East Coast Hydrogen

Paper 1:
East Coast Hydrogen Re-opener

Contents

1. Executive Summary

East Coast Hydrogen (ECH_2) was established by Northern Gas Networks (NGN), Cadent and National Gas (NG) to identify and ultimately deliver a pipeline network for low-carbon hydrogen thereby, facilitating the decarbonisation of industry in the east coast region. A Feasibility Study launched in December 2021, established the case for the programme and set out the roadmap for completing further investigation and design of the infrastructure required. The recently completed Pre-FEED study established the needs case, detailed a proposed network, and developed the required scope for a FEED study. The next step is to undertake the FEED study and this document is a request to Ofgem to provide funding for this work.

Purpose (Why is NGN making this submission?)

NGN aims to be a sustainable transporter of net zero energy by developing an investable solution for a long-term distribution network and maximising the sustainable use of existing distribution assets. The proposed FEED study is the next step in achieving these objectives. If the ECH_2 FEED study is not progressed it removes the opportunity to develop a regional and national hydrogen network that is a key element of the UK's hydrogen and net zero strategies.

What do NGN want to achieve with this - Aims

- To fully demonstrate that the proposed NZASP FEED study meets the Ofgem re-opener requirements in terms of scope, process, and materiality thresholds.
- To trigger the NZASP re-opener process, following the submission of NGN's pre-trigger proposal. This submission seeks to obtain approval under the NZASP re-opener guidelines to enable a regulatory adjustment to be made to fund a FEED study for ECH_2.
- To allow industrial energy users to have confidence that a suitable form of net zero energy will be available to them, giving them confidence to make investment decisions.

What does a successful outcome look like - Goals

- Ofgem agreement of the scope and funding of costs for the FEED study.
- An agreed mechanism to manage the uncertainty that remains around the details of the transport and storage business model, the outcome of NG options and the investment decision by key hydrogen producers and storage companies.
- A timely approval i.e., within 5 months that allows this project to achieve alignment with the Department for Energy Security and Net Zero (DESNZ) transport and storage model and proposals.
- Ofgem have met their obligations as detailed in the government policy statement.

Key Steps to achieving the project goals, i.e., what we are requesting funding for - Objectives

Once FEED funding is agreed the key steps in achieving the aims and goals above are:

- Re-engage with industry to confirm the certainty of hydrogen demand and timescales.
- Review the status of hydrogen production and storage projects.
- Re-asses each element of the current proposed network
    - Level and certainty of demand
    - Cost for delivery in relation to demand
    - Technical and environmental difficulty

- Confirm the network to develop now and that to be part of the wider roll-out phase, assuring a robust initial network.
- Carry out the required engineering and costing, and sufficient environmental and consultation work to ensure delivery viability.
- Early/mid 2025 review the final transport and storage business model requirements, the outputs of NG remaining transmission Optioneering and work with partners.
- Work with Ofgem to update the scope and cost for the final stages of the FEED study.
- Work with partners to prepare submission to DESNZ under the transport and storage business model.

What's in this submission

This submission details why ECH_2 is required, describes the work with have done during the recent Pre-FEED study, what we want to do in a FEED study and the associated cost and demonstrates the positive net benefit to the UK. It provides all the information requested by Ofgem in the NZASP re-opener guidelines and RIIO2 re-opener guidelines.

Key messages in our submission are:

- That ECH_2 perfectly aligns with government strategies, pathway documents, business models and policies that guide Ofgem considerations.
- The Cost benefit analysis carried out by an independent consultant line with Ofgem guidance clearly demonstrates a significant net benefit of over £3billion in developing the ECH_2 network.
- The NGNs ECH_2 project is integrated with NG development of a transmission network and the first phase NG's Project Union cannot be delivered without the NGN element of ECH_2.
- The ECH_2 network within the NGN area could consist of up to 500 km of hydrogen distribution network and over 650 km including transmission. Over 50% of this network will be repurposed making it a cost-effective solution.
- The ECH_2 project will enable investment in hydrogen storage projects, the growth of hydrogen production projects.
- Delaying this FEED study will mean that UK net zero target will not be met, and that future industrial investment is less likely to happen.

Why ECH_2 is the best and most realistic area in the UK to develop a regional hydrogen network

- There are more existing networks that have underutilisation allowing repurposing.
- The repurposed network better connects the industrial areas in the region.
- The ability to repurpose allows a quicker network development and a more cost-effective solution.
- Multiple production projects funded under different business models rather than a single major production project.
- Access to multiple areas suitable for geological hydrogen storage both onshore and offshore.
- Access to some of the world's largest renewable energy projects e.g., Dogger Bank.
- Will better meet the eligibility requirements of the transport and storage businesses.

Why is ECH_2 Project so important to the UK

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 obtained first-hand information demonstrating the need for a hydrogen network and identifying a hydrogen demand of 10TWh by 2034. 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, production, and storage.

Over 70% of the potential hydrogen demand is by companies who have a parent company headquarters outside the UK, they have advised that if net zero energy suitable for their processes is not available in the UK future investments is likely to be in other countries where it is available.

2. Document Structure

ECH_2 is an extensive and complex project where Northern Gas Networks (NGN) and partners have been working for the last 18 months on a detailed Pre-FEED study. There is, therefore, a large amount of information to convey within this NZASP re-opener submission, and a considerable number of supporting documents.

To achieve the Ofgem stated requirements for the re-opener to be concise and structured, NGN has taken the following approach to structuring the submission.

- Executive Summary. Covers the purpose, aims and key message of the submission.
- Re-opener narrative. Covers all the required points of the re-opener submission but without all the data and references to supporting information that would detract from the flow of the narrative.

The re-opener narrative document is followed by three core papers that provide additional information and links to the supporting appendices. The structure of the submission is therefore:

1. Paper 1 – East Cost Hydrogen Re-opener (this document)
2. Paper 2 - The Needs Case Paper
3. Paper 3 - The Engineering Justification Paper
4. Paper 4 - The Cost Benefit Analysis Paper
5. Appendices

This document, the re-opener narrative, comprises of 6 core chapters and is supported by additional appendices, designed to provide clear explanation and justification for the proposed scope and funding requirement to deliver the FEED stage for ECH_2.

1. **Project Description & Context:**
   Provides an overview of the long-term aims and objectives for ECH_2 and describes the limits of the project, organisations involved, history of the project, the current status and future plans.

2. **Needs Case:**
   Describes the current government policy position and NGN's understanding of the future landscape, with a demonstration of strategic fit and alignment with current policy objectives. This chapter includes an overview of the hydrogen demand, production and storage, wider system benefits and the key stakeholder engagement undertaken to date.

3. **Engineering Justification Paper (EJP) – What has been done to date:**
   This chapter describes NGN's approach to the development of the ECH_2 routing, including the consideration and shortlisting of options, cost benefit analysis for engineering solutions, options scoring, and conclusion.

4. **The Engineering Justification – FEED Scope – What we plan to do and why:**
   Outlines the aims and objectives for the FEED phase including the formulation of the FEED scope and describes how the FEED stage will be delivered.

5. **Cost Information:**

This chapter outlines the FEED Scope and the approach for developing project costs with costs broken down by work package and associated project outcomes. It describes the proposed regulatory treatment of costs and provides an explanation of how much funding is being requested including NGN's proposed contribution towards the project. It demonstrates how minimum cost has been assured to support value for money for gas network users and consumers.

6. **Assurance:**
   Outlines the key assurance activities undertaken for the re-opener submission.

7. **Appendices:**
   A comprehensive list of the additional information submitted in support of this re-opener application, which are referenced throughout the document.

3.Project Description & Context

The east coast region is home to the UK's two largest industrial emission clusters (Tees Valley & Humber), 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 infrastructure programme established by NGN, Cadent and National Gas (NG), along with a supporting consortium group comprising of partners across the full hydrogen value chain. The ECH_2 network will be an anchor in creating and catalysing the UK low-carbon hydrogen economy by connecting locations of hydrogen supply, demand, and storage through a mixture of repurposed and new pipelines.

ECH_2 will support UK government policy and net zero legislation by enabling green job creation, reducing emissions, and creating resilience in the whole energy system. The ECH_2 programme has identified approximately 83TWh of annual hydrogen production in ECH_2 the region, and over 63 TWh of annual industrial, commercial, power and aviation demand potentially materialising up to 2037.

ECH_2 will enable decarbonisation of Industrial and Commercial (I&C) and Power customers located within industrial clusters as well as those that are scattered outside of the clusters which represent 50% of UK's I&C emissions. It will also offer future optionality to decarbonise transport and heating sectors through effective utilisation of large-scale hydrogen infrastructures, thereby delivering better value for investment. The Pre-FEED stage has been completed, a technical feasibility assessment of the programme has been carried out and route design options have been developed to indicate which pipelines can be repurposed and where new assets are required.

In summary at the end of the Pre-FEED stage, the ECH_2 network includes the following new, modified or repurposed hydrogen Above Ground Installations (AGI's):

- Teesside – 9 AGI's
- Bishop Auckland to Pannal – 13 AGI's
- Leeds/ Bradford area – 12 AGI's
- Towton to Asselby – 5 AGIs
- Humber region – 16 AGI's
- Tyneside – 2 AGI's

The ECH_2 network pipeline summary includes:

- 285km of HP pipelines out of which 203km of pipelines will be re-purposed (71.2%)
- 77km of IP pipelines out of which 24.6km of pipelines will be re-purposed (46.9%)
- 203km of MP pipelines out of which 11km of pipelines will be re-purposed (5.4%)

The ECH_2 final routing is demonstrated as per the figure below.

Figure 1. ECH_2 Routing Map.

3.1. Problem Statement

UK government policy and net zero legislation are driving the need to reduce CO2 emissions and further decarbonise the 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. 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 of gas via a hydrogen pipeline network including access to hydrogen storage, to ensure demand can be met during peaks and troughs of energy use. 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 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, as part of this submission, NGN requests the funding required to complete the FEED stage of ECH_2 to deploy a 100% hydrogen network that connects producers and storage providers with industrial and large commercial gas users to decarbonise their hard-to-abate sectors.

3.2. NGN Strategic & Policy Alignment

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. 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 natural gas as a source of energy, and NGN's natural gas 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[1]. 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 NGN's 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 industry. 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.

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

4. Needs Case

In this section the needs case that has been previously presented in joint engagement sessions with Ofgem has been summarised. Within this document the focus is on the needs case related to the NGN area.

4.1. Strategic Fit and Alignment with 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 programme will enable timely attainment of UK government's hydrogen production targets described in the Hydrogen Strategy (2021) which sets out the aim to achieve 10 GW of low carbon hydrogen production by 2030, with at least 1 GW of production capacity by 2025, potentially supporting over 9000 UK jobs and over £4 billion in investment.

The ECH_2 programme will be a cornerstone for bolstering growth of a hydrogen economy by building hydrogen Transport and Storage (T&S) at scale and helping develop the nascent hydrogen market into a mature and competitive one by stimulating private investment. ECH_2 will enable the UK to diversify its energy supply by harnessing its offshore wind power and catalysing the production of 'home grown' energy in alignment with the British Energy Security Strategy (2022).

The National Infrastructure Commission (NIC) recommends development of a core hydrogen pipeline network by 2035. The ECH_2 programme can facilitate this ambition by joining the Humber and Teesside industrial clusters with other clusters in the UK. The Net Zero Strategy: Build Back Greener (2021) states all electricity generation to be decarbonised by 2035. ECH_2 will facilitate decarbonisation of 12% of the UK's electricity from natural gas, helping to abate over 6 $MtCO_2$/year within the east coast region. In addition, the programme will provide a network to help fuel switch 58 TWh of power sector natural gas demand by 2037.

Figure 2. UK Hydrogen Strategy and Policy Timeline

4.2. Future Government Policy Horizon

The recently published Hydrogen Net Zero Investment Roadmap (2024) highlights that UK is entering into a period of unprecedented growth for the hydrogen economy. The ECH_2 programme supports this trajectory by supporting deep 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). The second Hydrogen Allocation Round (HAR2) with a capacity aim of up to 875MW closes for applications in April 2024.

To support the expansion of strong, home-grown, clean energy supply chains, the government announced the £960m Green Industries Growth Accelerator (GIGA) fund for UK sectors including hydrogen and CCUS in November 2023. Excess renewable electricity can be used to produce hydrogen, which can be stored over time as strategic reserves and used to generate electricity when there is less renewable energy generation to power the grid.

The National Infrastructure Commission (NIC) recommends development of a core hydrogen pipeline network by 2035, for which the UK government has announced its support in principle. The ECH_2 programme facilitates this ambition by creating a core hydrogen backbone that connects the industrial heartland of the northeast with the Humber, Yorkshire, and Midlands, along with the potential to expand 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:

- 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.

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

The energy transition landscape in the UK is evolving rapidly and is 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 successful infrastructure projects can contribute to the overarching T&S strategic objectives.

The Energy Act set up National Energy System Operator (NESO) in October 2023 as an independent, public organisation at the heart of UK energy transition. NESO will take on strategic planning activities for hydrogen T&S from 2026. The NESO will perform as the Regional Energy Strategic Planner (RESP) for which Ofgem is currently undergoing extensive consultation with stakeholders to design in detail RESP's functions, governance mechanisms and boundaries.

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 establish a resilient and self-sufficient energy system. 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.

4.3. Externally Supported Evidence

Further to the alignment of ECH_2 with current and future government policy, evidence can be found of 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 National Infrastructure Commission (NIC), which has consulted with the public, industry, academics, and local and national government to inform their proposed roadmap for the future of infrastructure in the UK[2].

As demand for low-carbon products increases, 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 region.

A further report supporting the need for a 100% hydrogen network is the Hydrogen Champion Report by Jane Toogood[3]. As an independent expert advisor, her role was to make recommendations to the Secretary of State on what industry and government could do to accelerate investment in the hydrogen economy. As part of this report, fuel switching to hydrogen has been identified as having the potential to reduce annual industrial emissions between 7 and 18 MtCO2e 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. The deployment of ECH_2 can not only connect to these users, but also provide certainty to investment for users and producers and act as a crucial enabler for deploying their decarbonisation measures.

As part of their Large-Scale Electricity Storage Report, The Royal Society[4], an independent scientific academy in the UK, reported that pipelines would be crucial to transport hydrogen to and from stores, as trains or tankers would be too expensive. This is further supported by the Committee on Climate Change (CCC) report, Delivering a Reliable Decarbonised Power System[5], where it is stated that pipelines are the only suitable transport for 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 100km and 1,000km 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, 940km of new and reused infrastructure as part of ECH_2, going a long way to cover the need for this infrastructure. 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.

[2] Second National Infrastructure Assessment. The National Infrastructure Commission. October 2023.
[3] Hydrogen Champion Report. Jane Toogood. March 2023.
[4] Large-Scale Electricity Storage. The Royal Society. September 2023.
[5] Delivering a Reliable Decarbonised Power System. Climate Change Committee. March 2023.

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

4.4. Hydrogen Demand

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 I&C 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.

To determine the potential reliance of the likely users of hydrogen on NGN's network, today's availability and cost of technology were modelled, along with:

- Sector decarbonisation commitments from industry associations or UK 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 in NGN's network and secondary resources.

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/ hydrogen usage.

Modelling from the Pre-FEED stage shows a demand of hydrogen in NGN's region (NGN and NG's 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.

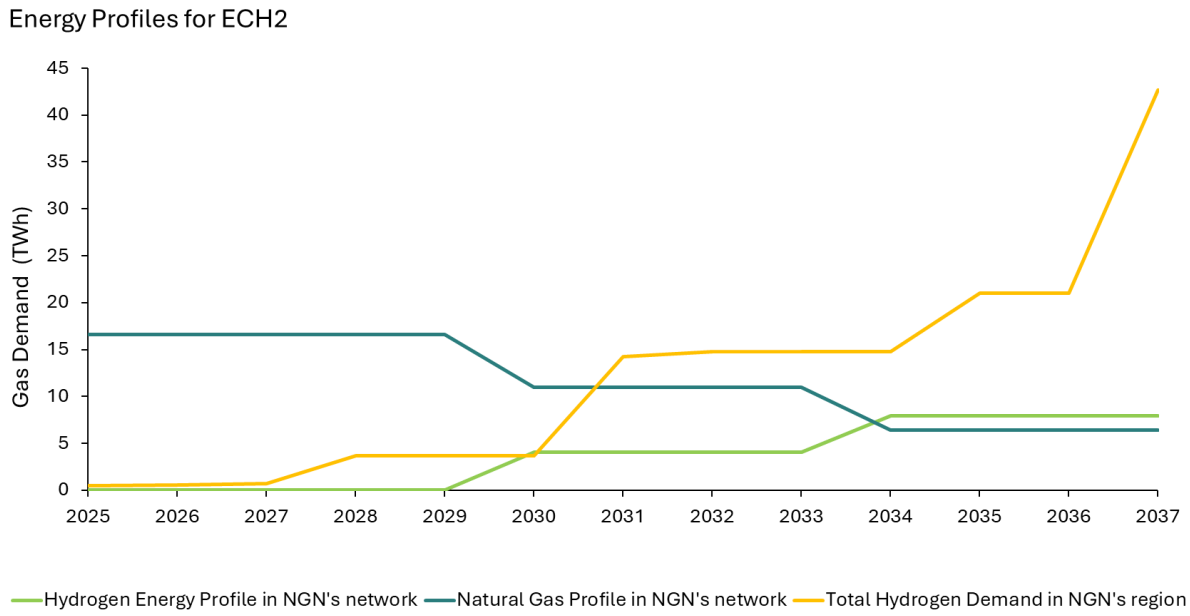


Figure 4. Calculated usage of hydrogen through fuel switching between 2025 and 2037 in NGN area.

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%).

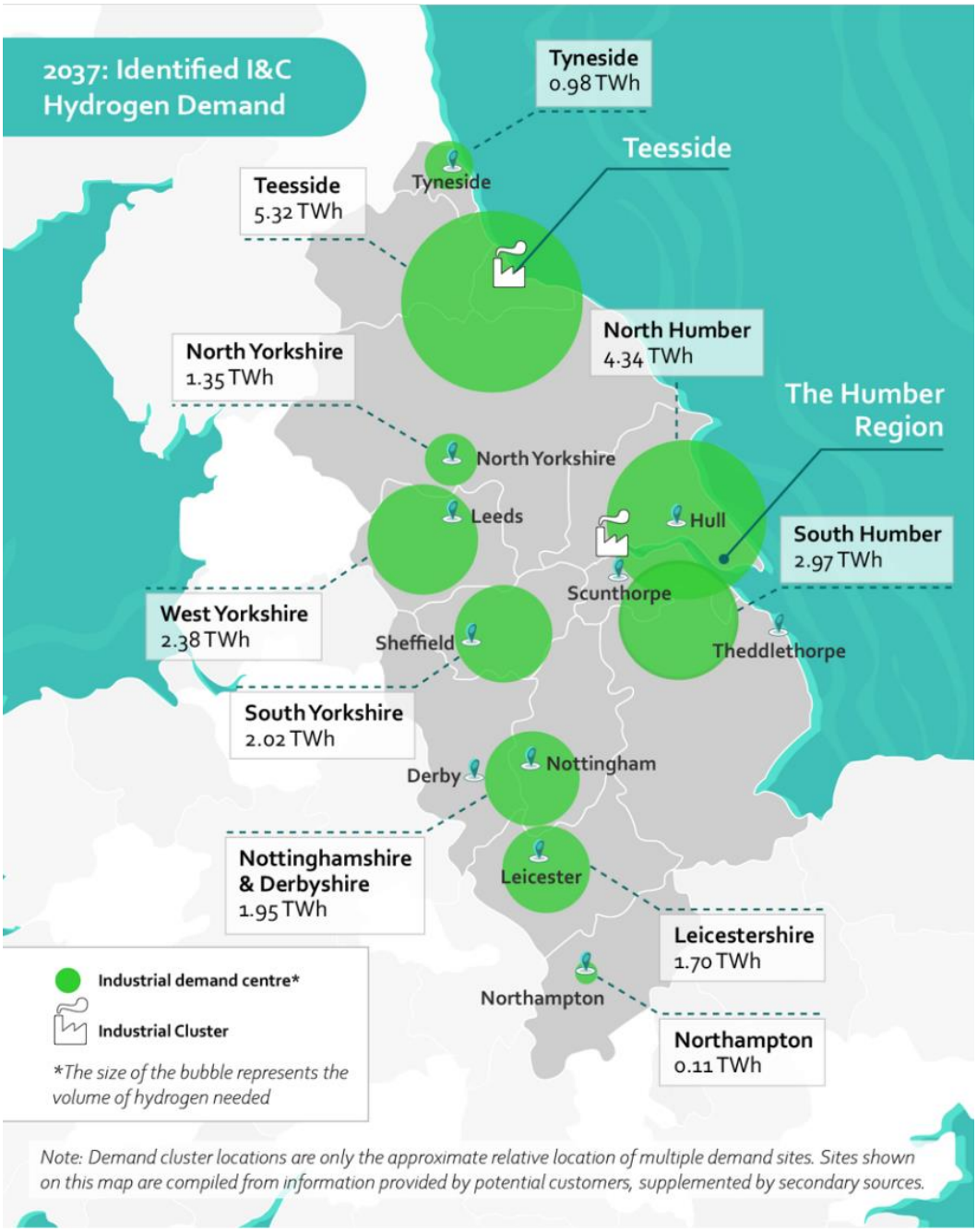


Figure 5. Hydrogen demand clusters in the ECH₂ region

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.

Large industrial players in the east coast region see switching to hydrogen as a route to decarbonisation. The current lack of hydrogen infrastructure and certainty of supply are barriers to investment.

[redacted]

Case Study: Quorn

"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]

Case Study: Syngenta

"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)".

[redacted]

[redacted]

Case Study: Inspired Pet Nutrition

"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]

Inspired Pet Nutrition.

4.5. Low Carbon Hydrogen Production

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. A summary of consortium members can be seen below. Many have indicated they would depend on connecting into a network to provide flexibility and resilience of supply to their customers. These include, Kellas, Centrica, BP, Equinor, RWE and SSE to name a few.

Figure 6. Consortium members.

All identified projects have been broken down into phases where applicable to enable a more granular forecast of potential hydrogen production to be developed. Forecasts have been considered in the greater context of the UK government's targets to produce 10GW of low-carbon hydrogen by 2030.

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.*

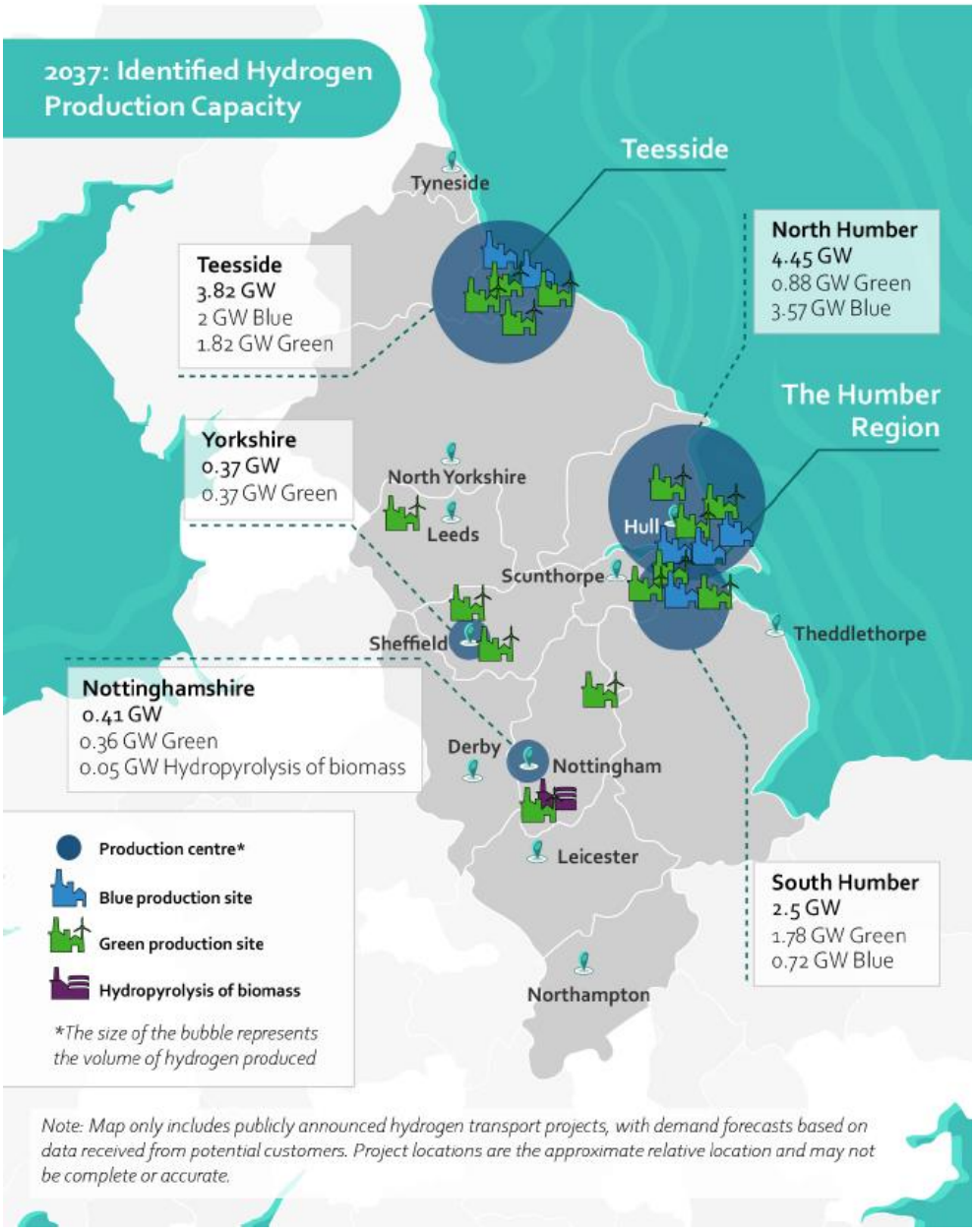


Figure 7. Identified hydrogen production hubs in the ECH$_2$ region.

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. This is even the case when considering further I&C demand identified in the whole ECH_2 NGN region.

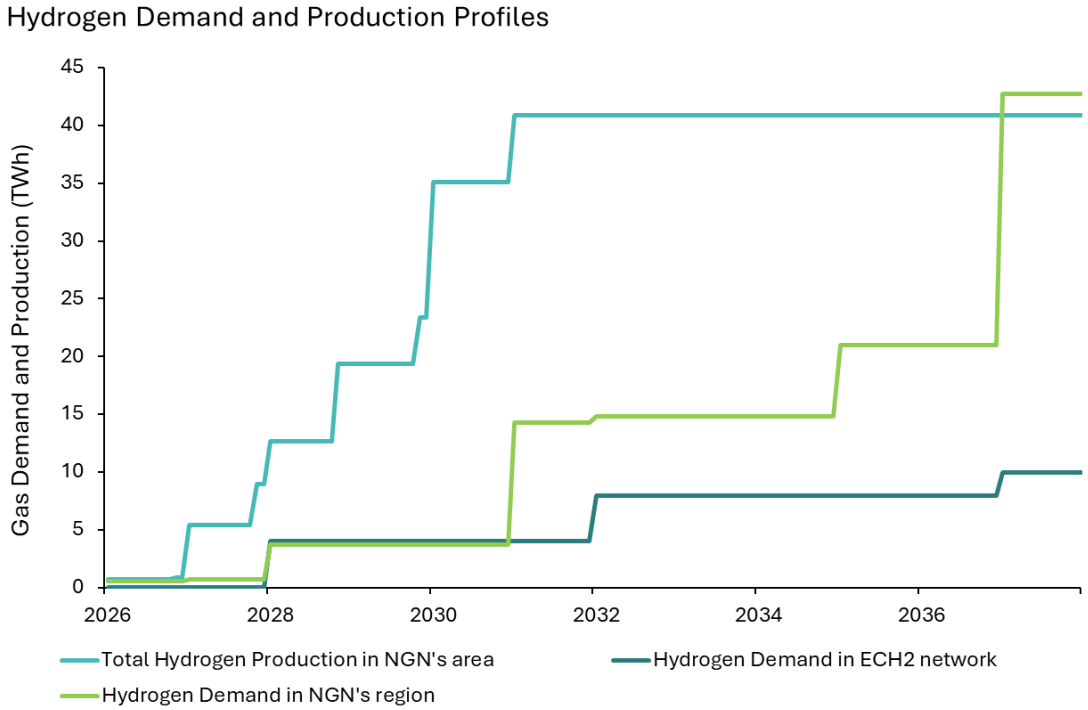


Figure 8. Hydrogen production and demand in NGN's region from 2025 to 2035

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.

4.6. Hydrogen Storage

Hydrogen storage is required in almost every independent third-party net zero scenario for the UK. Hydrogen storage capacity will be necessary for:

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

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

ECH_2 has collected primary quantitative and qualitative data from eight announced storage projects. This includes four off-site storage facilities which are co-located with production projects. These projects are in the early stages of development and are looking to secure funding or obtain planning.

There are plans for up to 0.7TWh of announced salt cavern storage by 2037, with 3.3TWh expected from Rough by 2030 and a further 10TWh 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.

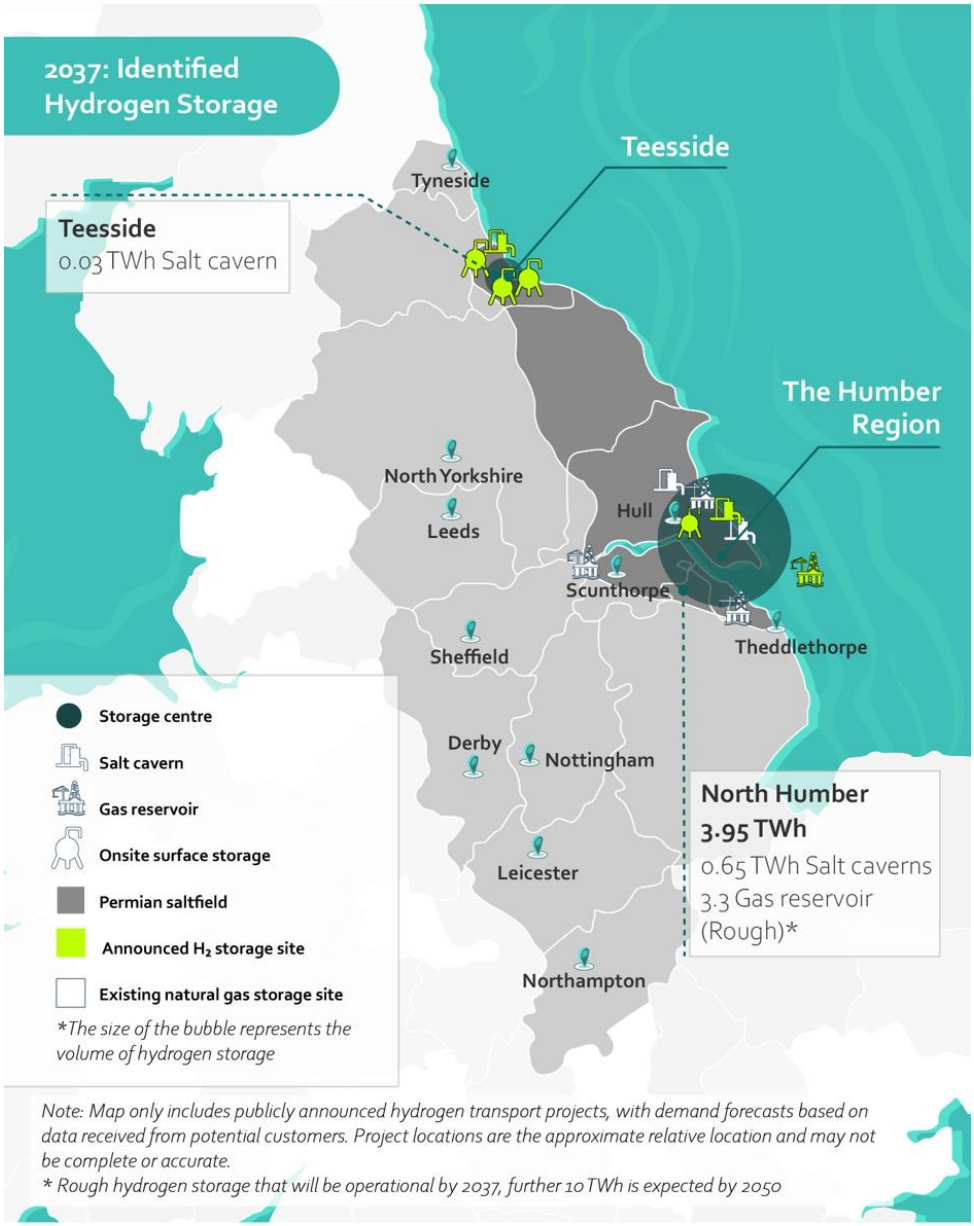


Figure 9. Identified hydrogen storage hubs in the ECH_2 region.

ECH_2 has support from various prospective hydrogen producers within the region, many of which would be dependent on connecting into a network for flexibility and resilience.

[redacted]

[redacted]

Case Study: Kellas

"The East Coast Hydrogen network would enable H2NorthEast to provide low-carbon hydrogen to customers outside of the Teesside area; helping them to decarbonise and minimise infrastructure cost".

[redacted]

[redacted]

Case Study: Meld

"We support the development of hydrogen elivering 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]

Case Study: Centrica

"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 H2 can be used during periods where it is of greatest value. Transport infrastructure projects such as ECH2 are essential to ensure the system maximises the benefits of low-cost H2 production and allows H2 to be produced where it is cheapest and to be conveyed to demand".

[redacted]

Centrica Energy Storage+.

4.7. Local Authority 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.

Table 1. Table summarising the engagement with local authorities to date.

Local Government Entity	Description	Engagement
North-East & Yorkshire (NEY) Net Zero Hub	The North-East 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.	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 will be published by Spring 2024, but the report already indicates 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.
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, they have commissioned the creation of a hydrogen roadmap for the region.	ECH_2 joined their 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] ‹shire Net Zero Hub Project to provide data that may inform their roadmap.
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	In 2023, TVCA launched its Net Zero Strategy, which outlined how, as the country's second-highest CO2 emitting region in the country, will reach net zero by 2050 by abating or capturing more than 11MT of CO2. This net zero strategy fully supports the use of hydrogen as a decarbonisation pathway for the industries in their region. With so much hydrogen production centred around Teesside, ECH_2 has closely aligned with TVCA plans through regular engagement with [redacted]

	development of Sustainable Aviation Fuels to pursue Net Zero flights by 2035 – making it the UK's first net zero airport.	
Humber Hydrogen Roundtable (9/11/23)	On November 9, 2023, [redacted], organised a Hydrogen Round Table for 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.	As part of the roundtable, political attendees and their representatives were keen to show 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.

4.8. Wider Benefits

4.8.1. Project Union Enabler

National Gas' flagship conversion project, Project Union, aims to repurpose the transmission feeders that provide Local Distribution Zones (LDZs) from natural gas to hydrogen. Within NGN's region, Feeder 7 will be the first transmission pipeline to be repurposed. For this to happen, NGN must modify the existing off-takes and AGI's that connect to Feeder 7. 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.

4.8.2. Facilitator of Transport Decarbonisation

Transport is the UK's largest carbon emitting sector, accounting for 27% of the UK's total Green House Gas (GHG) emissions, with a saving of 1,300-1,800 Mt CO_2e between 2020 and 2050 from transitioning away from fossil fuels[6].

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.

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

4.8.3. Conversion Blueprint

ECH_2 could 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.

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

It would also inform the UK National Energy System Operator (NESO) 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.

4.8.4. Economic Growth

ECH_2 would support the continued growth of local and regional economies by maintaining the current skilled workforce in manufacturing by providing industry with a suitable decarbonisation solution.

Manufacturing is the largest sector within the east coast region, generating £48.5bn for the UK in 2021. Food, beverages and metal products were the highest earning sectors, producing £13.6bn, accounting for up to 14% of the manufacturing sector and aligning to industry's forecasting the need for 6.1TWh of low-carbon hydrogen by 2037[7]. 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 comes from companies that are owned by non-UK entities.*

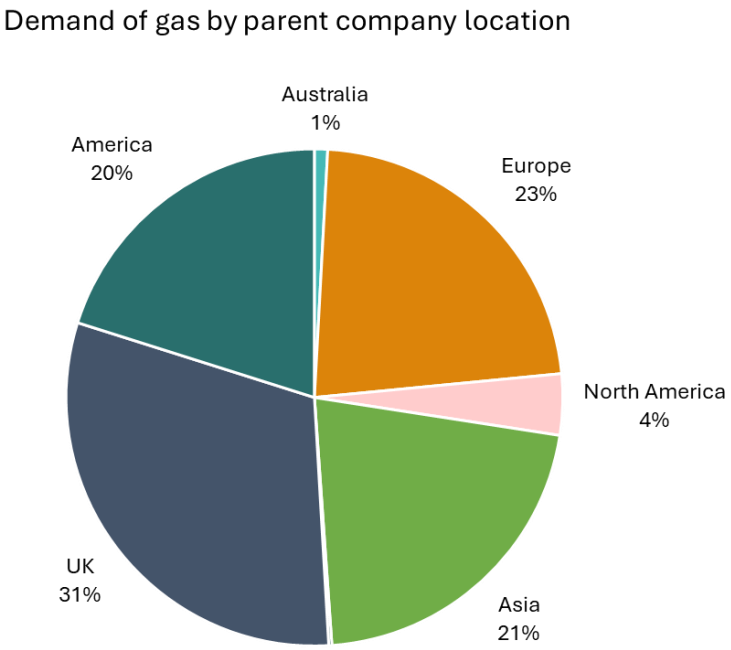


Figure 10. Demand of hydrogen by parent company location.

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.

[7] ECH_2 Delivery Plan. East Coast Hydrogen. November 2023.

4.9. Government, political and regulator engagement

4.9.1. DESNZ engagement

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

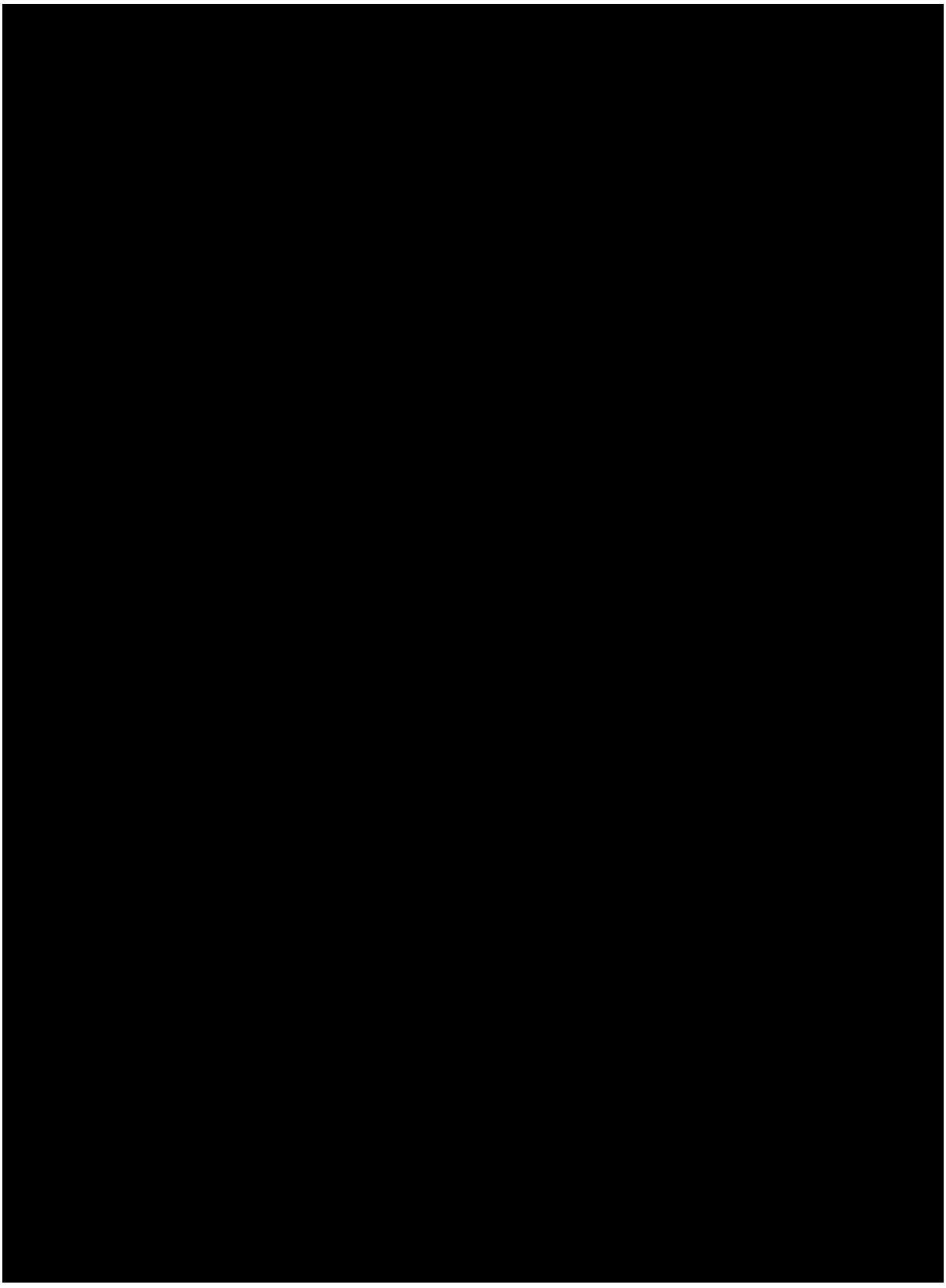
Table 2. DESNZ Engagement to date.

Engagement	Date	Description
ECH_2 Phase 2: Delivery Plan Launch at the House of Commons	01/11/2023	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 DESNZ hydrogen 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 ECH_2 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[redacted], 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 ECH_2 regarding the demand data and ECH_2 presented the background and understanding of industrial demand. DESNZ would like to work with ECH_2 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 ongoing dialogue with DESNZ that includes ECH_2, this is planned to continue through the FEED study.

4.9.2. Ofgem engagement

Table 3. Ofgem Engagement to date.



As discussed in the meeting that took place with Ofgem on the [redacted], the key points of the agreement were:

- That the NZASP re-opener 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 re-opener submission from NGN by February or/ March would be acceptable to Ofgem.
- That the requirements of the 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 NGN 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.

4.9.3. Wider Government Engagement

In addition to Ofgem and DESNZ, NGN have throughout the Pre-FEED study engaged with other government and political organisations 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 4. wider Government Engagement to date.

	Organisation /Individuals	Engagement during Pre-FEED	Planned Engagement during FEED
1	CATCH	Industry organisations on the Humber, presented at their meeting round table with the hydrogen champion.	Ongoing engagement to communicate plans and obtain feedback.
2	CBI	Engaged with CBI 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 ECH_2 with Teesside being the leading region for hydrogen production.
4	[redacted] Middlesbrough Mayor	ECH_2 presentation with NGN's 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 will continue to 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 will continue to host and participate in industry events to communicate plans and share the FEED outputs.
10	IGEM	Coordination with other gas networks, particularly on safety and innovation projects.	Development of specifications and standards.
11	Members of Parliament (MPs)	MPs were invited to the launch of the ECH_2 Delivery Plan in the House of Commons in November 2023 and to a drop-in session at Portcullis House. NGN has a regular programme of MP engagement and for those in	All MPs in the initial NGN east coast region have been invited to a parliamentary drop in Westminster on the 16th of May 2024. Individual plans will be prepared and presented for each

		the east coast area, meetings include a project briefing.	parliamentary constituency.
12	Prospective Parliamentary Candidates (PPCs)	Program of engagement with PPCs. Written to all PPCs.	Briefing event planned for all PPCs.
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.

4.10. Industry Engagement

During the Pre-FEED stage of the ECH_2 project, dedicated teams were formed to look after different aspects of the project to 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 NG and Cadent, three working groups were formed. Namely:

- Regulatory Engagement working group
- Stakeholder Engagement working group
- Technical Integration working group

4.10.1. 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., NG, 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 on a monthly basis.

4.10.2. 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, 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.

These meetings were held on a bi-weekly basis between all three networks.

4.10.3. 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 CBA for the ECH_2 project.
- Collaborate to find a solution to the flow of hydrogen through the transmission network system utilising the distribution assets.

These meetings were held bi-weekly in the initial stages and then monthly once the Pre-FEED stage was complete.

Further to the general industry engagement, regular meetings and workshops were held with hydrogen producers such as [redacted]. The aim was to understand the location of their production plants and private networks, as well as to advise them 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 [redacted] are ongoing to understand and develop the hydrogen route more efficiently to connect, production, storage, and the end users.

5.Engineering Justification Paper (EJP)

NGN commissioned a consultant to undertake a Pre-FEED exercise. This work has now concluded. This Pre-FEED has resulted in the development of the following:

- A proposed route to transport and distribute hydrogen gas.
- A programme plan for the FEED stage and;
- An understanding of the costs of the FEED stage of the programme.

The £17.8m funding requested through this re-opener submission is to undertake a FEED study and further Pre-FEED research in some areas where the Pre-FEED research could not be undertaken. The funding requested is to undertake a FEED study, not Capital Delivery works. Capital Delivery in the future would be subject to an application to the Hydrogen Business Model for Transportation and Storage.

The Pre-FEED work to date includes:

- **Stage 1a** – Information gathering – Determined the production, demand, and storage profiles of hydrogen.
- **Stage 1b** – Optioneering Preparation – Set out the re-purposing strategy and identified the options available to transport and distribute hydrogen.
- **Stage 2** – Optioneering – Modelled and assessed the different gas network pipeline cluster scenarios.
- **Stage 3** – Preferred Solution – Determined the preferred solution cost, delivery, and phasing plan.
- **Stage 4** – FEED preparation – Outlining the FEED design facilities, capital cost and design pipeline.

NGN has mobilised the necessary resource and budget to deliver this project. Engagement from board level and senior management team has been sought throughout the Pre-FEED stage of the project to ensure that the plans compliment the wider business strategy and commitments.

NGN proposes repurposing its network for the transportation of hydrogen rather than constructing new assets. Summaries of the detailed assessments of various clusters are described in Section 6 of the EJP Paper with further detail provided within the options study report in Appendix A20.

5.1. Selection Process

The main focus of the Pre-FEED was supplying the largest I&C and Power natural gas users with hydrogen from the production and storage facilities. The first approach to achieve this was to establish a High-Pressure Transmission line backbone through the NGN area. In collaboration with NG, it has been established that the existing feeder 7 from Bishop Auckland / Cowpen Bewley to Asselby via Pannal and Towton can be re-purposed for hydrogen transportation.

Once the transmission backbone was established, suitable supply points and the off-take points were confirmed. With the supply and off-take points confirmed, various hydrogen supply options were identified, and each option was evaluated using multi-criteria analysis. After the analysis the preferred option was selected.

During this selection process, priority was given to re-purposing existing pipelines wherever possible. While re-purposing some of the existing pipelines, a new natural gas network was proposed to reach the areas where building a new hydrogen network does not seem possible.

Once the draft hydrogen network was created, it was plotted using Google Earth along with the largest I&C and power natural gas users. The existing network (High Pressure, Intermediate Pressure and Medium Pressure) was also plotted.

A final analysis was carried out on further re-purposing of the existing pipelines to transport hydrogen, connecting the production and storage facilities with the users.

The detail of the optioneering and phasing study report can be found in options report Appendix A20 – Options and Phasing Study Report.

The transmission backbone for Cumbria and North Tyneside was not established until later in the Pre-FEED stage of the project and so further development of a hydrogen network could not be established for these two regions. Additionally, not all the largest users were connected in the Pre-FEED stage due to the complexity of the locations and distance from the core hydrogen network.

All the points raised in the previous paragraph will be subject to Pre-FEED during the proposed FEED stage of the project.

5.1.1. Do Nothing Option

The do-nothing option will result in the failure to decarbonise the I&C sector. By choosing this option, the government's target of achieving net zero by 2050, would be impossible.

A further consequence of the do-nothing option will lead to the costly de-commissioning of the vast existing natural gas assets, whereas the existing assets can be re-utilised with minor modifications to create a new hydrogen network.

The do-nothing option will also not support or enable Project Union which sees existing transmission lines re-purposed to transport hydrogen to the local distribution zones (LDZs).

5.1.2. Do Minimum Option

The minimum option for NGN would be to not develop its network to support hydrogen transportation. This may lead to the development of duplicated private networks that are not interconnected, not supporting the UK government's decarbonisation policies and targets regarding the establishment of a hydrogen economy.

As mentioned in the Needs Case, the Committee on Climate Change (CCC) is clear that not building a 100% hydrogen network would drive inefficiencies (e.g., in the location of assets or the volume of production and storage infrastructure required) and, in turn, increased system costs.

5.1.3. Market Based Option

Currently there are no practicable market-based options available for consideration. Market-based options may be appropriate where a network operator is considering reinforcing a network to address a peak in demand. However, in this case, the proposal is to develop an entirely new set of assets for hydrogen transportation. Market-based options will continue to be considered through the FEED.

5.1.4. Delaying Proposed Work Option

Although the RIIO-2 price control was finalised before ECH_2 could be incorporated, delaying ECH_2 to the following price control could significantly impede the attainment of the UK's net zero targets. ECH_2 is required to enable other major UK hydrogen project infrastructure, linking Teesside, Humber, and West Yorkshire industrial clusters, and connecting 5.6 GW hydrogen production capacity to gas users and storage in the northeastern and Yorkshire regions.

Further to this, with the announcement of the Transport and Storage Business Model and the associated timelines, delaying the FEED means that the government's set window for a hydrogen network to come online between 2028 and 2032 would be missed for the northeast of the UK.

5.2. Consideration of Options

After the selection of the transmission backbone and establishing the infrastructure and connection points, the NGN region was split into six areas for assessment:

- Teesside
- Bishop Auckland to Pannal
- Leeds / Bradford
- Towton to Asselby
- Humber
- Tyneside

Within these geographic areas, the producers, storage sites and users were grouped in clusters to develop the new hydrogen network.

5.2.1. Network Modelling

The initial high pressure (HP)/ local transmission system (LTS) network modelling has been done via NGN's LTS analysts using Graphical Falcon, a modelling tool which is used by NGN for planning and operational analysis. It has been used to establish whether the proposed HP mains selected for repurposing can be removed from the natural gas network and, if removed, whether the remaining HP network still provides adequate flow to direct customers on the network and to the customers downstream. Where analysis has identified mains that cannot be removed from the network, alternative solutions have been reviewed to maximise repurposing over new build hydrogen infrastructure.

Downstream of the HP network, further network modelling has been carried out on the below seven bar network using Synergi Gas, a hydraulic network analysis software tool that is also used by NGN for planning and operational analysis. Where HP mains are not required for one of the top 250 customer connections, repurposing of IP (intermediate pressure) and MP (medium pressure) mains have been considered in each case.

To date, analysis has only looked to remove the repurposed mains from the natural gas network and ensure the network is still capable of supplying its current customers. In some cases, it has been necessary to introduce new natural gas reinforcements or remove the demand from the customers that would be connected to the ECH_2 network. Further analysis will be required to ensure security of supply, including intricacy of the flow into the downstream network.

Details of the network modelling can be found in Appendix A17 – Initial Network Modelling Brief.

5.2.2. Routing Options Analysis and Scoring

The optioneering stage aimed to develop and assess the feasibility of the routes to connect the producers, network feeders (NG), potential storage and the users within NGN's area of the ECH_2 project.

The methodologies adopted to develop the hydrogen network are as below:

1. Geographical assessment of producers, users, and storage
2. Identification of probable routing areas
3. Establishment of industrial clusters for development
4. Identification of scenarios based on key decisions
5. Formation of the constraints to routing
6. Iterative routing of pipelines

Upon development of clusters, different routing options were created linking producers, users, and storage providers. These options were analysed in more depth to understand the viability, cost, and construction time of each pipeline so that the network clusters could be evaluated.

Continuum's Optioneer™ linear infrastructure routing tool was used. The tool considers route options via a constraint weighting and automated AI routing methodology that holistically considers constructability along with environmental and consenting criteria. This meant that routing options could be rapidly assessed, iterated on and analysed for metrics.

The AI tool was populated with GIS (Geographical Information System) layers representing the constraints to the routing. The data layers consisted of 117 separate datasets which cover aspects including:

- Sites of Special Scientific Interest
- Buildings
- National parks
- Electrical infrastructure
- Flood zones etc

For each data layer, a technical and consenting penalty classification was assigned. This allowed the determination of technical and consenting penalties for the study area and the input was given to the AI tool to develop the routes. The build-up of the overall penalty for each route option was generated by the tool to establish the most efficient route.

The classifications were quantified by constraint type, risk level, and designation type. With the tool populated with the layers and penalties, the required routing points were inputted, and multiple routes were created between each A to B point. They were assessed individually to ensure the tool correctly applied the criteria and that the routing was realistic.

After the routing was completed, a Multi-Criteria Analysis (MCA) was applied to analyse each option and an optimal solution was reached.

The details of the optioneering completed in the Pre-FEED stage can be found in Section 9 of Appendix A20 – Options and Phasing Study Report.

5.2.3. Description of Shortlisted Options

In each of the six geographical locations, referred to earlier, options for each of the new pipeline route corridors were developed and evaluated using Continuum Optioneer™ software to determine the optimal routings to include for each scenario.

The preferred options were then determined based on the lowest penalty and Capital Expenditure (CAPEX).

Fully developed preferred options were then analysed using MCA and the preferred options were selected.

5.2.4. Cost Benefit Analysis for Engineering Solutions

Continuum's Optioneer™ linear infrastructure routing tool has an added benefit of incorporating the CAPEX model. The tool applies different construction methods to each section of a route, dependent on the terrain or features it crosses and the complexity of these.

Costs were assigned to each construction methodology in terms of fixed costs (for start-up, equipment etc.) and linear costs (for labour, materials etc) which enabled the build-up of CAPEX for each pipeline, which was also used in the route selection process.

5.3. Conclusion – Preferred Option

The routing developed from the various methodologies as explained in the above sections were plotted on Google Earth. The new and re-purposed routes were then assessed against the existing natural gas pipelines for further re-purposing of the existing HP (High Pressure) and IP (Intermediate Pressure) pipelines.

Throughout this process the focus on users has been based on the assessment of the I&C and Power users connected to NGNs network. It was found more feasible to switch the supply of single users, due to the upgrading and /or modifications of the plant and equipment. However, there are instances where the routing connects to a single user which is in an area with multiple other industrial users close by, for example technology parks and industrial areas, but the demand of the other users has not been included. There is therefore an opportunity to further assess the potential demand in the clusters based on the additional users in close proximity. A map of preferred solutions from all scenarios is shown below.

Figure 11. Final ECH2 Routing Map.

The Cumbria and North Tyneside areas were not assessed at this stage as the repurposing of the national transmission system to hydrogen was not finalised. Other users in the core areas were also not connected at this stage, as laying pipelines over long distances to reach them for a lower demand was not deemed economically feasible.

A further Pre-FEED study (within FEED stage) is required for all discounted areas as discussed above to develop a detailed network within those regions.

At the end of the current Pre-FEED stage as the design stands, the hydrogen network attributes are:

- 285km of HP pipelines, out of which 203km of pipelines will be re-purposed (71.2%)
- 77km of IP pipelines, out of which 24.6km of pipelines will be re-purposed (46.9%)
- 203km of MP pipelines, out of which 11km of pipelines will be re-purposed (5.4%)

6. FEED Scope (EJP)

The FEED stage of the ECH_2 project will develop the level of detail and cost certainty to allow the formation and basis of an investment decision under the transport and storage business model. It will demonstrate to DESNZ a solution to enable widespread I&C decarbonisation through development of a hydrogen distribution network, utilising as much repurposed infrastructure as possible.

6.1. Aims & Objectives for the FEED Phase

The aims for the FEED and concurrent Pre-FEED are as follows:

- Develop a feasible network connecting supply, demand and storage.
- Enable the decarbonisation of multiple hard to abate sectors.
- Support the UK government in achieving low carbon hydrogen and net zero targets.
- Provide system resilience and flexibility to the UK energy system.
- Catalyse wider system benefits.
- Inform final investment decision and a methodology to deliver the project.
- Optimise the Return on Investment (ROI) by further optimising the network.
- Improve safety outcomes.
- Enable application to the anticipated Transport and Storage Infrastructure allocation round.
- Ensure the solution enables coordination with Project Union and the development of third-party pipelines.

The key objectives to in order to achieve the aims are:

1. Following Pre-FEED, confirm the existing demand, supply and storage data remains correct and update where required.
2. Further assess the technical viability of the proposed pipeline routes and further optimise routing corridors to determine final routing. If multiple routes are possible, a cost benefit analysis should be carried out before determining the final routing.
3. Undertake pipeline design and safety assessments.
4. Develop designs for the repurposing or development of the required Above Ground Installations (AGIs).
5. Progress the consultation and environmental assessments of each route and AGI.
6. Determine project costs to an AACE class 3 estimate to inform final investment decision.
7. Determine sequence of development and proposed delivery programme.
8. Develop packages to tender Engineering, Procurement and Construction (EPC) contracts to deliver the network.
9. Coordinate with all project stakeholders.

6.2. Formulation of Scope

The scope of the FEED stage is determined by the purpose, aim, goals and objectives outlined above. The project has been split into packages to enable the most effective delivery within the timescales whilst maintaining consistency of approach and also competition in the market.

The scope split and proposed programme has been determined to balance delivery timescales and the project risks determined at the Pre-FEED stage. The network development will begin with specific parts of the HP/IP package to enable Project Union as well as the MP package. This will

allow further collation and confirmation of information from stakeholders at the production and consumption ends of the network. The HP/IP package will start later once the connection points from the NG network, and the MP network have reached a greater level of certainty. The consenting and environmental package will begin at the start of the programme due to the long-term timescales required and the low risk works which can be undertaken at that stage. The stage 5 Pre-FEED works have minor dependencies from the other packages but does not form part of the critical path.

6.3. Project Delivery & Monitoring

The project will be executed in five distinct packages:

- Project Management Package
- HP / IP Package
- MP Package
- Pre-FEED Package
- Consenting and Environmental Package

The project delivery team will be led by dedicated resource within the NGN's ECH_2 project team.

This team will be responsible for the overall delivery of the collective outcomes of the five packages and will provide oversight for the whole project.

A project reporting structure and key performance indicators will be developed to monitor performance and quality of the project management services against time, cost, and quality metrics.

The governance structure identified will be organised as shown below:

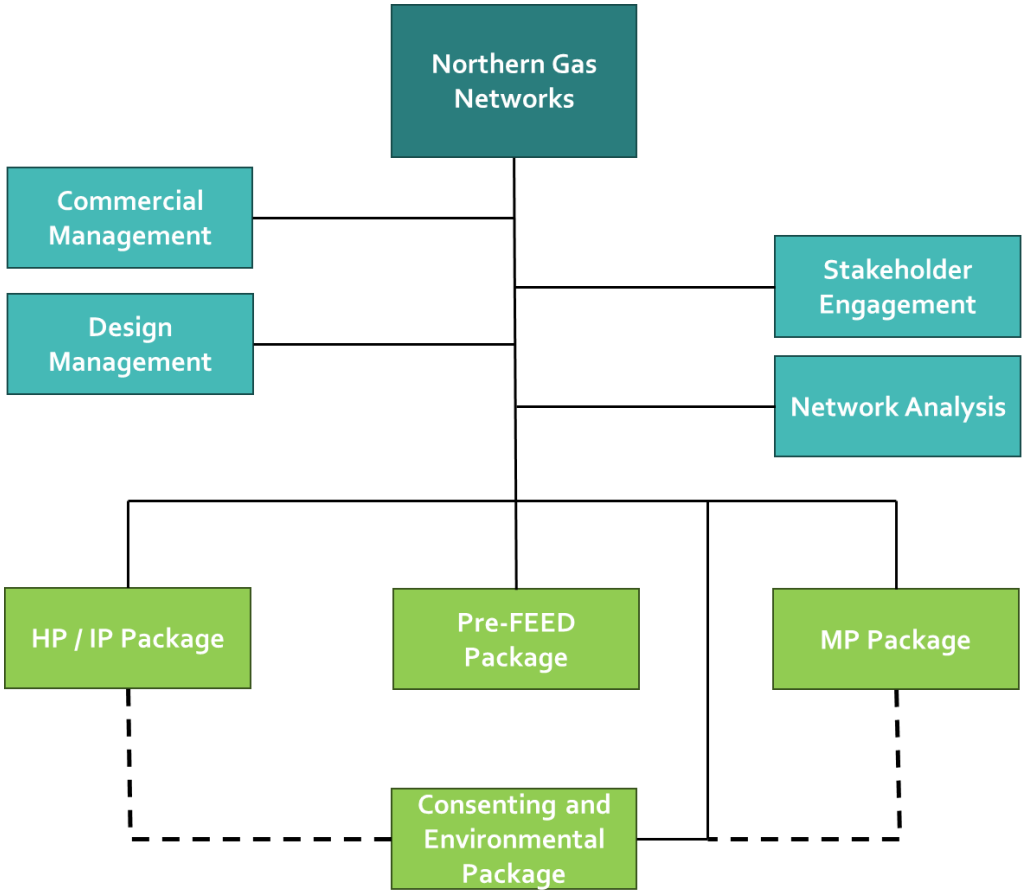


Figure 12. Project management governance structure.

Details of the goals to be monitored through this work package and key critical milestones to be achieved from the FEED are summarised in the following table:

Table 5. Key milestones and delivery dates.

Work Package	Deliverable Goals	Delivery Date
Stake Holder Engagement	MOUs obtained for: • Users • Producers • Storage Providers For the identified core network as part of Phase 3.	March 2025
	Data capture forms and letters of support obtained for users in Phase 5.	
Commercial Package	Cost of the project to deliver (CAPEX and OPEX) for each leg (re-purposed line, re-purposing enabler and new line).	July 2026
	Identify requirement of commercial arrangements from all off-takers, producers, and storage companies.	
	Commercial risk identification and mitigation measures.	
HP / IP Package	All drawings, design reports, risk assessment reports, risk register.	July 2026
	Long lead Item schedule	
	Material Take Offs	
	Cost Report	

MP Package	All drawings, design reports, risk assessment reports, risk register.	July 2026
	Long lead Item schedule	
	Material Take Offs	
Pre-FEED Package	Hydrogen network map for North Tyneside and Cumbria regions.	November 2025
	Report for options	
	FEED cost	
	FEED programme	

Throughout the FEED phase, the deliverable goals will be monitored against the delivery timeline and agreed cost with regular meetings and mitigation measures in place.

6.4. FEED Phase Project Governance

A project control manual will be developed at the beginning of the project and issued to package leads. The project control manual will be updated and re-issued from time to time throughout the life cycle of the project.

The objectives of the project control manual are to ensure the FEED phase of the project is delivered consistently in accordance with NGN requirements.

The key tasks and responsibilities covered in the project control manual will be as follows:

- Delivery strategy carried out in accordance with NGN policies and procedures.
- CDM (Construction Design and Management) responsibilities are defined.
- Management of Package contractors and sub-contractors – technical, commercial and timelines (including competence / design management).
- Programme management.
- Appropriate meetings are carried out at predetermined frequencies.
- Risks are managed appropriately.
- Performance improvement (lessons learned).
- Consents, Approvals and Notifications are managed.
- Ofgem management and interface strategy management.
- Effective communication and reporting between internal and external stakeholders.
- Quality Assurance - during FEED (auditing/ monitoring/ handover records/ decisions traceability).

6.5. Project Planning

NGN is submitting this NZASP re-opener license application at the end of quarter one 2024, anticipating that the detailed assessment phase will take place through quarter two and that Ofgem will make a re-opener funding decision by the start of quarter three 2024.

NGN intends to divide the FEED into five packages aimed at ensuring the expertise available is focused in the relevant area. The packages will be as follows:

1. Project Union enabling works
2. NGN HP/IP Package – The core NGN hydrogen network
3. NGN MP Package – Spurs to reach industrial clusters
4. Consultation / Survey Package - Supporting all other packages
5. Pre-FEED of North Tyneside, Cumbria & other industrial customers – the wider roll out

During the period between this submission and the subsequent funding decision, NGN will continue engaging with the producers, storage suppliers and end users to ensure continued support for the project. NGN will also conduct a tendering process ahead of a funding decision to ensure that work packages can commence immediately following award.

NGN recognises that a significant factor in delivering the NGN core hydrogen network, while maintaining parts of the existing NGN network, is the reliance on NG's Project Union scheme. To this end, the focus for the first three to four months, following a positive funding decision, will be completing asset data gathering for the Project Union enabling works, further defining the NGN core network, and establishing the design basis with the FEED consultants whilst NG finalise options. The relationship between the Project Union works and the NGN core network is complex. This will require continual liaising between the parties. The programme within Appendix 24 – FEED Indicative Programme shows the dependencies between the activities both NG and NGN need to undertake. NGN has made allowances for verifying initial FEED works, following the completion of the NG FEED for the Cowpen Bewley to Asselby section of Project Union.

It is intended that the FEED study for Project Union enabling will begin in early 2025 and be completed by quarter two 2026, including final verification against the NG Project Union FEED.

The FEED for both the NGN core network (HP/IP) and the NGN MP network will also begin in early 2025 with completion expected by mid-2026. It is intended to undertake a full review before the completion of the design basis of all the current potential demand options, with a view to focusing on those options that provide a greater cost benefit. The options not selected in this initial review will be further assessed along with the Cumbria and North Tyneside areas in the phase 5 wider development stage. This process may require the programme to be updated to reflect the revised priorities. The FEED delivery programme will focus on delivering each FEED, based on when the demand is required i.e., the initial effort will be on delivering the Project Union enabling FEEDs along with the high-priority pipelines and AGIs needing to be operational by 2028. Emphasis will then be placed on the remaining 2028 projects followed by those targeting operational delivery by 2032 and 2037. The "high priority" 2028 options will be defined as those that are critical to the wider rollout and provide the greater cost benefit.

The phase five Pre-FEED for the wider NGN network will commence in late quarter three 2025 once a greater understanding of the core network and the MP network has been achieved. It will also be dependent on the confirmation of the Project Union Cumbria and Scotland transmission schemes.

NGN has made a provisional allowance for the works required following the production of the FEED packages. Once the Transport and Storage Business Model is further defined, NGN will re-visit these allowances and re-submit further defined proposals for Ofgem to consider. These proposals will be to define the Environmental Assessments and Planning Processes (DCO/TCP/etc.).

The project management package and the environmental and planning consultation packages will span the proposed FEED plan period.

The following plan outlines the planned FEED programme. The detailed programmes are contained within Appendix A24 – FEED Indicative Programme. NGN has included the following pdf views:

- Delivery Programme - Full View

- Delivery Programme – Redacted View
- Delivery Programme – Project and Phase Key Milestones

A fully logic linked Primavera P6 file upon request.

Also included in Appendix A24 is a view of the typical individual FEED programmes for a repurposed pipeline, repurposed AGI, new pipeline and new AGI. These are indicative and will vary based on the length, size, complexity and location of each pipeline and AGI.

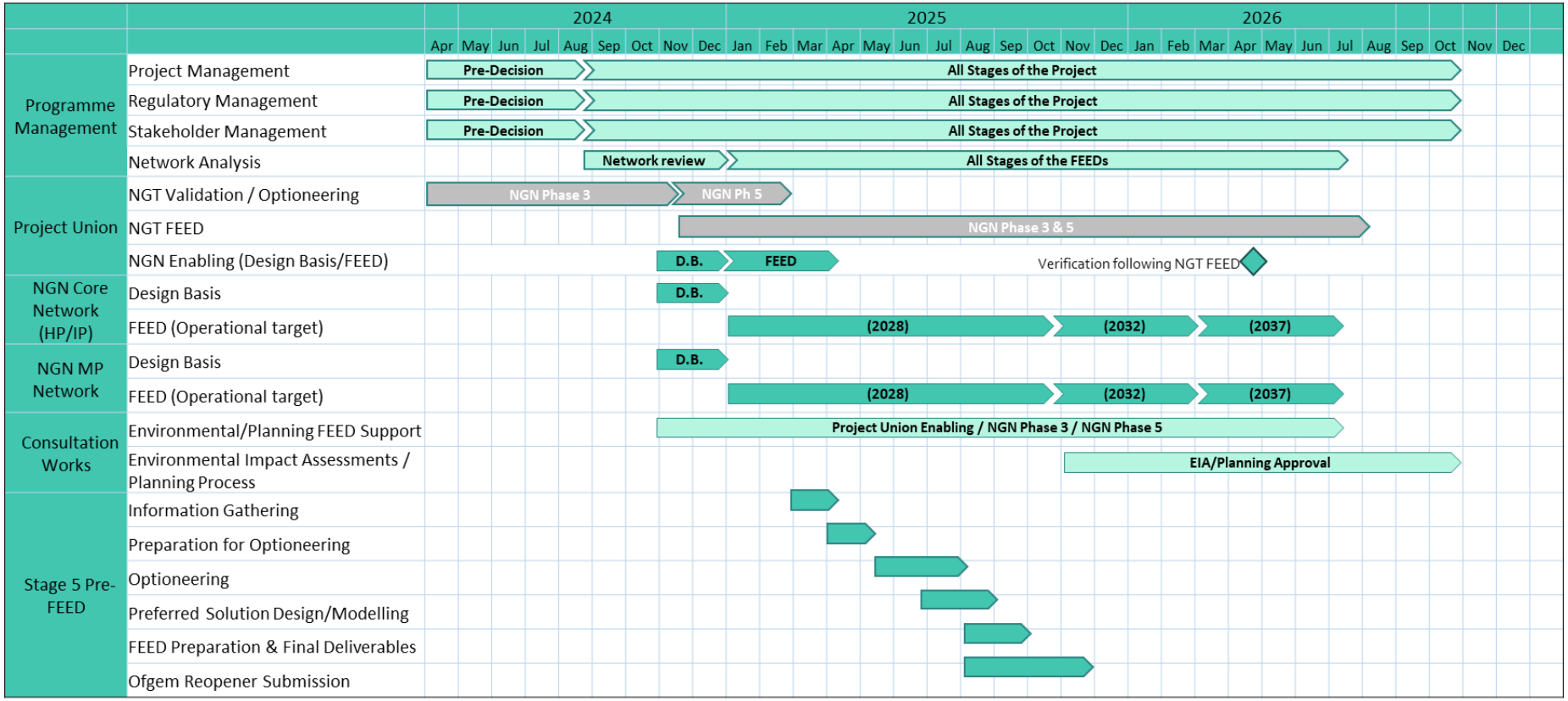


Figure 13. FEED Plan on a page.

6.6. FEED Engagement Plan

For the FEED, stakeholders have been divided into Direct & Indirect and engagement plans developed according to the type of engagement that will be required:

- **Direct Stakeholders** – These are the stakeholders required for the hydrogen network's development. This includes future users of hydrogen, hydrogen producers and hydrogen storage providers.
- **Indirect stakeholders** – These stakeholders will act as key enablers of the project. They include local authorities, various government bodies, and the wider industry.

All liaison and communication with stakeholders will be consistent, engaging, and meaningful. Through the stakeholder plan, stakeholders will:

1. Understand the project's purpose and how it will benefit the UK and them.
2. Be aware of project timelines and input needed at each point.
3. Have access to information in suitable formats.
4. Recognise the project team and have confidence in their engagements with them.
5. Have clarity on how any data they provide will be treated and with whom it will / will not be shared.

All stakeholder engagement activity and communications will be recorded using a central database (Tractivity) and various trackers to measure engagement, collate data, and avoid duplication.

Further details of the FEED Engagement plan can be found within Paper 3 - EJP.

7. Cost Information

7.1. Cost of FEED

This section explains how the cost requirements have been developed for this re-opener submission and how they comply with the requirements of RIIO2. The supporting excel spreadsheets are contained within Appendix A23 – FEED Cost Report.

7.1.1. Price structure

Due to the level of uncertainty regarding the final stages of the project, it has been split into two sections:

1. **Core FEED** – where the scope and price have been fully defined and costed.
2. **Business development model** – this section relates to the development of a business model submission where the scope and price cannot be finalised at this stage. This contains provisional sums. The alternative would have been to make a series of assumptions on risk probability and impact, and potentially apply very large risk allowances. NGN believes that this would artificially skew the price of the FEED without robust justification.

The price has been built using six work breakdown structure packages that reflect both the differing elements of the project scope and NGN's procurement strategy for delivery.

These packages are fully detailed in the FEED scope narrative in section six and appendix A22 – FEED Study Scope Report:

1. **Project Management**
   The project management resources to manage and ensure efficient delivery of the project objectives. Also includes the elements of the work that would be delivered by internal resources i.e. network modelling and industry engagement.
2. **HP & IP Pipelines and AGI's**
   The engineering works scope that enables National Gas works, as part of Project Union, and forms the core NGN network.
3. **MP Pipelines**
   The engineering works scope that allows repurposed and new MP distribution pipelines to be engineered to facilitate the supply of hydrogen to industrial consumers, forming the core network.
4. **Pre-FEED for wider roll out**
   This package explores how we will expand the network in the future, to reach areas such as Cumbria and North Tyneside. It will also examine further spurs, expanding the network in Teesside, West Yorkshire and The Humber. This is similar to the Pre-FEED words already completed and would lead to a subsequent re-opener submission that would be smaller in scale.
5. **Consents, Planning & Environmental**
   Supports other packages and is split into two sections. The first is for the core FEED and includes all the necessary consultation and engagement with third parties, to enable the network development to be finalised and accurately costed. The second is for provisional sums, to include necessary consultation and survey work for the Business Model submission.
6. **Business Model Submission**
   This section covers the work involved in taking the engineered and costed network to a full

submission under the Transport and Storage Business Model, it includes the investment analysis, the negotiation and legal works with partners, the further environmental and consultation work for EIA/DCO and planning submissions and the Business Model submission. The element is a provisional sum cost because of the key uncertainties outside NGN's control that will impact the scope and cost for this section i.e., Business Model details, NG optioneering, and investment plans of other potential partners. This will require further consideration in 2025 once the business model is finalised.

7.1.2. Approach to the development pricing of each package

7.1.2.1. Project Management

The project management structure has been developed to select experienced resources within NGN, including employees and retained professional consultants appropriate to the work packages. The resources have been evaluated, with timing and suitable allocation formed in conjunction with the needs of the programme. Each discipline has been separated on the resource histogram and collated by team. e.g., communications management, commercial management and network analysis. NGN has costed allowances for travel & subsistence separately for both employees and professional consultants. Furthermore, an allowance has been made in these work packages for events, workshops, roadshows, and website hosting which will allow the stakeholder management team to interface successfully with ECH_2 stakeholders.

For ease of reference, NGN has shown against each resource, the extra over-allocation associated with works package six - Business Model Submission. The resultant extra over cost forecast is carried into section six as a provisional sum amount.

The cost drivers for this section are the scope of work (as detailed in Appendix 23), the rates utilised and the programme duration. Cost efficiency for each of these is ensured by having a detailed FEED scope that clearly defines the activities to be carried out and therefore the project management required. The project management includes specific activities that will be delivered by NGN e.g. network modelling and industrial consultation. The requirements for these activities are detailed in the FEED scope. The rates used for staff are NGN's actual costs rates and where additional resources are anticipated, competitively tendered frame works rates are used i.e. professional services framework. The durations are efficient as they are based on the detailed FEED programme which is based on the detailed scope.

With the specific non-project management cost removed this cost can be benchmarked against other FEED contracts in terms of percentage against overall cost, it should be noted this is a complex, innovative project involving collaboration and engagement with a wide range of stakeholders.

7.1.2.2. High and Intermediate Pressure Pipelines and above ground installations

The scope for this package was developed throughout the Pre-FEED project and is contained in Appendix A22 – FEED Study Scope Report, with an explanatory narrative in Section six. This scope details specific engineering activities for each proposed new and repurposed pipeline. The scope details all the anticipated deliverables and an indicative programme for this scope has been developed and included in Appendix 24 – FEED Indicative Programme.

To price this document, NGN approached design framework partners and selected [redacted] to initially review the scope. [redacted] were then asked to prepare a detailed estimate that would form the basis of a future tender. This price build up was then jointly reviewed with [redacted] and Arup and forms the basis of the FEED price for this section.

[redacted] has completed a large number of FEED studies on the UK gas network and been able to benchmark this scope and cost against other projects of a similar type and scale.

NGN will employ an engineering consultant to deliver this element of the scope and believe this approach to pricing ensures that the cost allocated to this work package is in line with expected market conditions.

7.1.2.3. Medium Pressure Pipelines

The scope for this section was developed in the same way as the High-Pressure scope and again is contained in Appendix A22. NGN has greater capability to deliver these projects in house and has suitable historical data on these types of projects.

Once the scope was evaluated, Arup submitted an initial price for the works. After this, both Arup and NGN's in-house engineering team built up a cost looking at each specific pipeline and the general deliverables and activities. Both prices were similar, which gave NGN confidence in the cost allocated to this works package and therefore formed the basis of this price submission.

For both engineering packages above, NGN has assumed that at the start of FEED, the anticipated demand will be revalidated, and each element of the pipeline will be scored in terms of demand certainty, carbon saved, cost to deliver, technical and environmental challenges and their importance to the overall network configuration. The lowest scoring pipeline section will be removed from stage 3 scope and reconsidered for the wider rollout Pre-FEED within work package four and not progressed in terms of detailed engineering in the FEED study.

The rates used for both engineering package prices are based on NGN's design framework which has been recently re-tendered. This has ensured that current competitive market rates underpin the cost forecast. The cost for both HP and IP packages can be benchmarked against similar natural gas projects looking at the cost per kilometre for a particular diameter and pressure for pipelines and the cost per location for specific pressure rating for AGI's.

7.1.2.4. Pre-FEED for wider roll out

This section is a smaller version of the Pre-FEED that was completed in 2023 and was therefore priced by the Pre-FEED consultant [redacted] based on the costs of the initial Pre-FEED and the scope developed as detailed in section six and Appendix A22.

The use of [redacted], who NGN have efficiently worked with over the last eighteen months on the ECH_2 Pre-FEED, ensures that all lessons learnt are incorporated and the use of documentation and processes already developed is maximised. This price can be benchmarked against the recently completed Pre-FEED study for the core NGN ECH_2 network awarded to [redacted] whilst considering the other tenders received. The prices for this work were broken down into specific deliverables.

7.1.2.5. Consents, Planning & Environmental

All works contained within this package are planned to interface with the other work packages. Therefore, NGN has firstly focussed on the core FEED works to ensure accurate resources and pricing have been captured based on these known tangible deliverables. [redacted] has priced the scope by separating differing types of works and locations and applying the specialist resource and duration envisaged to successfully interface with both internal and external stakeholders.

Secondly, [redacted] has recalculated the same resources and durations applied against the envisaged involvement required to meet the needs of the Business Model Submission.

Prior to receiving the quotation fro[redacted] and to benchmark this package, NGN carried out a resource analysis to form a histogram of resource level and allocation in conjunction with the programme. Both outputs were very similar which therefore gave confidence in the cost values used for this package of works. This is the most difficult section to demonstrate efficiency and carry out benchmarking, due to the uncertainty of the scope in the latter stages of the project and hence the reason for splitting this scope into two parts, with the second part priced on a provisional basis as detailed in 7.1.2.6 below.

7.1.2.6. Business Model Submission

Based on knowledge from previous projects NGN has estimated resources associated with the anticipated requirements of the Business Model Submission. As this is NGN's interpretation of requirements, it is only correct to table this works package section as a provisional sum item which can be firmed up as the project moves further into the core FEED stage.

Costs have been collated from work packages one and six and these have been listed within the packages, but not taken into the core FEED cost forecast. They are shown as a separate works below the line as a provisional sum.

These costs assume these works will be concurrent with the core FEED scope of works and will generally start from 1st November 2025 and run until the end of the core FEED works, plus two months extra at the end in line with the current programme.

7.1.2.7. General

For the project as a whole, additional benchmarking can be carried out to compare the cost of the FEED. At [redacted] for the estimated cost of FEED (2023/24 prices) with the project delivery cost of [redacted] of the delivery cost, this is a low percentage for this type of FEED. A benchmarking cost can also be made in terms of price per kilometre which shows that the NGN ECH_2 FEED proposal proves cost efficient, in comparison to other hydrogen FEED projects.

7.1.3. Approach to Uncertainty

Within sections 7.1.1 & 7.1.2 NGN has identified the need for provisional sums to be allowed to cover unknown processes and workload levels.

With regards to uncertainty, NGN believes that risk has been sufficiently evaluated by either including allowances with the provisional sum item, or by pricing mitigation measures within the core FEED cost forecast.

NGN feels that by allowing for costs associated with known risks, which could be mitigated, it has provided a robust cost estimate for the core FEED works. Further risks associated with the development of the FEED and the Business Model Submission are better placed within the provisional sum amount, so that they can be accurately evaluated further into the project. This will avoid large subjective cost allowances needing to be made.

7.1.4. Risk Management

The project team and wider consultants have maintained liaison with each other during the build-up the of the re-opener application. Weekly risk workshops have ensured that risks are logged and discussed with resultant actions allocated to the team. This has ensured that any items that were not already included in the scope and cost forecast could be suitably evaluated.

The results of these evaluations have ensured NGN is able to remove these risks by making suitable allowances for mitigation measures.

An extract of a portion of the risk register in its current form is included within Appendix A25.

7.1.5. Cost Basis

NGN has calculated the cost forecast by using pricing at 2023/24 rates. Within the Application Cost Details in Appendix A23, pricing is shown at both 2023/24 and 2018/19 prices as required by Ofgem. The deflation calculations are shown within this document, with a separate tab identifying the factors used.

Also shown is the spend profile for each of the financial years of the project, in 2018/19 prices.

7.1.6. Price Sensitivity

The prices have been calculated using current frameworks and current NGN costs. Specific resources and their availability have been identified, and although there is a very high demand for this type of work, we believe the separation into a different package and a mixture of internal and external resources, limit the proposed price sensitivity to external market conditions.

7.2. Project Delivery Cost – Overall ECH2

The objective of this cost calculation is to estimate the total project CAPEX for the ECH_2 that is included in NGN's area. The cost estimates include the pipeline infrastructure that is developed in the network phase three during the Pre-FEED study.

The CAPEX estimates account for the following:

1. **Direct Costs** - this includes procurement, fabrication, and installation costs of pipelines and associated AGIs, including the cost of repurposing or modifying existing facilities. These costs are estimated for each facility and pipeline within the corresponding geographical area of phase three of the network. The total direct cost (TDC) is estimated by adding up the direct cost for each area.
2. **Indirect Costs** - this includes the cost for the management of the engineering, project, and commissioning. These were only applied as a percentage of the TDC.

A contingency of [redacted] has also been applied to the summation of total direct and indirect costs.

This cost estimation is based on 2023 prices and for the optimism biased price, the details are included in the CBA report by Frontier in Section 10.

7.2.1. Estimation of Direct Costs Methodology

The NGN area was classified into six geographical areas as detailed in the EJP section. Each geographical area is classified into different clusters. The detail of the selection process is defined in the EJP section.

In each cluster the following are selected, based on initial available data to carry out the design:

1. Pressure range of the pipeline i.e., HP, IP and MP
2. The nominal bore diameter of each pipeline
3. The length of each pipeline. This has been estimated from a desktop exercise for the new built pipeline and available records for the re-purposed pipeline.
4. Type of pipeline e.g., new pipeline or re-purposed pipeline

5. Number and types of infrastructure associated with the pipeline in each cluster including Pressure Reduction stations (PRI), Above Ground Installations (AGI), Off-Take connections, PIG trap facilities etc.

The per kilometre cost of each pipeline was estimated from past project experiences, based on material, fabrication, and construction costs.

A similar approach was adopted for the AGIs with cost estimation of valves, PIG traps, Tees, skid frames for pressure reduction facilities etc.

After the initial estimation per kilometre for the pipeline and piping accessories, these were applied to total length of the pipeline and the AGIs with a complexity factor.

The costs are summarised for each particular cluster and then for each geographical area. All these areas were then added up to arrive at the direct costs.

7.2.2. Key Assumptions in the Cost estimation

The following key assumptions were considered during the cost build up:

1. The pipeline repurposing cost is estimated based on a fixed factor relative to an equivalent new open-cut pipeline. The cost is assumed to include allowances for new natural gas assets needed to facilitate repurposing, investigations and condition assessments, replacement of any block valves and other costs associated with safety/environmental permits.
2. The fixed factor used for the above-mentioned costing is [redacted] of the equivalent new pipeline.
3. Land purchase costs for new/extended AGIs were considered to be [redacted] This was based on the pricing from NGN's land team and represents market rates.
4. Civil costs for new and extended AGIs assumed to be [redacted]
5. Fencing cost was assumed to be [redacted] per metre, based on past project experience and current market rates.
6. The complexity factors are considered as follows:
    - AGI has a complexity factor of 1
    - HP/ IP pipeline has a complexity factor of 1
    - MP pipeline has a complexity factor of 0.5

7.2.3. Delivery programme narrative

NGN has mapped out the overall ECH_2 scheme, dividing it into five stages:

1. Stage 1 Production & Storage
2. Stage 2 Transmission Development
3. Stage 3 NGN Core Network Development
4. Stage 4 Town Rollout (If required following heat decision)
5. Stage 5 Expansion of NGN's Hydrogen Network

The FEED Study is the next step in the stage gate process of the development of the ECH_2 following Pre-FEED works. It is a vital to allow for both the transmission development by NG and the development of an NGN core network to bring the plans for ECH_2 to fruition. Both will help to

deliver a regional and national hydrogen network, which is a key element of the UK's hydrogen and net zero strategies.

To meet the known demand for hydrogen and utilise the proposed production as well as storage, it is critical to commence the FEED phase at the earliest opportunity. It is envisaged that the FEED phase will take approximately two years, after which investment decisions will need to be undertaken. It is unclear at present how these investment decisions will be presented. The publication of the Transport and Storage Business Models (TSBM) in January 2025 should define this requirement. The NGN submission has accounted for this uncertainty by allowing for a provisional cost and mapping the process required to achieve a submission although this will be subject to confirmation following the publication.

During the above period NGN will undertake further Pre-FEED studies to assess those areas which couldn't be explored in the initial Pre-FEED study. These areas are in Cumbria and North Tyneside along with more remote end users around the NGN core network. The FEED phase will facilitate the wider network development to align with the government's long-term net zero targets.

The next stages will be the detailed design, procurement, build and commission of the proposed network. NGN will first target delivering to those users that are requesting a 2028 operational date. This will require the relevant Project Union phase being complete, which in turn requires NGN to undertake specific enabling works as identified on the FEED delivery programme. A completion of the foregoing by the end of 2028 requires commencement of detailed design by early 2027 to allow for material and equipment procurement to suit the expected build and commission durations.

NGN intends to repurpose existing pipelines and remodify the AGI's where possible. Currently a sizeable majority of the identified schemes follow this principle. The build phase will focus on ensuring the Project Union is enabled which will require continual engagement with NG. The next focus for constructing will be those spurs that facilitate a wider rollout, provide the best cost benefits and are within close proximity to the "backbone".

This will then be followed by further expansion of the network.

The following plan as below outlines the wider ECH_2 project:

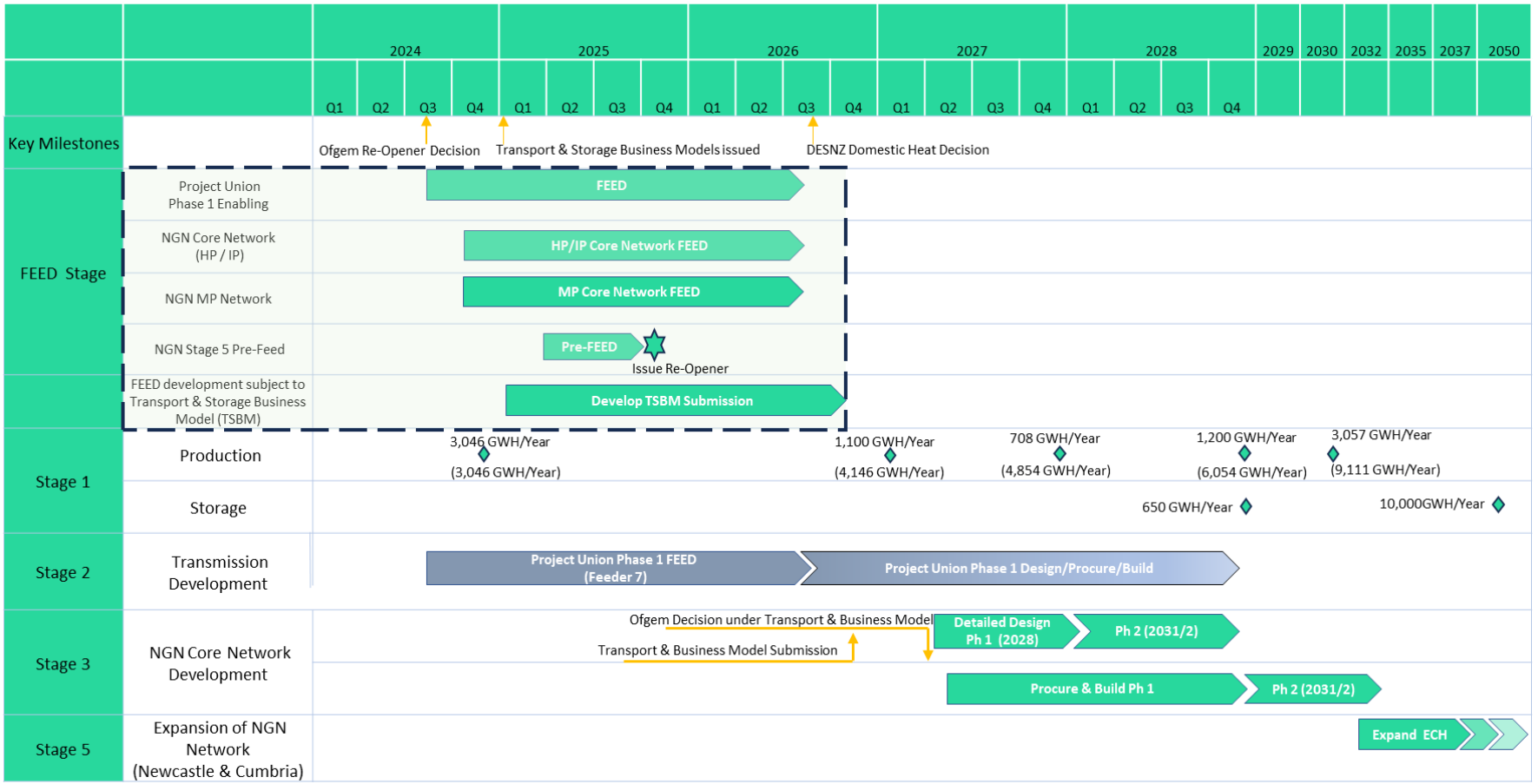


Figure 14. Project Delivery Timeline.

7.3. Cost Benefit Analysis (CBA)

Frontier Economics has carried out a societal CBA of the NGN hydrogen network investments forming part of ECH_2. The CBA follows HMT Green Book, Ofgem Re-opener and Investment Decision Pack (CBA) guidance. The proposal is relative to a counterfactual scenario that meets net zero without the proposed investments. This includes relevant options and sensitivity analysis across several scenarios and parameters. To ensure robustness and consistency between the various elements of the project, the CBA was completed in conjunction with Cadent and NG through regular engagement between all four parties. This approach has ensured the analysis is a robust and transparent decision support tool that is complementary to the engineering justification for the project. The CBA was developed iteratively over several months following challenge and scrutiny from network subject matter experts on regular working group meetings. The full CBA including details of compliance with guidance and full structured options development can be found in Paper 4. This includes full assumptions utilised and non-monetised as parts of the analysis.

The quantitative CBA focusses on estimating the Net Present Value (NPV) to 2050 of the project costs compared to the cost savings associated with NGN's network CAPEX and OPEX and wider energy system, including avoided decommissioning costs. The CBA considers both the costs and benefits of the FEED stage itself, as well as the value that would be added through the subsequent deployment of the ECH_2 network.

The CBA shows there are significant potential benefits from delivering the ECH_2 solution, compared to a future where no hydrogen network is developed. These benefits persist but are diminished if the rollout is delayed and are supplemented if a wider rollout takes place. To deliver these potential benefits, NGN must first deliver a FEED as an essential step to make ECH_2 a reality.

Within the CBA, Frontier Economics has considered four broad areas of benefits and disbenefits, these are described below:

1. Savings in industrial decarbonisation costs, i.e., the cost of decarbonising industrial and commercial processes which are recognised as being hard to decarbonise.
2. Avoiding the costs of reinforcing the electricity networks.
3. Hydrogen pipeline CAPEX and OPEX costs, i.e., the cost of converting and maintaining NGN's network to transport hydrogen.
4. Environmental costs and benefits, which include construction emissions, as well as fugitive emissions.

These have been applied to three different scenarios:

1. **Base Case** – This considers the deployment of the network at Stage 3, reaching users in the Humber, Yorkshire and Teesside.
2. **Delayed Demand** – In this case the demand in 2030 for the Base Case is delayed by 50% per customer for five years.
3. **Wider rollout** – This corresponds to the network at Stage 5, extending to North Tyneside and Cumbria.

Overall, the main finding from the CBA was that:

*The base case estimate is for a net monetised cost saving (relative to the counterfactual) of **£3.1 billion** (NPV, 2023 prices).*

This is summarised in the table below.

Figure 15. Breakdown of results: Savings in estimated industrial fuel costs are the main driver of the CBA results.

Quantified impacts (£, million)		**Case 1** *Base case*	**Case 2** *Delayed demand*	**Case 3** *Wider rollout*
Savings in industrial decarbonisation costs	Core network (Phase 3)	3,750	3,058	3,750
	Wider rollout (Phase 5)	0	0	1,221
Savings in electricity network costs	Core network (Phase 3)	16	16	16
	Wider rollout (Phase 5)	0	0	6
H2 pipeline CAPEX and OPEX	Core network (Phase 3)	-648	-648	-648
	Wider rollout (Phase 5)	0	0	-163
Environmental costs (fugitive and construction emissions)	Core network (Phase 3)	-33	-33	-33
	Wider rollout (Phase 5)	0	0	-10
Total net benefits (£, billion)		**3.09**	**2.39**	**4.14**

The CBA results remain positive under sensitivities considered for energy supply costs, and under other scenarios (including one considering a delay to uptake in hydrogen demand by industrial customers).

Further to this, the quantitative CBA result does not fully quantify certain strategic benefits of a hydrogen network (including potential reduced risks associated with meeting net zero goals and improved security of hydrogen supplies).

While the detail of the CBA is set out in appendices to this submission, some key points from the analysis are:

7.3.1.1. Industrial costs

Savings in estimated energy supply and network costs account for the majority of estimated savings in industrial decarbonisation costs. These arise because, with a hydrogen network in place, industrial customers can access lower-cost hydrogen production (backed up by underground hydrogen storage) and can avoid the additional costs associated with either electrification or on-site hydrogen supply in the counterfactual.

In the absence of ECH_2, hydrogen must be produced locally and piped to industrial customers and/or more costly electrification must displace natural gas demand. Therefore, the sum potential saved cost is equivalent to the TOTEX associated with the ECH_2 alternative. This includes the hydrogen conversion outlays, such as the costs of retrofitting gas technology (i.e. hydrogen boiler), CAPEX, fixed OPEX, and fuel efficiencies based on the CCC/Element Energy N-ZIP (Net Zero Industry Pathway) model. The hydrogen cost is based on levelised cost (LCOH) built on DESNZ assumptions for electricity costs (green hydrogen) and industrial gas supply costs (blue hydrogen).

7.3.1.2. Power generation costs

The economic assessment considers the effects of changing the location of hydrogen-to-power (H2P) capacity on electricity network reinforcement costs. To estimate the power generation costs of the counterfactual project, the CBA assumed a change in the demand location for the H2P. This has an implication and impact on electricity network costs. Here, demand for H2P is considered in the economic assessment, as this technology is expected to play an important role in providing flexibility to the electricity system. Moreover, H2P is required to be backed up by large-scale (underground) hydrogen storage capacity.

As with industrial and commercial customers, ECH_2 would allow demand and production to be physically separate. Therefore, ECH_2 would facilitate the optimal setting of hydrogen to power generation plants for both the nascent hydrogen sector and the electricity system, generating electricity network savings.

7.3.1.3. Pipeline costs

The costs of building and operating the hydrogen network are contrasted to the costs of decommissioning the pipeline in the counterfactual – the ECH_2 pipeline costs (CAPEX and OPEX). For NGN, this is made up of CAPEX estimates and FEED costs. As for hydrogen OPEX, GDNs do not have precise estimates, therefore a proxy is obtained using an approach that starts with the average methane network OPEX per km and then applies an uplift to reflect a possible increase in OPEX during the delivery of the gas grid transition from increased complexity and first of kind use.

Regarding the ECH_2 decommissioning costs, assets that would be repurposed in the factual are assumed to be decommissioned in the counterfactual to ensure an identical methane network configuration (and the resulting level of security of supply on the methane system) in the factual and counterfactual. In other words, the costs of building and operating the pipeline are larger than the cost savings from decommissioning in the counterfactual, with hydrogen pipeline CAPEX being the primary cost driver. It is assumed that NGN will use the sectioning and capping method to decommission the pipes and have estimated costs based on the approach taken by [redacted] in its recent report supporting the National Infrastructure Assessment.

There is a cost inherent in repurposing the system for hydrogen. However, ECH_2 would also avoid the cost of decommissioning the network if natural gas use ceases.

It is clear that the deployment of ECH_2 in the east coast region will result in a net £3.1 billion cost savings, on top of further strategic benefits such as bringing jobs to the area, improving hydrogen supply, and lowering risk to meet net zero.

7.4. Proposed Regulatory Treatment of Costs

This trigger application is necessary under Special Condition 3.9 Net Zero Pre-construction Work and Small Net Zero Projects Re-opener (NZASP) of NGN's Gas Transporters licence as it is a project that will support the achievement of net zero carbon targets. The ECH_2 FEED phase will cause

NGN's Licenced Activity and costs to increase during the RIIO-2 Price Control Period and there is no other provision available in the regulatory framework to fund and deliver this project. Therefore, the expenditure is additional to that already provided for by relevant ex ante allowances and cannot be provided through other uncertainty mechanisms.

There are several available approaches to Regulatory Treatment of Funding for ECH_2 FEED phase. The table below summarises the potential options and their relative strengths and weaknesses.

Table 6. Description of the different funding mechanisms and their suitability to fund this project.

Funding Mechanism	Pros	Cons
Ex-Ante Allowance (Additional TOTEX) **Preferred Approach**	Clear allowance based on forecasts. Simple / low regulatory burden. Incentive to outperform cost forecasts and share benefit with customers through the TOTEX Incentive Mechanism (TIM). Network is liable for ~50% of any overspend based on RIIO-2 TIM factors, which shares the risk between customers and networks. Partial capitalisation over 45 years reduces the in -year bill impacts on customers.	Partial protection for customers and networks from uncertainty in forecasts. Not ringfenced / no mechanism to claw back if underspend beyond TIM.
Use It Or Lose It (UIOLI)	Accounts for Cost Uncertainties. Flexible Mechanism. Low Regulatory Burden. Customer gets all of underspend back.	Lack of incentive to outperform costs / drive efficiencies. Network liable for any overspend, may encourage conservative cost forecasts.
Actual Cost Recovery (Pass Through)	Accounts for Cost Uncertainties. Flexible Mechanism. Low Regulatory Burden. Customer only pays for actual costs incurred.	Lack of incentive to outperform costs / drive efficiencies. Open ended risk to customers for overspend.
Price Control Deliverable	Unused allowances automatically returned to customers.	Lack of incentive to outperform costs / drive efficiencies.

	Specific deliverables linked to funding.	Network liable for any overspend, may encourage conservative cost forecasts. Requirement to demonstrate deliverables increase regulatory burden, plus challenges in measurement.
Volume Driver	Not appropriate in this case, due to discrete large-scale project.	No unit cost / standardised variable volume.
Delay to next price control	No bill impact in GD2.	Against GD2 / Net Zero commitments/ ambitions. Risks delay, increasing Net Zero costs for industry / UK as per needs case and CBA.

NGN supports the selection of the simplest and least burdensome way to approach Regulatory Treatment of Funding for the ECH_2 FEED phase, which fairly shares the risks between networks and customers, and incentivises efficient delivery of the project. It is NGN's preferred approach that ECH_2 is funded through additional TOTEX allowance. This would ensure that the funding is clear minimising project costs. Should the project cost less than forecast, customers benefit from the returning of funding via the TIM sharing mechanism. Should the project overspend, networks would be liable for funding their proportion of the TIM, currently ~50% at RIIO-2. This approach has the advantage of fairly sharing risks between customers and networks and sharing costs between customers over time due to the partial capitalisation of costs over 45 years through the TOTEX revenue mechanism and regulatory asset value. NGN must demonstrate that the project has been efficiently delivered on its objectives at closeout and Ofgem could recover costs if that wasn't the case. This ensures that customers are adequately protected. This is consistent with NZASP guidance Sections 2.21 and 2.22.

In addition to the choice of funding mechanism itself, there is the application of that mechanism across partners to recover costs of the project. NGN supports having the mechanism applied to NG and for them to recover the costs through NTS charges on customer bills as outlined in the NG presentation to Ofgem on the 11th of December 2023. This will socialise costs across Great Britain, which ensures minimal impact on individual customer bills, as discussed in Section 7. This project will ultimately benefit the UK by enabling a more cost-effective transition to net zero and is therefore a fair approach. This is consistent with NZASP guidance Section 2.21b.

To enable NGN to demonstrate that it has met Ofgem requirements for the regulatory treatment of funding, NGN considers it appropriate to have a close out report summarising delivery and that the ECH_2 FEED has met the objectives of the project and criteria outlined efficiently. This will also aid in dissemination of learnings and knowledge to industry and stakeholders from the project and related projects. As part of ex-post reporting requirements, NGN will commit to a stakeholder event to present the findings and outputs of the FEED stage to interested parties.

7.5. Funding Request

The cost forecast has been calculated using pricing at 2023/24 rates. As required by Ofgem, pricing at both 2023/24 and 2018/19 has been shown in the Application Cost Details in Appendix A23. The deflation calculations are shown within this document, with a separate tab identifying the factors used.

The cost forecast for the project is [redacted] at 2023/24 prices, which equates to [redacted] at 2018/19 prices.

Therefore, the funding request to Ofgem would be [redacted] at 2018/19 prices.

For the project, the following amounts (2018/19 prices) have been forecasted to enable spending within the relevant financial year.

Table 7. Funding Request Cost Summary

[redacted]

All amounts of funding requested will have to be inflated using the appropriate mechanism by the correct inflation factor attributable to the year of forecasted spending.

7.6. Contribution Towards Project

Along with other partners and consistent with Section 2.10 of the NZASP guidance, NGN will provide a private contribution towards the FEED project and lower the cost passed onto consumers equivalent to 10% of the total project cost. This is consistent with previous projects of a similar nature, such as the Redcar Hydrogen Community, and the default level of substantively innovative projects such as ECH_2. This is proportionate due to the nature of the project, the levels of risk associated with it and the extent of non-network benefits that the project has the potential to deliver.

[redacted]

7.7. Why the customer should pay

7.7.1. ECH_2 addresses the national net zero challenge

ECH_2 is a national infrastructure project that covers approximately two thirds of the UK gas industry network (i.e., NGN, Cadent and NG), and seeks to address a legally binding commitment to achieve net zero carbon emissions by 2050. Cognisant of the UK's levelling up agenda, spreading the cost of ECH_2 FEED study across all gas consumers and over time enables fair treatment of decarbonisation,

whilst benefiting all consumers at a national level, including those not directly involved in hydrogen fuel switching.

7.7.2. ECH_2 benefits all gas consumers

An interconnected and at scale hydrogen system, enabled by ECH_2 will ensure competition, minimise overall system costs and deliver value-for-money as well as improve the UK's resilience and security of supply of 'home grown' energy. Access to affordable, low carbon hydrogen allows I&C and power sectors to further invest and grow, protecting and enhancing local as well as national jobs. This could also catalyse export opportunities of UK produced low carbon hydrogen or low carbon industrial products to international markets.

Targeting FEED costs to a specific consumer group would create a 'post-code lottery' for consumers, potentially providing a negative market signal to UK I&C and Power sector to delay their decarbonisation plans. Investing early and spreading costs across all bill payers will keep all options for net zero open, and avoid the UK embarking on high first-mover costs and decarbonisation technology lock in.

7.7.3. ECH_2 seeks to minimise volatile and unpredictable gas bills

Socialising FEED study costs across all consumers avoids complex, volatile, and unpredictable gas bills for a minority group of consumers. Funding for similar infrastructure project scoping studies such as HyNet FEED, Project Union Pre-FEED, have already been socialised across all gas payers.

7.7.4. ECH_2 seeks to enable an affordable and secure whole energy system

The ECH_2 project scope includes re-purposing the natural gas grid, focussing on Teesside, West Yorkshire, and Humber regions, which helps reduce future gas bills by extending the useful life of the gas network. This also helps reduce the potential risk of asset stranding and associated accelerated asset depreciation cost, resulting in higher consumer bills.

Hydrogen provides a flexible, dispatch ready source of energy during Dunkelflaute when renewable electricity generation is low. Hydrogen infrastructure built by ECH_2 will play a vital role in facilitating a net zero power grid by 2035 and an overall affordable and secure UK energy system.

8. Assurance

As a part of the assurance requirements under Ofgem's re-opener guidance, NGN has provided confirmation from the CEO, [redacted] to ensure that the three assurance points requested by Ofgem have been met in the final submission.

Table 8. Summary of assurance requirements and how they have been met.

Re-opener Assurance Requirement	How is the requirement met?
1) We require high-quality information from licensees in their Re-opener applications in order to carry out robust and timely assessments of those applications. To this end, licensees must make Re-opener applications that are accurate, unambiguous, complete, and concise.	To ensure a high-quality application that is accurate, unambiguous, complete and concise, the application has been prepared by a multi-disciplinary team involving leaders and subject matter experts from NGN and external consulting organisations. The application has undergone an extensive and iterative internal challenge and review by senior leaders. Further, the content of the application has also been shaped through engagement with Ofgem and other project partners (i.e., NG and Cadent).
2) All re-opener applications must be accompanied by written confirmation from a suitable senior person within the company that the Re-opener application has been prepared and submitted, such that: • it is accurate and robust, and that the proposed outcomes of the Re-opener are financeable and represent good value for consumers. • there were quality assurance processes in place to ensure the licensee has provided high-quality information to enable Ofgem to make decisions which are in the interests of consumers. • the application has been subject to internal governance arrangements and received sign off at an appropriate level within the licensee. For example, this may be sign-off by the company board if appropriate.	The application is accompanied by a written confirmation from NGN's CEO to demonstrate the application successfully meets this requirement. The submission has been approved by each of the relevant functional directors. Engineering – Hydrogen Programme Director Regulation – Regulation and Strategic Planning Director Commercial – Head of Commercial Finance Communications – Head of Policy and Engagement This submission has been approved on behalf of the board by the NGN CEO, [redacted].
3) A point of contact must be provided for each Re-opener application,	A point of contact is provided within the covering letter to this submission.

	including name, position, email, and phone number.

9. Glossary of Terms

Term	Definition
AACE Class 3	Association for the Advancement of Cost Engineering – Cost Estimate Classification System – Class 3
AGI	Above Ground Installation
AMP	Asset Management Plan
Blue Hydrogen	"Blue" hydrogen splits natural gas into hydrogen and carbon dioxide, with the carbon captured and stored.
CAPEX	Capital expenditures are funds used by a company to acquire, upgrade, and maintain physical assets such as property, plants, buildings, technology, or equipment. CAPEX is often used to undertake new projects or investments by a company.
CBA	Cost Benefit Analysis
CDM	Construction Design & Management Regulations 2015
Depreciation	Depreciation is a measure of the consumption, use or wearing out of an asset over the period of its economic life.
DCO	Development Consent Order - the means of obtaining permission to construct and maintain developments categorised as Nationally Significant Infrastructure Projects (NSIPs)
DESNZ	Department for Energy Security and Net Zero
Dunkelflaute	A German word referring to a period of winter weather with low light and little to no wind
ECH2	East Coast Hydrogen. A collaborative project between National Gas, Cadent and Northern Gas Networks
EIA	Environmental Impact Assessment
FEED	Front End Engineering and Design
FSO	Future System Operator
GDNs	Gas Distribution Networks- There are 8 individually licenced gas network areas operated by 4 companies: Cadent, Northern Gas Networks (NGN), SGN and Wales & West Utilities (W&WU). The GDNs are supplied with most of their gas from the NTS and deliver it to industrial, commercial, and domestic customers.
GHG	Green House Gas
GIGA	Green Industries Growth Accelerator
GIS	Geographical Information System
Green Hydrogen	"Green" hydrogen uses electrolysis, passing electricity through water to separate out the hydrogen and oxygen
GSMR	Gas Safety Management Regulations
H2P	Hydrogen to Power
HAR	Hydrogen Allocation Round
HP	High Pressure – 7 Bar and above
HTBM	Hydrogen Transport Business Model
HyNet	HyNet North West is an innovative low carbon and hydrogen energy project that will unlock a low carbon economy for the North West and North Wales.
IP	Intermediate Pressure – 2 Bar to 7 Bar
LDZ	Local Distribution Zone
LP	Low Pressure – 30 mBar to 75 mBar

LTS	Local Transmission System - The pipeline system operating above seven bar that transports gas from national transmission system offtakes to distribution systems.
MCA	Multi-Criteria Analysis
MP	Medium Pressure – 75mBar to 2 Bar
NESO	National Energy System Operator
NEY	North-East & Yorkshire Net Zero Hub
NG	National Gas
NGN	Northern Gas Networks
NIC	National Infrastructure Commission
NPV	Net Present Value
NTS	National Transmission System - The high-pressure gas transmission system in Great Britain
NZASP	Net Zero Pre-construction Work and Small Net Zero Projects Re-opener- This mechanism allows Gas Transporter licensees to undertake early design, development, general pre-construction work, and Net Zero facilitation capital projects that will enable the achievement of Net Zero Carbon Targets.
N-ZIP	Net Zero Industry Pathway
Ofgem	Office of Gas and Electricity Markets
OPEX	Operating expenses or expenditure, refers to the costs incurred by your business via the production of goods and services. It can include a broad range of expenses, such as materials, labour, machinery, packaging, shipping materials, and so on.
PCFM	Price Control Financial Model
Price Control	The control developed by the regulator to set targets and allowed revenues for networks companies.
RAV	Regulatory Asset Value- The value ascribed by Ofgem to the capital employed in the licensee's regulated transmission business.
Regulatory Burden	A term used to describe the cost- both monetary and opportunity- of regulation.
RESP	Regional Energy Strategic Planner
RIIO	Revenue=Incentives + Innovation + Outputs (Ofgem's regulatory framework)
ROI	Return on Investment
RPE	Real Price Effects- Expected changes in input prices, e.g., wages, relative to the Retail Price Index (RPI)
RPI	Retail Prices Index- An aggregated measure in changes in the cost of living in the UK.
SAF	Sustainable Aviation Fuel
TIM	TOTEX Incentive Mechanism
TOTEX	Total expenditure- TOTEX generally consists of all the expenditure relating to a licensee's regulated activities but except for some specified expenditure items. The annual net additions to RAV are calculated as a percentage of the TOTEX.
TSBM	Transport and Storage Business Models
TVCA	Tees Valley Combined Authority
UIOLI	Use It or Lose It. A funding approach whereby unspent money is clawed back.
WYCA	West Yorkshire Combined Authority

10. Appendices

Appendix Number	Appendix Title
A1	Demand Study Report
A2	Top 250 Tracker
A3	Business Development Tracker
A4	Project Delivery Timeline
A5	Continuum Options Cost Estimation
A6	Indicative Project Cost Report
A7	Frontier CBA Calculation
A8	Ofgem engagement presentations and notes of engagement meetings
A9	Pre-Trigger Proposal and Ofgem trigger
A10	Assessing the Regional Demand for Geological Hydrogen Storage
A11	Delivery Plan
A12	Production Study Report
A13	Storage Study Report
A14	Letters of Support
A15	Repurposing Strategy
A16	Options Design Basis
A17	Initial Network Modelling Brief
A18	Demand Capture Forms
A19	Template Stakeholder Contact Email
A20	Options and Phasing Study Report
A21	Pre-FEED Report
A22	FEED Study Scope Report
A23	FEED Cost Report
A24	FEED Indicative Programme
A25	Project Risk Register
A26	Assumption and Decisions Register
A27	Re-opener Guidance Linking Table
A28	Assurance Letter

11. Redaction Statement Strategy

The documents listed below will be redacted ahead publishing. This is predominantly due to client confidentiality and commercially sensitive information being included.

Table 9. Redaction Strategy.

Section	Type of Redaction	Reason for redaction
Section 5 & 6 – EJP and FEED Scope	Partial	Only sections regarding any commercial material have been redacted.
Section 7 – Cost of FEED	Partial	This section contains commercially sensitive information regarding the cost of the project. As a result, mention of specific monetary values has been redacted.
Section 8 – Needs Case Document	Partial	Some of the case studies shared have been deemed commercial sensitive by the producer and they have requested it is redacted from the public version.
A2 – Top 250 Tracker	Full	Tracker includes company names and gas usage. This has been deemed sensitive information.
A3 – Business Development Tracker	Full	Tracker includes details on stakeholder engagement. This has been deemed sensitive information.
A5 – Continuum Options Cost Estimation	Full	This section contains commercially sensitive information regarding the cost of the project and has therefore been redacted in full.
A6 – Indicative Project Cost Report	Full	This section contains commercially sensitive information regarding the cost of the project and has therefore been redacted in full.
A12 – Production study Report	Partial	Section 5.2 and Appendix A2 of this document has been redacted as this contains commercially sensitive information that is not currently publicly available.
A14 – Letters of Support	Partial	One of the Letters of Support has been redacted from the appendix upon request from the entity that provided it.
A18 – Demand Capture Forms	Full	Gas usage information is present in the tracker and tis has been deemed sensitive information.
A23 – FEED Cost Report	Full	This section contains commercially sensitive information regarding the cost of the project and has therefore been redacted in full.
A25 – Project Risk Register	Full	This section contains commercially sensitive information regarding the cost of the project and has therefore been redacted in full.