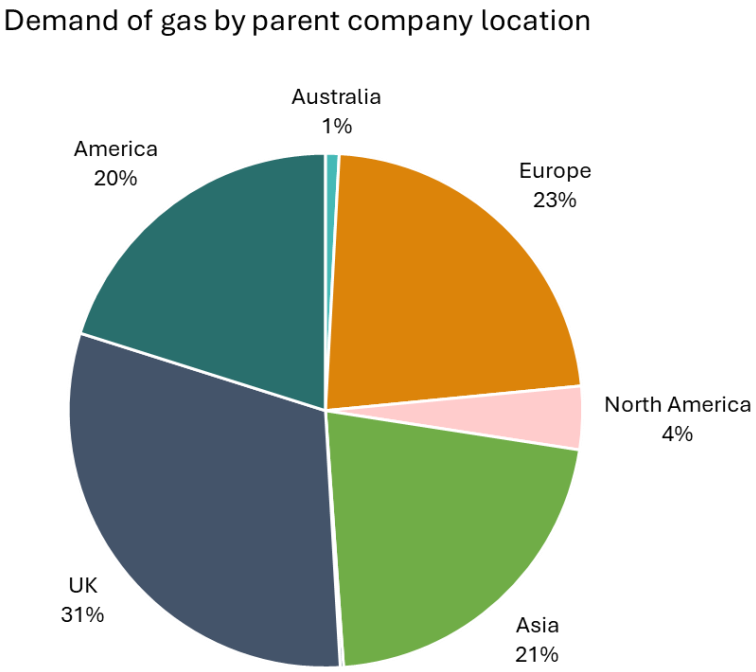


Figure 21. Demand of hydrogen by parent company location.

If the infrastructure to support the transition of these hard-to-abate sectors is not developed, the region risks seeing jobs and investment move either out of the area or abroad, putting the local economy at risk. Having a hydrogen network will be an incentive for industry to locate in the area providing a further boost to the regional economy and jobs.

Furthermore, a planned hydrogen network such as ECH$_2$ will provide certainty to users needing to invest in equipment required for a hydrogen conversion, ahead of the network being commissioned, enabling a speedier and smoother switch to hydrogen as soon as it becomes available.

[27] Data was collected from the Office of National Statistics (ONS) dataset titled 'Regional gross value added (balanced) per head and income components. The latest available data for 2021 was used to calculate the regional GVA per head across the UK and the GVA by industry at current basic prices.
[28] East Coast Hydrogen Delivery Plan. East Coast Hydrogen. November 2023.

10.5 Supporting the electrical network

Demand for the electrical network is set to rise significantly to 570 TWh/year by 2050[29]. Due to the volatile nature of renewable electricity, the electrical grid must be complemented by other flexible low-carbon sources, such as hydrogen storage. A hydrogen network would provide certainty of demand to the electrical network through connection to this large-scale hydrogen storage.

The peak capacity of the gas network is currently significantly larger than the electrical network. With timelines for a connection already being a limiting factor for those companies that want to decarbonise through electrification, a hydrogen network would support the demand for low-carbon energy as well as ensure further pressures are not placed on the electrical grid if the gas network were to be decommissioned.

A hydrogen network would also allow hydrogen production to be located in areas where the electrical grid is not saturated for demand, decoupling the need for production to be placed in congested areas where potential gas users are[30].

10.6 Lowering disruption with repurposed infrastructure

As the demand for natural gas decreases over the next decade, a hydrogen network such as ECH_2 can repurpose infrastructure that otherwise becomes redundant. Decommissioning the sections planned to be repurposed as part of the ECH_2 network for NGN would cost £46M[31] alone.

Furthermore, repurposing the gas distribution network to ECH_2 would reduce disruption caused by the decommissioning of the natural gas network and any disruption caused by the need for further electrical grid reinforcement, as mentioned in the previous section.

[29] Large-scale Electricity Storage. The Royal Society. September 2023.
[30] The Second National Infrastructure Assessment. National Infrastructure Commission. October 2023.
[31] East Coast Hydrogen: Cost Benefit Analysis of NGN Investments. Frontier Economics. February 2024.

11Government, political and regulator engagement

11.1 DESNZ engagement

Throughout the Pre-FEED, NGN has engaged regularly with DESNZ, either through ECH_2 directly or through wider NGN activities.

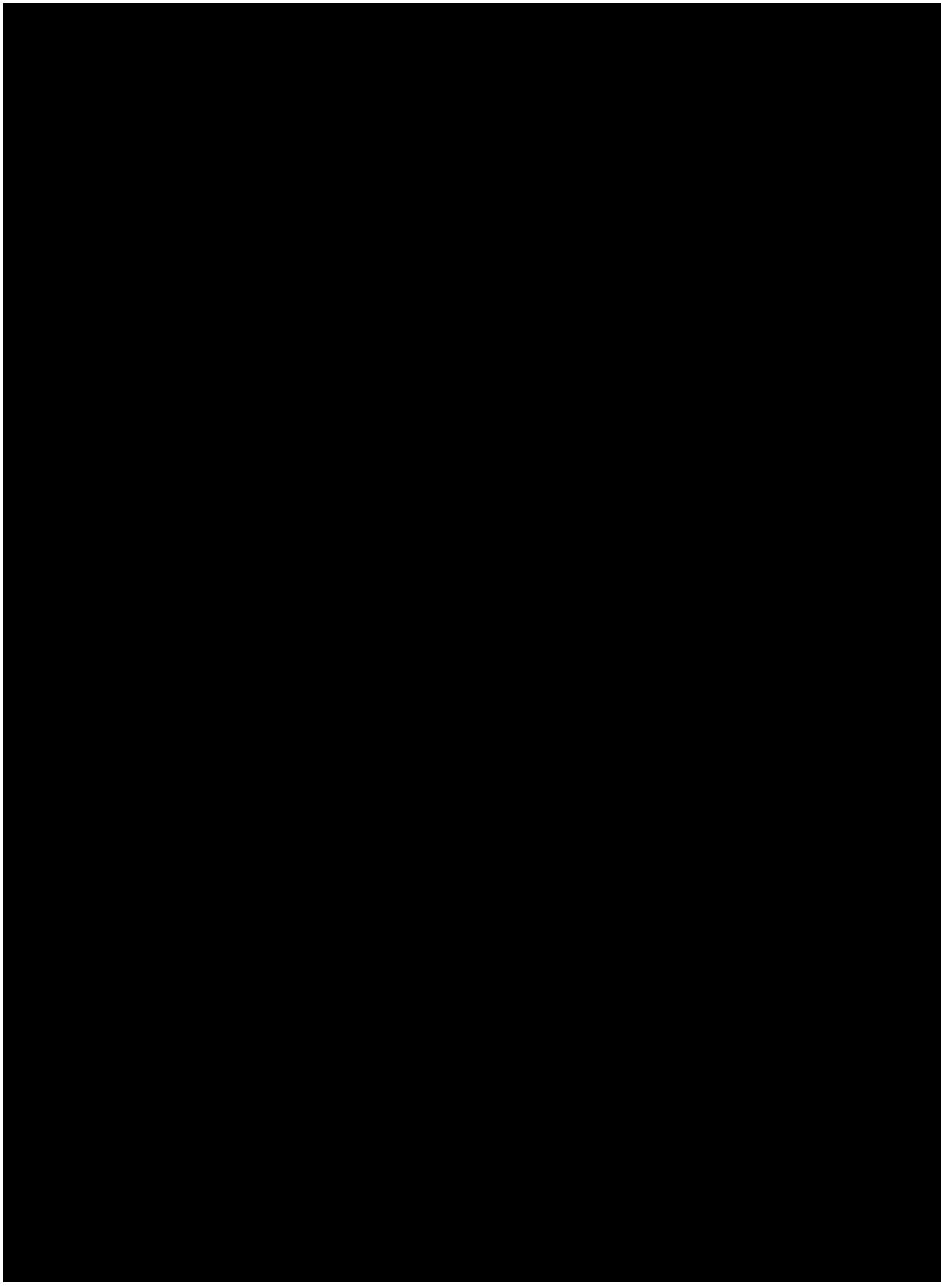
Table 1. DESNZ Engagement.

Engagement	Date	Description
ECH_2 Phase 2: Delivery Plan Launch at the House of Commons	1/11/2023	On November 1, 2023, the Delivery Plan for ECH_2 was launched at the House of Commons. As part of this event, keynote speakers Lord Callanan, Minister for Energy Efficiency and Green Finance, and MP Alexander Stafford, Energy Security & Net Zero Committee, spoke of their support for the project. With over 100 attendees, the event showcased the demand for ECH_2 and how the programme will be delivered. Large gas users spoke at the event to reiterate the importance of a suitable alternative to gas for the survival of their businesses.
ECH_2 Phase 2: Delivery Plan Webinar	01/02/2024	For those unable to join the launch, this webinar provided details on the Delivery Plan for ECH_2. Attended by over 400 people, including representatives from DESNZ, Ofgem, and various hydrogen value chain entities, the webinar gave updates on the alignment of the project with the December 2023 announcements and allowed for a half-hour Question and Answer session.
Transport and Storage Business Model Working Group	2023 and 2024	The transport and storage business model is the mechanism through which ECH2 will be delivered. NGN has been part of the DESNZ working group since its inception, and they have helped formulate the business model details.
Carbon Connect: Energy Security Roundtable	21/02/2024	Representatives from NGN attended the roundtable, chaired by Lord Teverson, to discuss the status of the future energy system and the infrastructure requirements to support large-scale storage.
ECH2 Hydrogen Demand	15/02/24	Following the delivery plan webinar DESNZ contacted the ECH2 re the demand data andECH2 presented the background and understanding of industrial demand. DESZ would like to work with ECH2 during the FEED study in a joint effort to update data on industrial demand

The above are examples of NGNs engagement with DESNZ. There is an ongoing dialogue with NGN that includes ECH2, this is planned to continue through the FEED study.

11.2 Ofgem engagement

Table 2. Ofgem Engagement to date.



As discussed in our engagement with Ofgem on the 11th of December 2023 the key points of agreement were:

- That the NZASP reopener is the correct funding mechanism for the ECH_2 FEED study.
- That a standalone Engineering Justification Paper is not required but a signposting document that details where the required evidence is located is acceptable.
- That the needs case and cost benefit analysis will not include any domestic heat requirements.
- That a reopener submission from NGN by February/ March would be acceptable to Ofgem.
- That the required requirements of Pre-Trigger engagement had been completed.

The Energy Act legislated for set up National Energy System Operator (NESO) in October 2023 as an independent, public organisation at the heart of UK energy transition. The NESO will work with the Regional Energy Strategic Planners (RESPs) for which Ofgem is currently undergoing extensive consultation with stakeholders such as Northern Gas Networks to design in detail the RESP functions, governance, mechanisms, and boundaries.

Appendix A8 - Ofgem engagement presentations and notes of engagement meetings, contains full details of the presentations with Ofgem and the minutes of these meetings, it is anticipated that this twelve months of engagement with Ofgem will expedite the review and approval of this submission.

11.3 Wider Government Engagement

In addition to Ofgem and DESNZ NGN have throughout the Pre-FEED study engaged with other government and political organisation and individuals. There has also been engagement with local industrial groups. Examples of this engagement are listed below along with plans for continued engagement.

Table 3. Wider government engagement.

	Organisation /Individuals	Engagement during Pre-FEED	Planned Engagement during FEED
1	CATCH	Industry organisation on the Humber, presented at their meeting, round table with Hydrogen champion.	Ongoing engagement to communicate plans and obtain feedback.
2	CBI	Engaged with to assist with industry contact at the appropriate level.	Will assist with engaging with hard to contact smaller business.
3	Tees Valley Combined Authority	Coordination of plans for the Teesside area.	TVCA will be a key partner for the development of ECH2 with Teesside being the leading region for Hydrogen Production.
4	Middlesbrough Mayor	ECH presentation with our CEO	Will continue to engage with all local government leaders.
5	Lord Ben Houchen - TVCA Mayor	Signatory to delivery plan	Will continue to engage with all local government leaders.
6	Energy Network Association	Coordination with other Gas networks, particularly on safety an innovation project.	Will continue to coordinate with other Gas networks via the new organisation replacing ENA.
7	Hydrogen UK	Alignment of Hydrogen strategies	Continued engagement with all industry groups.
8	Darlington Round table	Organised by NG/Chambers local government and industry.	NGN ill continue host and participate in industry events to communicate plans and share the FEED out puts.
9	Hydrogen Leaders	Presented at Breakfast meetings throughout the region.	NGN ill continue host and participate in industry events to communicate plans and share the FEED out puts.
10	IGEM	Coordination with other Gas networks, particularly on safety an innovation project.	Development of specifications and standards.
11	Members of Parliament (MPs)	MPs were invited to the launch of our Delivery Plan in the House of Commons in	All MPs in the initial NGN East Coast regions have been invited to a

		November 2023 and to a drop-in session at Portcullis House. NGN has a regular programme of MP engagement and for those in the east coast area, meetings include a project briefing.	parliamentary drop in Westminster on 16th May. Individual plans will be prepared and presented for each parliamentary constituency.
12	Prospective Parliamentary Candidates (PPCs)	Program of engagement with PPCs. Written to all PPCs.	Briefing event planned for all Prospective Parliamentary Candidates.
13	Local Councils and Combined Authorities	Dedicated round table events held in Teesside and Hull.	Cross region briefing events scheduled with West Yorkshire, York & North Yorkshire, Teesside, the Humber, and Hull. In total, these five events will cover 26/32 of all local authorities in which NGN operates.

12 Wider industry engagement

During the Pre-FEED stage of the ECH_2 project, dedicated teams were formed to take responsibility for different aspects of the project and ensure alignment with the other project partners, government and broader industry. These additional working groups focused on regulation, technical alignment, wider stakeholder engagement, direct engagement with the producers and storage companies, and engagement with the users.

In co-operation with National Gas and Cadent, three working groups were formed. Namely:

- Regulatory Engagement Working Group
- Stakeholder Engagement Working Group
- Technical Integration Working Group

12.1 Regulatory engagement working group

The main aim of this working group was to engage with the OFGEM and DESNZ to:

- Set out the project phases (discussed in the FEED SCOPE section).
- Launch a single delivery plan from the Pre-FEED outcomes for all three networks (e.g., National Gas, NGN and Cadent).
- Understand the funding mechanisms for the next phase of the project.
- Establish the key milestones and interdependencies of ECH_2 with the work that DESNZ and Ofgem had planned.
- Establish an understanding of project timelines.
- Updates on progress of the Pre-FEED.

These meetings were held monthly.

12.2 Stakeholder engagement working group

The focus of this group was for the networks to align and support each other in the engagement with external stakeholders, including, users of gas, hydrogen producers and storage providers as well as local authorities and political figures.

Some of the topics covered were:

- The establishment of relationships with industrial and large commercial users to capture data on their readiness for net zero, energy usage, capability of converting to hydrogen, and timelines.
- Event planning, including the Delivery Plan launch at the House of Commons and webinars held throughout the Pre-FEED.
- Identification of key political stakeholders and the coordination of the planned engagement with them.
- Website design.
- Alignment on social media strategies to raise the profile of ECH_2 online.

This meeting was held on a bi-weekly basis between all three networks.

12.3 Technical Integration Working Group

The main aim of this group was to:

- Understand the energy consumption distribution between different sectors, such as power generation, steel manufacturing, chemicals, etc.
- Design the routes in each geographical location, ensuring the maximum number of customers could be connected to the network.
- Identify and understand any initial barriers and seek solutions.
- Carry out the Cost Benefit Analysis for the ECH_2 project.
- Collaborate to find a solution to the flow of hydrogen through the transmission network system, utilising the distribution assets.

This meeting was held bi-weekly in the initial stages and then monthly once the Pre-FEED stage was complete.

Further to general industry engagement, regular meetings and workshops were held with hydrogen producers such as BP, Kellas, Equinor and SSE. The aim was to understand the location of their production plants and private networks, as well as to advise on how NGN's existing network can be used to transport hydrogen from the production plants to the end users. Proposals to connect to their private networks directly were also discussed, whilst ensuring that connection to ECH_2 has been considered and engineered.

Engagement with other storage parties like SABIC, Statera and Centrica are ongoing to understand and develop the hydrogen route more efficiently to connect, production and storage with end users.

13 Conclusion

As this document demonstrates, there is strong need for a ECH_2 FEED study to support development of hydrogen for industry in the NGN region. For many local I&C customers who need to decarbonise but are unable to electrify, hydrogen is vital to their continued existence and operation in the area. The creation of a hydrogen network is essential for the region's economy to continue thrive and supports many government policies and assessments by wider industry bodies.

ECH_2 will support the Transport and Storage Business Model through a whole systems approach, developing the hydrogen market and enabling multiple I&C customers to reach net zero. ECH_2 would further support the development of the NESO and RESP ambitions to develop clean energy and net zero infrastructure by creating a core hydrogen network connecting industrial, commercial, and power consumers across multiple regions.

ECH_2 is directly aligned with the publications of wider industry bodies, such as the NIC, Royal Society, The Hydrogen Champion, and the CCC. All of them express the need for a 100% hydrogen transport backbone in the UK, which is required not only to support I&C fuel switching but also to support the decarbonisation of the electrical grid and achieve robust domestic energy systems.

Through its engagement with 111 gas users across its region, NGN has gathered information first hand to demonstrate the need for a hydrogen network and identify a hydrogen demand of 10TWh by 2034. In total 98% of users contacted indicated that if a hydrogen network reached their site and hydrogen was priced competitively, they would be interested in fuel switching to hydrogen.

While the region could meet this demand, with 40TWh of hydrogen production planned by 2032, 60% of the demand is outside the clusters. ECH_2 would address this by providing producers with a route to supply hydrogen to users outside the clusters in the wider northeast region.

ECH_2 would also enable the commission of large-scale hydrogen storage by providing the infrastructure required to connect demand and production to the storage.

Finally, deploying ECH_2 will provide further benefits, such as enabling Project Union, creating a conversion blueprint for transport infrastructure, and supporting the decarbonising road and rail transport.

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*Delaying or not progressing such an infrastructure project would not unlock the **1.9 Mt/CO2** that could be avoided a year, the equivalent of **CO2 avoided** by decarbonising all the homes in the cities of **Manchester, Sheffield and Leeds**.*
