Cadent
Your Gas Network

EAST COAST HYDROGEN PIPELINE (ECHP)

NORTH – PHASE 1

NZASP RE-OPENER SUBMISSION

PUBLIC (REDACTED) VERSION

Governance Table

The table below outlines where each section of this application relates to Special Condition 3.9 of our Gas Transporter licence, as well as Ofgem's requirements as set out in Special Condition 9.4.

Ofgem Requirement	Application Chapter/Section
Special Condition 3.9 Net Zero Pre-Construction Work and Small Projects Re-opener (NZP_t)	
Support the achievement of Net Zero (3.9.1)	Exec Summary Chapter 2 – Needs Case
Application Requirements (3.9.4 a-d)	All chapters (1 to 8)
Re-opener Guidance and Application Requirements document (Feb 2023)	
Introduction (value and justification of adjustment) (para 3.1 to 3.5)	Exec Summary Chapter 1 – Project Description
Gas Distribution Sectors (para 3.6 to 3.7)	Chapter 5 - Cost information
Needs case and preferred option (para 3.8)	Chapter 2 - Project Needs Case Chapter 3 - Project Option Selection
Alignment with overall business strategy and commitments (para 3.10)	Section 2.5 - Alignment with overall business strategy and commitments
Demonstration of Needs case/problem statement (3.11)	Chapter 1 - Project Description Chapter 2 – Needs Case
Consideration of Options and Methodology for Preferred Option (para 3.13)	Section 3.1 – Strategic Options Section 3.2 – Project Phasing and Selection of the Project
The Preferred Option (para 3.14)	Section 3.3 - Pipeline Network Development
Project Delivery and Project Monitoring (para 3.15)	Chapter 6 – Project Delivery and Monitoring
Stakeholder engagement and whole system opportunities (para 3.16 to 3.18)	Chapter 7 - Stakeholder Engagement and Whole System Opportunities
Cost Information (para 3.19 – 3.21)	Chapter 5 - Cost information
Cost Benefit Analysis & Engineering Justification (para 3.22 & 3.23)	Section 2.10 - CBA Section 2.11 - CBA results Section 2.12 - Commentary on CBA Results Section 2.13 - Additional Benefits of Building ECHP North – Phase 1 Section 3.1 Strategic Options Section 3.2 Project Phasing and Selection of Project Section 3.3 Pipeline Network Development
Net Zero Pre-Construction Work and Small Projects Re-opener Governance Document (March 2023)	
Scope and Eligible Projects (para 2.1 to 2.3)	Chapter 4 – FEED Scope of Works Chapter 8 – Regulatory Treatment and Bill Impacts
Materiality Threshold (para 2.4 to 2.6)	Section 5 – Cost Information (this re-opener is above £1m)

Process (para 2.7 to 2.9)	Pre-engagement with Ofgem is detailed in Section 7.1 – Engagement with Ofgem and DESNZ
NZASP Contribution (para 2.10 to 2.13)	Section 5.7 – Cadent contribution

KEY CONTACTS

The Key contacts for this Re-opener and to who questions regarding this submission should be made are:

Sally Brewis (Head of Regional Development) – Sally.Brewis@cadentgas.com (07816 109424)

Adam Knight (Project Director) – Adam.Knight2@cadentgas.com (07929 065038)

March 2024

Classification: Confidential

In this application we have redacted all cost information on the basis that this is commercially sensitive. Other areas have been redacted on the basis that information is considered sensitive or the 3rd party that has provided the data has requested that it should be redacted.

Contents

Executive Summary

Since early 2021, we have collaborated with National Gas and Northern Gas Networks (NGN) to develop the **East Coast Hydrogen (ECH_2) programme**. The aim of ECH_2 is to connect industry and power generation sites to low carbon hydrogen production sites across the North-East, Yorkshire and the East Midlands via repurposed and new pipelines. The map of the ECH_2 area is shown in Section 1.1, Figure 1 and 2.

Our portion of the ECH_2 project is known as **East Coast Hydrogen Pipeline (ECHP)**. It's an integrated hydrogen pipeline network that connects Immingham with South Yorkshire and the East Midlands. Due to its extensive geographical coverage, it has been segmented into sections, each to be delivered through a separate project. The map for ECHP can be viewed in Section 1.2, Figure 3.

We are applying for funding for **£33.39m (2018/2019 prices)** to undertake Front End Engineering Design (FEED) and consenting on the first of our ECHP projects: **North – Phase 1,** which connects Immingham (a major hydrogen production centre) with industry based close-by and in Scunthorpe, Doncaster and Rotherham. The pipeline will supply **3.4TWh** per year of hydrogen to industry and power generators by 2030, abating c.**0.4mt/CO_2e per annum**.

ECHP North – Phase 1 was selected as the first project to move into FEED and consenting stage for several reasons as explained in Section 3. Compared to other sections of ECHP, North – Phase 1 connects the largest volume of industrial hydrogen demand per kilometre, and has five different production projects planned for connection, offering a diversity of supply. Production in Immingham is forecasted to produce 17TWh per year of hydrogen by 2030, exceeding our 2030 and 2035 demand by a large margin. ECHP North – Phase 1 is also close to **large geological storage** that is being developed at Aldbrough, North of the Humber River.

ECHP North - Phase 1 is supported by local government, hydrogen producers and the industries that will use the hydrogen to switch away from natural gas. Stakeholders relevant to the ECHP North – Phase 1 project make up at least 20 of the 122 organisations that support the wider ECH_2 project. From our regular engagement with producers and supply chain organisations, we know that the ECHP North – Phase 1 project is the most well-developed 'live' large-scale pipeline plan in the region and will be critical to providing offtake connections for the planned production projects by 2030, initiating the local hydrogen economy. The high quality of our Pre-FEED work delivered by organisations with global hydrogen experience, our firm stakeholder relationships and up-to-date understanding of demand and supply, and the certainty of our preferred routing make the ECHP North – Phase 1 pipeline a very strong proposition. Added to this, our development of the HyNet pipeline, which has completed FEED stage, has created invaluable learning and a track record that will make the 'deliverability' of ECHP North – Phase 1 higher.

This ECHP North – Phase 1 Re-opener application is the first of multiple planned ECHP Re-openers that will seek to build further pipelines that connect supply and demand in the East Midlands ('South - Phase 1'), connect the 'North' and 'South' Phase 1 projects, and expand deeper into the regions. Our aim is complete the full ECHP by 2037.

The full Cadent ECHP region, the multiple phases of ECHP and the North – Phase 1 preferred pipeline route is shown in Section 1.4, Figure 4.

The following table outlines the key points for the ECHP North – Phase 1 project:

Name of Project	**East Coast Hydrogen Pipeline (ECHP): North – Phase 1**
Project Phase	FEED and Consenting
Primary Investment Driver	The Net Zero Pre-Construction Work and Small Net Zero Projects Re-opener (NZASP)
Initiation Year	2024
Close Out Year	2028
Funding Requested (2018/19, £m)	33.39
Cadent Contribution (10%) (2018/2019, £m)	3.71
Total FEED and Consenting Cost (2018/2019 £m)	37.10
ECHP North – Phase 1 Class 5 CAPEX Project Construction Estimate (£m,2023)	732
Cost Estimate Accuracy (%)	+33% to -12%
Pipeline Length	Circa 136km
Number of Hydrogen Above Ground Installations (HAGIs)	Circa 8 mainline + additional for producers and some customers (circa 12 additional)
Total Hydrogen Demand (2030,TWh)	5.7 (with Pilot Town)* 3.4 (without Pilot Town)
Total Available Production (2030,TWh)	17
Emissions savings (Mt CO2e) by 2030 per annum	0.4 excluding pilot town 0.7 including pilot town*
Anticipated Construction years	2028-2031 (based on current planning assumptions)
* If required, ECHP North – Phase 1 could supply low carbon hydrogen to Scunthorpe and enable a 'Hydrogen Town Pilot', subject to Government's heat policy decision in 2026.	

We are requesting, via this Re-opener, **£33,393,898 (2018/2019 prices)** of funding with Cadent contributing **10% contribution** of ([cost data] 2018/2019 prices) to undertake a FEED and consenting stage from 2024 to 2028. Of the total phase funding of [cost data], funding allocation is [cost data] on the FEED and Development Consent Order (DCO) submission, £5,962,488 on DCO acceptance/examination and finally a [cost data] on a contingency allowance.

This FEED and consenting phase can now be undertaken because of the completion of a successful Pre-FEED that finished at the end of 2023. Completion of the FEED and consenting by the end of 2027 will enable a **Final Investment Decision to be made in 2028**, subject to current planning timelines being met. The main two deliverables that the funding will enable are:

1. The completion of a FEED Study: Including technical considerations of pipeline routing, pressure control, materials and safety case.
2. The preparation, submission and examination of a DCO: It is likely that ECHP North – Phase 1 will be classified as Nationally Significant Infrastructure, therefore a DCO application will be required to be submitted.

Developing the ECHP North – Phase 1 pipeline could unlock a series of benefits:

The delivery of hydrogen in this region provides a means for the industrial sector to decarbonise. Through our extensive engagement work over the last 2.5 years, industries have advised that they require hydrogen as part, or all of their energy needs, to transition away from natural gas. The ECHP North - Phase 1 pipeline has **23 industrial and power generation sites** as initial connectees to a new hydrogen pipeline, of which 21 have provided detailed hydrogen forecasts and 18 have signed Memorandum of Understanding's (MOU's). Signatory industries, which include chemicals, steel, power and glass, have advised that hydrogen is the most cost-efficient and practical way for them to decarbonise their operations. With the 23 industrial and power connections that are being assessed as part of the DCO and FEED stage of ECHP North – Phase 1, plus the potential Pilot Town, fuel switching to low carbon hydrogen would result in an **estimated abatement of c.13Mt CO_2e between 2030 and 2050.**

We have completed a conservative cost benefit analysis giving a positive Net Present Value (NPV) across all four of the scenarios explored, including a scenario where demand could be delayed. The Cost Benefit Analysis (CBA) also remains positive even if half of the hydrogen customers never connect to the pipeline. **The Base Case 1b has an NPV (2023 – 2050) of £1312m in 2023 prices**.

In addition to decarbonisation, the delivery of hydrogen to industrial and power customers in the region provides an anchor for the sector as a whole, kick-starting the regional hydrogen economy, enabling the creation of high value jobs, and also protecting the heavy manufacturing sector. Development of a full hydrogen value chain in the East Midlands region (includes Lincolnshire) will add £10Bn Gross Value Added (GVA) and create or protect 110,000 jobs by 2050[1].

Lastly, the pipeline could supply one of the first **Hydrogen Pilot Towns** in the UK. Whilst the final locations have not yet been selected, the outline planning stage is expected in 2024. Scunthorpe was submitted as an option for the government to consider and can be supplied with hydrogen form the ECHP North – Phase 1 pipeline if required.

The ECHP North – Phase 1 project will support many of the UK policy objectives including:

- Support reaching net zero by 2050 and meeting the UK's 6th Carbon budget by 2035.
- Enabling a net zero electricity system to be in place by 2035, as is currently targeted.
- Enabling the UK to reach the 10GW hydrogen production target by 2030, by distributing hydrogen from centres of production to areas of demand over a large geographical area. The most cost effective and efficient means of transporting bulk low carbon hydrogen is via pipeline as opposed to any other method (i.e. road, maritime, rail).

[1] PWC (2023), 'The Economic Value of Hydrogen for Domestic Heat in the UK'

Through our experience with the HyNet project, we are in a fortunate position to use this valuable learning to ensure that the FEED and consenting for the ECHP North – Phase 1 project is delivered on time, within budget and achieving the deliverables required to ensure a successful FEED and consenting stage. We will continue to align closely with National Gas and NGN, who will continue to work on their individual FEED and consenting stages, via regular meetings, to ensure that best value is ensured for gas customers.

The proposed increases to our income as a result of the Net Zero and Small Project (NZASP) Re-opener mechanism for the FEED and consenting of ECHP North – Phase 1 are presented in the table below and can be viewed in further detail of Section 5 of this document. The cost phasing in the below table is based on a linear cost spend for each phase, however, should funding be granted, we would wish to review before agreeing detailed funding and payment schedules. We anticipate there will be £19,454,686 of spend attributed to RIIO GD2 and a further £17,649,646 in RIIO GD3 (both costs in 2028/19 prices). **All costs are apportioned to Cadent's Eastern Network.**

Activity	Price Base	2024/25 (£m)	2025/26 (£m)	2026/27 (£m)	2027/28 (£m)	2028/29 (£m)	Total £
FEED and Consenting	**2023/24**	[Cost data]	[Cost data]	[Cost data]	[Cost data]	[Cost data]	**46,518,025**
	2018/19	[Cost data]	[Cost data]	[Cost data]	[Cost data]	[Cost data]	**37,104,332**

The remainder of the Re-opener document has been filled out as per the Ofgem Governance in Re-opener Guidance and Application Requirements Document (February 2023) and Net Zero Pre-Construction Work and Small Net Zero Projects Re-opener Governance Document (March 2023).

Before the submission of this Re-opener, Cadent, National Gas and NGN undertook extensive engagement with Ofgem and the Department of Energy Security and Net Zero (DESNZ) on the ECH$_2$ project throughout 2023. Topics covered included: engagement to date with key stakeholders and the outline Needs Case and culminated in the Pre-Trigger document being submitted to Ofgem in December 2023. Ofgem confirmed that the Trigger Requirements had been met in January 2024. The guidance provided by Ofgem and DESNZ throughout the Pre-Trigger engagement period has been acted upon when constructing our ECHP North – Phase 1 Re-opener.

Document Structure

This document sets out eight core chapters plus annexes to show the 'Need Case', options analysis, cost basis and project scope to undertake a FEED and Consenting project for a purpose-built hydrogen pipeline called ECHP North – Phase 1, that is a constituent part of our ECHP project and the wider cross-network ECH_2 programme. The structure of the Re-opener is based on the regulatory information requirements found in Ofgem's governance and guidance documents for RIIO-GD2 Re-openers to NZASP. A high-level chapter description is as follows:

1. **Project Description –** This chapter describes the ECH_2 cross-network programme, the Cadent section of this programme (ECHP) and then a description of the first ECHP project to be taken forward into FEED and consenting, which is ECHP North – Phase 1. Included is a high-level summary of the project and cost for ECHP North – Phase 1.

2. **Project Need Case –** This chapter looks at the policy context and how the ECHP North - Phase 1 project supports the UK's CO_2 reduction policies. We also discuss why hydrogen is an important technology in a future net zero energy system and how our own strategies and business justifications align with the project. The overarching needs case is discussed and how the project will meet hydrogen demand and support the emergence of hydrogen production and storage, whilst saving CO_2 emissions from industry and power. We describe the comments we have received from those who we are looking to use the hydrogen via case study examples and findings from a survey. Finally, we discuss the CBA, which is net positive in all scenarios.

3. **Project Options Selection –** This chapter details the stages of hydrogen network design development that we completed through the Technical Feasibility and Pre-FEED stages, along with the outputs from each stage. It describes how we developed the strategic network options, customer connections and pipeline route corridor options through various stages of assessment, leading to the selection of a preferred project option to progress into FEED.

4. **FEED Scope of Works and Outputs –** This chapter considers what activities are going to be undertaken in the FEED and consenting stage that funding is being sought for. A detailed breakdown of the work-packages within the FEED and the consenting stage are given.

5. **Cost Information –** This chapter sets out the principles, stages and processes we have taken through the project lifecycle, from our initial Pre-FEED procurement strategy through to our final detailed cost breakdown structure for the FEED project. It aims to provide clear substantiation of all cost activities and why we believe this delivers value for money for a project of this scale and complexity.

6. **Project Delivery and Monitoring –** This chapter looks at how the project will be delivered by the team, including internal project team positions, project governance, the monitoring plan and associated documents to be submitted to Ofgem. Also discussed is how we will interface with project partners ensuring that we work effectively together and share learning.

7. **Stakeholder and Whole System Opportunities –** This chapter discusses how key stakeholders have been proactively engaged to date and describes what stakeholder engagement will happen in the future, including the consenting process.

8. **Regulatory Treatment and Bill Impacts –** This chapter confirms the eligibility of this project for funding under the Net Zero Pre-Construction Works and Small Net Zero Projects Re-opener (NZASP) mechanism and outlines the range of benefits and reasons to socialise the cost of this project across all gas users.

The final sections, that sit apart from the eight-core chapters include the statement of **Assurance** that underlines the key assurance activities that have taken place. The **Annexes** are listed through-out the document and point to additional sources of information that support the eight core chapters.

1.Project Description

This chapter describes the ECH_2 cross-network programme, the Cadent section of this programme (ECHP) and then a description of the first ECHP project to be taken forward into FEED and consenting, which is ECHP North – Phase 1. Included is a high-level summary of the project and cost for ECHP North – Phase 1.

1.1. East Coast Hydrogen (ECH_2)

The aim of ECH_2 was to develop a programme that allowed the three gas transporters (GTs) to connect low carbon hydrogen production predominantly in Humber and Teesside, to industry and power generators across the North-East, Yorkshire and the East Midlands, helping to decarbonise their operations. A map of the ECH_2 region can be seen in Figure 1; The National Gas ECH_2 plan spans both the Cadent and the NGN network areas.

Figure 1: ECH_2 region showing Cadent's network area

By transporting hydrogen to heavy industry and power generators, the GTs would be playing their role to support the government in meeting the UK's 2050 Net Zero targets and the target of connecting 10GW of hydrogen production by 2030. The feasibility study[2] for ECH_2 was delivered in November 2021, and it demonstrated huge potential and ambition from prospective hydrogen producers, users and storage providers, which could only be realised with a resilient pipeline network to connect the sites together.

The feasibility study highlighted the following:

1. **Potential Hydrogen Demand:** The Humber and Teesside account for up to 50% of the UK's industrial cluster emissions and across the region there are more than 39,000 industrial sites consuming 66.1TWh of natural gas that could potentially be switched to hydrogen, saving more than 11mt/CO_2e/yr of industrial emissions. 20% of the UK's domestic, industrial and commercial gas usage is in the ECH_2 project area. Since the feasibility study was launched, we have gathered detailed hydrogen forecast information from industry and power generators in the region, which is discussed later in this chapter.

2. **Hydrogen Production:** The East Coast Cluster has been selected as Track 1 in the sequencing process to be one of the UK's first industrial capture projects, with storage of CO_2 in the Endurance Fields enabling blue hydrogen production. Since then, the Viking Project, with a potential CO_2 store off the coast from Theddlethorpe (NE Lincolnshire) has been announced as one of the Track 2 clusters, further strengthening potential for blue hydrogen production in the Humber. Development of more than 10GW of offshore wind capacity (3.4GW currently online) positions this region for electrolytic hydrogen production (green), making use of the renewable energy before new electrical transmission infrastructure can be constructed onshore. In November 2021 plans were announced for 7GW hydrogen production in the ECH_2 region, which has now increased by 4.5GW[3].

3. **Hydrogen Storage:** The feasibility study highlighted that the East Coast region is home to the UK's largest Permian salt field, which can provide the cheapest form of large-scale storage in salt caverns, as well as access to Rough, an offshore natural gas store that is being considered for redevelopment as a hydrogen store. In the ECH_2 region, the latest forecasts from storage providers are for 4TWh of hydrogen storage by 2030 and 10.7TWh by 2050.

The feasibility study identified the need for up to 800km of repurposed and dedicated new build hydrogen pipeline to connect the identified demand to production and storage. Subsequently the three GTs each commissioned separate engineering studies to identify the optimum pipeline corridors and initial line sizing to connect the sites together, enabling industrial and power generation decarbonisation. The results of this work have been drawn together in a cross-network ECH_2 Delivery Plan[4] that was launched in November 2023 and provides extensive information on the 'Needs Case' for the cross-network pipeline network and how the plans will be phased and delivered collaboratively by the three GTs. The cross-network plan can be seen in Figure 2, which illustrates the planned ECH_2 100% hydrogen pipelines from Cadent, NGN and National Gas.

[2&3] Cadent, NGN, National Gas (2021) East Coast Hydrogen Feasibility Report: https://www.nationalgas.com/document/138181/download

[4] Cadent, NGN, National Gas (2023) ECH2 Delivery Plan: https://www.eastcoasthydrogen.co.uk/east-coast-hydrogen-delivery-plan/

Figure 2: Map of ECH_2 region showing proposed 100% hydrogen pipelines by 2037.

1.2. Cadent Pre-FEED of ECHP

Following the positive ECH_2 feasibility study, we commissioned a technical feasibility and a Pre-FEED study for ECHP. Our ECHP is designed to be a large-scale local transmission hydrogen network with associated producers, industrial connections and network assets, such as hydrogen above ground installations (HAGIs). The project footprint aligns to our existing East Midlands network area which hosts concentrated industrial clusters in the South Humber (Lincolnshire), South Yorkshire, Nottinghamshire, Derbyshire and Leicestershire.

We tendered and awarded the technical feasibility and Pre-FEED contract to Worley Europe Limited. Their bid included strategic partners to support the work, including Murphys (construction advice), SLR (consenting lead), Fisher German (land and access) and Camargue (consenting communications).

During the feasibility stage (2021) and the procurement stage for Pre-FEED (2022), we engaged intensively with our 120 largest gas users, establishing whether they needed hydrogen to decarbonise (or were planning alternative options) and gathering hydrogen forecasts from them if it was required. We also secured hydrogen production and storage forecasts from other providers. These detailed forecasts were used to 'size' and route the full ECHP pipeline as part of the technical feasibility and Pre-FEED studies.

The project commenced technical feasibility in January 2023, completing at the end of March 2023, including completion of the strategic options and recommendations to progress to Pre-FEED. The project then commenced Pre-FEED in April 2023 and completed in December 2023. As the Pre-FEED stage developed and the strategic options and phasing were reviewed, we decided to split ECHP into a northern section and a southern section, with an inter-connecting section. One phase of one section was selected to progress into FEED and consenting, called **ECHP North – Phase 1, for which we are requesting funding through this Re-opener**. The full Cadent ECHP region, the multiple phases of ECHP and the North – Phase 1 preferred pipeline route is shown in Figure 3. A detailed description of ECHP North – Phase 1 is given in Section 1.4 of this chapter, including mapping.

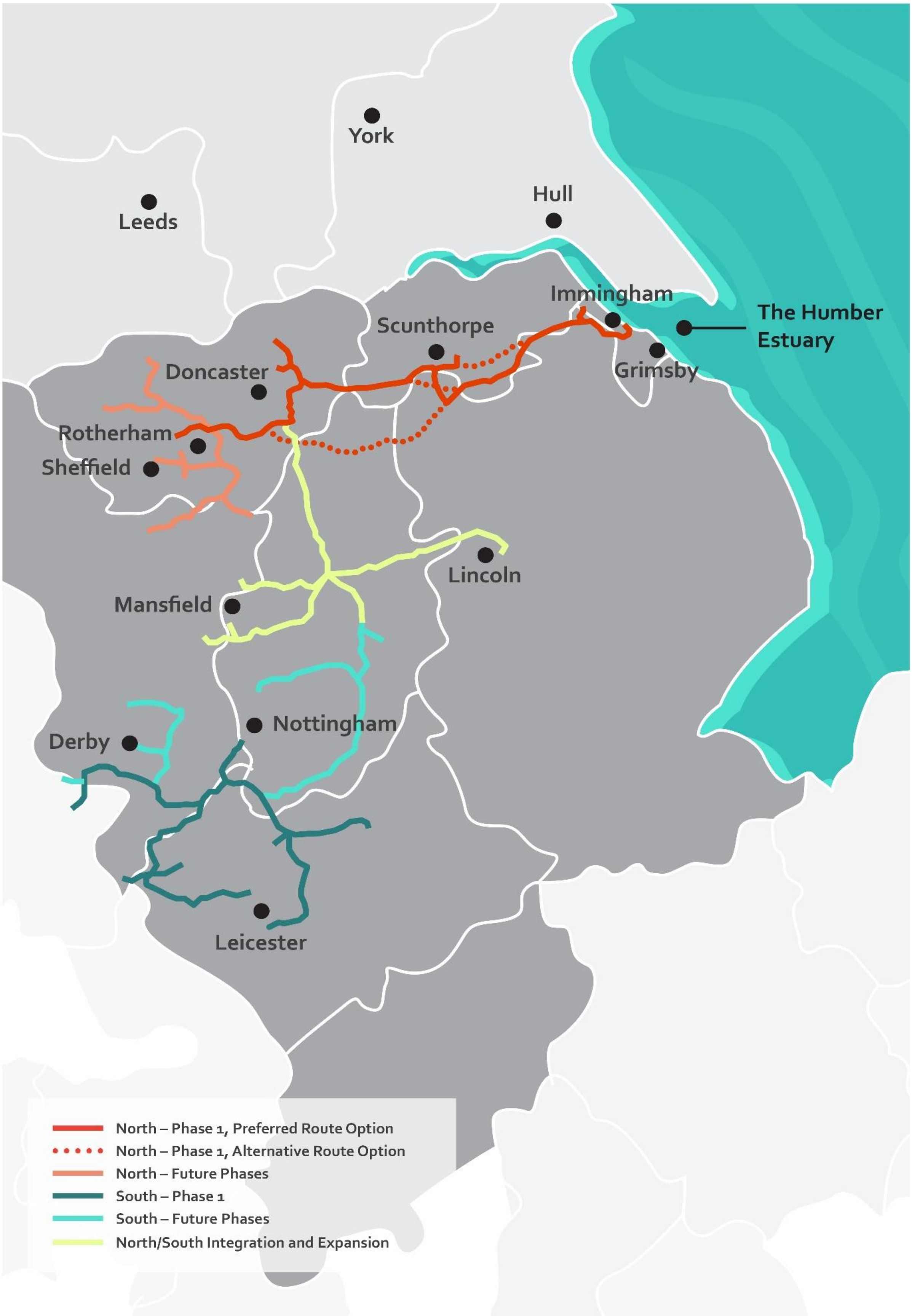


Figure 3: Map of ECHP Phases

1.3. Project Objectives of ECHP

To guide the development of the ECHP project, a set of aims and objectives were developed at the technical feasibility stage and further defined during Pre-FEED. This is shown in Table 1.

The aims of the project were as follows:	
1.	Decarbonising industry and supporting low carbon economy transition.
2.	Route to market for hydrogen producers, enabling supply of hydrogen to locations of industrial and power generation demand.
For the project to deliver these aims, the following objectives have guided the project:	
3.	Design a network to supply hydrogen, via hydrogen producers, to industrial, commercial, and other non-domestic Cadent customers within the project footprint, who have told us that they want hydrogen, and who have been assessed as viable for connection.
4.	Assess the industrial customers to determine the Cornerstone Users (CUs) (which are used to define the pipeline route) based on their annual natural gas consumption and their expected 2030, 2035 and 2035+ hydrogen consumption.
5.	Provide a connection to Scunthorpe to meet the requirements of the Government's Hydrogen Pilot Town programme if required (the delivery of the hydrogen volume required only, with no detailed planning).
6.	Develop the best technical and economic solution for the overall ECH_2 project in collaboration with partners Northern Gas Networks (NGN) and National Gas.
7.	Provide an option for hydrogen supply to additional towns for domestic consumption.
8.	Provide a degree of future proofing.
9.	Provide phasing possibilities to enable efficient and progressive roll out.
10.	Develop a resilient network offering the greatest level of supply security possible.
11.	Ensure the selected design is technically and economically fit for purpose.
12.	Develop a project that is able to receive the relevant consents.
13.	Select an engineering solution that can be safely constructed and safe to operate.

Table 1: ECHP Project Aims

A key objective at the Pre-FEED stage was to include flexibility in the design such that a degree of optionality can be taken forward for further scrutiny and/or consultation where uncertainty exists around routing or siting. The project will be taking forward some areas of uncertainty into FEED and consenting. For example, we know that on the routes that we have selected there are areas of environmental sensitivity and the implications of this will need greater consideration. We also know that line sizing will need further consideration when dynamic network modelling and transient flow analysis (Section 4.2.1) is undertaken, and we have a greater understanding about whether there is a requirement for a Town Pilot programme in Scunthorpe. Currently we have chosen to include the capacity of Scunthorpe Town Pilot into our pipeline sizing due to the difficulties of needing to add it later if it is decided it is required, but it can be removed if necessary. This decision was made in discussion with DESNZ and Ofgem during the pre-trigger engagement sessions.

1.4. Detailed Project Description of ECHP North – Phase 1

A map of the preferred route for the ECHP North – Phase 1 pipeline can be seen in Figure 4, below.

Figure 4: ECHP North – Phase 1 Routing Preferred Option

The detail of the decision to separate our ECHP into northern and southern sections and why ECHP North – Phase 1 was selected as the section to progress first into FEED and consenting is detailed in Section 3 – Options. In summary, the ECHP North – Phase 1 pipeline section is currently the most 'deliverable' when compared to the other sections of the ECHP and best meets the aims of decarbonising industry by connecting them to a low carbon hydrogen supply.

Compared to other sections of ECHP, North – Phase 1:

- Has the highest number of customers, requiring the largest volume of hydrogen (3.4TWh per year) that are ready to transition to hydrogen by 2030.
- Will connect customers to a diverse range of five different producer sites in Immingham that are planning 17TWh of production per year by 2030.

- Is the closest of all ECHP sections to potential salt cavern storage at Aldbrough (north of the Humber) which will be needed for resilience.
- Can enable a Hydrogen Town Pilot in Scunthorpe if required by government following the heat policy decision in 2026.

Many of the industrial and power generation customers that plan to connect to ECHP North – Phase 1 do not have viable alternative decarbonisation options other than hydrogen. This is further detailed in Section 2.

ECHP North – Phase 1 will be a new hydrogen Local Transmission System (LTS), operating at high-pressure between seven to 75 barg and will therefore need connection or 'spur' pipelines to each customer. The total pipeline length, including the mainline, will total approximately 136km in length, including circa eight LTS mainline HAGIs, to enable the flow and pressure of hydrogen in the network to be adequately controlled. Further smaller HAGIs will be required at production entry points and at some customer connections. This will be further detailed during the FEED stage.

Furthermore, the Pre-FEED has provided two pipeline capacity options, one which will accommodate industrial demand only (plus Scunthorpe Pilot Town), and one which enables delivery of hydrogen for domestic heat in further towns across South Yorkshire and the East Midlands. This optionality allows a decision on whether to upsize the pipeline to be made by DESNZ and Ofgem, ideally prior to the FEED commencing.

It should also be noted that from a CBA perspective, the cost of providing capacity for these town conversion options has been included, but **the financial benefit from decarbonisation of domestic heating has not been included in the CBA,** (due to heat policy decision uncertainty). However, the CBA result of all scenarios is still positive, despite the exclusion of domestic decarbonisation benefits (see Section 2.10). The primary aim of our ECHP is industrial and power generation decarbonisation, with optionality for town conversion being provided to enable decision-making by DESNZ and OFGEM.

1.5. Project and DCO and FEED Phase Costs

The total cost for this phase (FEED and DCO) of the ECHP North – Phase 1 project, is [Cost data] (2018/19 costs). This includes [Cost data] on the FEED and DCO submission, [Cost data] on DCO acceptance/examination and finally a [Cost data] on a contingency allowance.

We have prepared a detailed cost estimate for all activities associated with delivering the FEED and DCO phase, incorporating all learnings and cost-efficiencies from the HyNet project. The costs include the DCO acceptance and examination period and post-DCO approval to enable a Final Investment Decision (FID) to be made. This ensures that the most efficient process can be undertaken to enable a FID to be made in 2028 and construction to begin soon after, allowing bulk hydrogen to be transported to heavy industry in the 2030s. If a staged funding approach was adopted where we were required to apply for DCO costs later, in a separate stage, this would delay the FID and eventual construction of the ECHP North – Phase 1 pipeline, delaying the carbon abatement benefits.

The cost estimate per phase, is shown in Table 2 in 2018/19 prices and also 2023/24 prices.

PHASE	Duration (Months)	2018/19 Prices (£)	2023/24 Prices (£)
FEED AND DCO SUBMISSION	32	[Cost data]	[Cost data]
DCO ACCEPTANCE AND EXAMINATION	16	[Cost data]	[Cost data]
POST DCO APPROVAL	0	[Cost data]	[Cost data]
CONTIGENCY ALLOWANCE		[Cost data]	[Cost data]
TOTAL COST ESTIMATE	**48**	**£ 37,104,332**	**£ 46,518,025**

Table 2: FEED & DCO cost breakdown

Further detail on costs can be viewed in Section 5 of this document.

We are proposing a 10% contribution to costs, which means we will contribute £3.71m (2018/19 prices) and request £33.9m (2018/19 prices) from Ofgem via the NZASP mechanism.

The total project cost for construction of ECHP North - Phase 1, up until the point of commissioning the pipeline, is expected to be in the region of c.£732m, further details can be found in Section 5.

1.6. Project Timelines

The estimated timeline for the ECHP North – Phase 1 pipeline is shown below (Figure 5) and further detail in ANNEX A:

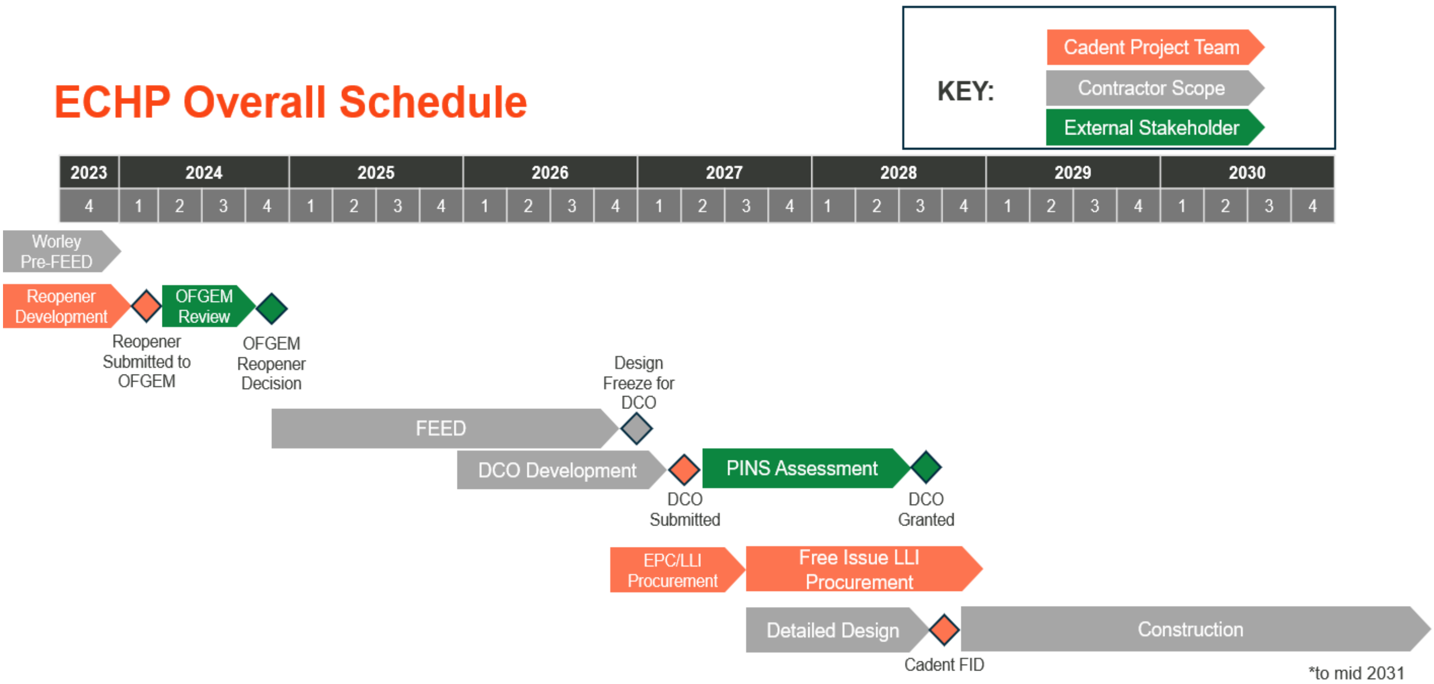


Figure 5: Estimated Overall Project Timeline

The Ofgem Re-opener decision date will determine when the FEED and DCO stage begins. We will look to resubmit a detailed timeline once a decision has been made, but it will take at four months for recruitment and onboarding of the FEED team to be completed and for work to start. If a decision is made by Ofgem in the summer months of 2024, then a DCO submission will be targeted in April 2027. The Planning Inspectorate (PINS) assessment period will be approximately 16 months, achieving an estimated DCO approval in August 2028. The new hydrogen pipeline is planned to be built and commissioned in stages from late 2028 until 2031, enabling demand to come online progressively instead of waiting until the whole pipeline has been built, therefore accelerating decarbonisation impacts. The initial connections are likely to be in the immediate area surrounding Immingham, where just over half of the industrial demand is located, ensuring that a quick and meaningful amount of decarbonisation can be achieved in the early part of the construction phase.

2. Project Needs Case

This chapter looks at the policy context and how the ECHP Phase – 1 North project supports the UK's CO_2 reduction policies. We also discuss why hydrogen is an important technology in a future net zero energy system and how our own strategies and business justifications align with the project. The overarching needs case is discussed and how the project will meet hydrogen demand and support the emergence of hydrogen production and storage, whilst saving CO_2 emissions from industry and power. We describe the comments we have received from those who we are looking to transport hydrogen to via case study examples and findings from a survey. Finally, we discuss the CBA, which is net positive in all scenarios.

2.1. UK Policy for Net Zero

The UK Climate Change Act 2008 made the UK the first country in the world to set legally binding carbon budgets, aiming to cut emissions (versus the 1990 baseline) by at least 34% by 2020 and 80% by 2050. In 2019, this target was amended, requiring 2050 emissions to be 100% lower than the 1990 baseline.

The UK's Sixth Carbon Budget[5] is the latest carbon budget, covering the period 2033 to 2037. The Carbon Budget sets out the steps which must be taken by this period to help the UK reach net zero carbon emissions by 2050. The recommended pathway requires a 78% reduction in UK territorial carbon emissions by 2035 (compared to the 1990 baseline). The Carbon Budget identifies that substantial investment will be required to meet these targets: it is estimated that low carbon investment must reach £50 billion each year to deliver net zero. The Carbon Budget also identifies that fuel supply must be decarbonised, with low carbon hydrogen playing a significant role in achieving net zero when deployed for applications where electrification is less feasible.

2.2. ECHP North – Phase 1 Supports Government Policy Commitments

The East Coast Hydrogen Delivery Plan shows how the full ECH_2 project supports over 20 different policy commitments to drive hydrogen infrastructure roll-out and carbon emissions reduction.

A selection of three of these policy commitments is shown in Table 2, alongside a description of how ECHP North – Phase 1 will contribute to achieving them.

[5] Sixth Carbon Budget Found Online: https://www.theccc.org.uk/publication/sixth-carbon-budget/; [Accessed 14/02/24]

Policy	Policy Commitment	How Cadent's ECHP North - Phase 1 will support
The Climate Change Act 2008 (updated 2019)	Commits the government by law to reduce greenhouse gas emissions by at least 100% of 1990 levels (net zero by 2050)	0.7mt/CO_2e to be abated every year from 2030 (including abatement from the Scunthorpe Pilot Town) or 0.4mt/CO_2e excluding the Pilot Town emissions savings.
Industrial decarbonisation strategy (2021)[6]	Switch 20TWh of per year of fossil fuels to low carbon fuels (including hydrogen) by 2030	3.03TWh of natural gas will be displaced by hydrogen at 18 industrial sites by 2030 (excludes Town Pilot), this represents 15% of the total industrial fuel switching target.
Net Zero: Build back Greener (2021)[7]	All electricity generation to be decarbonised by 2035	0.37TWh of hydrogen could replace fossil fuels at 5 power generation sites.
British Energy Security Strategy (2022)[8]	10GW of hydrogen production by 2030, with 60% from green hydrogen.	By 2035 the ECHP North – Phase 1 pipeline can connect to 0.65GW of hydrogen production, accounting for 6.5% of the 2030 target.

Table 3: UK hydrogen policy

Government's evolving policy consistently highlights that low carbon hydrogen has a key role to play in a future net zero economy; this is especially the case in sectors that are difficult or expensive to electrify, such as many industrial applications. The ECH_2 programme specifically ECHP North - Phase 1 is aligned with government policy and will have a critical role in the early and future roll out of the hydrogen economy.

2.3. The Case for Hydrogen in a Net Zero Energy System

Hydrogen can be produced using methods that have either zero, or minimal carbon emissions. Low carbon hydrogen can replace natural gas and when combusted does not produce carbon dioxide emissions as there are no carbon elements contained within a hydrogen molecule. This means that hydrogen can have a central role in the UK's energy mix as it moves from an energy system that is heavily reliant on unabated burning of fossil fuels to a future system that has a large mix of energy technologies such as renewables, nuclear, green gases, hydrogen and carbon capture, storage and utilisation (CCUS) to name a few.

Hydrogen is one of the most abundant elements in the universe, it rarely occurs on its own but instead within molecules such as water (H_2O) and methane (CH_4). As a consequence, hydrogen has to be extracted from other molecules before it can be used as a fuel. The most common methods of hydrogen production are the electrolysis of water or steam reforming of natural gas, the biggest component of which is methane (CH_4). Whilst hydrogen is

[6] Industrial Decarbonisation Strategy (2021), Found Online: https://www.theccc.org.uk/publication/sixth-carbon-budget/ [Accessed 14/02/24]
[7] Net Zero Strategy: Build Back Greener (2021) Found Online: https://assets.publishing.service.gov.uk/media/6194dfa4d3bf7f0555071b1b/net-zero-strategy-beis.pdf [Accessed 14/04/24]
[8] British Energy Security Strategy (2022) Found Online: https://www.gov.uk/government/publications/british-energy-security-strategy/british-energy-security-strategy [Accessed 14/02/24]

already used and produced within the UK today, only a very small proportion is made using methods compatible with net zero. The challenge the UK has is to scale up hydrogen production using net zero compatible methods so that hydrogen can account for 20-35% of the UK's total energy consumption by 2045, which is the equivalent of 250-460TWh of energy according to UK Government analysis[9].

Industrial and commercial sectors, with particular emphasis on industry and power generation, have been identified as 'hard to abate sectors' in the UK's Hydrogen Strategy[10] with hydrogen playing a leading role in decarbonisation. The Climate Change Committee (CCC)[11] has stated that low carbon hydrogen can replace natural gas in parts of the energy system where electrification is not feasible or is prohibitively expensive, for example industrial heat processes and back-up power generation. More recently, the National Infrastructure Committee (NIC)[12], have called for there to be a core hydrogen network in their Second National Infrastructure Assessment, published in 2023. The NIC clearly identifies the benefits, including decarbonisation of the large industrial users, where decarbonisation using electricity looks to be challenging.

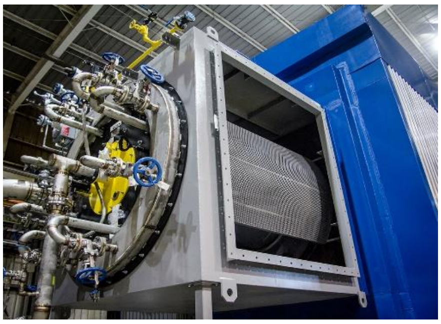
2.4. Description of the ECH$_2$ Cross Network Programme Needs Case

Preparations for the Cadent, NGN and National Gas network Pre-FEEDs ran throughout 2022 with delivery starting in 2023. The Pre-FEED outputs were compiled into a single East Coast Hydrogen Delivery Plan[13] that was launched on 13th November 2023 and is now publicly available. The Delivery Plan emphasises the strong Needs Case for delivery of a cross-company pipeline network to connect industrial and power generation demand for hydrogen with production and storage sites across the East Midlands, Yorkshire, the Humber Region and the North-East. Figure 6 gives an overview of the key facts and figures from the whole ECH$_2$ programme, including the NGN and National Gas component projects.

---

[9] Hydrogen Champion Report (Mar, 2023) Found Online: https://assets.publishing.service.gov.uk/media/6564cfd7888c060013fa7db6/hydrogen-champion-recommendations-report.pdf [Accessed 14/02/24]
[10] UK Hydrogen Strategy (2021): Found Online: https://assets.publishing.service.gov.uk/media/64c7e8bad8b1a70011b05e38/UK-Hydrogen-Strategy_web.pdf [Accessed 14/02/24]
[11] Climate Change Committee (2018) Hydrogen in a low-carbon economy. Found Online: https://www.theccc.org.uk/publication/hydrogen-in-a-low-carbon-economy/ [Accessed 14/02/24]
[12] National Infrastructure Commission (2023) – The Second National Infrastructure Assessment. Found Online: https://nic.org.uk/app/uploads/Final-NIA-2-Full-Document.pdf [Accessed online14/02/24]
[13] East Coast Hydrogen (2023) – ECH$_2$ Delivery Plan. Found online: https://www.eastcoasthydrogen.co.uk/east-coast-hydrogen-delivery-plan/ [Accessed 14/02/24]

Demand



63TWh/y
Identified demand for hydrogen.

55%
Of hydrogen I&C and power demand is outside the Humber and Teesside clusters – in the East Midlands, Yorkshire and Tyneside

64 Power sites
make up 55% of total announced hydrogen demand by 2037

Production

83TWh/y
Planned hydrogen production in the region.

Rise In Green Hydrogen
ECH_2 could meet 73% of the 6GW electrolytic hydrogen target by 2030

30%
of all projects to be selected for UK Gov funding are in the ECH_2 region

Storage

Over 19%
Of the UK's 56TWh storage requirements will be met by Rough

4 large scale
sites to be connected across North Humber and Teesside

Over 10TWh
Of planned storage in the region by 2050

Figure 6: Overview of ECH2 Hydrogen Demand, Production and Storage Plans

The ECH_2 region's ambition for hydrogen production and storage, and hydrogen demand, dwarfs that of any other region in the UK. But **fuel switching, hydrogen production and hydrogen storage are inter-reliant, and these projects cannot be delivered if there is no pipeline network to connect them together**. Production needs to be connected to demand and storage sites by pipeline; the ECH_2 network fulfils this need. The full ECH_2 pipeline plan can be found in Figure 2, Section 1.1.

2.5. Alignment with Overall Business Strategy and Commitments

In addition to the delivery of a safe and efficient methane gas network, we have a strategy to support the delivery of net zero. This includes the reduction in gas emissions through our operations and leakage reduction, supporting projects that enable decarbonisation (such as hybrid solutions and biomethane connections) and enabling a transition to low carbon hydrogen at the right time. We have led or partnered on several hydrogen initiatives that are seeking to enable the transition away from natural gas. Notable projects that we have either led or co-led include HyDeploy (hydrogen blending) and HyNet, a hydrogen pipeline project that will deliver hydrogen to power generators and industry in the North-West. The ECH$_2$ project has a similar industry and power generation focus as HyNet but is located in the East. We are also developing similar programmes in our other network areas, for example the East London Hydrogen Pipeline (part of the Capital Hydrogen programme) and the Hydrogen Valley (which covers the West Midlands and a corridor to Bacton on the Norfolk Coast). We have also been involved in a wide range of technical hydrogen projects covering hydrogen safety, consumer attitudes and economic analysis. We launched our own Ten Point Plan on hydrogen[14] that firmly demonstrates our commitment to hydrogen and how this is firmly embedded into our overall business strategy.

2.6. Needs Case for ECHP North – Phase 1

2.6.1 Hydrogen Production

There are five hydrogen production projects on the route of the ECHP North - Phase 1 pipeline that have submitted hydrogen production forecasts for connection to the pipeline. The forecasts include a projection from each respective company on how much hydrogen will be produced in 2030, 2035 and 2037+ onwards. These production sites are all located in the Immingham area and represent a collective 2.42GW of production capacity that will create 17TWh per year of hydrogen by 2030, rising to over 20TWh between 2030 and 2035. We anticipate that over 33% of hydrogen will be green hydrogen by 2037, with the remainder being blue hydrogen that meets the government's Low Carbon Hydrogen Standard (LCHS). The total amount of expected hydrogen production exceeds the 4.5 to 6.9TWh per year of hydrogen that is required for our customers (with or without Scunthorpe Town Pilot) by 2037+. The remaining hydrogen could feed into the National Gas hydrogen network or storage to help meet their wider customer demand, for example.

[redacted]. During the FEED, further clarity will emerge on the technical considerations of the producer connections and the likely commissioning dates of both the Cadent and National Gas pipelines, all of which will drive the final pipeline configurations. Table 4 shows the expected production for each producer in 2030, 2035 and 2037 onwards. They have specifically asked to remain anonymous.

Hydrogen Production – Immingham, Humber Region					
Type	**Plant Capacity (H_2 MW)**	**Year online**	**2030 (GWh)**	**2035 (GWh)**	**2037+ (GWh)**
Reforming/CCUS	1200	2029	10510	10512	10512
Electrolysis	400	2028	1400	2803	2803
Electrolysis	500	2028	1490	3723	3723
Electrolysis	100	2028	[Commercially Sensitive]	[Commercially Sensitive]	[Commercially Sensitive]
Reforming/CCUS	720	2028	[Commercially Sensitive]	[Commercially Sensitive]	[Commercially Sensitive]
		Totals	**16780**	**20440**	**20440**

[14] Cadent 10 Point Plan on Hydrogen (2022) – Found Online: https://documents.cadentgas.com/view/852427184/

Table 4: Hydrogen Production in Immingham

The production projects are currently in the planning stage and include two blue hydrogen projects in Immingham which plan to apply for funding through the Track 1 expansion or Track 2 process, whilst the green hydrogen projects will apply through Hydrogen Allocation Round 2 (HAR2) or allocation Round 3 (HAR3).

An example of planned hydrogen production in the Humber region is Uniper's H2ub Project. The key statistics for this project are in Figure 7.

H_2UB ® (Green) Killingholme, Immingham

Up to 720MW

Capacity and commissioned in early 2030s

Gas Reformation

technology will be used to produce the hydrogen with associated CCS ensuring CO_2 is stored in permanent geological storage offshore in the North Sea

1.6 Mt of CO_2

Could be captured each year, reducing the emissions of hydrogen customers

Figure 7: Uniper Production Case Study

We will continue to work with hydrogen producers as their plans develop, firming up the amount of hydrogen that will be available for our network, connection dates and technical considerations. In April – June 2024 we will ask producers to confirm their latest hydrogen production forecasts to ensure that the FEED uses the latest position. We already know CCUS-enabled production projects are likely to start slightly later than was previously forecasted (summarised in Table 4) due to revised timings of the Track 1 Expansion and Track 2 CCUS competitions.

2.6.2 Storage

As the ECHP North – Phase 1 pipeline matures and connects more and more demand, including more peaking power demand, storage will inevitably be needed to ensure that the pipeline has sufficient resilience and can accommodate peaks and troughs in demand. Storage requirements for North – Phase 1 will be identified through our FEED. Throughout the Pre-FEED, we have been keeping abreast of progress on hydrogen storage through our relationships with several different developers. We're in discussion with the Aldbrough Hydrogen Storage Project and are considering how it can support the North – Phase 1 storage requirements; this is evidenced via letters from Equinor (co-owner and co-developer of the Aldbrough gas storage site) in ANNEX B. The entire East Coast region has significant potential for salt cavern development for the storage of hydrogen, with the largest Permian salt field lying between North Lincolnshire and Teesside.

In Figure 8, the planned storage by 2037 is 3.95TWh, which comes from a combination of onshore salt cavern storage and offshore storage in a depleted gas reservoir at Rough. By 2050, it's estimated that there could be 10.6TWh of storage available from these sites. We are also aware of unannounced potential hydrogen storage projects both North and South of the Humber Estuary and we are in regular contact with developers working on these sites.

A transient flow analysis during FEED will identify how much additional hydrogen storage is needed over and above the 'line pack' storage which will exist within the pipeline itself. In the ECHP footprint, we have two options to link into large-scale storage, which will be further considered during FEED. These are:

[redacted]

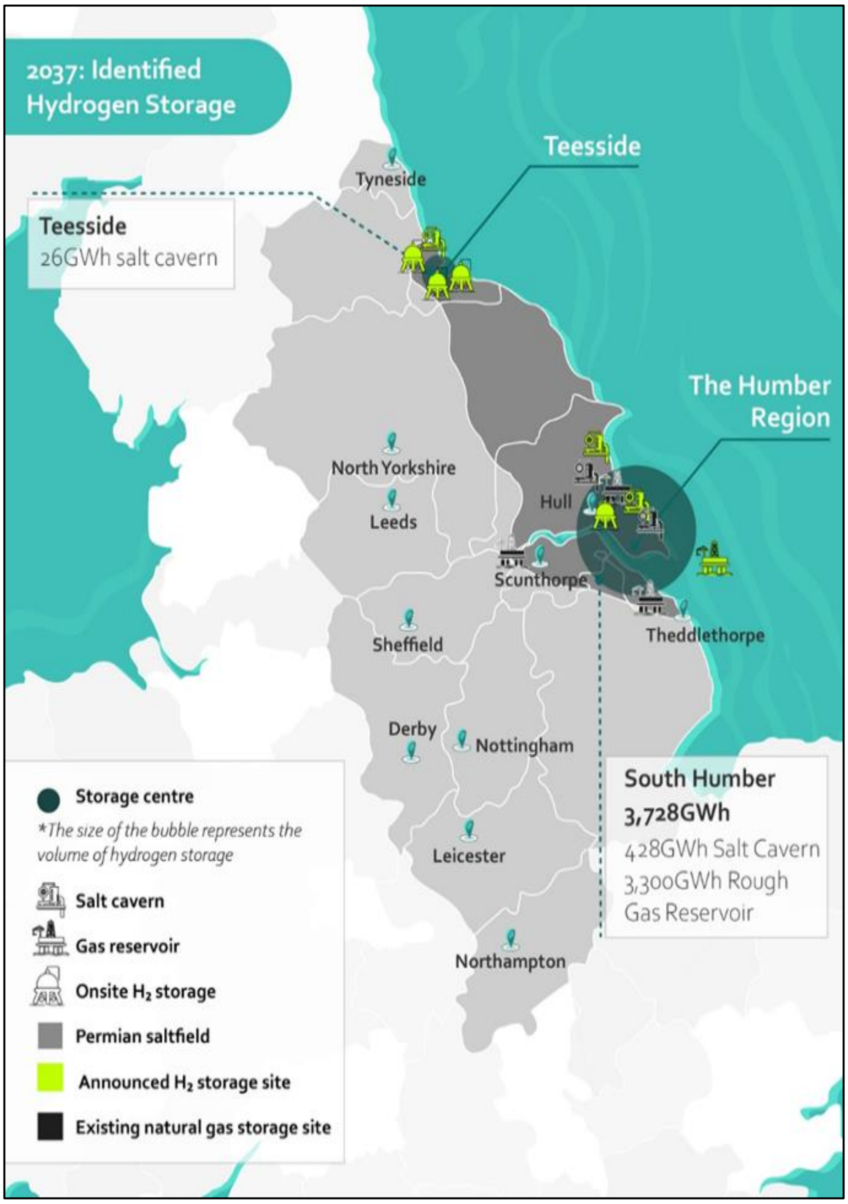


Figure 8: Planned hydrogen Storage by 2037

2.6.3 Customer Demand

We have engaged closely with all of the organisations that we are looking to transport hydrogen to in ECHP North - Phase 1. We have received hydrogen demand forecasts directly from 21 of the 23 sites (excluding the Scunthorpe Town Pilot) that we are planning to connect. These forecasts ask for quantitative information on existing natural gas consumption, forecasted hydrogen consumption out until 2037+ (which means from 2037 onwards) and data on whether the hydrogen will be blended with natural gas on-site initially or whether a full switch is expected at the outset. Of these 23 sites, we have MoUs in place with 18 of the sites. This can be seen in ANNEX C. The demand data we received can be viewed in Table 5. These organisations have specifically asked for their future demand data to be anonymised.

	Sector	Region	2030 Hydrogen Demand (GWh)	2035 Hydrogen Demand (GWh)	2037+ Hydrogen Demand (GWh)
1	Power	Doncaster	83	83	83
2	Food	Doncaster	30	30	30
3	Glass	Doncaster	75	75	75
4	Health	Doncaster	33	33	33
5	Building materials	Humber	288	288	288
6	Building materials	Humber	213	425	425
7	Chemicals	Humber	516	549	549
8	Chemicals	Humber	510	510	510
9	Chemicals	Humber	250	417	417
10	Chemicals	Humber	24	47	47
11	Fuel	Humber	90	90	90
12	Power*	Humber	6	107	107
13	Power*	Humber	6	107	107
14	Power	Humber	14	54	54
15	Glass	Rotherham	193	193	193
16	Health	Rotherham	108	108	108
17	Power	Rotherham	22	21.54	21.70
18	Steel	Rotherham	176	440	440
19	Steel	Rotherham	136	339	339
20	Building materials	Scunthorpe	1	1	12
21	Food	Scunthorpe	60	60	60
22	Steel	Scunthorpe	36	89	89
23	Steel	Scunthorpe	500	500	500
	Totals:	**GWh**	**3368**	**4566**	**4577**
24	Town Pilot	Scunthorpe	2315	2315	2315
		GWh	**5683**	**6881**	**6892**

	**Two power sites located in Immingham are owned by the same company and are situated next door to each other. The owner of the sites submitted an identical forecast for each, hence these two rows are not duplicates, they represent two separate sites.* *For the two sites where engagement is underway but a forecast has not yet been formally received in writing, we assume a 100% switch to hydrogen from 2030.*

Table 5: Industrial and Power Generation Site Demand, ECHP North – Phase 1

Figure 9 shows the distribution of the ECHP North – Phase 1 demand regions of Humber, Scunthorpe, Doncaster and Rotherham.

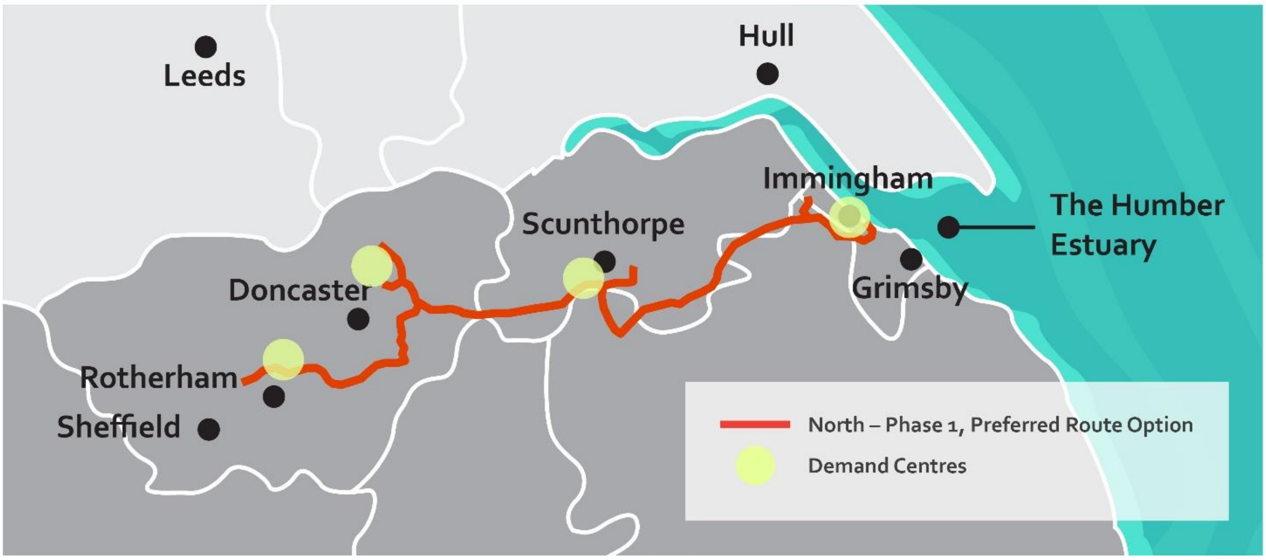


Figure 9: Hydrogen Customer Locations and demand by 2037+

The prospective hydrogen customers have provided us with demand data and in many cases detailed explanations of their plans to decarbonise. Where uncertainties exist in their plans, they have explained their latest thinking and how it will mature in the coming months and years. The areas with the biggest industrial and power generation hydrogen demand by 2035 across the pipeline area are around the Humber, which includes Immingham, Stallingborough and Barnetby, followed by Rotherham and Scunthorpe, with Doncaster having the smallest demand out to 2035. Table 6 shows demand per region, with the Humber region having the biggest hydrogen demand for industry.

	Customer Sites	2030 Hydrogen Demand (GWh)	2035 Hydrogen Demand (GWh)	2037+ Hydrogen Demand (GWh)
Humber	7 x Industrial	1889	2325	2325
	3 x Power Generation	26	270	270
	Total	1915	2595	2595
Doncaster	3 x Industrial	138	138	138
	1 x Power Generation	83	83	83
	Total	221	221	221
Scunthorpe	4 x Industrial	596	649	660
	0 x Power Generation	0	0	0
	Total	596	649	660
Rotherham	4 x Industrial	612	1080	1080

	1 x Power Generation	21	21	21
	Total	633	1101	1101
TOTALS	18 Industrial	3268	4192	4203
	5 Power Generation	130	374	374
	Total (GWh)	**3368**	**4566**	**4577**

Table 6: Table of power generation and industrial customer demand per region

The chemicals sector makes up the largest proportion of demand 33% (1.5TWh). This is closely followed by the steel sector, which accounts for 30% (1.3TWh) and then in third place, the building sector at 16% (0.7TWh). It is anticipated that once a hydrogen pipeline is commissioned, more companies that are existing within the locality will subsequently connect to the pipeline to access hydrogen for decarbonisation. It is also expected that new companies will move into the pipeline route corridor area; for example, we are already aware of Sustainable Aviation Fuel (SAF) companies who are exploring this as an option due to the strong possibility of low carbon hydrogen being available. Figure 9 shows the demand breakdown via sector.

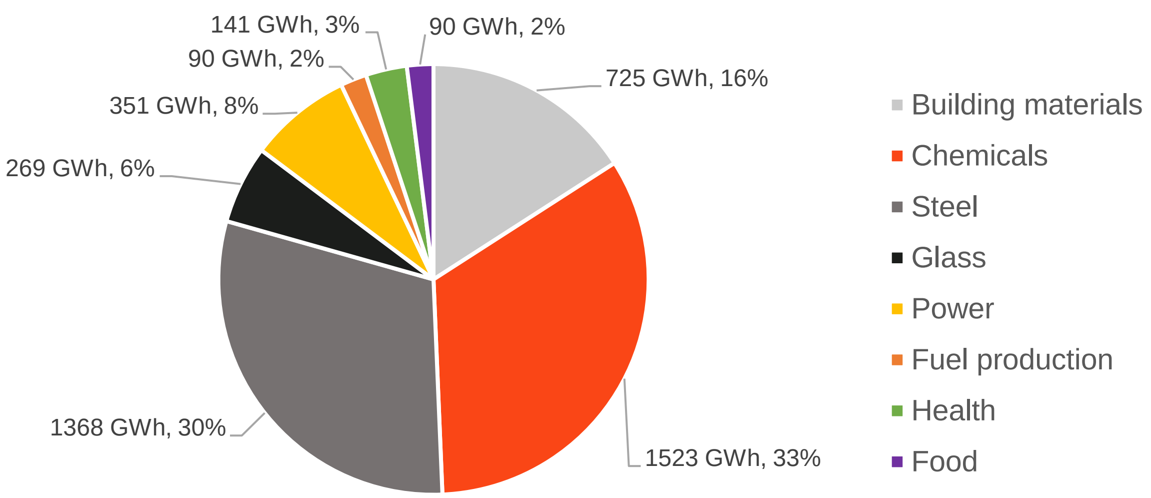


Figure 9: Demand per Sector in 2035

As previously outlined, across 24 sites (including the Scunthorpe Pilot Town) that we are assessing in FEED and consenting in ECHP North - Phase 1, we have received 6.9TWh of hydrogen demand forecasts per year by 2037 and 20TWh of production by 2035 that can be used to meet this demand. Customer demand starts in 2026, before the pipeline is constructed, which illustrates that industry will be ready to switch when the pipeline is commissioned in stages between 2028 and 2031. In the period between 2028 and 2038, production will exceed demand according to current forecasts, based on a steady state demand. Figure 10 shows hydrogen production vs our ECHP North - Phase 1 demand.

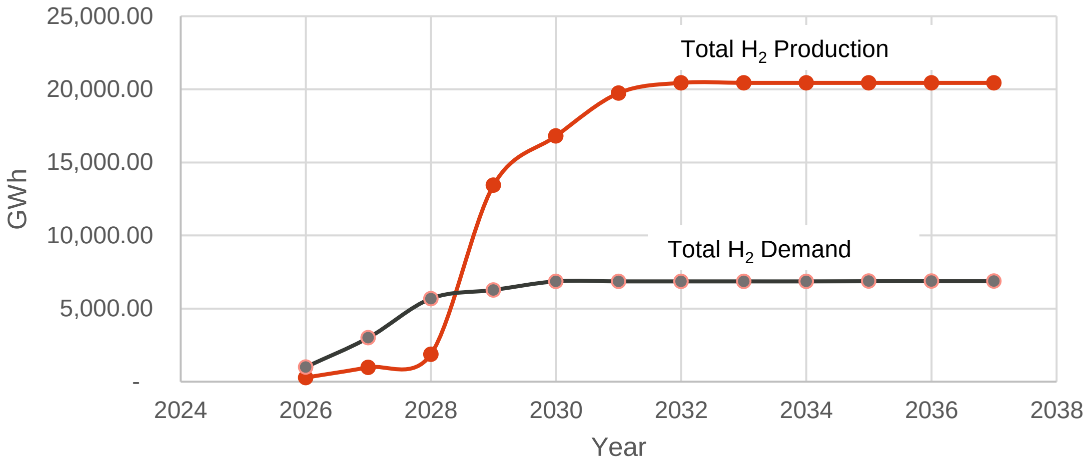


Figure 10: Planned H_2 Production vs H_2 Demand connected to ECHP North – Phase 1

2.7. ECHP North – Phase 1 CO_2 Savings

The combined demand that is being considered in the FEED and consenting phase of the ECHP North – Phase 1 project is 6.9TWh per annum by 2037 and onwards if the Scunthorpe Town connection is required, or 4.6TWh if only the 23 industrial and power generation customers are connected. If 6.9TWh of hydrogen displaces natural gas from 2035, this means that approximately c.0.8mt/CO2e are prevented on an annual basis, or c.0.6mt/CO2e if only the industrial and power generation customers are connected. Table 7 shows the anticipated CO_2 savings attributed to each region and then broken down in industry and/power and includes the Scunthorpe Pilot Town. The regions include the Humber (Immingham, Stallingborough and Barnetby), Scunthorpe, Doncaster, and Rotherham.

Region	Customer Sites	2030 1000t/CO_2e	2035 1000t/CO2e	2037+ 1000t/CO2e
Humber	7 Industrial	22.97	28.27	28.27
	3 Power Gen	0.32	3.28	3.28
Doncaster	3 Industrial	1.68	1.68	1.68
	1 Power Gen	1.01	1.01	1.01
Scunthorpe	4 Industrial	7.25	7.89	8.03
	0 Power Gen	0	0	0
	1 Town Pilot	28.15	28.15	28.15
Rotherham	4 Industrial	7.44	13.13	13.13
	1 Power Gen	0.26	0.26	0.26
Totals	18 Industrial	39.34	50.97	51.11
	5 Power Gen	1.58	4.55	4.55
	1 Town Pilot	28.15	28.15	28.15
(Thousand tonnes) Kt/CO_2		69.07	83.67	83.80
(Million tonnes) Mt/CO_2e		**0.7**	**0.8**	**0.8**

Table 7: CO_2 emission savings per region

2.8. Case Studies

The following companies are planning to connect to the ECHP North – Phase 1 pipeline. An asterisk symbol (*) indicates that the company has asked for their case study to be redacted in the public copy of this document.

[redacted]

[redacted] *

[redacted]

[redacted]

[redacted] *

[redacted]

LIBERTY

A steel manufacturer with four sites across North Lincolnshire and South Yorkshire. Liberty Steel UK is the UK's largest hot rolled steel manufacturer of Aerospace Steel, Engineering Steel Bar and Merchant Steel Bar, with an annual capacity of 1,200,000t. Hydrogen will be required in steel production alongside electric arc furnaces; it will be used in boilers to create steam for vacuum degassing and for combustion to heat the ladle that contains the molten steel (up to 1200degC). It will also be used for re-heating of steel prior to rolling (13000degC) and in Heat Treatment Furnaces. These processes would be difficult or costly to electrify so hydrogen is required.

Velocys are developing a Sustainable Aviation Fuel (SAF) project in Immingham, Humber region called Altalto. This plant, once fully operational will take over 500,000 tonnes per year of household and office waste to convert into 60m litres of cleaner burning sustainable jet and road fuel each year. Hydrogen will be used as a feedstock for creation of the fuel, for onsite processes and also to decarbonise process heating. The site once operational, aims create over 100 permanent jobs.

[redacted] *

[redacted]

[redacted]

A global chemicals manufacturer with over 16,000 employees is interested in using hydrogen to decarbonise their operations at their chemicals plant located in Grimsby. This plant produces polymers and flocculants primarily for the mineral processing industries and requires a source of heat for drying processes.

MERCIA POWER RESPONSE

Mercia Power Response currently provide security of supply to the UK's electricity system by running gas reciprocating engines and have a turnover of £110m per annum. Hydrogen is the main option to decarbonise their gas engines. The inability to secure a reliable and resilient hydrogen supply would require a drastic shift in business models.

Figure 11: Case Studies

2.9. Survey on Reasons that Customers Require Hydrogen

Twelve prospective hydrogen customers on the ECHP North – Phase 1 route have submitted responses to a survey that explores the reasons that their organisation requires hydrogen and asks what alternative options they have considered to decarbonise their operations. The survey was completed by customers from the chemicals, building materials, glass, power, food and drink and steel sectors. A list of the participating companies can be found in ANNEX D. The script of the survey can be found in ANNEX D also, alongside the survey questions.

The 12 companies that responded to the survey, have a combined annual turnover of over £30bn and employ 23,000 people across their organisations. Whilst these figures are not solely in relation to the project area of ECHP North – Phase 1, it does show the important financial and employment benefits of these companies to the UK economy. This is particularly the case in the Humber region and South Yorkshire, which is the UK's seventh-largest region in terms of Gross Value Added (GVA), and the fourth largest manufacturing region in the UK. Yorkshire and the Humber generates 14.6% of its regional output from manufacturing, significantly above the UK average of 9.6% and over 300,000 are employed in manufacturing in the region[15].

[15] Make UK (2021) Regional Manufacturing Outlook 2021.

Of the companies questioned, 58% (seven companies) stated that they have a decarbonisation plan, with 41.7% (five companies) stating that they do not. However, for those companies who don't currently have a plan, decarbonisation looks to be gaining importance with 90% (four out of the five companies) stating that there are plans to create a decarbonisation programme. Most of the companies are looking to reach net zero emissions between 2036-2040 (four companies, 33.3%), 2041-2045 (two companies, 16.7%) and 2046-2050 (four companies, 33.3%), so in total 10 of the 12 companies are looking to reach net zero between 2036-2050. The ambition of these companies to decarbonise can be supported by the deployment of the ECHP North - Phase 1, which has a complementary timeline.

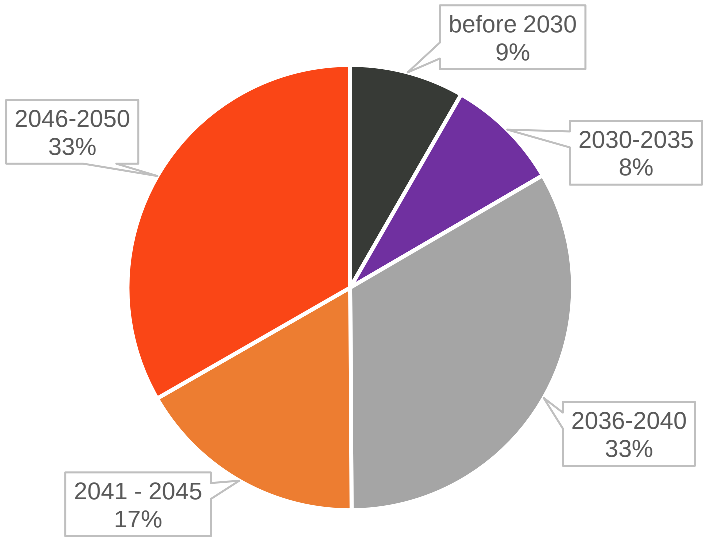


Figure:12 When does your company expect to reach net zero?

When we asked the question 'if hydrogen was unavailable to you at scale before 2050, would you still have the means to reach net zero?', only 25% believed that they would have the means to reach net zero (using other technologies), with 50% saying they were unsure if they could, and the remaining 25% saying they could not reach net zero without hydrogen. With 75% of the companies (nine companies) believing that they either are unsure or believe that they do not have the means to reach net zero without hydrogen. This shows the huge importance hydrogen being available in the region to serve industrial demand.

One mineral processing company and one chemicals company stated that methane with CCUS could be an alternative to hydrogen, but they were uncertain as to whether they could gain access to CCUS infrastructure. Electrification has been considered in many cases but for the majority of companies, hydrogen is the most viable option without having to undergo significant technical changes on site or grid connection upgrades where cost is prohibitive. More than one customer has stated that electrification will be more disruptive and significantly more expensive than hydrogen as things currently stand. Another commented that electrifying is possible, but it is unlikely that electrical transmission and connection infrastructure will be in place in time for them to meet their decarbonisation targets. One company, a power provider, stated that if hydrogen is not available, this would require a drastic shift in their business model – from energy generation to a more short-term energy storage model using batteries.

Having established that hydrogen is the preferred decarbonisation option for these companies, and in some cases is seen as their only option, we explored the next layer level of detail surrounding whether the availability of hydrogen pipeline networks would have material impact in the ability to decarbonise operations and reach net zero by 2050 or whether there are other ways that hydrogen will be transported to sites of demand (i.e. tanker, rail etc). Results found that 58.3% (seven companies) agreed that it would have a material impact on their ability to meet 2050 targets if a hydrogen network was unavailable, 25% (three companies) were unsure and 16.7% (two companies) did not agree. That said, **all the companies stated that they are expecting to be connected to a hydrogen public pipeline network, such as the ECHP North – Phase 1 project**. This shows that there is a clear need for the hydrogen pipeline network infrastructure.

Between them, the companies have looked at a large variety of technologies to enable them to decarbonise and have not solely focused on hydrogen. Hydrogen, energy efficiency improvements and electrification are the top technologies that have been considered by the companies. This is shown in Figure 13.

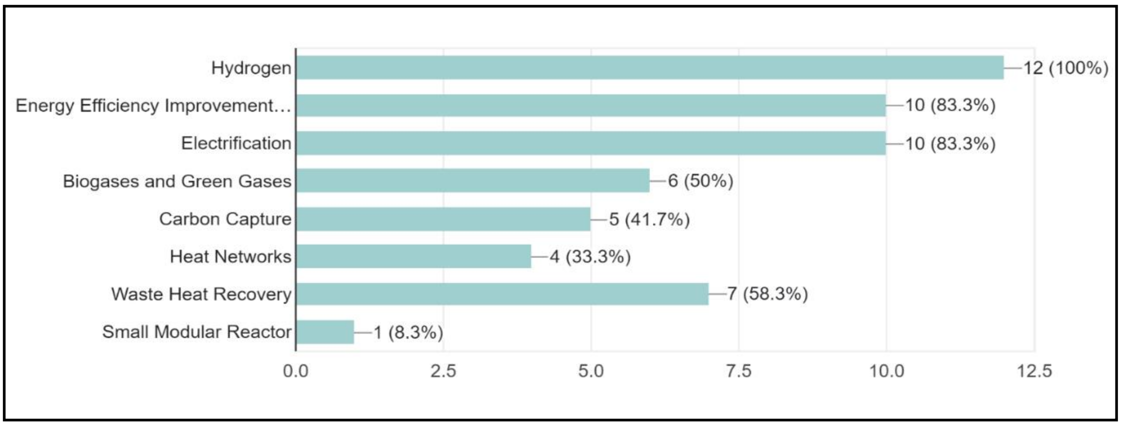


Figure 13: Decarbonisation Technology considerations

The survey also explored the reasons that some of these options had been discounted. Reasons for discounting options included:

- Carbon capture was excluded due to many companies being located outside of the CCUS clusters, and therefore not having access to the infrastructure. Carbon capture was also excluded because of a lack of confidence in the technology itself, with no successful examples of CCUS in action in the UK to date and doubts over whether CCUS would be available in a timely way if located outside a Track 1 CCUS cluster.
- Electrification discounted due grid constraints, new electrical equipment being cost prohibitive and also electrification of equipment not possible.
- Small modular reactors discounted due to cost and uncertainty around technology options.

2.10. Cost Benefit Analysis (CBA)

2.10.1 CBA Summary of Results

We contracted Frontier Economics to undertake a CBA on the ECHP North – Phase 1 pipeline project and it showed a positive Net Present Value in all of the scenarios considered. The four scenarios and their associated Net Present Values are illustrated in Table 8.

Scenario Number	Scenario Description	Net Benefits (£ 2023, million)
1a – Base Case	Core network with large pipeline and demand levels as per customer forecasts	1202
1b – Base Case with small investment	Core network with small pipeline and demand levels as per customer forecasts	1312
2	Core network with large pipeline and demand delayed by 5 years	824
3	Core network with large pipeline and 2035 demand levels achieved earlier, in 2030	1287

Table 8: CBA Scenario results

ANNEX E contains the slides that Frontier presented at the end of their work. The timeline for the assessment considers costs and benefits until 2050, when net zero emissions has been mandated to be reached. To ensure that the analysis only considers costs and benefits that are attributable to the period up to 2050, all capex has been annualised, using illustrative assumptions for the cost of capital as per the Spackman approach.

2.10.2 CBA Scenarios in Detail

Three customer segments have been included in the CBA scenarios: Cornerstone Users (CUs) (ten customers, 3.2TWh of demand by 2035), Additional Users (13 customers, 1.4TWh of demand by 2035) and also a further 11 connection points that can supply ‘future connections’ (11 sites, 0.9TWh of demand by 2035). Demand levels are delayed or accelerated in Cases 2 and 3 respectively. The definition for each customer segment is in Figure 14.

Cornerstone Users	Additional Users	Future Connections
		
Are identified based on having some of the largest hydrogen demands in each regional hydrogen demand cluster with strong readiness to connect by 2030. They are the customers that have been used to determine the optimum pipeline route corridor and will be initial connectees of the pipeline. All CUs have submitted a hydrogen demand forecast to us.	The large majority of these customers have submitted a hydrogen demand forecast* to Cadent and are located within 5km of the pipeline route. These customers either have lower hydrogen demand than CUs or submitted their forecast to Cadent too late to be considered in the Pre-FEED. A 'back -check' in June 2024 will establish which of these customers will be initial connections to the pipeline, and which will need to connect at a slightly later date (if their connection in the initial stage adds too much complexity and risk to the main construction project). *2 of the 11 Additional primary customers have not yet submitted a formal hydrogen forecast to Cadent at the time of writing (February 2024) but have been assumed to switch to 100% hydrogen in 2030 or 2031, depending on their location, in the base scenario.	Future connections have been considered in the CBA to show expansion once the pipe has been commissioned with additional customers. The figure used is based on real industrial and power generation natural gas customers who Cadent has not yet engaged with, that are located on industrial estates across the North – Phase 1 pipeline corridor. They are assumed to switch to 100% hydrogen from 2035. It may not be these specific customers who are the future connections of the pipeline and could instead be others who move into the area specifically to access low carbon hydrogen for feedstocks or as a fuel. Based on our experience of HyNet, we expect the amount of future connections to be far higher than 0.9TWh by 2035 but for now a conservative approach has been adopted.

Figure 14: Hydrogen User Types

The ECHP North – Phase 1 pipeline has been routed and designed specifically to address the needs of the industrial and power generation sites that are its primary customers. However, given the high cost of building the pipeline and its close proximity to towns, it is logical to consider whether or not the pipeline should be 'up-sized' at incremental cost to supply domestic properties if required, subject to the 2026 heat policy decision. Whilst additional infrastructure would be needed to facilitate town conversion, a single pipe that has been 'up-sized' would be cheaper to construct than two smaller pipes, with the second being built later if required for domestic heat. Our scenario work and CBA is designed to help provide inputs for a decision on the scale of demand that the pipeline should be designed to accommodate, a decision which will be made in consultation with Ofgem and DESNZ prior to the start of the FEED.

The core scenario, '1a – Base Case', has a core network with a large pipeline. The large pipeline diameter assumes that all customers (domestic, commercial, industrial) in towns in northern Lincolnshire, South Yorkshire and East Midlands switch from natural gas to 100% hydrogen with a flat consumption profile. This scenario was sized during the Pre-FEED to give an idea of how much bigger the pipeline will need to be to transport hydrogen at town conversion scale in this region (rather than solely supplying the industrial and power generation customers from whom we have received forecasts). The small pipeline diameter, which is '1b – Base Case with small investment', assumes that only industrial and power generation demand is accommodated (plus Scunthorpe Pilot Demand if needed), with a flat consumption profile. Further consideration on 'Line Sizing' is given in section 3.4. Scenario 2 looks at if all customer demand is delayed in 2030 for five years to 2035, whilst the final Scenario 3 – faster demand, assumes that the 2035 forecast moves five years earlier to 2030. Table 9 provides an overview of the rationale and comments.

Case	Investment	Demand	Rational	Comments
1a – Base Case	Core network with large pipeline	Forecasted industrial demand in the core network informed by: 10 Cornerstone, 13 Additional connections, 11 Future Connections	Testing the benefits for the UK society of building a core network with large investment	We are working on two possible investment dimensions, given the level of uncertainty. Plans rely on new build pipelines. The costs of future connections are uncertain, so averages have been taken based on other customer costs
1b – Base Case with small investment	Core network with small pipeline		Testing the benefits for the UK society of building a core network with larger investment	
2 – Delayed demand	As per 1a	Delayed demand with respect to 1a (all customer demand is delayed by 5 years)	Testing the benefits for the UK society of building a core network with large investment, if growth is slower than expected	For all customers, demand in 2030 is delayed by 50% per customer for 5 years in the absence of any specific evidence to suggest customers or categories of customer that are more likely to be subject to delay
3 – Faster demand	As per case 1a	Accelerated demand with respect to 1a (2035 demand levels are achieved 5 years earlier)	Testing the benefits for the UK society of building a core network with large investment, if the growth of hydrogen demand is faster than expected	Cadent´s demand forecasts expected by year 2035 is moved 5 years earlier (to year 2030)

Table 9: CBA Case Scenarios

2.10.3 CBA Infrastructure Requirements Assumptions

Each scenario considered a factual where the ECHP North – Phase 1 pipeline was built and a counter-factual comprising options to decarbonise if the pipeline is not built. The counter-factual is predicated on customers either electrifying or using onsite green hydrogen production from electrolysis, as blue hydrogen was not considered viable at small-scale in the counterfactual. For power generation it was assumed that the power generators would need to move their sites next to large-scale salt cavern storage and new power lines would be installed to take the electricity to the location on the network where it is required, this is discussed in Section 2.10.4. Table 10 outlines the assumptions.

Case	Underground storage	Hydrogen Distribution	Power Gen (Wider Impacts)	Electricity Networks	Natural gas supply and infrastructure costs. CO_2 infrastructure costs
Factual (With ECHP North - Phase 1)	Underground storage (e.g. salt caverns are needed for power generation. Electrolytic hydrogen also requires hydrogen storage to ensure cost effective baseload supply.	North - Phase 1 investments take place.	Our industrial customers consume hydrogen (mix of green and blue). Power generation is required to meet demand for electrolysis.	**Industrial demand**: investments in electricity network required to keep pace with BAU growth in electrification. **Existing Hydrogen to Power (H2P) sites within our network**: No further assessment required.	Blue hydrogen production forms part of the mix, uses natural gas, and makes use of natural gas and CO_2 infrastructure.
Counterfactual (Without ECHP North - Phase 1)	Underground storage (e.g. salt caverns) is needed for power generation. Electrolytic hydrogen serving industrial cannot access underground storage in the absence of a network.	North – Phase 1 investments do not take place.	Our customers electrify or use grid-based electrolysis. Increase in electricity demand - both since greater share of electrolysis in hydrogen mix (since blue hydrogen ruled out) and due to electrification.	**Industrial demand:** Compared to factual, increase in electricity consumption. This is due to modelled increase in electrification and to assumed increase in share of (network-fed) electrolysis in hydrogen production mix (since we assume blue hydrogen production is not feasible in the counterfactual). **H2P capacity within our network:** Generating capacity assumed to co-locate with storage, meaning additional investments needed to connect demand with underground storage.	Blue hydrogen production is not feasible in the counterfactual.
Impact of ECHP North – Phase 1	Increase in underground storage needs for electrolysis. We capture this impact via the assumed baseload hydrogen supply cost in the factual.	Increase in hydrogen network costs.	Lower electricity demand, driving **savings in power generation costs** (captured via assumed energy supply costs in counterfactual).	**Industrial demand: Savings in electricity network costs** resulting from lower demand (captured via assumed energy supply costs in counterfactual). **H2P capacity within our network:** Savings in power distribution costs.	Increased costs of gas supply (production and network) and increased CO_2 transport and storage costs.

Table 10: CBA Assumptions

2.10.4 CBA Costs

There have been several costs inputted into the CBA, that include:

Industrial Costs: The factual (where ECHP North - Phase 1 is built) includes industry's costs to convert to hydrogen, for example the cost of retrofitting gas technology (e.g. a hydrogen boiler). To ascertain the CAPEX, fixed OPEX cost and efficiencies the economic consultant used the CCC/Element Energy N-ZIP model as a basis. Energy costs were based upon published sources (mainly DESNZ). For electricity costs in the counterfactual the long-run variable costs (LRVC) were used, which capture a long-run average of wholesale energy cost + transmission + distribution cost[16]. This implied distribution is likely to be conversative. For electrolytic hydrogen in the counterfactual when hydrogen is co-located with industry, DESNZ hydrogen production cost projections[17] were used. Onsite generation of hydrogen was only selected as the counterfactual for the sections of customer energy demand where customers had told us that they absolutely cannot electrify. Two cases are considered for costs, which are offshore wind production + salt cavern storage and onsite baseload electrolytic production. The cost of blue hydrogen includes the cost of gas supply, network costs and CO_2 transportation costs. The cost of the blue hydrogen was sourced using DESNZ published material. The counterfactual considers it unrealistic that a single site would create its own blue hydrogen supply onsite due to the large sale required (multiple 100MW), therefore the self-supply of hydrogen in the counterfactual is green, using smaller scale electrolysers. It is accounted for that the cost of green hydrogen may increase in the counterfactual due to the electrolysis not being able to access geological hydrogen storage through an integrated regional network. Given the relatively high cost of onsite hydrogen supply, electrification was generally modelled as being the cheapest alternative for many processes and sites. Overall, 96 of the 126 modelled processes (76%) were modelled as being electrified in the counterfactual, this corresponds to 81% of the average annual demand under Case 1.

Power Generation Costs: Hydrogen to Power (H2P) is considered in this CBA as a technology which is expected to play a role in providing flexibility on the electricity system, turning hydrogen into power as back-up to intermittent renewables. Ideally, H2P needs to be connected to large storage so it can have sufficient access to hydrogen to meet peaking demand. In the factual, connectivity to a hydrogen network enables H2P to be located more optimally as it can be located to wherever it provides optimum benefit to the electrical grid. In the counterfactual, it is assumed that H2P needs to locate itself close to geological storage. Other alternatives have been considered such as building dedicated above ground storage and transportation of hydrogen to a store using trucks, but neither are viewed as cost effective. Therefore, the economic assessment considers the effects of changing the location of the H2P capacity on electricity network reinforcement costs to where they have been relocated. The unit cost assumption for the electricity distribution cable is £2,060[18] per km with an average plant capacity of 28MW and 15km. These figures are thought to be very conservative and could be significantly larger, but a conservative approach has been preferred. There are clear benefits with regards to the factual as costs can be avoided for H2P relocation to near to storage.

---

[16] DESNZ – Green Book supplementary guidance: valuation of energy use and green house gas emissions for appraisal. Found Online: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal
[17] Hydrogen Production Costs for 2021, DESNZ. Found Online: https://www.gov.uk/government/publications/hydrogen-production-costs-2021
[18] Growth Scenarios for UK Renewables Generation and Implications for Future Developments and Operation of Electricity Networks, BERR June 2008

Pipeline Costs: Include our CAPEX and also FEED costs. With regards to hydrogen OPEX, there are not yet precise costings, so an approach has been followed which starts with the average methane network OPEX cost per kilometre and an uplift has been included, reflecting a possible increase in OPEX during the delivery of a hydrogen gas grid. ANNEX E, Slide 48 considers this further.

There is no counterfactual cost for the pipeline (as it is not built) and decommissioning does not apply. For our CAPEX costs, in total, six cost types have been included. Currently, we do not have exact costs for future connections, but the working assumption is that these costs will be similar as the sites are not further away than the costed cornerstone/initial connection spurs, so the cost of the required spurs has been calculated using distance between the main pipeline and future connections and an average cost per kilometre.

The pipeline costs that have been included are reflected in the table in Table 11.

Type of investment	Cost (£M GBP)		Construction period
	Small diameter	Large diameter	
FEED Costs	[cost data]	[cost data]	2025-2028
Main Line	[cost data]	[cost data]	2029-2032
HAGIs	[cost data]	[cost data]	2029-2032
CU spurs	[cost data]	[cost data]	2029-2032
Additional customer spurs	[cost data]	[cost data]	2029 -2032
Future connection spurs	[cost data]	[cost data]	2031-2034
Totals	[cost data]	[cost data]	
*FEED costs were put into CBA before final costings review was undertaken.			

Table 11: CBA pipeline costs

Environmental Costs: There are two components of environmental costs, which are fugitive emissions and construction emissions. Fugitive emissions are assumed to occur at a rate of 0.26% of the total demand connected to the distribution network. Construction emissions are assumed to be 27tCO_2e per km of pipes laid through-out the period of 2025-2050.

2.11. CBA Results

Table 12 provides an overview of the results of the CBA. All scenarios show a net positive outcome, with Case 1(b) being the highest positive NPV, predominately due to the hydrogen pipeline CAPEX and OPEX being less than Case 1(a), which is sized to include town conversions (but does not include the carbon savings benefit of the town conversions).

Net cost savings (NPV 2023-2050, £ 2023, million)		**Case 1 (a) Base case large**	**Case 1 (b) Base case small**	**Case 2 Delayed demand**	**Case 3 Accelerated demand**
Savings in industrial decarbonisation costs	Cornerstones	1,434	1,434	1,150	1,516
	Additional customers	416	416	320	420
	Future connections	187	187	187	187
Savings in electricity network costs	Cornerstones	1	1	1	1
	Additional customer	8	8	8	8
	Future connections	3	3	3	3
Hydrogen pipeline CAPEX and OPEX	FEED + Main line + HAGIs	[cost data]	[cost data]	[cost data]	[cost data]
	Cornerstones	[cost data]	[cost data]	[cost data]	[cost data]
	Additional customers	[cost data]	[cost data]	[cost data]	[cost data]
	Future connections	[cost data]	[cost data]	[cost data]	[cost data]
Environmental costs (fugitive and construction emissions)	Cornerstones	-10	-10	-9	-10
	Additional customers	-4	-4	-3	-4
	Future connections	-2	-2	-2	-2
Cornerstone Customers – total Benefit (with costs removed)		669	779	386	750
Additional Customers – incremental benefit		379	379	284	383
Future Connections – incremental benefit		154	154	154	154
Net Benefits		**1202**	**1312**	**824**	**1287**

Table 12: CBA Results

2.12. Commentary on the CBA Results

It is important to note that every single scenario considered in our assessment gave a positive CBA result.

Case 1a – Base Case 'Large'

The base case assumed 'large demand' (and therefore larger pipe diameter), but only carbon savings benefits associated with the industrial and power generation customer demand were included. The benefits could be far larger with this scenario, because the pipeline has the capacity to transport 8TWh of additional hydrogen per year (assuming a flat consumption profile). This additional hydrogen could be used to decarbonise either all of the local towns (see footnote for a full list[19]) or could be used to decarbonise transport applications (e.g. Ports, HGVs or a large airport such as Birmingham through onward pipeline connection).

Furthermore, if only the ten CUs were connected to the pipeline and no other customers, the CBA results are positive (£669m). Adding the 'Additional Customers' (who are asking for a 2030 connection) and projected Future Connections (real industrial customers whose sites are along the pipeline route but who we have not yet engaged with), the maximum CBA result in this scenario is £1202m. This is a very strong position to be in as it provides an element of resilience to the project – the CBA is positive even half of the customers never connect at all.

Case 1b – Base Case 'Small'

In this scenario the pipeline is 'right-sized' for only the industry and power generation customers, assuming a flat consumption profile, which means a smaller diameter, lower cost pipe than in Case 1a. During the FEED, when the actual demand profiles and ramp-up rates of industry and power generators are accounted for, we may find that a larger pipeline diameter is required to accommodate industrial and power generation customer needs, which is why it is useful to be able to show that the CBA is positive for a larger pipeline diameter, but the same annual demand level, as in Case 1a. The lower cost of the smaller pipeline in 1b, but the same level of benefits from industrial and power generation carbon savings, mean that the NPV is more positive for Case 1b (£1312m).

Case 2, Delayed Demand and Case 3, Accelerated Demand

Delaying the demand reduces the benefits of the carbon savings by 2050 but is still a positive CBA result (£824m), and accelerating the demand increases the NPV vs. Case 1a – Base Case 'Large' (£1287m), but Case 1b - Base Case 'Small' still has the highest NPV (£1312m).

Access to a hydrogen network increases the pace and likelihood of decarbonisation of the identified sites

The primary driver for the positive CBA results is the savings in estimated fuels costs; these account for most of the savings in industrial decarbonisation costs. This shows that if industry and power in the region can have access to low carbon hydrogen that is connected to a store via a pipeline/network, then this offers them significant savings and pace to decarbonise compared to having to electrify or use onsite electrolysis.

This finding is backed up by what we are being told by our 23 prospective hydrogen customers, many of whom say that electrification (the connection itself and the energy cost) is simply too expensive for their business models to accommodate.

The energy costs greatly outweigh the cost of onsite technical changes to equipment, and therefore analysis has been undertaken to understand sensitivity of results in different (low, central, high) energy supply costs. This can be further viewed in ANNEX E, Slide 11.

---

[19] * Including the following towns: Scunthorpe, Grimsby, E Doncaster, Gainsborough, Doncaster, S Doncaster, SE Doncaster, Barnsley, Rotherham, Sheffield, Dronfield, Mosborough, Aston, Killamarsh, Staveley, Chesterfield, Lincoln, Lincoln Villages and Louth.

2.13. Additional Benefits of Building the ECHP North – Phase 1 Pipeline

As well as the quantified results, there are a number of strategic benefits that should also be considered that have not been quantified in the CBA itself. These are:

Reducing the risk of missing carbon budgets and the net zero target: In the quantitative assessment, it assumes that alternative infrastructure that would be necessary in the absence of hydrogen network investments, such as electricity distribution, and large quantities of above-ground hydrogen storage, and that these could be delivered over the same timescales as hydrogen network investments. In practice, such infrastructure may be subject to delivery challenges such as consents, space requirements and most importantly the existing backlog in electricity distribution and transmission upgrades. All of our customers who have explored electrification have been told that it could take many years (often eight-ten years) to get access to the upgraded supply that they would require if they electrified. If a delay in delivering counterfactual infrastructure resulted in continued temporary use of methane by industrial customers (instead of decarbonisation) then, as an illustration, each year of delay could lead to additional GHG emissions of 0.5mtCO_2e/year, or c.£150m/year of benefits in the factual. Decarbonisation of industry and power generators through pipeline connected hydrogen means less reliance on electricity network upgrades, therefore spreading and reducing risk of missing net zero targets.

Resilient to shocks: In the factual, with hydrogen supply via pipe, consumers have access to numerous and diverse supply sources. This will be more resilient to shocks (such as unplanned outages of hydrogen production) than in the hydrogen counterfactual, where the consumer opts for hydrogen from a single source (note: these are customers for whom hydrogen is demonstrably the only decarbonisation option they can utilise). The additional costs of ensuring baseload hydrogen supply have been partly accounted for in the counterfactual, including provision of enough above ground storage to cover one day of demand. But this is unlikely to fully capture the cost of insuring against unexpected shocks. It can take weeks to fix a broken electrolyser, for example. Many of the HAR1 projects that have been funded involve onsite or near-site hydrogen production. The hydrogen supplied will be blended into existing on-site natural gas supplies, giving the option for these sites to switch back to 100% natural gas if there is a hydrogen supply issue. Our hydrogen counterfactual assumes switching of industrial equipment to 100% hydrogen supplied by onsite production and gives no opportunity for a natural gas back-up (and only limited hydrogen back-up). The financial risks of this may be prohibitive for industrial customers and ultimately a pipeline connection will need to be in place before a full switch to hydrogen from natural gas can take place.

Enabling a hydrogen heating option: Given uncertainty regarding government's strategic decisions on hydrogen in domestic heating, we have not included such benefits in our headline CBA result (nor accounted for any additional hydrogen lower pressure tier network requirements).

As an illustration, however, the benefits from the emissions saved annually from serving our current heating demand in local towns[20] with low carbon hydrogen instead of methane could amount to around £381 million per year (in 2030) (see ANNEX E, Slide 53 for more information). Note that this estimate does not include the costs of hydrogen for heating, it only includes the emissions savings, as an illustration of the potential benefits.

[20] Including the following towns: Scunthorpe, Grimsby, E Doncaster, Gainsborough, Doncaster, S Doncaster, SE Doncaster, Barnsley, Rotherham, Sheffield, Dronfield, Mosborough, Aston, Killamarsh, Staveley, Chesterfield, Lincoln, Lincoln Villages and Louth.

By comparison, the incremental cost of building the larger pipe in 'Case 1a' to accommodate the higher demand level (hydrogen to be used either for domestic heating demand or alternatives such as transport), compared to the smaller pipe in 'Case 1b' that can accommodate the industrial power generation demand (assuming flat consumption levels), is only £111m.

Protecting gas consumers' investment: The existing gas network is a hugely valuable energy transportation asset delivering peak energy demands highly efficiently. The gas network typically delivers five times more energy to a home on a peak demand day than electricity. Through their bills, gas consumers have funded this network, and extending its useful life protects that significant investment. Early hydrogen economy projects that demonstrate the value and effectiveness of hydrogen, will improve the likely re-use of existing gas network assets, protecting gas consumers' investment, and protecting consumers from the cost of decommissioning. According to a recent Arup[21] report and the scenarios they modelled, decommissioning could cost between £46-74bn, depending on the scenario undertaken.

[21] Arup (2023) – Future of Great Britain's Gas Network

3. Project Option Selection

This chapter details the stages of hydrogen network design development completed through the Technical Feasibility and Pre-FEED stages, along with the outputs from each stage. It describes how we developed the strategic network options, customer connections and pipeline route corridor options through various stages of assessment, leading to the selection of a preferred option to progress to FEED.

As described in Section 2 and in Section 7, during 2021, 2022 and 2023, we carried out multiple engagements with prospective hydrogen customers, producers and storage providers in the region; where appropriate each site or project owner submitted a forecast for their hydrogen demand requirements, or their planned hydrogen production and storage projects. This information was used to inform a Technical Feasibility and Pre-FEED study which followed the objectives as detailed in Section 1.3.

The approach taken to developing the project in this phase was to split into two distinct parts. Technical Feasibility, with the main output of a Strategic Options Report, followed by a more detailed Pre-FEED with multiple outputs linked to pipeline route corridor development and HAGI location. Figure 15 shows the Pre-FEED approach taken. One of the key parts of the approach was to use sequential design freeze and back checks to ensure that any previous decisions made remained valid as the project developed.

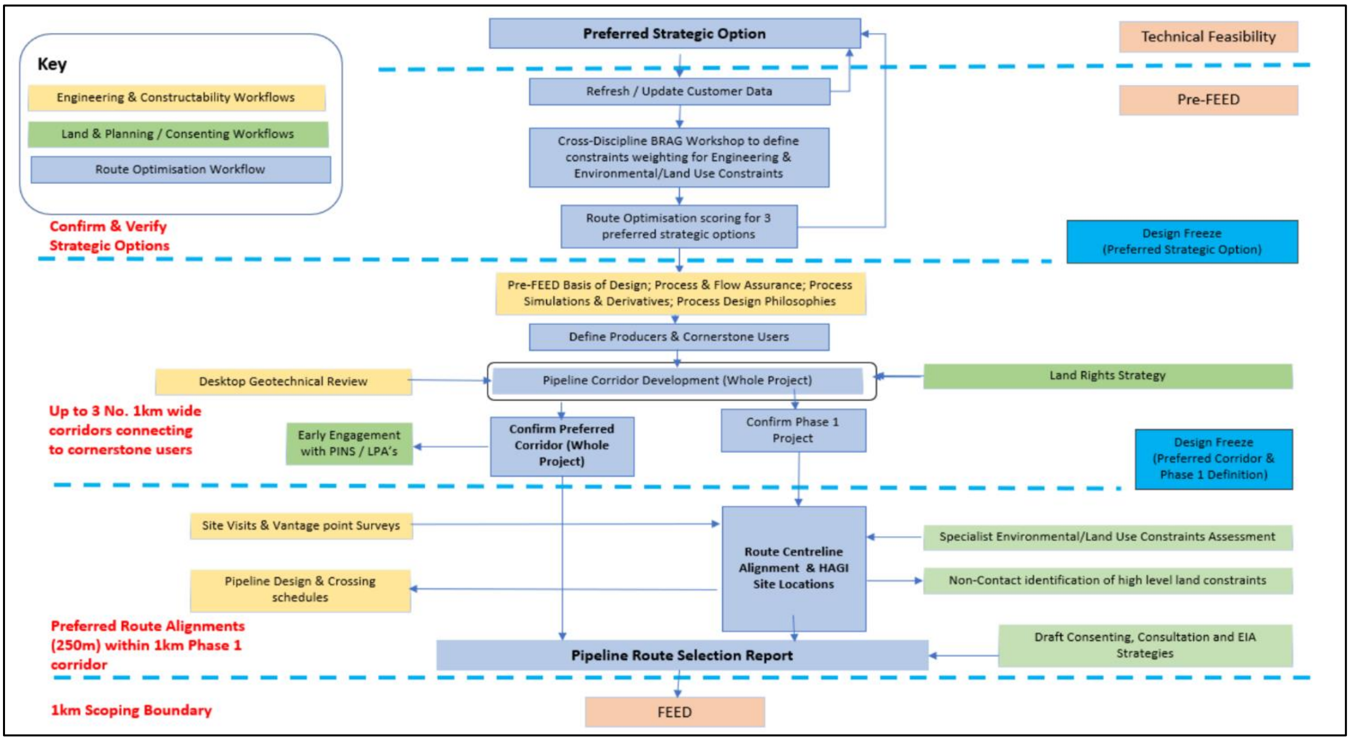


Figure 15: Process Flow for the development of pipeline corridor routes and HAGI locations during Pre-FEED.

3.1. Strategic Options Report

3.1.1 Mapping of Prospective Hydrogen Industrial Customers During Pre-FEED

The region in scope for the ECHP Pre-FEED covered our 'East Midlands Network' area, which includes the counties of South Yorkshire, Nottinghamshire, Derbyshire, Leicestershire, Lincolnshire, Rutland and Northamptonshire, this can be seen in Figure 16. The project study area is a refined geographical footprint that includes the industrial and power customers and hydrogen production sites, who have submitted hydrogen demand or production forecasts to us (outlined in Section 2 of this report).

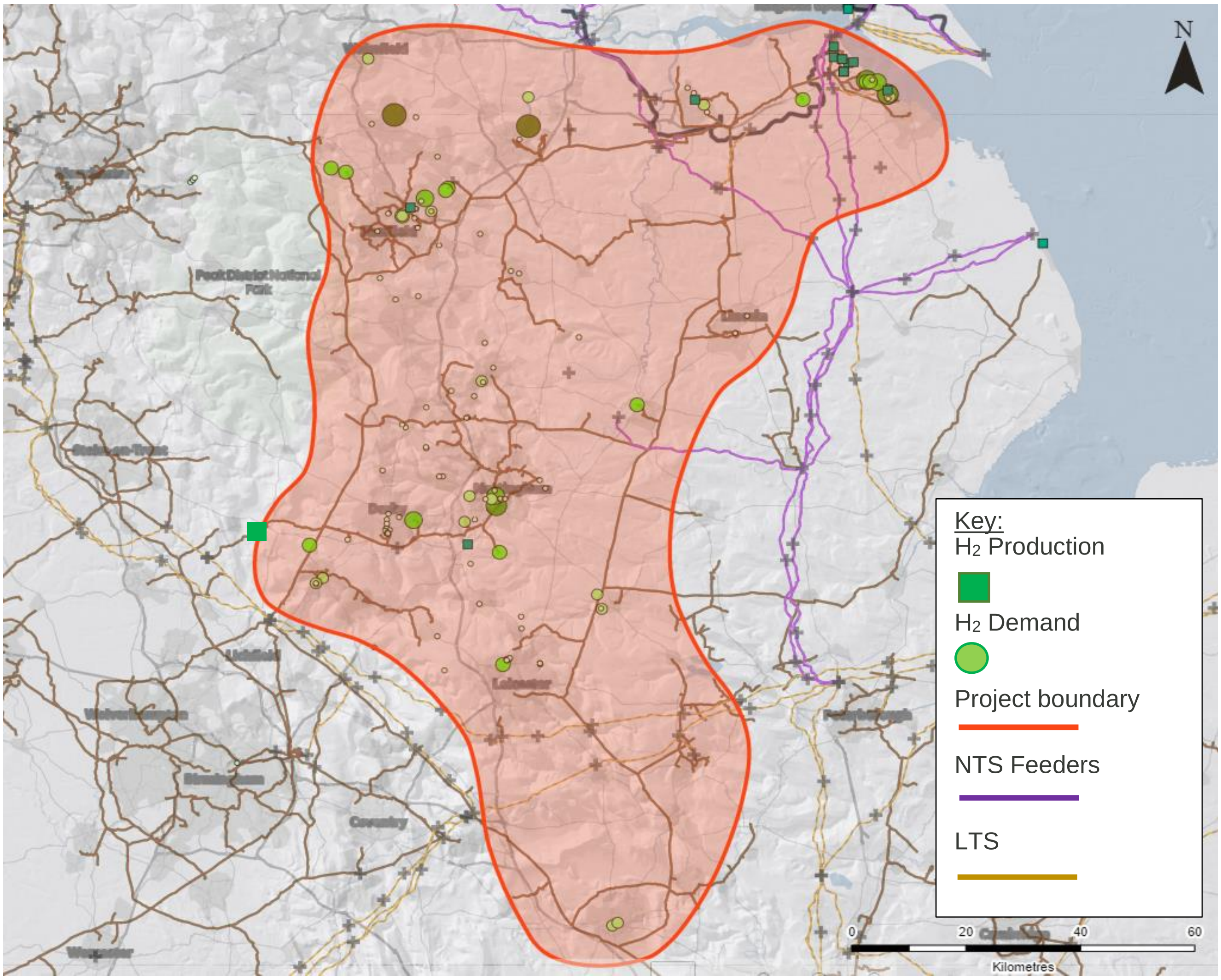


Figure 16: Cadent's East Coast Hydrogen Project Study Area

The project study area boundary sets out the potential spatial scope of our full ECHP project. Within that boundary, to develop network level strategic options and subsequent pipeline, it was important to identify some key anchor points or localised geographical areas of concentrated hydrogen production and demand that a pipeline could be routed to. This was achieved by assessing the size and location of the production and demand and then grouping them into geographical clusters. Ten individual clusters were identified – nine demand clusters and one hydrogen supply cluster. It should be noted, that whilst the majority of planned hydrogen production is located at Immingham, there is also a significant hydrogen production cluster in Nottinghamshire, and a smaller one in Sheffield. Table 13 and Figure 17 illustrate the ten clusters. By spatially defining the customer clusters and hydrogen production cluster, the ECHP project study area was further refined, with the red hashed line showing the new boundary of the project, as shown in Figure 17.

Cluster No.	Cluster area	Cluster No.	Cluster area
1	Immingham – Producers only	6	Nottingham and Derby
2	Immingham and Grimsby	7	Leicester
3	Scunthorpe	8	Newark and Lincoln
4	Doncaster	9	Northampton
5	Sheffield and Barnsley	10	Mansfield and Chesterfield

Table 13: East Coast Hydrogen Area Demand Clusters.

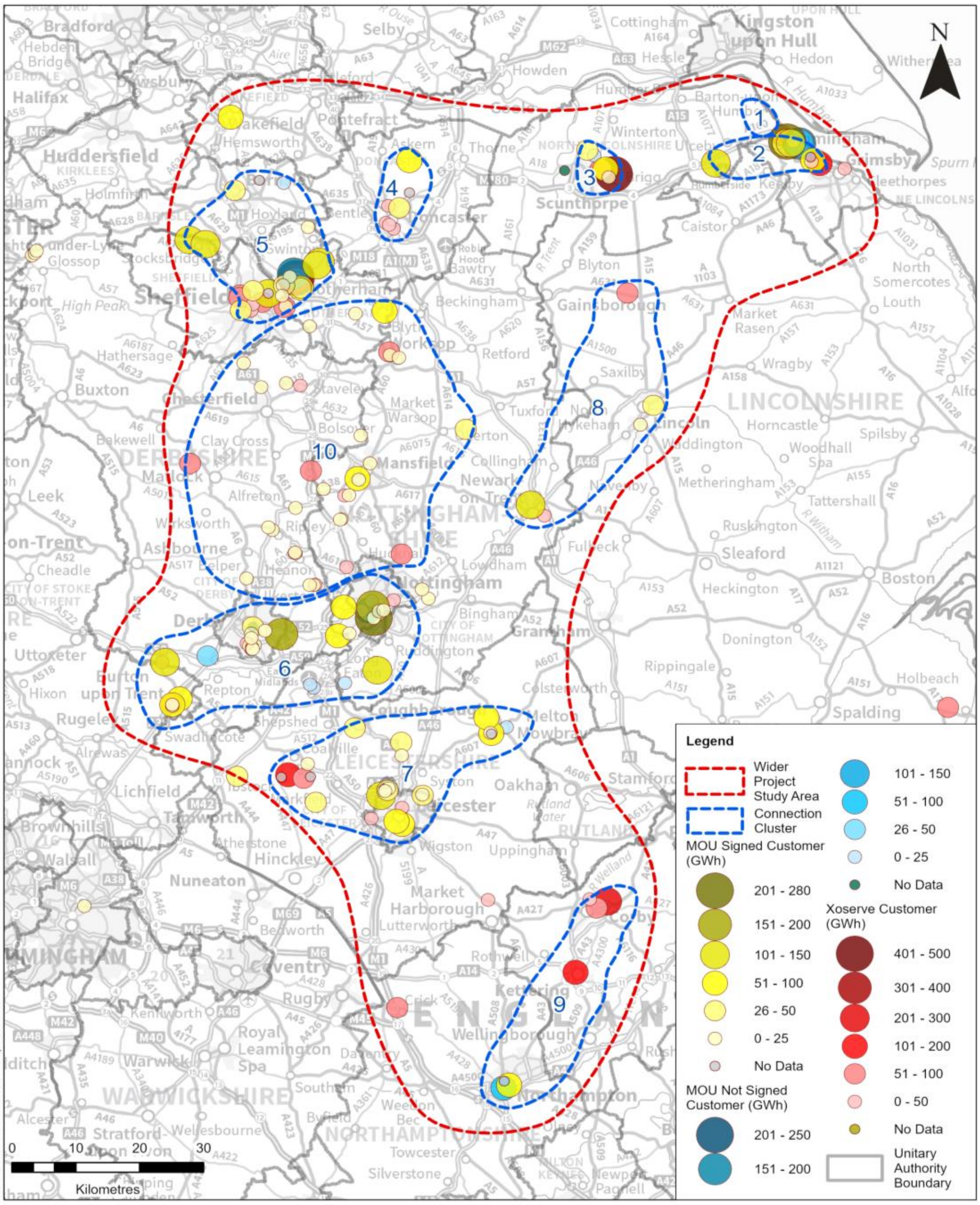


Figure 17: Refined Project Boundary and Demand Clusters

In Figure 17, the customer sites labelled 'XoServe Customer' in red and pink, are those that are listed amongst our Top 120 highest natural gas consumption in the region, but who we had not yet engaged with or had not yet received a forecast from at that time (Q2 2023). The size of the circle is determined not by forecasted hydrogen consumption but by annual natural gas consumption.

3.1.2 Preferred Strategic Option Methodology

Once the project boundary had been established, as set out in Figure 17, we explored how the ECHP area could be formulated to ensure that it offered the most decarbonisation value but with minimal footprint and complexity with regards to pipeline routing. Due to the size of the ECHP area and the large number of differing options that were presented, a Strategic Options Appraisal was completed. The aim of the Strategic Options Appraisal was to identify what the overall ECHP project could look like.

The Strategic Options Appraisal methodology adopted the following steps:

1. Identification of strategic network configuration options for the whole Pre-FEED project study area
2. Development of a set of criteria to score each of the strategic options against. Criteria weightings were guided by the Project Objectives and scored using a range of 1 to 4.
3. Each Strategic Option was scored against the criteria (see Table 14). The scoring criteria had different weighting depending on the priority of each of the criteria. Customer readiness to convert to hydrogen was given the highest weighting.
4. Total weighted scores for each strategic option were calculated.
5. The output from the Strategic Options Appraisal was reviewed and considered as part of a project team workshop to review and challenge the scores.
6. The strategic options with the highest total weighted score were designated as the 'preferred' strategic options.

Criteria	Weighting	Justification
Current customer demand (in project area) based on natural gas consumption	15	This criterion is important to understand both current and potential future demand in a cluster. As demand for hydrogen is a critical driver for the project this criterion receives a relatively high weighting.
Current readiness to convert hydrogen	20	Assessing customer readiness for hydrogen conversion allows identification of the clusters and therefore the strategic options which are most viable for development. As this is the principal driver and objective of the project this receives the highest weighting.
Connects producers and provides routes to market for scaling up supply	15	Connecting producers with customers is a core project objective, and therefore, receives a relatively high weighting at 15%.
Meets the objectives of East Coast Hydrogen interconnectivity with partner projects	10	This is a key objective of the project but receives a lower weighting than the previous elements which are more critical to the forming of the project.
Network resilience, security of supply and continuity	10	As per previous criteria, an important project objective but of lower importance than hydrogen supply, demand and readiness to convert.
Future proof (including future domestic opportunities) and phasing option possibilities (short and longer term)	5	Future proofing is an important consideration, but out of the criteria listed is the least important in forming the project and, therefore, does not receive a weighting that would overly influence a strategic option scoring.
Engineering and constructability (principally topography and major crossings and cost)	10	The constructability of the project is key to assessing the options and, therefore, developing a viable project. It receives a moderate level of weighting.
Environment, land use and consentability	10	The environmental and land use criterion evaluates the likely consentability of a strategic option. It receives a moderate level weighting as it is an important consideration but is not a principal driver of the Project like supply, demand and readiness to convert.
Proximity to urban areas	5	There is a preference where possible to avoid major urban areas for safety and constructability reasons. It receives a lower weighting as whilst an important consideration this is more of a detailed design consideration and therefore, should not overly influence the selection of strategic options.

Table 14: Scoring Criteria Justification

3.1.3 Strategic Options Assessment Outcomes

As a result of the Strategic Options Appraisal, a total of eight different whole project strategic options were developed and are summarised in ANNEX F*.* The eight options were assessed and scored, and the results ranged from 235 to 375 out of a total of 400, as illustrated in the summary of strategic options scoring table in ANNEX F. The review of constraints and scoring against the criteria found that there are relatively few significant technical constraints that would immediately discount any of the strategic options. However, Option 3 (shown in Figure 18) is the top performing option for the whole project study area with a score of 375 out of 400, scoring highly in its ability to connect current customer demand, provide network resilience, phasing potential and future proofing.

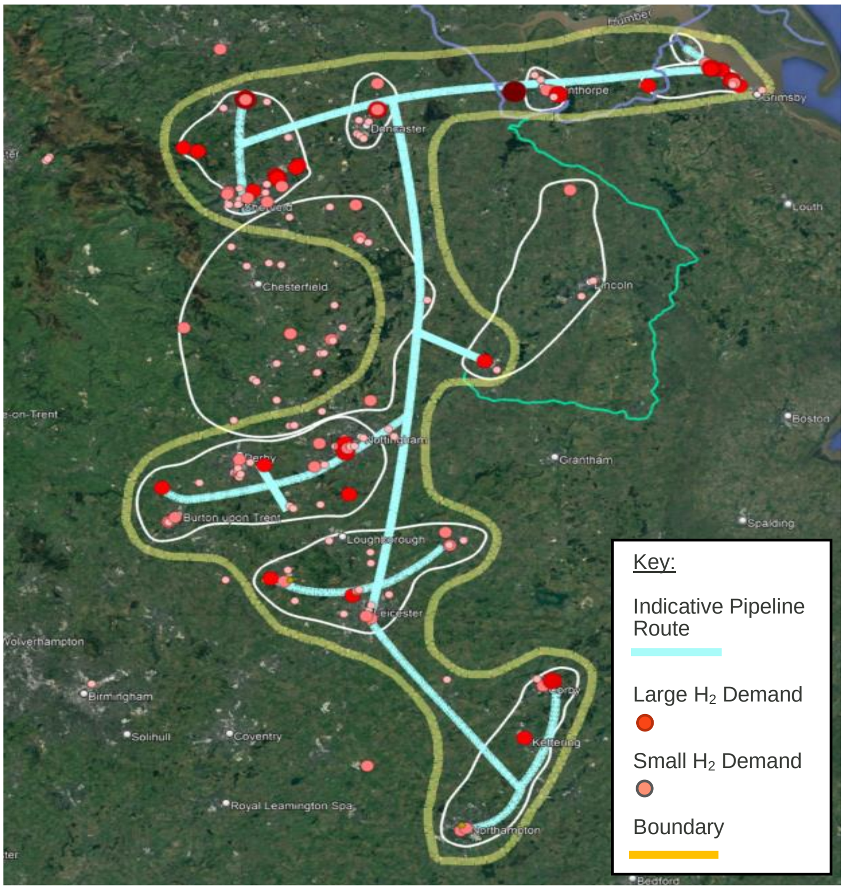


Figure 18: Strategic Option 3, the preferred strategic option

Strategic Option 3 (as shown in Figure 18), the preferred option, connects all ten customer and producer clusters and can be independently developed subject to the connection of hydrogen supply in Cluster 1 and Cluster 6. It performed better than other options due to its ability to connect all demand clusters and for its ability to avoid the majority of the significant engineering constraints (more challenging terrain in Cluster 10 and additional crossings of the M1 motorway) and environmental constraints (mainly the better-quality agricultural land found in Lincolnshire).

[redacted]

The principal reasons for the differences in the strategic options scoring were the following:

- Ability to secure a connection to demand clusters.
- Number of strategic engineering crossings and principally the M1 which runs south from Sheffield to between Derby and Nottingham.
- Terrain South of Sheffield and through Cluster 10 making construction slightly more challenging.
- Agricultural land classification is higher east of Cluster 4 and 10 through North Lincolnshire. Food supply and crop production has become a significant issue on recent development projects; and

- Network resilience and continuity through ability to connect into other sources of potential supply or the ability of the network to continue to operate if parts of the pipeline failed.

3.2. Project Phasing and Selection of Project

Once the preferred strategic option (Option 3) had been identified it was clear that the project in its entirety would be too large to consent and construct as a single phase and would need to be further broken down into phases to establish a sensible sequence of delivery. We focussed on prioritising the largest demand customers who are ready to switch away from natural gas to hydrogen in the shortest possible time, to achieve the maximum decarbonisation in the first phase. This involved assessing the customers in a two-stage process, considering multiple parameters and also developing pipeline route corridors to connect them. Once this was done, we were then able to break the project down in to what were considered as deliverable phases and assessed which one gave the maximum benefit in terms of hydrogen conversion versus the likely cost and this enabled us to select what should be the first phase of the project.

3.2.1 Cornerstone Users (CUs)

CUs are defined as the customers on our network that were prioritised for connection to the project during assessment of viable pipeline route corridors. The potential project routes were directly focused on serving the CUs and they served as anchor points to enable some of the preliminary pipeline route corridor options, with additional spurs developed for other customers along the pipeline route. The identification of CUs was carried out in two stages:

- Stage 1: Demand data driven approach.
- Stage 2: Practicability approach.

The Stage 1 Assessment of customers to identify CUs was carried out using the customer demand data received via the customer hydrogen forecast responses. The outcome of Stage 1 was a list of the highest demand customers identified within each demand cluster. Customers had been ranked based on their current annual natural gas consumption, forecast annual hydrogen consumption for 2030, forecast annual hydrogen consumption for 2035 and the forecast annual hydrogen consumption for 2035+, which was then taken into Stage 2 for further analysis.

The Stage 2 Assessment further evaluated the Stage 1 customers within each cluster and refined the number of CUs by identifying cornerstone customers that would be designed, consented and connected as a part of the first phase of the northern project. The selection was based upon several factors, similar to the Stage 1 assessment, but also considered other factors such as 2030 readiness, constructability, ability to gain consent, safety considerations, HAGI locations, cost and business justification. The outcome of Stage 2 was a list of CUs within each cluster for the project.

Following the outcome of the Stage 1 and Stage 2 assessment, a total of 51 customers were selected as the Pre-FEED list of CUs. There was at least one CU identified in each of the 9 demand clusters. The project phasing assessment (described in Section 3.2.2) took this list of CUs into account when assessing the potential first ECHP phase to take forward to be developed in FEED.

3.2.2 Project Preliminary Routing and Phasing

A review of the Stage 1 CU high demand groups (shown in Figure 19), based on future hydrogen demand and readiness for 2030 and 2035, showed an emergence of two project areas, North and South, as shown in Figure 19. The yellow dots represent the top ten mini-clusters of user hydrogen demand and the orange dots are centre points of mini-clusters that are not within the top ten demand clusters ready in 2030.

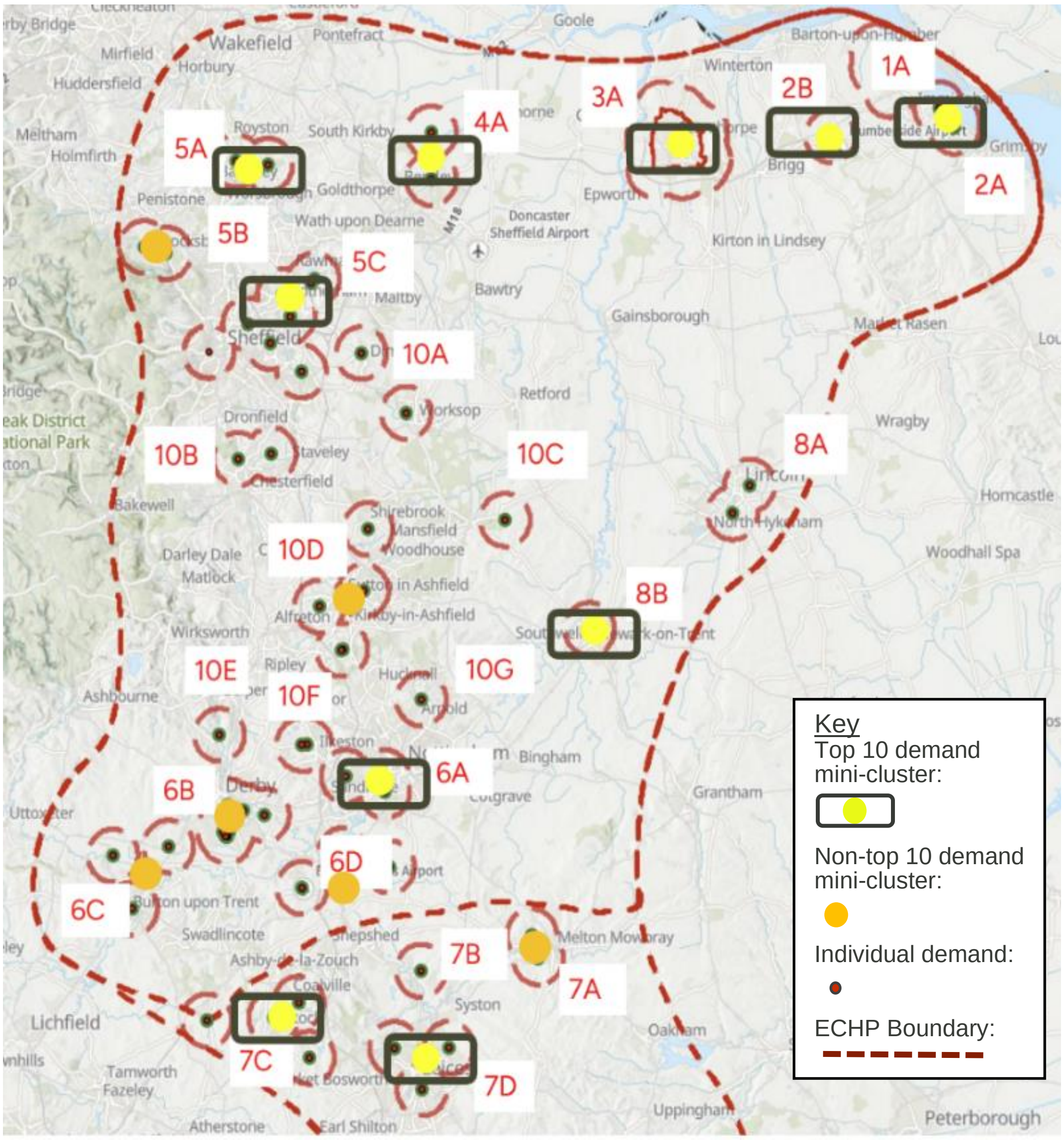


Figure 19: Map of Stage 1 CU customers and high and low demand mini-clusters

3.2.3 Project Selection

Large-scale production is planned at Immingham in the Humber Region and Ratcliffe-On-Soar in the Nottingham area. The analysis showed that the quickest way to connect demand to production is to build out directly from the two production locations to demand sites. The location of the mini-clusters of demand, and the work completed on the strategic options evidenced that the project should be split into a North and a South phase, where production in each location is connected to sub-regional demand, followed by a future interconnecting phase (i.e. Phase 2). There was little material gain from further developing a link from North to South as part of this first stage of the project because:

- It connects only small amounts of demand from multiple users spread over a reasonably large geographical area;
- There was no announced hydrogen production planned in the mid-North/South region at the time when the Pre-FEED analysis was conducted, so this pipeline section would be reliant on hydrogen from the North or South. N.B. In December 2023, a small production project at High Marnham in northern Nottinghamshire was awarded HAR1 funding.
- National Gas may develop a North to South hydrogen pipeline in East Lincolnshire. It was deemed sensible to wait until those plans were further defined and if appropriate at that point, to assess whether our South section could be connected to the North section partly by utilising the potential National Gas hydrogen pipeline.

The Pre-FEED technical team therefore focussed, using initial routing analysis, on a North and a South project assessment as shown in Table 15. The purple, black and green lines all illustrate potential different route options to connect the production to the demand. The crosses indicate potential HAGI locations. The red dotted line is the project boundary.

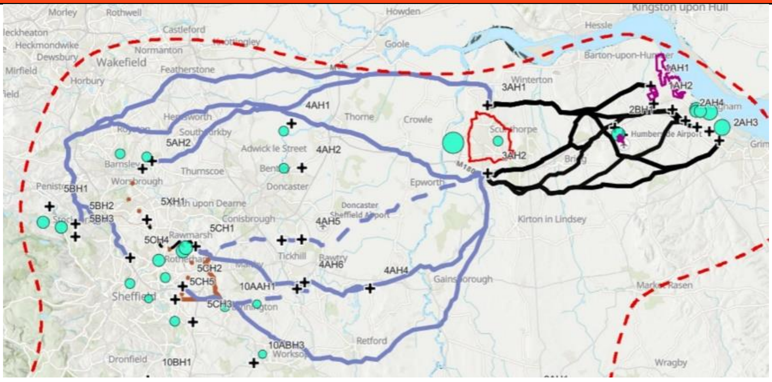
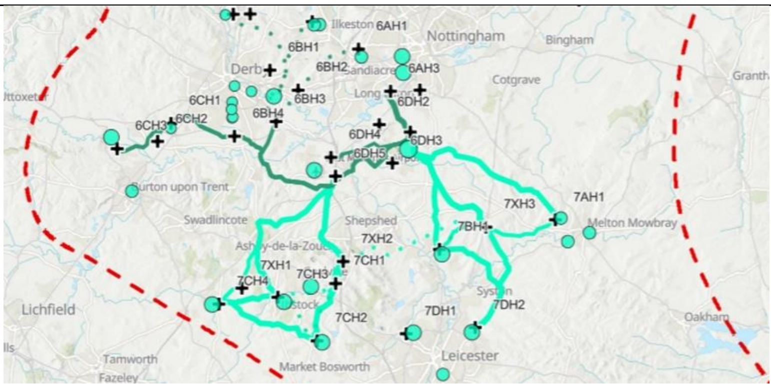
Section	Location	Initial Routing Map examples
Northern Section	Immingham to Sheffield	
Southern Section	Nottingham, Derby and Leicester	

Table 15: Example routing options for the northern and the southern sections

The initial analysis of the North and South sections was as follows:

	Immingham to Sheffield ('North')	Nottingham, Derby and Leicester ('South')
Total Cluster demand by 2030	3368 GWh (based on Cornerstone Customers and additional Connections)*	1472 GWh (based on CUs only)*
Potential top users – >50GWh 2030	potentially 15 CUs	potentially 10 CUs
Approx length of LTS pipeline (not including spurs)	Circa 120km	Circa 150km
Phasing opportunities	Outwards from Immingham + Scunthorpe. Onwards to Sheffield/Rotherham and Doncaster	Outwards from Ratcliffe to Nottingham, Derby, Burton and onwards to Leicester
Scunthorpe Pilot Town Connection	Yes	No
Engineering	complex routing in built up areas around Sheffield	no significant challenges, urban areas increase length of pipeline routes
Environmental and consenting	No significant constraints	No significant constraints
*Adjustments have ***since*** been made to the demand totals and the pipeline lengths because additional customers have been deemed appropriate to be added to the 'initial connections' list		

Table 16: Initial Analysis of 'North' and 'South' ECHP Sections

From the initial review it was concluded that the best performing project phase was Immingham to Sheffield (North) for the following reasons:

- Alignment to project objectives (given in in Section 1).
- Shorter overall pipeline route, therefore lower consenting risk and a more manageable project.
- According to customer forecasts received, there is higher total hydrogen demand in 2030 (3.4TWh).
- Planned hydrogen production in the ECHP North – Phase 1 region (Immingham) of 17TWh by 2030 compared to 5TWh per annum in the South.
- The Humber is home to at least three planned blue hydrogen production (CCUS enabled) projects that can be connected through the East Coast Cluster Track 1 extension or through the Track 2 Viking Cluster. The Humber has both CCUS-enabled and electrolytic hydrogen production projects at FEED stage, providing diversity of production technology and therefore lowering risk.
- There are five potential hydrogen supply points in Immingham, in the North, compared to two potential hydrogen supply points in the South. A greater diversity of production projects reduces risk of having insufficient hydrogen to meet customer demand and greater resilience if a production unit goes offline (maintenance repair etc.).
- Our pipeline section in the North is geographically closer to the ECH_2 partner hydrogen networks being developed by NGN and National Gas. There are options to interconnect and coordinate with those networks, which gives a greater chance of a resilient network sooner than in the South.
- The North phase is closer to potential storage locations such as Aldbrough and Rough – connection to storage enables system flexibility and far greater resilience.

- The ECHP North – Phase 1 route can deliver hydrogen to Scunthorpe if it is required for the DESNZ Hydrogen Town Pilot.
- No significant consenting constraints that cannot be managed.
- Good phasing opportunities and rapid decarbonisation impact (high intensity of demand close to production).

The 'North' section of the ECHP was selected as the priority section from which to identify a Phase 1 Project for ECHP, which could then be taken through to FEED and DCO.

3.3. Pipeline Network Development

An important part of the Pre-FEED involved the development of initial pipeline route corridor options. This was an iterative process that involved preliminary pipeline routing and HAGI search area locations linked into the Stage 1 CU assessment and initial phasing decision. Then, the more detailed analysis of locating specific HAGI locations and more refined pipeline routing informed the Stage 2 CU assessment and vice versa. Through this work the project developed multiple routing corridor options for assessment, and the output was identification of a section of preferred routing corridor for the project Local Transmission System (LTS) mainline pipeline to progress into the FEED stage.

3.3.1 HAGI Search Areas and Locations

The identification of potential HAGI locations formed an important part of the pipeline routing process and experience shows that a robust process for the siting of HAGIs is a key part of the consenting process. The location of HAGIs is particularly important from a pipeline routing perspective as pipelines run from one HAGI to another. The key factors considered in the initial siting of HAGIs included:

- Minimising disruption to the public
- Location of producers and customers
- Design Code requirements
- Safety and separation distances
- Environmental impact and sensitive areas
- Area requirements/sizing of HAGIs
- Access
- Onward connection and future network expansion
- Land use - existing and future land usage.

The methodology for locating HAGIs to enable pipeline routing followed a staged approach that has been used on other similar projects where siting of above ground infrastructure has been required. These stages are linked heavily to the pipeline routing that is described in the following sections. The steps taken to identify potential HAGI locations were as follows:

1. Defining search areas - broader areas close to customers that could be suitable for HAGIs
2. Refining the search areas to remove any key areas of constraints that would be unsuitable for a HAGI
3. Identifying HAGI siting options within the refined search areas (that act as anchor points for developing pipeline corridor routing options)
4. Backchecking of HAGI locations after initial Pipeline Routing using an automated GIS routing tool and also after the list of CUs was confirmed at both stages of the CU assessment.

3.3.2 Preliminary Pipeline Corridor Routing

One innovative and important aspect of the pipeline routing was the use of a Geographical Information System (GIS) auto-routing tool developed by one of the Pre-FEED partners, SLR. The system can quickly and thoroughly assess the potential pipeline route options. It works by combining all the source data around potential 'constraints' into a GIS mapping system. The constraints are then ranked in terms of the criticality of avoiding them and the system automatically generates multiple pipeline route options. These were then reviewed by our competent team of engineers and consenting specialists and used to develop pipeline route corridor options. The GIS system was also used to assess the potential HAGI search areas and specific locations within them.

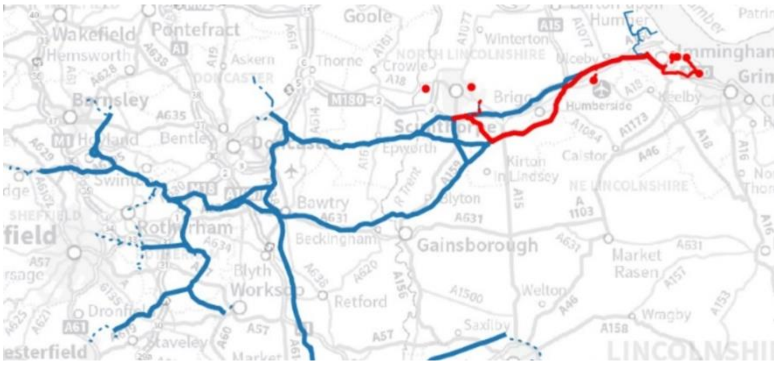
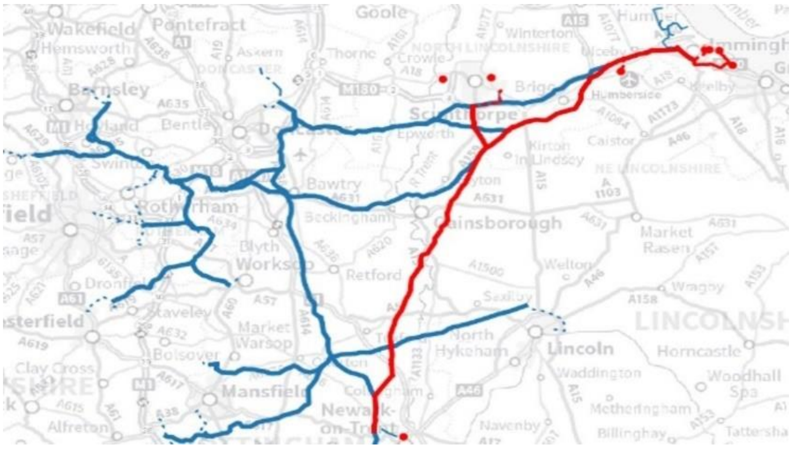
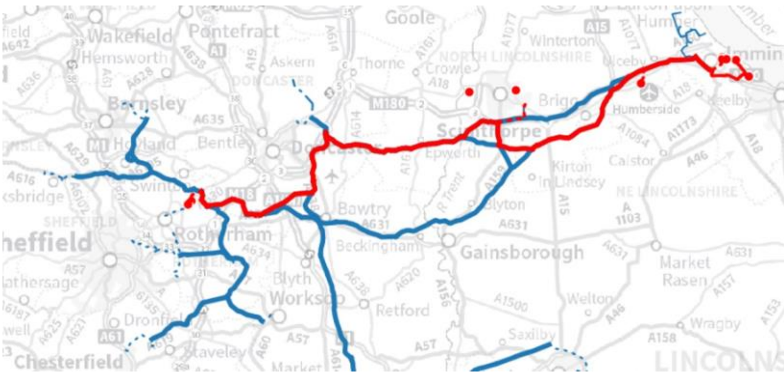
Following confirmation of Stage 1 CU assessment, representative HAGIs for Stage 1 CU pipeline spur connections were identified to provide start and end points for use in preliminary Local Transmission System (LTS) routing. Following the identification of representative HAGIs, preliminary routing was undertaken using GIS.

The preliminary routing identified a broad geographic range of options for connecting Immingham and Scunthorpe to the Stage 1 CUs in the Rotherham/Sheffield area. The options appraisal identified that options taking a more northerly route to connect them to the West of Rotherham, would require much greater lengths of LTS pipeline that went through significantly larger areas of environmental constraint (such as flood zones 2 and 3 and higher-grade agricultural land). As a result, shorter, more direct connections that ran to the South of Doncaster were taken forward.

3.3.3 Preferred Pipeline Route Corridor Development

Following further development of LTS routing, the location of representative HAGIs was reviewed to confirm whether the initial siting locations were appropriate for inclusion within the wider project scheme and further consideration during FEED. The review included consideration of vantage point findings, land allocations within extant local planning policy, a review of major planning applications and/or planning consents and wider review by the project team. In many locations, the review of spur connections led to HAGIs being re-positioned to provide better opportunities to connect to the Stage 1 CUs. Additional HAGIs were also identified where branch points are required on the LTS system or where pipeline spurs branch to connect to multiple CUs.

After completing the Stage 2 CU assessment and routing development, the next step was to identify which specific part of the North should be delivered as the first phase. Five scenarios were identified for further appraisal and consideration for the ECHP North – Phase 1 project and they are shown in Table 17. The red lines are the various options that were assessed, the red dots are the CUs, and the blue lines are the remaining route corridor sections that are not under consideration in that option.

Option	Drawing
Option A: Immingham to Grimsby and Scunthorpe.	
Option B: Option A + Doncaster.	
Option C: Option A + in [commercially sensitive] Newark.	
Option D: Option A + Rotherham (excluding Doncaster) – included north and south connection options.	

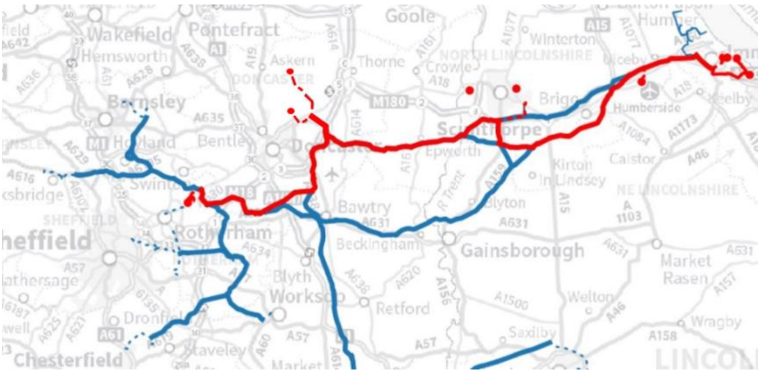
Option E: Option A + Doncaster + Rotherham – included north and south connection options.	

Table 17: ECHP North Phase 1 Route Options

Each option in Table 17 was assessed against the criteria listed in Table 18.

Criteria	Scenario A:	Scenario B:	Scenario C:	Scenario D:	Scenario E:
2030 hydrogen industrial demand (GWh)	1812	1969	2096	2123	2280
No. of LTS HAGIs	5	6	7	6	8
Total LTS length (km)	47	78	100	106	109
Total spur length (km)	13	22	13	16	27
Total length (km)	60	100	113	122	136
Number of CUs	7	9	8	9	11
GWh of hydrogen/km	30	20	19	17	17
Customer readiness & future demand	Doesn't perform as well as other options due to limited number of customers and future demand	Doesn't perform as well as other options due to limited number of customers and future demand	Performs better than some other Scenarios with greatest hydrogen demand and number of CUs, but not the best performing scenario	Performs better than some other Scenarios with greatest hydrogen demand and number of CUs, but not the best performing scenario	Performs better than other Scenarios with greatest hydrogen demand and number of CUs
Route to market or upscale hydrogen production	Offers the lowest route to market due to limited connectivity	Offers good route to market and potential to upscale hydrogen production.	Offers good route to market and potential to upscale hydrogen production.	Offers good route to market and potential to upscale hydrogen production.	Offers greatest route to market and potential to upscale hydrogen production.
Future proof/phasing options	Future Phasing would be Scunthorpe/Doncaster/Rotherham/	Future Phasing would be Doncaster/Rotherham/Newark	Limited connectivity with long LTS route through	Provides spine connection from which other phases can be progressed	Provides long spine connection from which other phases can be progressed

	Newark connections, but would be a long LTS connection	connections, but would be a long LTS connection	countryside with limited future connectivity		
Resilience	Low project resilience due to limited number of CUs (greater impact if CUs withdraw from project)	Low project resilience due to limited number of CUs (greater impact if CUs withdraw from project)	Some project resilience if CUs withdraw from project.	High project resilience if CUs withdraw from project.	High project resilience if CUs fall away from project.
Environmental and consenting	No major designations	No major designations	No major designations but longer route so increased consenting risk	No major designations but longer route so increased consenting risk	No major designations but longer route so increased consenting risk
Engineering	Shortest route makes this option the least complex engineering scenario	Shorter route and lower number of crossings reduced complexity of construction	Shorter route and lower number of crossings reduced complexity of construction	Greater length and number of crossings means more complex engineering required	Greater length and number of crossings means more complex engineering required
Construction Timescale	Under three years	Under three years	Approx. three years	Over three years	Over three years

Table 18: ECHP North - Phase 1 Scenario Options Review

3.3.4 Recommendation – How the Preferred Option Addresses the Needs Case

It was recommended that Scenario E was taken forward as the ECHP North – Phase 1 project, as it best meets the aims and objectives of the ECHP project as follows:

- It offers the greatest potential to decarbonise industry within the ECHP project area through meeting the highest 2030 hydrogen demand and connecting the greatest number of CUs of all of the options.
- It provides early phasing opportunities by being able to connect users in Immingham and Stallingborough. It is estimated that up to 60% of the 2030 hydrogen demand is in this area.
- It delivers low carbon hydrogen to the biggest natural gas consuming sites around Doncaster and Rotherham. Reaching Doncaster and Rotherham then enables future connections as part of smaller and quicker FEED and construction projects. For example, there are some large users in Stocksbridge and Barnsley which could be accessed via a second phase of development. These are harder to reach areas when considered in isolation, but as onward connections from Rotherham they would be more accessible and relatively straightforward.
- It offers a high degree of futureproofing by creating an LTS pipeline spine connection across the North of our ECHP project area that enables connections to future hydrogen demand from customers in the South Yorkshire region as well as demand clusters to the South.
- This option provides a connection to Scunthorpe for domestic hydrogen supply if the town is taken forward as a Hydrogen Town Pilot project.

Overall, Scenario E does represent a large project, which means that the construction period is longer than the other options that have been explored. However, it is still a manageable size to consent and construct. It not only has the biggest decarbonisation impact of all the options explored, it also provides a greater number of opportunities for connection to additional demand clusters. In addition, having a greater number of CUs due for initial connection means that if any CU drops out, there is a greater likelihood that the project remains economically viable with a positive cost benefit analysis. This builds resilience into the FEED and consent application stages of the project.

The main reasons for discounting other options are as follows:

- **Scenario A**: Immingham to Stallingborough and Scunthorpe – whilst there is high demand in these towns, the project is reliant on a few large CUs and future rollout would require significant additional LTS pipeline. This option would mean that customers in Rotherham and Doncaster could not access the hydrogen that they need in 2030.
- **Scenario B**: Immingham, Grimsby, Scunthorpe and Doncaster – was considered a viable option for Phase 1 as it begins to route the LTS network closer to CUs in South Yorkshire. However, it was rejected as it was reliant on only two CUs in Doncaster which are not the largest demand and both show no increase in demand by 2035. This option also misses the opportunity for significant decarbonization of sites in Rotherham and does not create a good platform for connecting to additional demand in South Yorkshire.
- **Scenario C**: Immingham, Grimsby, Scunthorpe and Newark. This option makes it harder to unlock future roll out opportunities because it is still some distance to the next cluster of CUs in South Yorkshire, northern Nottinghamshire and northern Derbyshire. The connection to Newark is also long and does not follow the preferred ‘whole project’ LTS pipeline route for connecting North and South parts of the project.
- **Scenario D**: This option is exactly the same as Option E, the preferred option, but does not connect to the customers in Doncaster. This option was rejected because it requires a similar pipeline length to the preferred option, but does not benefit from the carbon savings associated with two additional customers in Doncaster.

3.3.5 ‘Additional Users’ for Initial Connection to the ECHP North – Phase 1

There are also customers who have submitted hydrogen forecasts that are located within 5km of the ECHP North - Phase 1 pipeline route corridor. Some of these customers did not submit their forecasts in time to be considered within the Pre-FEED, whilst others were in time but were not selected as CUs. As the objective of the project is to maximise early decarbonisation of industry and power generators, an evaluation of these ‘additional users’ was carried out to identify whether it would be cost effective and practical to add some of these sites to the list of ‘initial connections’ to the ECHP North - Phase 1 pipeline. Preliminary routing was undertaken to give an understanding of any risks with regards to making a spur to these additional users and this resulted in a high-level cost being attributed to each spur.

Concurrently these ‘additional users’ were contacted to check that they still had a requirement for hydrogen. Of the 13 additional users identified, 11 had already submitted a forecast for hydrogen and two of them had not. The two customers who have not yet submitted a formal forecast have been contacted and have expressed an interest in switching from natural gas to hydrogen. Our current assumption is that these sites will switch to 100% hydrogen from 2030. These additional 13 customers have a demand of 1.3TWh by 2035.

A ‘back-check’ exercise in summer 2024 will establish which of these customers will be initial connections to the pipeline, by considering whether or not their connection in the initial stage adds too much complexity and risk to the main construction project. Any ‘additional customer’ that can’t be added to the main project will be considered separately in a future East Coast Hydrogen Distribution Project, which will look to see whether they can connect to the main ECHP North – Phase 1 pipeline on the same timelines through a spur that is fully or partially created by re-purposing of natural gas pipeline. If this option is not viable, engagement with the additional user will continue and we expect that they will be able to connect to the main pipeline through a new spur once the main LTS pipeline has been constructed, in the same way as new natural gas connections are enabled today.

3.3.6 Summary of the ECHP North – Phase 1 Preferred Option

Summary	
Project Selection	Northern Phase 1 Pipeline – Immingham to Rotherham via Scunthorpe and Doncaster
No. Customers	11x CUs (including Scunthorpe Town trial) + 13 additional customers (to be further assessed prior to and during FEED)
Pipeline Length	LTS – 109km Spurs – 27km Total – circa 136km
No. HAGIs	Circa 8x LTS Mainline Additional HAGIs for producer and some customer connections (circa 12 No.)

Table 19: Summary of Options Table

3.4. Line Sizing

One of the Pre-FEED outputs was the initial line sizing of pipelines in the ECHP network. This was completed by carrying out the first part of network modeling i.e. steady state flow assurance. Prospective customers had not necessarily provided detailed hydrogen demand profiles at this early stage, only annual forecasted consumption, and this meant that we carried out a 'steady state' modelling exercise rather than dynamic or transient analysis. The steady state flow assurance showed some initial potential line sizes, assuming the network was operating with flat supply and demand profiles. The key parameters that affected the pipeline diameter outputs of the steady state flow assurance were:

- The hydrogen composition/specification where two parameters were modelled; 100% hydrogen and 98% hydrogen (with the same detailed hydrogen specification that has been used on HyNet).
- The maximum design velocity where two different parameters were modelled; 60 m/s and 20 m/s. Whilst a design velocity of 60 m/s is generally lower than the API-14E erosional velocity recommended by IGEM/TD/1 Ed. 6 - Steel pipelines for high pressure gas transmission including supplement 2 – High pressure Hydrogen pipelines, opting for a design velocity of 20 m/s allows a level of conservatism in the required pipeline sizing and also allows for an increase in future capacity once the pipeline is operational by increasing the pipeline's maximum operating flow rate. This is also consistent with HyNet and aligns to the existing natural gas network for unfiltered gas.
- The minimum customer arrival/inlet pressure in the ECHP North – Phase 1 network lines should be higher than seven barg, to ensure adequate pressure to meet customer requirements and to avoid operating with very high flow velocities in the network.

The analysis was carried out for two levels of demand resulting in two different pipeline network capacities with different maximum pipeline diameters. The smaller demand case, Scenario 1b in the previously mentioned CBA (see Section 2.8) is sized appropriately for all the industrial and power generation hydrogen demand (customer forecasts), plus Scunthorpe town.

The larger demand case referred to in the CBA (Scenario 1a) assumes that all customers (domestic, commercial, industrial) in towns in Northern Lincolnshire, South Yorkshire and East Midlands switch to 100% hydrogen. This scenario was completed to give an idea of how much more capacity the pipeline would need to be able to transport hydrogen at town conversion scale, in this region. As explained during our Re-opener pre-engagement sessions with Ofgem and DESNZ, this exercise was completed to inform future discussions with both organisations about 'futureproofing' of the pipeline. This information could be used to decide on the appropriate demand case and therefore maximum diameter of the pipeline to prevent the scenario where the pipeline that is constructed has inadequate capacity to accommodate either domestic demand (if needed), or demand for hydrogen from other sectors such as transport demand (aviation, marine, rail and HGVs) and new industrial connections.

It should be noted that the additional towns demand had no influence over the routing of the pipelines in Pre-FEED. Routing was carried out from an industrial customer only perspective (with the addition of Scunthorpe town only), this exercise was only undertaken to review the impact on the potential line size if the town demand were to form part of the scope of the project.

For ECHP North – Phase 1 network Scenario 1b demand case (industrial and power generation users plus Scunthorpe Pilot Town), the initial line sizing showed that the maximum line size recommended for the network is currently 24-inch regardless of design velocity. When the analysis was conducted on Scenario 1a with the addition of town demand (towns in South Yorkshire, Lincolnshire, Nottinghamshire and Derbyshire), the maximum recommended line size is currently 30-inch.

The intention is to make a decision on which demand level to scope into the FEED before the study begins, through discussions with DESNZ and Ofgem. Assessment of the initial line-sizing determined in Pre-FEED will be further refined during FEED through transient flow analysis following a period of further data gathering from customers. These granular forecasts will be gathered from ECHP North – Phase 1 customers before FEED, between April and June 2024, and will include peak demand and ramp up or down rates. The transient flow analysis will look at how pipeline sizing and specifications change when the peak demand, seasonality and transient effects of network operation are accounted for. The final line sizes will need to be confirmed once the steady state and transient analysis has been carried out during the FEED.

3.5. Repurposing

As a key aim of this project is enabling the transition of industrial customers from using natural gas to using hydrogen for their processes, one underlying question in the development of hydrogen pipeline networks is the extent to which existing natural gas network infrastructure can be repurposed to transport 100% hydrogen. The evidence around repurposing has been or is being built up via various industry research projects including, but not limited to:

- H21 Programme (below seven bar)
- LTS Futures (above seven bar)
- FutureGrid (Transmission)

Given the level of uncertainty around the ability to repurpose LTS assets, with the research still ongoing in projects such as LTS Futures, for the purposes of developing this project and managing the risk and uncertainty to project scope, our Pre-FEED did not factor in repurposing of LTS assets.

The project team have focussed on identifying the optimum pipeline corridor and sizing to meet the needs of customers. This approach has avoided potentially abortive work looking in detail at existing pipelines that may not be beneficial to repurpose to meet the aims of this project, for example they may be in the wrong location or have insufficient capacity. With this in mind, the Pre-FEED was developed on the basis that it would be a network of new assets to enable transportation of hydrogen from the potential producers to the potential customers, it didn't take into account repurposing of any specific pipelines or installations.

Now that the Pre-FEED stage is complete, the project has started the process of investigating the LTS assets in the existing gas network that could be repurposed to form part of the ECHP North – Phase 1 network.

Some work has been completed via the DESNZ system transformation project, however more in-depth analysis is required to answer the following questions for our ECHP footprint:

- How can the existing network capacity be unlocked for repurposing to hydrogen?
- Could any repurposed section of LTS pipeline provide sufficient capacity to meet all the downstream hydrogen demand?
- What would it take from a technical integrity perspective to repurpose any of the specific LTS pipelines of interest?

During FEED the project team will look to answer these questions. However, given the level of uncertainty that currently exists, with research ongoing and the need to have a very clear set of objectives and project definition heading into a potential DCO consenting process, the project in FEED will submit for consent based upon a new pipeline network. The repurposing assessment will therefore focus on what potential there is to repurpose existing LTS to carry hydrogen in future expansion phases of the ECH_2. As customers transition to hydrogen, this will remove demand for natural gas and make it easier to convert existing natural gas pipelines to carry hydrogen.

This approach will ensure that repurposing opportunities are assessed, identified and ultimately realised, and it will also allow the ECHP North - Phase 1 FEED for the project to progress through to consent submission, whilst the research and development shows whether or not repurposing of LTS pipeline assets is technically feasible.

4. FEED and Consenting Scope of Works and Outputs

This chapter considers what activities are going to be undertaken in the FEED and consenting stages that funding is being sought for. A detailed breakdown of the work packages within the FEED and the consenting stage are given.

4.1. FEED and Consenting Plan

We will undertake the design and consenting activities for the proposed hydrogen distribution system known as ECHP North – Phase 1, as detailed in Section 1 - Project Description, that stretches from Immingham in the East to Rotherham in the West. All activities associated with hydrogen storage, hydrogen production or carbon capture and carbon storage is outside the scope of this investment request and will not be undertaken by Cadent. ANNEX G has a detailed schedule for FEED and consenting stages of ECHP North – Phase 1.

Under the legislation set out in Section 14 and Section 20 of the Planning Act 2008, the project is anticipated to be classed as a Nationally Significant Infrastructure Project (NSIP) and therefore require a formal DCO submission to the Planning Inspectorate (PINS). This next phase of design and consenting of the project will therefore need to align with the DCO requirements and will comprise of the following main activities:

- Engineering and design
- Non-statutory consultation phase
- Surveys and Environment Impact Assessment (EIA)
- Statutory consultation phase
- DCO application phase
- DCO examination
- Post approval
- Legal planning and land support
- Cadent activities
- Third party land payments.

The engineering, design and consenting consultant's detailed programme for the FEED and consenting stage is included in ANNEX G.

4.2. FEED and Consenting Project Outputs

The purpose of the FEED stage is to take the network concepts developed in the Technical Feasibility and Pre-FEED stage and develop further, building engineering detail and design maturity. As covered in more detail in the following sections, this will include more detailed flow assurance and network modelling, more detailed pipeline routing work including Geotechnical Investigations (GI), development of HAGI layouts and locations, and further development of all key engineering disciplines.

Similarly, this stage will cover all the activities required to enable a DCO application as required for a NSIP set out in the legislation contained in The Planning Act 2008. This will include engagement and negotiations with Persons with Interests in Land (PIL's), EIA and associated surveys, stakeholder consultation, DCO application, DCO examination, post-DCO approval. Whilst the FEED and consenting deliverables can be separated and delivered by the different members of the team with relevant expertise, in practise they will need to be delivered in tandem as they interface each other heavily and will be developed in an iterative way to provide a technically robust and consent-able project design. The main project outputs from this stage are listed and described in the following sections.

4.2.1 Flow Assurance/Network Modelling

The main flow assurance work to be carried out in FEED is the transient flow analysis, the network resilience study and any ad-hoc studies linked to the process design, and it will build on the steady state analysis and initial line sizing already carried out during the Pre-FEED. The project will deliver a transient flow assurance technical report that shows the results of the transient analysis. It will include cases covering the range of customer ramp up and ramp down scenarios as well as potentially the impact of connections with other hydrogen networks, and production and storage facilities. A network resilience study will be carried out to determine what level of resilience the network design developed in FEED can achieve and how they compare to any supply obligations that we may have in owning and operating the ECHP North – Phase 1 network.

The output of the flow assurance work will be confirmation of the various options on pipeline diameters given the potential variables such as limiting velocities, pressures losses and our anticipated supply obligations. The outcomes of transient analysis should also detail if there any requirements for hydrogen storage to enable a specific level of network resilience. This analysis will then be used to inform the ECHP North – Phase 1 design as part of FEED.

4.2.2 Pipeline Route Corridor Development

The purpose of the FEED stage is to refine the pipeline route corridor that was identified during Pre-FEED to create an optimised design suitable for the DCO application.

4.2.2.1 Pipeline Route Selection – Consideration of HAGI Siting

It is expected that by the end of FEED the project will have identified and assessed pipeline routes within the previously identified preferred route corridors and also identified specific HAGI layouts and locations within the identified siting/search areas. The identification of potential HAGI locations will also form an important part of the pipeline routing process. Initial siting of HAGIs was completed during Pre-FEED, based on initial assumptions of the size of a HAGI, and shall be developed further through the FEED stage.

For each HAGI the project will carry out formal site location and site layout studies. The location and number of HAGIs will consider the pipeline design requirements covered in the relevant design codes as well as the need for ongoing pipeline maintenance and inspections. Safety and security of the HAGI will be a key parameter in the selection of the final location along with a range of environmental and planning constraints.

Another key driver for the location of HAGIs are the requirements for pipeline spur connections to hydrogen producers and customers. The design will give consideration of potential future connections to industrial users not forming part of this initial project, but possibly connecting at a later stage.

4.2.2.2 Pipeline Routing – Refinement

One of the key engineering and design considerations for a new hydrogen network is where to route the pipeline to give the most cost-effective route that meets the project objectives, whilst also accounting for the planning and consent requirements set out in local and national legislation. As mentioned, the location of HAGIs links directly to the routing process as do the requirements of the DCO process. The purpose of the FEED stage is to refine the pipeline route identified in the project Pre-FEED to create an optimised design suitable for a successful DCO application and there are broadly two parts to this process, which are as follows:

Consultation on the Pipeline: This starts with the EIA scoping process which will consult on a circa 1km corridor around the preferred 250m corridor. Followed by informal and formal consultation on the detailed routing and land right requirements with a narrow project footprint, referred to as the draft order limits, which will sit within the original 250m corridor. As a critical part of the DCO process, the purpose of consultation is to gather feedback and views on the emerging design. This feedback can be used to identify potential concerns from local communities and stakeholders and to identify potential ways to resolve such issues which may or may not influence the route of the pipeline; and

Design Optimisation: This is an ongoing process of design refinement as detailed engineering, land and environmental data is gathered and assessed throughout FEED. This process will flag potential issues and the requirement for amendments.

4.2.2.3 Pipeline Routing - Key Considerations

The following sections describe the key considerations of the FEED methodology to support the development of the pipeline route and HAGI location and layout design optimisation:

Engineering Constraints and Route Optimisation: The design and optimisation of the pipeline route and HAGIs will involve consideration of detailed engineering studies to verify and optimise the pipeline route and HAGI layouts. Key to this will be the ground investigation work carried out on the preferred route alignment with particular attention taken for the major crossings.

Quantitative Risk Assessment (QRA): The project will carry out a QRA that shall consider inputs from existing risk studies and determine whether the residual risks to the public, operational personnel, the assets and others can be demonstrated to have been reduced to As Low as Reasonably Practical (ALARP). The QRA will also make recommendations on risk reduction measures where appropriate, and these recommendations will be taken into consideration when developing both the pipeline routes and the locations of HAGIs.

Constructability: As the design develops it will be assessed from a constructability perspective, informed by the geotechnical surveys and site visits to gain information on working widths, laydown areas and site access requirements. Ensuring constructability during the FEED phase is particularly important in the context of a DCO application given the constraints this may impose on the construction phase, e.g. red line boundaries may limit construction techniques.

EIA Surveys: The project will commence on-the-ground field environmental and ecological surveys. Where possible, on-the-ground surveys will be supported by desk based and aerial data to target areas of highest sensitivity. The surveys are required to establish the impacts of the proposed scheme and to provide opportunity for adjustments and mitigation during design for inclusion within the DCO. The results from the surveys will feed into the Environmental Statement, required as part of the application.

Land Ownership: The project will start to undertake collection of non-contact and contact land referencing information and will start consulting with affected parties on the emerging pipeline route. As this process progresses, the project will build up a database of information on landowners and land uses with feedback and information being fed back into the route optimisation process. HAGIs will be designed to minimise their overall footprint to limit the amount of land acquisition required and where possible locations will be sited on previously developed land or unproductive agricultural land, whilst following existing planning policy and guidelines.

Stakeholder Feedback: The developing network configuration, preferred pipeline route and potential HAGI locations will be subject to a wide range of stakeholder engagement with both statutory and non-statutory consultees engaged via statutory and non-statutory consultation events. The consultation and communications strategies to be developed at the start of FEED will address the consultation requirements set out in the Planning Act 2008 as required to support the DCO application. Stakeholder feedback has the ability to provide insights or objections into the project proposals. The project must demonstrate in its DCO application how stakeholders have been adequately consulted and how feedback has been taken into account in the project design. Refer to Section 7 for further details on stakeholder engagement.

4.2.3 Engineering Discipline Deliverables

There are several industry design codes already in place for example IGEM TD/1 supplement for hydrogen transportation. However, the research into detailed discipline requirements remains ongoing or is clearly different to the natural gas requirements, but not yet sufficiently documented in things like discipline procedures or specifications. The project will prepare a complete suite of discipline specific deliverables applicable to the project engineering and design. It is intended that the contents of these deliverables can be applied throughout the project including later project phases of Detailed Design, Construction and Commissioning. This will include, but not limited to:

- Design Philosophies / Basis of Design
- Specifications
- Datasheets
- Lists / Material Take Offs
- Schematics / Layouts
- Procedures
- Analysis / Reports

And the disciplines they will cover include, but are not limited to:

- Procurement
- Geotechnical
- Flow Assurance Process
- Pipeline
- Piping
- Mechanical
- Material Selection
- Corrosion Control and Cathodic Protection
- Electrical
- Civil and Structural

- Instrumentation Control and Telecoms
- Safety Engineering

4.2.4 Safety Case

For all hydrogen projects, there is a need for the gas transporter to create, develop and ultimately gain approval of a gas transporter safety case for the hydrogen network. As a minimum, the safety case needs to achieve the conditions set out in the Gas Safety Management Regulations (GSMR, 1996). Though the GSMR is not currently applicable to the specific application of hydrogen (above 0.1mol), the principles and parameters are being applied for the hydrogen network's safety case by the HSE. The project will hold a workshop and deliver a report with all relevant key stakeholders internally within Cadent to review the status and development of our overall hydrogen safety case and document what amendments may need to be made and what additional items may be needed to be delivered specifically by this project. Discussions will also be undertaken with the HSE in due course after the workshop to discuss ongoing engagement with them to the point of safety case submission and then the review of the safety case.

4.2.5 Operational Readiness

In readiness for the transition from operating natural gas distribution networks to also operating hydrogen networks, we are developing several strategies and philosophies specifically linked to operational readiness and control and automation. This work will contain information on how hydrogen networks will be operated once they are commissioned. Like the safety case mentioned above, the project team will hold a workshop with all relevant Cadent stakeholders to review the status and development of our operational readiness deliverables, document what amendments may need to be made and record what additional items may be needed to be delivered specific by this project.

4.2.6 DCO Submission

It is anticipated that the scale of this project will result in its classification as a NSIP in accordance with criteria set out under the Planning Act 2008. Early in FEED we will seek a Section 35 Directive from the Planning Inspectorate to confirm the project's suitability to be treated as a DCO under the Planning Act or whether it needs to be consented in a different way e.g. under the Town and Country Planning act 1990 and/or other existing statutory instruments.

Assuming the project does require DCO, such infrastructure is required to make an application to PINS for Development Consent. The application will be examined by PINS with a recommendation made to the relevant Secretary of State (SoS) for their final decision on whether to award the DCO, which is required to construct and operate the proposed infrastructure.

The project will follow the requirements set out under the existing legalisation and the NSIP guidelines provided by PINS to prepare the DCO application. This includes the creation and progression of all data, literature, publication documentation, presentations, and consultations, required to demonstrate how the projects meets the requirements needed to be granted DCO approval. The DCO submission project plan is divided into five phases as shown in Table 20.

Phase	Scope
1. Non-Statutory Consultation Phase	• Develop the Consenting Strategy • Develop the Consultation and Engagement Strategy • Anticipated Section 35 Directive to confirm the projects suitability to be treated as a DCO under the Planning Act. • Developing and agreeing Planning Performance Agreements with the Local Planning Authorities. • Start liaison with PINS. • Develop protective provisions. • Develop the EIA strategy document. • Develop the EIA scoping report. • Obtain access and undertake physical surveys. • Develop the Land Rights and Referencing Strategy. • Commence land stakeholder liaison. • Commence statutory and non-statutory stakeholder engagement. • Develop consultation documentation. • Undertake non-statutory consultation and feedback report.
2. Statutory Consultation Phase	• Develop the Preliminary Environmental Information Report (PIER). • Develop heads of terms and agreements such as options agreements. • Submission of section 42 and 56 notices. • Develop the Statement of Community Consultation (SoCC). • Develop statutory consultation materials. • Undertake statutory consultation and feedback report.
3. DCO Application Phase	• Develop the Environmental Statement (ES). • Develop the Book of Reference (BoR) for submission as a part of the DCO application. • Develop and submit the DCO application to PINS.
4. Examination Phase	• Coordination and input to Statements of Common Ground (SoCGs). • Coordination of all examination deadline deliverables. • Review of examination timetable and principal issues. • Provide responses to all examination questions.
5. Post Approval Stage	• Discharge of DCO conditions. • Issue statutory notices following approval. • Development of the information to be supplied to the Engineer, Procure, Construct (EPC) contractor.

Table 20: Description of DCO Phases

4.3. FEED and DCO Schedule

The Level 1 FEED project schedule is given in Figure 20 and in more detail in ANNEX A:

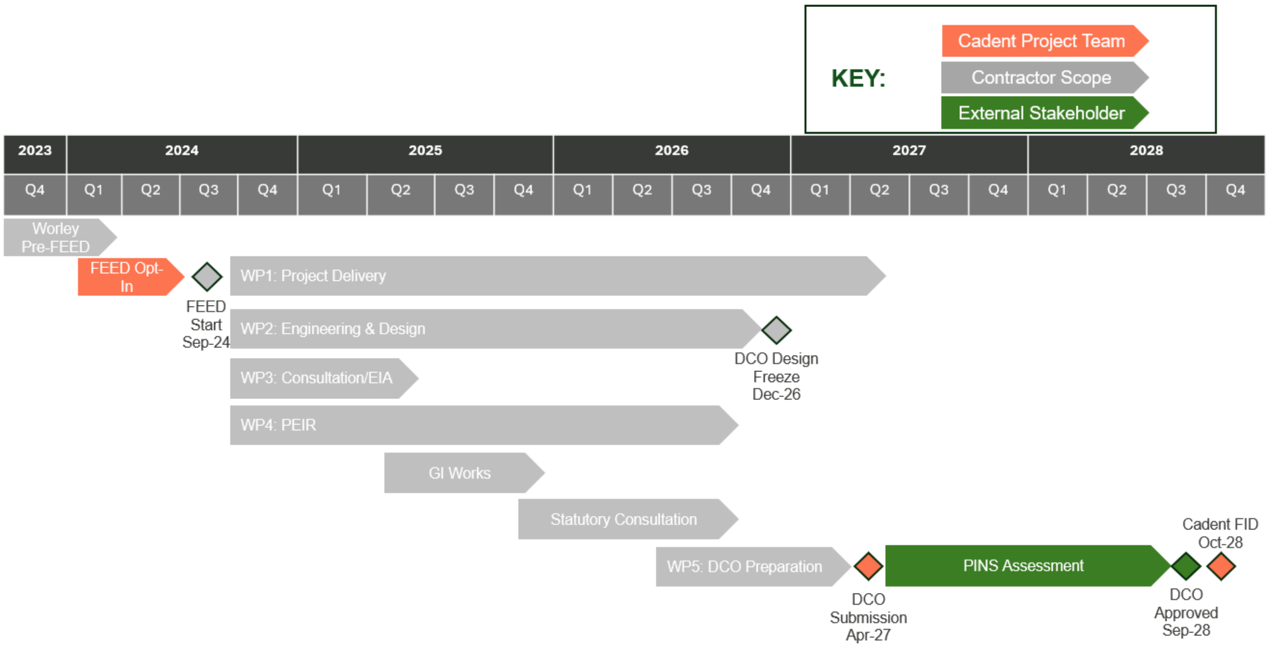


Figure 20: FEED Stage Schedule

It is anticipated that some activities will begin in Q3 2024, including mobilisation of the FEED stage consultant. The consultant will mobilise for FEED and commence development of the EIA scoping, engineering and access arrangement for surveys/groundwork investigation. The main bulk of the work will commence in 2025, including the further development and refinement of the routing and engineering work completed during pre-FEED, the environmental surveys and ground investigation work, development of the Preliminary Environmental Information Report (PIER), completion of engineering deliverables and the start of the DCO application work which will enable a DCO submission circa Q2 2027. To support the DCO submission, non-statutory consultation will be undertaken in early 2025 and the statutory consultation period will commence early 2026.

It is anticipated that the PINS examination of the DCO will last approximately 15-16 months, with an estimated decision made in Q3 2028. This allows a Final Investment Decision (FID) to follow on from this in Q3/Q4 2028. This overall programme is based on an assumed FEED start date in Q3 2024.

Milestone	Planned Date
FEED stage commencement	02-Sep-24
Design freeze for PEIR	17-Oct-25
Commence Geotechnical Investigation Surveys	11-Jun-25
Commence non-statutory consultation	15-Jan-25
Commence statutory consultation	16-Feb-26
Design freeze for DCO submission	18-Dec-26
DCO application submission	23-Apr-27
DCO award	Q3 2028
FID	Q4 2028

Table 21: FEED Schedule Milestone Table

5. Cost Information

This chapter sets out the principles, stages and processes we have taken through the project lifecycle, from our initial Pre-FEED procurement strategy through to our final detailed cost breakdown structure for the FEED project. It aims to provide clear substantiation of all cost activities and why we believe this delivers value for money for a project of this scale and complexity.

5.1. Procurement Strategy for Pre-FEED and FEED

Prior to Pre-FEED, when developing our procurement strategy, our intention was to optimise the programme and deliver value for money engineering design studies. This meant not focusing solely on the Pre-FEED, but also considering the subsequent FEED stage.

Delivering a high-quality Pre-FEED requires knowledge and experience of subsequent design and consenting stages, such as FEED and a DCO. This knowledge ensures the project is set-up appropriately to facilitate successful progression through the project lifecycle in a way that optimises time, quality, and cost impacts.

5.1.1 Pre-FEED with FEED Opt–In

Consideration was given to whether to tender the Pre-FEED and FEED separately, or to tender the Pre-FEED with an Opt-in clause for the FEED. The pros and cons of the two options considered are detailed in Table 22.

	Pro	Con
Option 1 Award Pre-FEED and go back to Market for FEED	Greater FEED scope definition can be drafted following Pre-FEED. There is limited project definition at Pre-FEED tender phase so if FEED is included as an opt-in, the FEED estimate may not be robust. Allows re-tender if poor delivery performance during Pre-FEED.	The potential handover from one design consultant to another at the end of Pre-FEED creates a risk that the FEED consultant would not take on the design work of the Pre-FEED consultant. This could result in re-working large elements of the Pre-FEED, schedule impacts and additional costs. Impacts programme by adding a 6-month for the FEED tender period. Additional cost and resource commitment for a separate FEED tender.
Option 2 Award Pre-FEED with a FEED Opt-In	Reduced cost and time for rechecking and potential rework that would be required if a new contractor takes on Pre-FEED from another supplier. Removes additional time and cost associated with a second procurement event. Open-market procurement for both Pre-FEED and FEED is more attractive to consultancies and attracts a wider resource and competency pool, bringing transferrable learning, experience, and developments from hydrogen infrastructure projects. Allows re-tender if poor delivery performance during Pre-FEED. Opt-in does not create an obligation to proceed into FEED so maintains focus on costs and enables cost negotiations. Ability to have a standalone procurement event if deemed necessary following negotiations. Greater resource security as the consultant can provide longer term visibility of work to their staff. This can enable mobilisation of the FEED at pace, with continuity of subject matter experts that worked on the Pre-FEED.	Requires close management and scrutiny of FEED re-estimate to ensure value for money from Opt-In.

Table 22: Pros & Cons of Pre-FEED with FEED Opt-in

Based on Table 22, we concluded that *Option 2, awarding a Pre-FEED with FEED opt-in*, offered best value for money and that, subject to successful delivery of the Pre-FEED, would facilitate the project to mobilise into FEED at pace, which is positive from both a cost and schedule perspective. The subsequent DESNZ market engagement on the Hydrogen Transportation Business Model (HTBM) focuses on deliverability and decarbonisation at pace, which further supports this decision.

A further benefit of Option 2 and a FEED opt-in was that it generated far greater levels of interest from the global supply chain, further enhancing the opportunity to drive a competitive tender with organisations that are highly experienced in delivering comparable projects. This is illustrated by the statistics at each procurement stage:

- 37 organisations responded to the expression of interest.
- Nine organisations made it through to the PQQ (Pre-qualification Questionnaire).
- Four bid teams (made up of multiple organisations) made it through to RfP (Request for Proposal).
- Three bid teams (made up of multiple organisations) made it through to final presentations.

5.1.2 Competitive Tender for Pre-FEED and FEED Opt-In

Upon making the decision to proceed with Option 2, we then considered how to procure the services. Two options were evaluated and compared against each other. The key considerations are detailed in Table 23:

	Option 1- Utilising Cadent's existing design services framework	Option 2- Competitive tender for the Pre-FEED and FEED Opt-In
Technical	Considerable number of contractors on the framework with extensive experience designing and engineering Natural Gas transmission pipelines and assets. Concerns over the level of specific Hydrogen experience and the capability to model, network balance and develop a completely new network of this scale. [Note: this concern played out in reality with many Cadent framework contractors not moving past the HyNet PQQ stage.] Due to the limited resource pool on the framework, there is a risk of only having access to consultants that are capable of delivering Pre-FEED and are not experienced enough in FEED delivery.	Extends the opportunity to reach contractors that have wider experience. Enables inclusion of contractors with upstream/offshore oil and gas experience and competence where Pre-FEED and FEED is standard practice. Opportunity to utilise their experience in delivering FEED, to ensure the Pre-FEED delivers the right outputs. Adept at designing and engineering new large-scale networks with complex interfaces, network balancing and modelling. Access to large global organisations that can attract experienced and competent resource. Risk of appointing consultant not capable of delivering FEED mitigated by global open tender event and accessing tier 1 contractors.
Commercial and Legal	Reduced procurement time and associated resource time supporting the tender event. Minimal legal time, costs and support required as existing contractual terms and conditions are in place.	An open market approach extends the procurement event period and requires resources to support it. Time and legal costs required for drafting new contract terms and conditions.

Table 23: Options for Pre-FEED tender

We decided that Option 2 would deliver best value and launched a competitive open market commercial tender event. This allowed us to access a wider market of globally experienced consultants that had the technical competency to deliver major DCO infrastructure projects and develop new philosophies and design code for Hydrogen pipelines.

5.1.3. Award of a Single Contract

The strategy to appoint a single contractor for Pre-FEED with FEED Opt-in was driven from the lesson learnt on the HyNet project where the scope of services had been procured in two lots:

- Lot 1 – Engineering Design
- Lot 2 - Land, Consent, and Communications (LCC)

- Based on the HyNet experience, it was decided that procuring one contractor to manage the project integration and management of engineering design, land, consent, and communications for a DCO infrastructure project offered best value for the following reasons:
- It removes the cost and complexity with Cadent having to manage two separate contracts and the interface between their deliverables.
- It drives efficient delivery with one consultant responsible for all deliverables across multiple work packages that require specific discipline expertise.

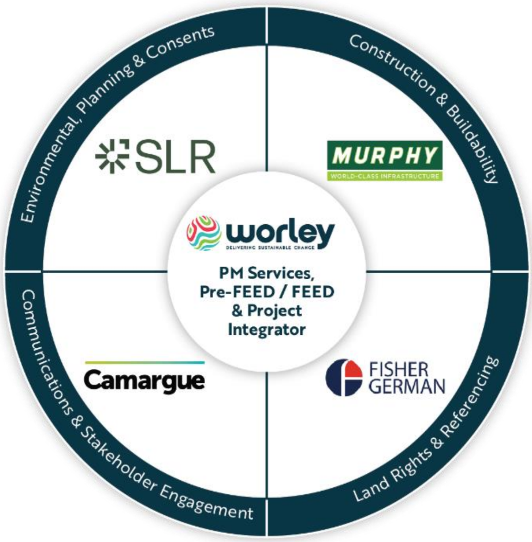
5.1.4 Bidders and Bid Evaluation

Worley scored highest on the bid evaluation criteria, and whilst their cost estimate was higher, it was within acceptable tolerances and was offset by their technical score. The key technical differentiating factors are in Table 24.

Technical Factor	Comments
Construction experience	Having a constructor as part of their organisational structure was considered a significant benefit. This was important for Pre-FEED but critical for FEED to ensure the consented & designed route is physically buildable.
Hydrogen Design Codes	Were able to demonstrate experience and capability in developing new hydrogen design code, design philosophies and specifications.
Delivery	High levels of confidence to deliver against their submission, based on their project structure and integrated team.
Technical resource	Demonstrated competency in developing new design codes and specs from large scale projects in the UK and globally. The partners also demonstrated live experience of major pipeline infrastructure projects that are in development and/ or projects requiring a DCO.
Customer Assessment	Demonstrated the ability to develop definition of a Hydrogen network by implementing a robust methodical process to assess large quantities of customer data, both quantitative and qualitative, to inform pipeline routing options, consenting requirements and phasing of connections.

Table 24: Technical Reasons for selecting Worley

Worley's integrated project structure and its delivery partners are detailed in Figure 21:



1. Worley is a leading global design and engineering consultancy, with ~35,000 employees, who have supported over 350 hydrogen projects.
2. Murphy is a leading global, multi-disciplined engineering and construction company, who specialise in cross country pipeline construction.
3. SLR are a leading global environmental, planning and consents consultancy who have supported major UK infrastructure projects DCO consents.
4. Fisher German is a leading UK land and property services consultancy who are supporting other major UK cross country pipelines, including Cadent's HyNet pipeline based in the North West of England.
5. Camargue is a leading UK communications agency who are supporting other major UK cross country pipelines, including Cadent's HyNet pipeline based in the North West of England.

Figure 21: Pre-FEED Project Structure and Delivery partners

5.1.5 Approach to Risk Allocation

We also considered allocation of risk as part of the procurement and contracting strategy. The various renumeration models available under the NEC4 Professional Services contract were considered and the most relevant options are summarised in Table 25:

Option	Scope Definition	Cadent Cost Certainty	Share risk with Supply chain	Drives cost innovation	Comments
Fixed Price (NEC Option A)					The level of project definition in the early-stage development of a major project lifecycle, makes this an unavailable option.
Target Cost (NEC Option C)					Option C provides a higher level of cost certainty and ensures the supply chain are accountable for estimating inaccuracies and productivity issues.
Reimbursable (NEC Option E)					Option E would not have provided the required level of cost certainty and would result in Cadent sitting with all cost risk.

Table 25: Risk Allocation

Option C was deemed the most appropriate for the Pre-FEED and FEED phase as it shares the risk of cost overruns between the contractor and Cadent, but equally incentivises cost savings through efficiency and/or innovation. Table 26 details the pain/gain mechanism in the contract:

From	To	Consultant's Share %
0%	85%	[commercial]
85%	89%	[commercial]
90%	99%	[commercial]
100%	109%	[commercial]
109%	114%	[commercial]
114%	120%	[commercial]
120%	120% and above	[commercial]

Table 26: Pain/gain contractual mechanisms

This mechanism ensures that we do not contribute to any overspends where the target cost is exceeded by the 120% threshold. Any overspend beyond this point is incurred by the consultant only.

Further, to mitigate costs associated with schedule delays, delay damages have also been included in the Contract.

We are satisfied that the procurement strategy and contract set-up has delivered value for money for Pre-FEED via a robust competitive tender procurement process and fair allocation of cost risk, whilst also securing highly specialised technical delivery partners for the FEED, who are ready to mobilise and deliver at pace.

5.2. Updated FEED Cost Estimate and Review Process

The original FEED scope provided to the bidders during the competitive tender process for Pre-FEED and FEED Opt-in was based on several baseline assumptions to allow normalisation of the bid returns.

On completion of the Pre-FEED, the updated FEED scope was issued for Worley to provide a revised cost estimate. Having received a revised FEED cost estimate from Worley, we conducted a detailed review and found that:

[redacted]

To resolve these issues, we organised a face-to-face workshop in January 2024 to align Worley, and its partners, on project requirements, approach to addressable risk and expectations in relation to cost competitiveness.

Figure 22 was used to frame the project's approach to addressable risk and articulate that we sought a 'medium' risk profile, with scaled mitigation measures to be taken during the FEED phase. It was agreed that transferring some risks to future phases (where they did not significantly impact the project's overall deliverability) represented value for money during FEED. A high-risk approach would be to push multiple addressable risk items into subsequent phases; this approach could have led to costs increasing by many multiples and could have threatened the DCO application. Transferring too much risk into future phases also reduces confidence around the deliverability and was therefore ruled out.

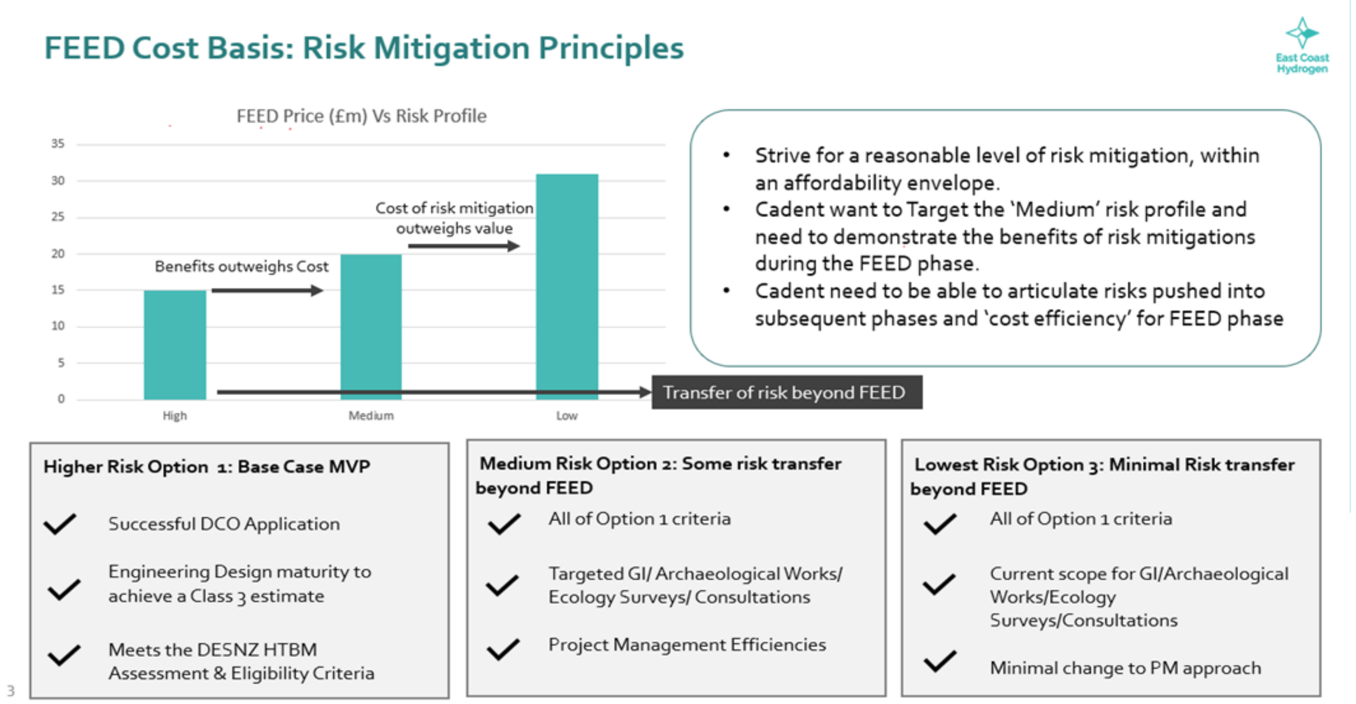


Figure 22: Approach to address Project Risk

[redacted]

[redacted]

Figure 23: Summary to changes and risk impacts

The rationale of the changes made to Worley's revised proposal and the impact on the project deliverability profile are set out in Table 27.

Description	Risk	Risk Impact (Comments from Consultant)
BREEAM scope reduction		BREEAM (Building Research Establishment Environmental Assessment Methodology) is a science-based suite of validation and certification systems for sustainably built environments. It can be deferred to detailed engineering and construction where achieving an Outstanding rating is still possible, although earlier project decisions could prevent the contractor from achieving this level. An allowance within the cost estimate remains for BREEAM strategy documents to be prepared.
Dedicated Project Office		Dedicated project office removed from Provisional Sum. The project intends instead to make use of a balanced combination of regular face to face meetings and the virtual meeting technology that the project team is already familiar with and proven to be effective
Removal of overlaps - better synergy between partners		Rationalisation of overlaps between partners
LIDAR - removal of duplication between surveys		Proposed LIDAR surveys to be completed for archaeology and topographical purposes can be combined.
Remove Route optionality		Optionality and flexibility will remain across the 1km wide route corridor as detailed in Section 3, but not across two separate pipeline corridors.
Ecology Survey - Remove contingency from provisional sum		Updated assumption that there are no material changes from Statutory Consultation to justify a Targeted Consultation. Cadent to make suitable contingency should this be required. Note that we believe there will be sufficient time in the proposed programme to address this if needed.
Management and Project Controls		Rationalisation of hours and positions (namely project management efficiencies and management systems to ensure integration and manage interfaces).
Engineering and Design		Rationalisation of hours and positions (namely project management efficiencies and management systems to ensure integration and manage interfaces).
Land and Consents Pre - Non-Statutory Consultation & EIA Scoping Report		Rationalisation of assumptions and revised process assumptions
Reduction in GI Survey Scope & Management		Targeted scope for Geotechnical Investigations (GI) e.g. bore holes for major crossings that require 3rd party consents only. Target cost savings include design, management, expenses, and land.
Archaeological Trial Trenches - reduction of provisional sum		Significant reduction [commercial] in Provisional Sum estimate for trial-trenching to support Environmental Statement (ES) development and DCO application, and associated resources / target costs for management of this work. Allowance remains for targeted works during FEED, risk that quantum of work required to support the ES and satisfy statutory consultees increased and that pushing this cost into EPC phase of the project is not accepted. Cadent to allow contingency and/or budget for these during EPC phase of project.

Table 27: Project Deliverability Impact

It should be noted that some of these costs have been removed from the Consultant's costs and are to be held within our contingency allowance. This allows us to better control these costs. It was also confirmed that there was no 'fee on fee' applied to Worley's delivery partners costs.

Subsequently we completed a benchmarking exercise against our HyNet project, a process which revealed that the revised Worley proposed cost is comparable to the HyNet FEED costs (actual) plus the HyNet planned DCO costs. The agreed [commercial] reduction in costs satisfied us that value for money had been achieved. This is quantitively illustrated at the end of Section 5.3.

5.3. FEED and DCO Cost Estimate

In parallel to the activities detailed above in 5.2, we have prepared a detailed cost estimate for all activities associated with delivering the FEED and DCO phase, incorporating learnings and cost efficiencies from the HyNet project.

The FEED and DCO cost estimate captures all associated activities to progress the project to DCO award. The estimated duration through to DCO approval is 48 months, which includes 16 months for the DCO application process. ANNEX H has a detailed breakdown of FEED & DCO costings.

The cost estimate for this phase in 2018/19 prices is £37,104,332.

The Cost per phase is given in Table 28:

PHASE	Duration (Months)	£ 2018/19 prices	£ 2023/24 prices
FEED AND DCO SUBMISSION	32	£ [cost data]	£ [cost data]
DCO ACCEPTANCE AND EXAMINATION	16	£ [cost data]	£ [cost data]
POST DCO APPROVAL	1 ½	£ [cost data]	£ [cost data]
CONTINGENCY ALLOWANCE		£ [cost data]	£ [cost data]
Total Cost Estimate	**48**	**£ 37,104,332**	**£ 46,518,025**

Table 28: Cost per phase

The Cost per deliverable is given in Table 29:

Cost Elements	£ 2018/19	£ 2023/24
CADENT COSTS	£ [cost data]	£ [cost data]
FRONT END ENGINEERING DESIGN (FEED)	£ [cost data]	£ [cost data]
LAND AND CONSENT COSTS	£ [cost data]	£ [cost data]
OTHER PROJECT COST	£ -	£ -
CONTINGENCY ALLOWANCE	£ [cost data]	£ [cost data]
Total Cost Estimate	**£ 37,104,332**	**£ 46,518,025**

Table 29: Cost per Deliverable

The below Table 30 adds greater granularity to the costs and how they align to the scope of work. This includes all the key costs, further granularity is in ANNEX H.

Cost Element	2018/19	2023/24	Key Deliverables
CADENT COSTS	[cost data]	[cost data]	
Project and Engineering Management	[cost data]	[cost data]	We have incorporated key learnings from HyNet when structuring the project management, project controls, design, engineering, and land and consents team required to support a cross country pipeline project. The project team for the FEED stage requires additional technical and engineering support compared to the Pre-FEED stage and additional resources for the onsite environmental surveys and geotechnical works. The project has reviewed the resourcing requirements and is a combination of full and part time resources. Key roles that will be critical during the project life cycle are typically Cadent staff, and where appropriate an Owners Engineer will support the project to ensure appropriate utilisation and value for money. Refer to the project organogram in section 6.1 for further details of the project team for the FEED stage. As detailed above, to support with cost efficiency we will appoint an Owners Engineer to enable the project team to flex resources up and down as required. Post DCO submission the team will move to a 'skeleton team' to reflect the reduced level of effort required, whilst maintaining an appropriate level of support.
Other Costs	[cost data]	[cost data]	An allowance has been made for, independent project reports, ad hoc major project SME support, ad hoc legal advice, Cadent Travel and Subsistence and system costs. Additionally, support for agreements with key stakeholders such as Network Rail (Basic Asset Protection Agreements), National Highways etc have been allowed for.
Cadent Overhead	[cost data]	[cost data]	As part of Cadent's License Condition, we are required to ensure contracts are entered on an arm's length basis using normal commercial terms, fully costed to avoid any potential creation of a cross-subsidy. In addition, competition law requires us to not abuse our natural monopoly and thus ensure that we do not offer excessively high or excessively low prices. Therefore, to ensure prices are fully costed, we have included a 20% overhead to Cadent's personnel costs only, to recover support costs, such finance, legal, information systems and other office-based support.
FRONT END ENGINEERING DESIGN (FEED)	[cost data]	[cost data]	
Management and Project Controls	[cost data]	[cost data]	The consultant's project management and project controls team will be expanded at the FEED stage compared to the Pre-FEED due to the increase in the scope and volume of work to be delivered. The consultant will provide an expanded project management team suitable to manage and implement the project and deliver the required level of governance and reporting needed for projects of this scale.
Engineering and Design	[cost data]	[cost data]	The Cadent ECHP FEED Engineering and Design scope will take the network concepts developed in the Technical Feasibility and Pre-FEED stage and to develop them further in FEED. This will be to a level of maturity that can support

			an AACE class 3 capital cost estimate as a FEED output but moreover enable a level of design certainty for consenting purposes which is particularly important for a DCO application. This key aspects of this are detailed in section 4 of this document but broadly include more detailed flow assurance and network modelling, more detailed pipeline routing work including geotechnical investigations (covered under provisional sums), development of HAGI layouts and locations as well as discipline engineering of all the key Engineering disciplines. Built into this design stage are iterative processes for feeding in key findings from activities such as surveys, stakeholder engagement and consultation process as well as process safety assessments, such as HAZIDs, HAZOPs and constructability reviews etc. The other more broader aspects that are considered in this section are Operational Readiness and the development of the Cadent Hydrogen Network Safety case. The build of this cost element is mostly comprised of and driven by the need for the relevant technical experts across multiple disciplines to feed into the iterative design process to ensure a sufficiently detailed and robustly challenged solution is implemented. The scope and deliverables have been developed with learning from HyNet and adjusted to suit ECHP.
Land and Consents Pre - Non-Statutory Consultation & EIA Scoping Report	[cost data]	[cost data]	The initial phase of the project requires significant input into a strategy and plans to ensure that the foundations of the project will meet the legislative requirements set out in the 2008 planning act. The scale and complexity of the project will require detailed interaction with 6 LPA's (Local Planning Authorities) and 1,000 + land interests. The EIA scoping report will require significant input from statutory bodies and regional stakeholders, which will influence the survey areas and survey methodology required to inform the PEIR and ES. Thousands of people along the 135km+ route in local communities will be invited to participate in meaningful consultation, to ensure that the project can communicate its objectives, and also be open and receptive to the information and feedback it receives.
Land and Consents Pre-Statutory Consultation, PEIR & Consultation Feedback Report	[cost data]	[cost data]	Building on the approaches and strategies developed in the early part of the project, significant land access across circa 33 million square metres of land is expected. Access to land is required to facilitate the physical surveys necessary to collect ecological and environmental information, in line with existing legislation and regulations governing habitats and species and the potential Environmental Impacts of the project. Surveys will be conducted over a circa 250m corridor in line with the methodology set out in the scoping report. Following the initial identification of habitats and species, targeted surveys of protective species and habitats will follow to inform the PEIR. Access will need to take place at specific seasonal times in accordance with the regulations set out in protect species legislation and habitat regulations. Once the project has sufficient design and assessment maturity to produce a red line boundary, Statutory

			consultation will take place with the relevant consultees as defined by the Planning Act. The consultation will provide the opportunity for affected parties to be informed on the proposed impacts of the scheme and allow them to provide feedback to inform the design process. The consultation will be monitored against a pre-agreed methodology (Statement of Community Consultation) with LPA's to ensure compliance with the requirements. The findings of the statutory consultation will be analysed and published as part of a consultation feedback report
Land and Consents DCO Application	[cost data]	[cost data]	Following the inputs referred to above, the application to the Planning Inspectorate for the DCO requires significant documentation to be produced and uploaded, for review and acceptance by PINS before its examination by the assigned planning inspector(s). The information provided in the PEIR (Preliminary Environmental Information Report) will be updated in line with the final design proposals and submitted as part of the ES (Environmental statement). The application will also include the book of reference and corresponding land plans, detailing all the persons with interest in land, within the redline boundary of the proposed scheme. To ensure compliance all registered titles must be reviewed along with wider information provided by PIL's. The book of reference will also detail special category land. The application to PINS is expected to include in excess of 130 documents consisting of: o Application forms o Compulsory Acquisition Information o Environmental Statement o Draft DCO o Plans o Reports
DCO Acceptance and Examination	[cost data]	[cost data]	Following acceptance by PINS of the application, the information submitted will then move towards the examination phase, this will consist of PINS appointing an inspector(s) to review the proposals. The examination will invite statutory parties to provide information and objections against the proposal which will be explored during the examination through open hearings and/ or written representatives. The project team will be required to comply with the examination timetable and provide sufficiently detailed responses to the topic areas raised to meet the requirements of the inspector. This will require input and coordination across the project team in order to meet key dates and provided updates and information to the level of detail necessary to meet the questions raised. Once the examination is concluded, the inspector will make their recommendation to the secretary of state on whether to grant the DCO or not.
Post DCO Approval	[cost data]	[cost data]	Following the Secretary of State's decision there will be a six-week judicial review period for legal challenge. The project team will be available to assess any such challenge and respond according to PINS. The project team will ensure the necessary notices and notifications are issued in line with the requirements set out under the planning act, along with reviewing the discharge of requirements accompanying the DCO and compiling an action plan to ensure compliance with the relevant statutory bodies governing the conditions.

Provisional Sums	[cost data]	[cost data]	As detailed in section 5.5
LAND AND CONSENT COSTS	[cost data]	[cost data]	
Non-Intrusive Surveys	[cost data]	[cost data]	Set payments are made to landowners/ occupiers in exchange for the signing of an access licence to enable to project to take up to 12 months of walking access over land. The payments are benchmarked against other utility company payment rates. Achieving voluntary access promotes a positive working relationship with landowners/ occupiers and avoids the cost and programme delay of serving statutory notices of entry. It is expected circa 1,000 landowners/ occupiers will require access licences, along with their incurred professional fees (Land Agents)
Intrusive Surveys	[cost data]	[cost data]	Given the nature of ground investigation, a separate voluntary licence agreement is offered to landowners/ occupiers where intrusive surveys are identified. Set rates for the types of survey (i.e. bore hole, trial pits) are offered in recognition of the expected time and losses incurred by intrusive surveys. The payments are benchmarked against other utility company payment rates. It is expected circa 140 intrusive surveys will be require, along with their incurred professional fees (Land Agents)
Pipeline Easement Option Agreement	[cost data]	[cost data]	To enable Cadent to build, operate and maintain its pipelines, formal land rights in the form of a Deed of Easement (DoE) are required with landowners/ occupiers. The guidance set out by PINS shows a requirement to deliver voluntary land rights where possible, with compulsory acquisition being used as a last resort. Accordingly, option agreements are sort which enable the value of the DoE to be agreed, with 20% being paid for the option to complete the DoE should the DCO be granted, this approach is benchmarked against industry norms and enables Cadent to demonstrate its commitment to achieving voluntary agreements were possible, whilst limiting the exposure to cost before DCO approval. This figure accounts for over 136km of pipeline that crosses various land types and corresponding values and is based on 50% of landowners/ occupiers signing the Option Agreements during this phase.
HAGI Option Purchase Agreement	[cost data]	[cost data]	To enable Cadent to build, operate and maintain its HAGI's, we need to own the freehold for the site. The guidance set out by PINS shows a requirement to deliver voluntary land acquisition where possible, with compulsory acquisition being used as a last resort. Accordingly, option agreements are sought which enable the value of the land to be acquired to be agreed, with 20% being paid for the option to complete the freehold transfer should the DCO be granted. This approach is benchmarked against industry norms and enables Cadent to demonstrate its commitment to achieving voluntary agreements where possible, whilst limiting the exposure to cost before DCO approval. The estimate cost is based on 50% of landowners/occupiers signing the Option Agreements during this phase.
DCO Examination Costs	[cost data]	[cost data]	The application and examination phase of the DCO submission have fees associated, which are payable by the promotor. These include: • Fee to accompany the application (the 'Acceptance fee') • Pre-examination fee following the appointment of the Inspector(s) initially chosen to examine the application (based on panel of three Inspectors) • Examination fee (assuming 60 days £4,919.00 /day)

			• Costings for Production, Event Management and Equipment for DCO Hearings • Inspector Lodgings • Venue Hire
Legal - Strategic and DCO Examination Support	[cost data]	[cost data]	Given the scale and complexity of the project, strategic input from planning lawyers is required to provide confidence and assurance that the legalities of the DCO process are being managed and complied with. The scope of this work includes: • Development of a robust need case/justification to form the backbone of the DCO application • Providing input into the development and review of strategies and approaches • Providing input into the development and review of DCO application documents • Consideration of and compliance with Cadent's statutory duties and obligations e.g. Gas Act 1986, Planning Act 2008 • Reviewing/ implementing evolving legislation • Ongoing strategic planning and consenting advise to the project • Support during the examination phase of the application The costs have been based on the completion of a tender event amongst Cadent existing framework providers, with weighted scores being awarded against experience, delivery and cost against a prescribed scope to ensure the best appointment for the project.
Legal - Land Support	[cost data]	[cost data]	The option agreements referred to above require solicitors to complete the legal transaction of the option agreement, and the subsequent execution of the Deed of Easement (Pipeline) and the Freehold transfer (HAGI). The legal costs have been based on the completion of a tender event amongst Cadent existing framework providers, with weighted scores being awarded against experience, delivery, and cost to ensure the best appointment for the project. The transactions required to complete the options have been costed on a unit rate, with firms invited to demonstrate efficiencies of cost and delivery.
MATERIALS AND INSPECTION	**£-**	**£-**	Cost Efficiency - leverage work undertaken on HyNet
OPERATIONAL READINESS	**£-**	**£-**	Cost Efficiency - leverage work undertaken on HyNet
OTHER PROJECT COST	**£-**	**£-**	
CONTINGENCY ALLOWANCE	[cost data]	[cost data]	As detailed in section 5.6

Table 30: Cost and Scope summary

The full ECHP cost estimate was built up on 'bottom up' principles with inputs from the project team, subject matter experts and consultant quotations. Once compiled, the cost estimate went through several reviews and challenges prior to being benchmarked against data from our HyNet project. To illustrate that value for money has been achieved on the ECHP North – Phase 1 Worley costs and total project costs, we highlight some specific examples that show how close they are to the HyNet (actuals + forecasted) costs:

- **Cadent Costs**: Our team costs are [Commercial] than the comparable HyNet costs.
- **Worley's FEED and Consenting Costs**: Worley's cost estimate is [Commercial] than HyNet, however the pipeline is 36% longer with more HAGIs and trenchless crossings.
- **Total FEED and up to DCO Submission Costs**: the ECHP overall cost estimate for this phase is [Commercial] than HyNet.
- **Total DCO Examination and Acceptance Costs**: the ECHP cost estimate for this phase is [Commercial] than the HyNet cost estimate.
- **Cost Efficiencies**: The ECHP project will benefit from [Commercial] of operational readiness and material testing work undertaken on the HyNet project.
- **Total Overall Cost Estimate**: The overall cost estimate to take the ECHP project through to DCO approval, inclusive of contingency and provisional sums, is [Commercial] than HyNet.

The overall project and consultant costs are aligned to those on our HyNet project for the FEED and Consenting scope. Whilst Worley's costs are [Commercial], savings elsewhere mean that the total costs are only [Commercial] than HyNet, and we deem this value for money considering the ECHP North – Phase 1 pipeline is 36% longer and includes more trenchless crossing and HAGIs.

In addition to the HyNet analysis, we feel value for money is demonstrated by:

- The final FEED costs have been through several different bench-marking processes designed to ensure that they are as cost competitive as possible as follows:
    - Original Worley cost estimate for FEED performed the best in a competitive tender
    - [redacted]Worley revised their quote post-Pre-FEED following updated scope from Cadent; this was bench-marked by Cadent against other design frameworks, [redacted]
    - Final cost estimate from Worley was [Commercial] lower than their revised cost estimate
- Confidence levels on the delivery capabilities of Worley remain high and delivery accounted for 70% of the bid evaluation criteria.
- The additional time (6-12 months) and costs associated with a re-tender and mobilisation does not align with 'decarbonising at pace' or value for money.
- A retender would likely result in a loss of project knowledge and additional costs with Pre-FEED revalidation.

5.4. Provisional Sums

There are a number of activities that, on completion of the Pre-FEED, are not yet well enough defined to allow a robust cost estimate or their incorporation into the base scope at this stage. A provisional sum allowance of [cost data] (2018/19 prices)/ [cost data] (2023/24 prices) has been made against these items with the with key (non-exhaustive) allowances being detailed in Table 31, additional granularity is in ANNEX H:

Description	Summary	£ 2018/19	£ 2023/24
Physical Ground Investigation works	A targeted GI programme will be defined during the FEED.	[cost data]	[cost data]
Archaeological Field Work- geophysics and trial trenching	A targeted archaeological programme will be defined during the FEED. It is acknowledged that the Lincolnshire planning authorities are unlikely to support the project without an adequate level of diligence being completed.	[cost data]	[cost data]
Travel and Subsistence	The scale of the project and onsite nature of large portions of the scope will result in consultants travel and subsistence costs. Allowances have also been made for project and other stakeholder meeting that are required on major projects.	[cost data]	[cost data]
Additional CUs	An allowance has been made to add additional CUs during the FEED. This provides a level of flexibility to accommodate additional identified users during the early stages of FEED.	[cost data]	[cost data]
Early/Security payments	Prior to DCO submission it may be necessary to make payments for district licensing, Network Rail (BAPA's), National Highways, CRT etc.	[cost data]	[cost data]
Lidar and Topography	An allowance has been made for surveys to be completed.	[cost data]	[cost data]
BREEAM Studies	An allowance has already been made in the core FEED costs for base activities, however we have made an allowance for additional BREEAM scopes, should they be required.	[cost data]	[cost data]

Table 31: Provisional sums

Whilst the provisional sums are based on the data currently available and on HyNet experience, there is a risk that as the scope is defined through FEED, the **allowances are not sufficient and we will be required to draw down on contingency**.

5.5. Contingency Allowance

The project held a risk workshop to identify and quantify the potential financial impact of risks associated with delivering this phase of the project, whilst incorporating key lessons from the HyNet project. The output of this workshop is a detailed register as ANNEX H, and demonstrates the quantitative approach taken. The contingency allowance calculations totalled [cost data] (2018/19 prices) which is [commercial] of the total cost estimate and is aligned with industry norms.

5.6. Construction Estimate

A deliverable of the Pre-FEED was a AACE class 5 cost estimate for the Engineering, Procurement and Construction (EPC) phase, with an expected accuracy range of -50% to +100%. Using the more mature Class 3 estimate on the HyNet project and its own internal costs data, Cadent were able to add a greater level of accuracy the cost estimate provided by Worley. The level 1 breakdown of these costs are shown in Table 32.

Cost Element	Cost
Engineering and Project Management	[cost data]
Construction Management	[cost data]
Pipeline	[cost data]
HAGI's	[cost data]
Owners Costs	[cost data]
Development and Contingency Allowance	[cost data]
Total Estimate	**£732,000,000**

Table 32: Construction Cost Estimate

5.7. Cadent Contribution

We recognise the unique opportunity that the development phase of this project represents and have confirmed a contribution of 10% of the FEED and consenting phase costs.

Based on the cost breakdown of the FEED that equates to £3.71m (2018/19).

6. Project Delivery and Monitoring

This chapter looks at how the project will be delivered by the team, including internal project team positions, project governance, the monitoring plan and associated documents to be submitted to Ofgem. Also discussed is how we will interface with project partners ensuring that we work effectively together and share learning.

6.1. Project Team and Responsibilities

We intend to deliver the FEED and consenting for the ECHP North – Phase 1 pipeline project by mobilising a hybrid of external and internal team members, which will manage an organisation/s contracted to develop and deliver the scope. Cadent have reviewed their resourcing and will have adequate resource should funding be awarded, subject to a successful recruitment process being undertaken. However, core positions such as Project Director, Head of Project Delivery and Project Design manager have already been allocated should the project be awarded funding. The project team structure is shown in Figure 24:

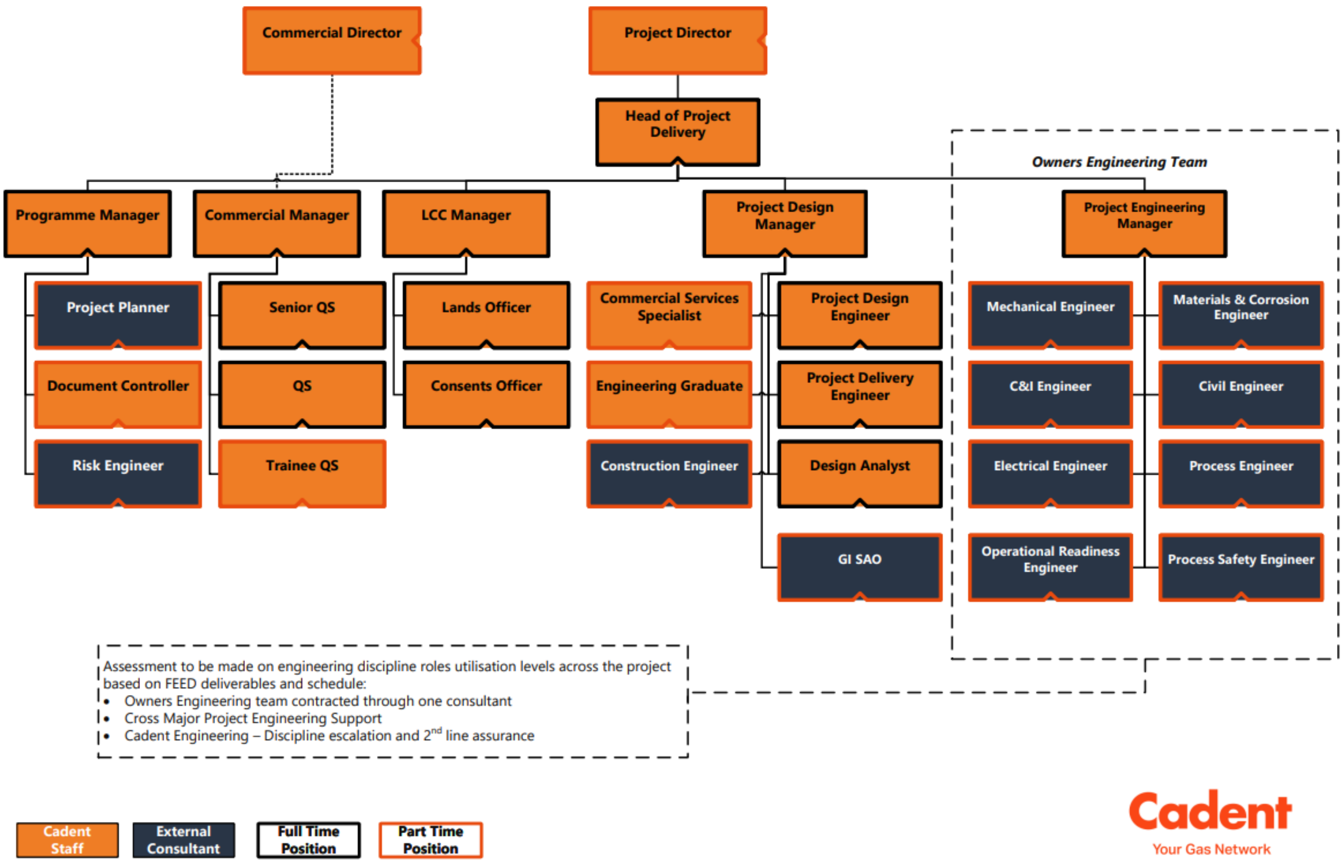


Figure 24: Cadent Project Team

Project Director (PD): Leads the project team and is accountable for the success of the ECHP Project and ECHP North – Phase 1 more specifically, reporting to the project sponsor, who is part of the Cadent Executive Team and the Net-Zero Transition Committee (NZTC) executive leadership team. The PD keeps the sponsor and NZTC informed of progress, seeking approval for any major decisions. The PD is responsible for providing optimal conditions for the operation of the project team, therefore ensuring successful project delivery and is responsible for any updates to the project's business case. The PD is also responsible for managing interfaces with external funders (such as Ofgem) and any important stakeholders who shape strategic direction, such as Government departments.

Head of Project Delivery: Manages the overall delivery of the FEED and DCO stages and is responsible for the day-to-day management of the project, including responsibility for contract administration, commercial budgets, FEED stage delivery and project reporting. The Head of Project delivery reports to the Project Director.

Project Design Manager: Responsible for decision making on routing technical solutions and ensuring the design is being developed to the agreed standards, policies, and procedures. The Design Manager works closely with the Engineering Manager to progress the project.

Project Engineering Manager: Provides focus and expertise on technical activities outside of the design process and therefore not covered by the Design Manager. This includes, but is not limited to, flow analysis, QRA and safety case support. The Engineering Manager works closely with the Design Manager to progress the project to a successful completion.

Land Consents and Communication Manager: Leads on the planning and consenting process, including environmental elements, land access, stakeholder engagement, consenting and public consultations, legal considerations and the DCO submission.

Commercial Manager: Responsible for cost estimation, cost management, procurement and the commercial management of contracts for any 3rd parties that are involved in the project. Provides critical input to the development of the business case, which is under constant assessment as the project progresses.

Programme Manager: Ensures that the integrity and coherence of the programme is maintained. The Programme Manager integrates the full scope of the service across all aspects of the project, including engineering, design, land and consent. The Programme Manager will maintain several logs on behalf of the Project Director including the risk, decisions, action and issues log.

6.2. Description of Project Governance

The project is sponsored at the executive level within Cadent. The project team will work under the guidance of a Net Zero Transition Committee (NZTC) and will ultimately report to the project sponsor who sits on and chairs the NZTC. The project sponsor is not a part of the project team but has an important role in ensuring that the project team is represented at the NZTC and can act as an intermediary between the project team, particularly the project director, and other members of the NZTC as required. Cadent's governance structure and Lifecycle stage for the project is as follows in Figure 25:

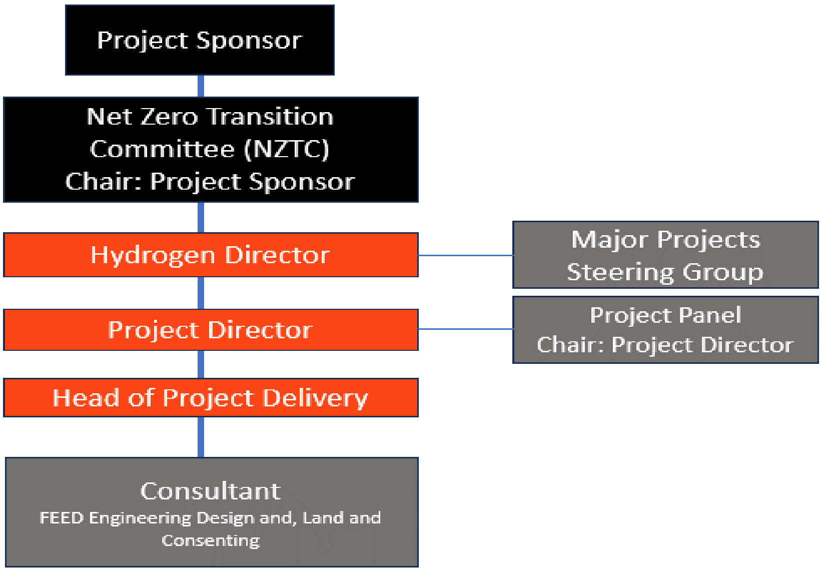
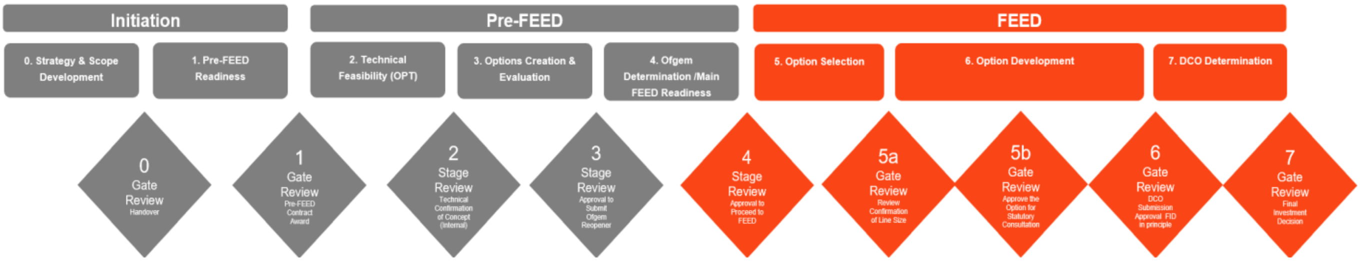


Figure 25: Governance Structure

Decision Making at Project Stage Gate Reviews: Project stage gate reviews will be held in accordance with the project lifecycle as shown in Figure 26. The decision to accept the successful completion of any given stage and approval to proceed to the next stage lies with the NZTC and the PD.



Note: Stage gates in grey are complete

Figure 26: Project Lifecycle

Operational Decision Making: During the daily operation of the project, the Head of Project Delivery is responsible for decisions that relate to project delivery, stakeholder management, commercial and contractual matters and the team set up/structure. For some elements of the scope, they may delegate responsibility to other members of the team, in particular the Design Manager, where applicable. The managers that sit directly under the Head of Project Delivery are responsible for making decisions within their own specialism, whilst keeping other members of the team abreast of progress.

Budget Ownership: Budgets will be reviewed monthly and approved during stage gate reviews where the Commercial Manager and Senior QS will take the lead. However, ownership and accountability for budget allocation within the project lies with the PD, who will in turn brief the Project Sponsor and the remainder of the NZTC on budgetary progress.

Key Meetings – Cadent Project level: Project level meetings will be undertaken on a monthly basis and shall include the following:

Meeting	Scope
Net Zero Transition Committee (NZTC)	Project Status Update (Schedule, Risk, Commercial), Decision Paper Review & Approval, Phase / Stage Gate Review and Approval
Major Project Steering Group	Overall project update to internal key stakeholders. Customer Updates, Finance, Schedule, Risks
Project Panel - Attended by Cadent & Consultant	Project reporting, Deliverables update, Programme review, Commercial

Table 33: Key Meetings - Project Level

Key Meetings – ECH Programme: As previously described, Cadent's ECHP North – Phase 1 project, is a part of the overall ECH_2 project, a collaboration programme between Cadent, Northern Gas Networks and National Gas. A set of governance work stream groups were formed and held regularly during the Pre-FEED stage for the project partners. Cadent expects these working groups will continue (subject to all parties receiving funding) and will be held throughout the FEED and DCO stage of the projects to ensure that lessons learnt, and examples of best practice can be shared and the projects can be adequately deconflicted to ensure that duplication doesn't occur and collaboration can occur.

6.3. Project Reporting and Deliverables

The project will provide an engagement update to Ofgem on the project's progress upon completion of the following activities:

- Flow assurance transient analysis - updated line sizing
- Confirmation of initial customer and producer connections
- Public project Launch
- Non-Statutory Consultation
- Class 4 Overall Project Cost Estimate

It is expected that this shall be approximately within the first 12 months from project start date. Based upon the current forecast schedule mobilisation date of September 2024.

The project will provide a milestone update to Ofgem of the project's progress through a formal FEED close-out report.

- FEED study
- Confirmation of DCO acceptance from PINS
- Class 3 overall project cost estimate and full project lifecycle programme

It is expected that this shall be approximately 32 months from project start date.

The project will provide an update back to Ofgem, after announcement of the DCO outcome, at approximately 48 months from the start date. At the end of the project, Cadent will submit a closedown report. This will set out how Cadent has met the conditions and any instances of under or non-delivery.

We would anticipate a Licence Condition should this Re-opener be successful, to include a schedule of deliverables. The table below, translates the reporting described above into a set of potential Licence deliverables, based on our experience with HyNet:

Output	Anticipated Delivery Date
Present conclusions and outputs to Ofgem following the completion of: • Flow assurance transient analysis to inform pipeline sizing • Confirmation of initial customer and producer connections • Public project Launch • Non-Statutory Consultation • Class 4 Overall Project Cost Estimate	Within first 12 months following mobilisation
DCO Submission Acceptance by the Planning Inspectorate	Within 32 months following mobilisation
Project Close-out report including: • FEED Study • DCO Submission to the Planning Inspectorate • Overall project Class 3 cost estimate • Overall project programme	Within 32 months following mobilisation

Table 34: Project Deliverables

6.4. Supporting Projects Overview

The following projects will support North – Phase 1 project of ECHP:

Future Grid: This project is the first step towards a full-scale conversion of the existing National Transmission System (NTS) to transport hydrogen and is led by National Gas. The project has seen the construction of test facilities from decommissioned assets that will be tested using hydrogen (instead of natural gas) in an offline environment. The tests will demonstrate the impact the hydrogen will have on a range of assets as well as operation of the NTS itself. There will be a number of technical evidence safety outputs from the project that it will have to be reviewed and incorporated into our ECHP North - Phase 1 project if applicable.

LTS Futures: This project reviews whether the Local Transmission System (LTS) can be repurposed to transport hydrogen instead of natural gas. The SGN team have been carrying out surveys on a 30km stretch of LTS pipeline to determine whether it can be repurposed to transport hydrogen via a determination of the pipeline's current integrity.

HyNet: This Cadent-led project has undertaken a FEED study for a DCO for a new purpose-built hydrogen pipeline in North-West of England. The pipe will take hydrogen from the key production site at the Stanlow Refinery (owned and operated by Essar Oil subsidiary Essar Energy Transition (EET)) to the significant hydrogen users across the region, displacing natural gas with hydrogen, and to hydrogen storage in Northwich. As the ECHP North – Phase 1 project team is looking to undergo a similar scope of works to that undertaken by the HyNet project team, the development and learnings from the HyNet project will continue to be vital. The two projects already maintain close working relations and this will continue to ensure efficiencies are realised wherever possible.

HyDeploy: This project looked at primarily the technical considerations of a introducing a hydrogen blend onto the gas distribution network. Whilst the core aim of HyDeploy is to clear technical barriers for hydrogen blending, social and economic constraints are also considered. HyDeploy served as the first example of a safety case being approved by the HSE for hydrogen to be injected into a gas network above 0.1% and the safety case approach will be adopted for ECHP North – Phase 1.

6.5. Integration with other ECH_2 Projects

Concurrently to the FEED and DCO being undertaken on Cadent's ECHP North Phase – 1 project, it is assumed that National Gas and NGN will also be undertaking a FEED and consenting study, subject to funding approval. It is important that the Cadent's project team engages with both NGN and National Gas on a regular basis to ensure that plans are fully integrated and there is consistency and clarity of approach across the separate projects.

6.6. Challenges and Risks

6.6.1 Strategic Challenges to the ECHP North – Phase 1 Project

If hydrogen is to play its full potential role in the future energy system, and if the ambitions of the UK Government's Hydrogen Strategy are to be realised, it is critical that the necessary midstream infrastructure is developed in a timely manner. Whilst there has been progress across the value-chain, including T&S business model development, the expansion of industrial clusters, progression of large-scale hydrogen production technology engineering studies and the development of consumer trials such as H100 Fife, there still remains some uncertainty across the supply-chain that is, to a degree, inevitable in an emerging industry such as hydrogen. In the coming months and years that lie ahead, building on the positive work that has been undertaken so far, the final barriers will be overcome to enable the hydrogen economy to reach its full potential.

Management of Policy and Regulation Uncertainty: The UK government has made demonstrable progress in 2023 with positive policy decisions on hydrogen transport and storage business models, hydrogen blending and the initial Hydrogen Allocation Round 1 (HAR1) being completed. Work continues on hydrogen production business models and a comprehensive set of other workstreams such as the low carbon hydrogen standard (LCHS). The momentum created in 2023 now needs to be built upon with the HAR-2 being opened, confirmation of the process for Track 1 Expansion and Track 2 CCUS enabled blue hydrogen projects, and progress continuing on the hydrogen transport and storage business models for the first projects. There are some policy decisions that will directly impact upon ECHP North - Phase 1 and East Coast Hydrogen more generally; this includes the decision about whether hydrogen will be used for domestic heating, with a decision due in 2026 and as a consequence of this decision about whether a hydrogen pilot town is required. Our approach to navigating this uncertainty has been to provide optionality in the following two ways:

1. **Inclusion of Scunthorpe Town in Base Case pipeline capacity provision.** Pre-2030 timelines for the conversion of Scunthorpe Town to hydrogen (if required by Government for its 'Pilot Town' potential policy commitment) can only be achieved if the ECHP North- Phase 1 pipeline is sized to account for its potential domestic demand. If the domestic heat policy decision does not favour use of hydrogen in homes, the additional capacity in the pipeline can be used to enable future growth of the network for example extending South of Northamptonshire or Southwest into the West Midlands. Industrial, power generation or aviation fuel demand for

hydrogen can be satisfied in these additional regions, or alternatively demand from developing sectors such as hydrogen-fuelled freight (trains, HGVs, marine).

2. **Opportunity to 'up-size'.** The 'large diameter' pipeline referenced in the CBA under scenario 1a (section 2.10) gave an indication in how much bigger the pipeline diameter would need to be in order to satisfy residential demand across a number of towns in South Yorkshire, Lincolnshire, Nottinghamshire and Derbyshire. The CBA showed a positive financial result even if the larger pipeline diameter was constructed but only the financial benefits of carbon savings from industrial and power generation customers were included. This work will enable discussions with Ofgem and DESNZ in 2024 to make a decision on whether potential demand from multiple towns should be scoped into FEED.

Creating Technical Certainty: The supply chains essential to the hydrogen economy are new and still evolving, with a variety of approaches and technologies being explored globally. For example, work is still ongoing to define safety and technical standards for storage and distribution. The UK Government and industry need to work together to assess the storage capacity needs and drive policy development that will support hydrogen storage projects. There are also a number of technical considerations that need to be uncovered relating to individual hydrogen applications in an industrial setting and whether certain types of equipment can receive a hydrogen blend or 100% or whether they need modifying. Final technical considerations need to include what measures need to be undertaken to move to 100% hydrogen in industrial and commercial applications. Many companies are at the early stages of understanding what they need to do to make their equipment on site compatible with hydrogen.

Commercial Framework: There is a large amount of work ongoing in the hydrogen space ensuring that the commercial markets and frameworks are correct to ensure that hydrogen can be successfully deployed across a range of different sectors. The commercial work is being led as part of the hydrogen production business model development, which is making very strong progress. However, there will still be a series of commercial considerations that need to be made after hydrogen production business model work concludes, including how hydrogen blending is billed, if it alters the Flow Weight Average CV of the network, and how hydrogen is priced to different sectors – for example the transport sector where the counterfactual is currently diesel and petrol.

Stakeholder Engagement: Although customers in the region understand the benefits of hydrogen, the wider public has limited awareness of hydrogen as a low-carbon energy source and is unfamiliar with its expected use – this became clear in the recent hydrogen village projects undertaken by Cadent and NGN. In both examples the consumer base knowledge of options available to them was initially quite limited which could affect how consumers feel about hydrogen infrastructure developments in their local area. Additionally, uncertainty around when and how hydrogen will be supplied make it difficult for industrial and power generation customers to commit to transitioning their operations. Network users' demand may not materialise as forecasted, resulting in under-utilisation of assets or insufficient capacity to connect all customers. It should be noted that one of our CBA scenarios was that less demand (50% of demand delayed to 2035) came online in the timelines specified, and the result was still positive.

Consenting: A DCO is required for the construction and operation of this major hydrogen distribution system; this is a prescriptive, highly detailed and iterative process which could lead to project delays if it is not completed correctly or circumstances beyond the project team's control come to the fore – such as a challenge to the DCO from a third party at Judicial Review stage.

6.6.2 FEED and DCO Risks and Mitigations

Table 35 shows the major risks that could impact the FEED and consenting stage of the project. Each of the major risks has a mitigation that will have a designated owner from the project team. There will be regular project risk register sessions on a monthly basis where new risks will be identified, and the existing risks reviewed and updated. The risk register is owned by the Project Director but is maintained by the Programme Manager.

Risk	Mitigation
User/Producer/Storage driven scope change, including demand.	Cadent will maintain contact with users, producers and storage providers throughout the FEED stage of the project and update the project team of any changes. Changes will be reviewed by the project team and the impact on programme and cost assessed before being issued to the consultant to incorporate. This challenge will persist throughout the project and will be managed through regular interface by Cadent and the customers, producers and storage providers. Cadent will also invest in sharing of best practice on industrial fuel switching from HyNet customers to East Coast Hydrogen customers. Cadent is already helping to create and support initiatives in the ECH_2 region that allow industry to prepare for and execute the transition to hydrogen.
CUs defined in Pre-FEED may change - joining or leaving	Customers will be re-approached during period between Pre-FEED completion and FEED commencement and ongoing through FEED Stage in order to keep engagement levels high and identify any potential changes early, reducing the potential impact.
Insufficient resilience and storage requirements	Completion of the transient analysis shall be completed at an early stage during FEED. The output of the analysis shall feed back into the design to ensure this challenge is overcome.
Decision on hydrogen towns pilot	The project has allowed for a connection to Scunthorpe in line with the Cadent proposal for the Towns Pilot. If the Scunthorpe Town Pilot is not selected, or a decision is made not to have any town pilot then this will be managed during the FEED stage but should have minimal impact.
Land access being restricted for surveys and other land work	Early engagement and communication at the early stages of FEED to obtain necessary access from landowners. Potential use of Section 172 notices (Housing & Planning Act 2016) for survey access if required.
Safety case approval from the Health and Safety Executive (HSE).	The safety case for hydrogen is being developed with support from the HyNet project. At an early stage in FEED, the project will meet with HyNet and the Cadent resources developing the safety case to ascertain what input this project will need to provide. It is expected that the safety case will be in place for HyNet and so should not have an impact on this project.
Public perception of hydrogen diminishes	At the early stages of the project a robust and detailed stakeholder strategy was put in place with subsequent plans to be developed and implemented to minimise such risk during the FEED. This stakeholder strategy will be revisited at the start of the FEED. The project will have several forms of communication with the public including social media messaging, letters and public events, all ensuring the public's perception of hydrogen is maintained or improved.
Challenges procuring long lead time items	During the FEED stage a list of long lead time items will be established, and market research conducted on procurement timelines. This will be built into the overall project programme to ascertain the correct point at which to procure the items.
Hydrogen transport business models have not been developed or approved in time for the North – Phase 1 project.	The hydrogen T&S business models are expected by 2025. Cadent will look to continue to work with central government to ensure the timely delivery of the hydrogen transport and storage business models.
Challenges to the DCO process, DCO Rejection- Challenges from stakeholders	Cadent are undertaking a procurement event to engage a specialist legal team to assist with the development of the DCO application and to provide advice during the FEED stage to ensure a successful outcome is achieved. The learning from the HyNet project will also be incorporated and updated as HyNet goes through the various stages of DCO submission.

DCO Needs Case is insufficient	An initial project needs case was produced during the Pre-FEED stage and shall be developed during the FEED stage, alongside the project business case. The consultants delivering ECHP North- Phase 1 are highly experienced in developing DCO needs cases and will work closely with Cadent throughout the DCO application and determination period.
Technical hydrogen standards are still evolving and the ECHP North – Phase 1 project loses touch with the latest guidance.	The project is working to current technical hydrogen standards, but not all technical standards required for hydrogen have been completed. Utilising industry best practice as it evolves and learning from the HyNet project and other hydrogen research projects will help to mitigate this risk. Hydrogen standards can also be utilised from other research projects such as LTS Futures.
Pipeline line size requirements might change	Initial line sizing calculations are based upon steady state flow assurance, but further insight will be gathered during FEED through the transient analysis. This could potentially lead to an change in line sizing. Work on assimilating transient demand data from hydrogen customers has already started to ensure transient flow analysis can happen early within FEED.
Ensuring the integration with NGN and National Gas ECH_2 designs	As the FEED projects with NGN and National Gas are planned to run concurrently, it is important to ensure that duplication does not occur and that hydrogen customers' needs are met. It is anticipated that there will be regular technical meetings with NGN and National Gas to keep abreast of progress, share lessons learnt and examples of best practice.
Major crossings – Design & Consenting	The configuration of the network means it will need to cross some major obstacles. The design solutions shall be developed, and the stakeholder consulted during the FEED stage.
Siting of above ground infrastructure (HAGIs)	As HAGIs will be sited above ground, significant work will be required to ensure that its impact on the surrounding area is minimised. HAGIs are significant in size and will require permanent land take.
Accommodating for future demand requirements	During the Pre-FEED stage the pipeline line sizes were assessed to include the demands of potential future towns connections if required. A decision will need to be taken by DESNZ and supported by Ofgem before FEED starts, on how much additional demand should be accounted for in pipeline capacity design (whether for towns or for emerging sectors such as hydrogen freight and aviation fuel). Changes to key design inputs at a later stage will introduce delay and additional re-design costs.
SSSI, Ecological and Environmental	The ecological and environmental impact of such a long pipeline system may give rise to many mitigation methods being required. Ecological and Environmental studies will be undertaken during the project and their input considered during pipeline routing.

Table 35: Major Risks during FEED & Consenting

7. Stakeholder Engagement and Whole System Opportunities

This chapter discusses how key stakeholders have been proactively engaged to date and describes what stakeholder engagement will happen in the future, including the consenting process.

7.1. Engagement with Ofgem and DESNZ

Alongside NGN and National Gas, we have engaged with DESNZ and Ofgem throughout the period of the Pre-FEED as shown in Table 36. This culminated in the submission of the Re-opener Trigger document to Ofgem at the end of 2023, which was accepted by Ofgem in January 2024.

No.	Date of meeting	Topics discussed/Meeting agenda
1.	[sensitive] OFGEM	1. Introduce representatives from DESNZ and Ofgem to the ECH_2 project team. 2. Provide an overview of ECH_2 project and specific objectives of ECH_2 project and the specific objectives of Phase 2 (the Pre-FEEDs and Delivery Plan) which was delivered throughout 2023. 3. Discuss a number of questions regarding the best approach to effectively engage with Ofgem and DESNZ.
2.	[sensitive] OFGEM	1. Pre-FEED progress updates 2. Project and Delivery Plan 3. Re-opener structure and approach
3.	[sensitive] OFGEM	1. Needs case for hydrogen production 2. Progress overview 3. Temperature check
4.	[sensitive] OFGEM	1. Needs case for hydrogen demand and storage, including discussion on pipeline sizing and inclusion of Scunthorpe Town Pilot in Base Case. 2. FEED study needs case 3. Temperature check
5.	[sensitive] OFGEM	1. Pre-FEED technical progress update 2. Re-opener submission timeline 3. Pre-FEED maturity 4. Implications of emerging energy policy 5. Pre-trigger engagement health check
6.	[sensitive] DESNZ	1.Vision for ECH_2 2. ECH_2 Needs Case 3. Pre-FEED update 4. Discussion on project
7.	[sensitive] OFGEM	1.Submission timelines 2. CBA and options for assessment – Ofgem guidance - Overarching approach - Guidance for CBAs from Ofgem 3. Managing uncertainty 4. Pre-Trigger engagement 5. Summary and actions log
8.	[sensitive] 11/12/23	1. Benefits for natural gas customers 2. ECH_2 phasing strategy 3. Indicative plan for engagement post March 4. Review of actions 5. AOB

Table 36: Engagement with Ofgem & DESNZ

7.2 Stakeholder Engagement in Pre-FEED

We have engaged extensively with relevant stakeholders during the Pre-FEED, these include:

Hydrogen Producers: We have been engaging with a large number of hydrogen producers across the ECH_2 area. These producers have interests in hydrogen production from a range of different means, including steam reformation with CCS, electrolysis and pyrolysis/gasification. The hydrogen producers have been able to share with us their hydrogen production forecasts and the location of their production units, ensuring that we are able to account for their plans within the pipeline design. Since the end of Pre-FEED we have re-engaged with all producers in the region to show them the Pre-FEED assessment outputs on pipeline routing and to start to discuss technical aspects of connection. We will also be asking producers for an updated supply forecast by June 2024, so that an even greater level of granularity can be taken through into FEED.

Hydrogen Customers: We have actively engaged with 50 organisations, that represent circa. 180 industrial and power generation sites on their plans for decarbonisation and their requirement for hydrogen. When organisations expressed an intent to switch from fossil fuels to hydrogen, we issued a ‘forecast questionnaire’ to customers, requesting meter locations, consumption rates, future changes to consumption rates and potential to switch to hydrogen (either as a blend or full switch) for 2030, 2035 and beyond 2035. Forecasts were received from 43 companies covering 168 sites across the East Midlands, South Yorkshire and Lincolnshire. We have also signed 30 separate MoUs with these organisations. The MoU commits the company in principle to transitioning some or all of their natural gas to hydrogen, commits us to include their site in the Pre-FEED and if appropriate, the FEED. The MoUs include details of the expected total annual volumes of hydrogen required by each site over time. Since delivering the Pre-FEED study, potential hydrogen customers have been informed of the Pre-FEED results via a series of meetings. All CUs in line for a connection to our ECHP North - Phase 1 project have been informed and have subsequently confirmed that they still require hydrogen to their respective sites. As for hydrogen producers, an even greater level of data granularity will be required from customers to carry out the transient flow analysis. This will be collected from prospective hydrogen customers in the coming months so that it can be processed before the FEED is planned to start in the Autumn.

Hydrogen Storage Providers: We have engaged with known hydrogen storage providers such as Equinor at the Aldbrough site. We have also been working with private companies on storage opportunities in our region using disused oil fields, and we expect to be able to release more information on this publicly in the coming weeks. We will continue to work with storage providers and gain more granular data from them that can be inputted into the FEED.

Regional Stakeholders: We have been engaging with a myriad of regional stakeholders to make them aware of the project, including what we hope to achieve, areas they are able to offer support, and next steps and key barriers to overcome. These conversations have been very positive and have included the following key stakeholders – local MPs, metro-mayors, local planning authorities, freeport leaders, Local Enterprise Partnerships (LEPs) and regional council representatives. Aside from regional political stakeholders we have also engaged with industry bodies and Think-Tanks on the plans for the ECHP North – Phase 1 project.

7.3 Stakeholder Engagement in FEED and DCO

For the purposes of planning engagement and stakeholder management for the hydrogen pipeline, individual stakeholders can be categorised into broad audiences. Some of these audiences will be closely involved throughout the project's development, while others will be involved at key milestones. Some audiences will require detailed, technical information and others will be content with an overview. Each of these groups bring different requirements and will have differing preferred methods of engagement. The various stakeholder groups are shown in Figure 27, with the groups being internal groups to Cadent, groups involved with the DCO including public and landowners and elected representatives (MPs, Councillors etc), technical stakeholders (including the planning offices, Environment Agency, Natural England etc), ECH_2 consortium members and partners, hydrogen producers, storage providers and customers.

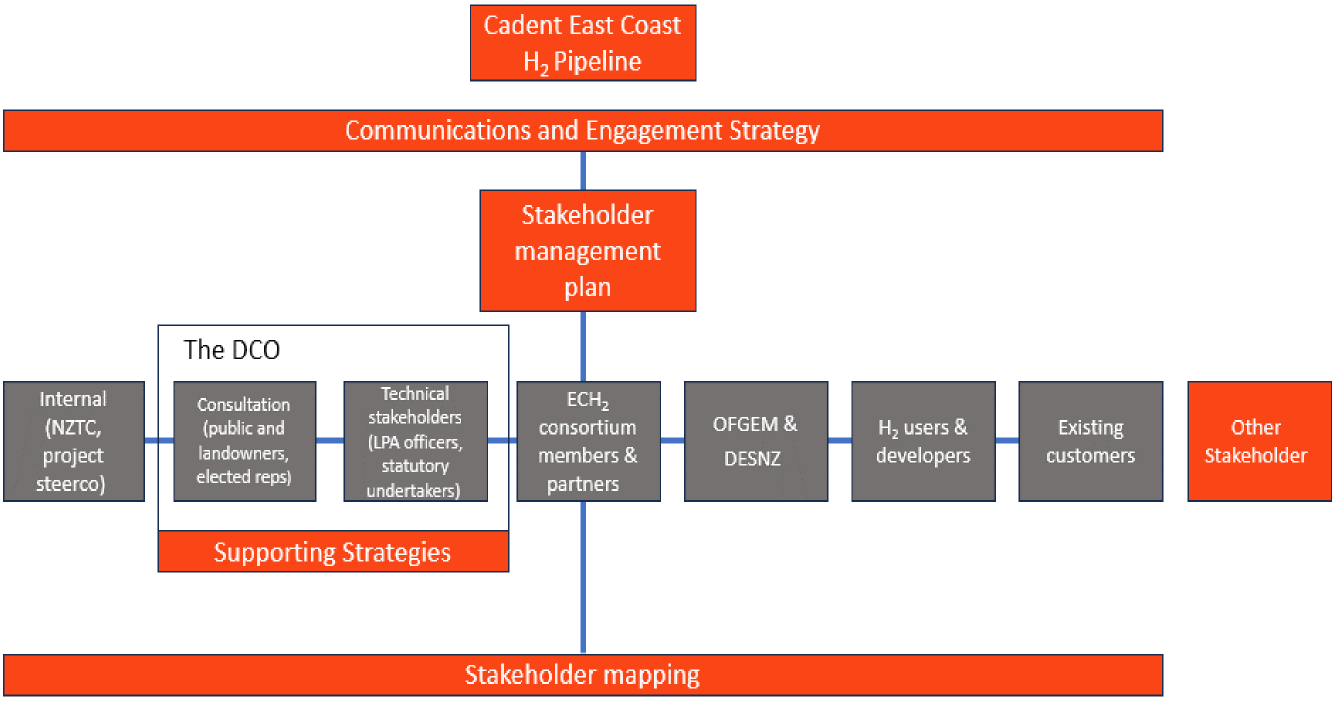


Figure 27: Project Engagement in FEED & Consenting Stage

Internal Audiences: This includes our Board and Executive Team, asset strategy, communications (internal and corporate) and our Eastern network leadership. There are a number of supporting groups that will need to be kept abreast of project progress, including our Net Zero Transformation Committee (NZTC). Project reporting will be carried out within our existing governance structure, with the project team reporting to NZTC. The project will be led by a Project Director, this is discussed more in Section 6.1.

Local Communities: Examples of local communities that the project will need to engage with include, residents and the wider community, parish and town councils, PIL's, landowners, elected representatives, seldom heard groups and local businesses. Local businesses within the project consultation will be consulted alongside other statutory and non-statutory consultees, but effort should be given to identify and engage with other businesses within the wider area. The establishment of a robust supply chain will not only de-risk the construction phase of the project but also support any BREEAM aspirations.

Local communities will be engaged via the:

- Engagement and Communications Strategy – this includes the overall approach to communications, engagement and consultation.
- Consultation Strategy – sets out the detailed delivery plan for consultation on the project, including consultation zone, event planning, materials, how feedback will be captured and reported.
- Land Referencing Strategy – this document details how the project will identify those who may own or have interest in the land affected by the project, and how their interests with be represented in the Book of Reference.
- Land Rights Strategy – sets out the project's approach to acquiring voluntary land rights (including survey access) for the FEED stage and enduring land rights to operate the infrastructure post construction.
- Statement of Community Consultation (SoCC) – this will be developed following non-statutory consultation. It will set out how the statutory stage of the consultation with local communities and statutory consultees will be undertaken, with the subsequent statutory consultation reviewed against the agreed steps set out in the SoCC to ensure compliance.

Engagement with all of the local community audiences will principally be part of the pre-application consultation under the Planning Act 2008, with evidence and findings included as part of the application.

Technical Stakeholders: This includes Local Planning Authority (LPA) offices, statutory environmental bodies (such as Heritage England, Natural England and Environment Agency), statutory undertakers requiring interface (Network Rail, HSE, National Grid and water companies) and the PINS. There will be supporting strategies to engage with these groups, including a Consenting Strategy and an EIA Strategy. The Consenting Strategy will provide a clear roadmap to guide the DCO process and the requirement for any separate or early consents. It sets out the project consent objectives and the DCO application process. The EIA Strategy will cover the approach to delivery of the EIA and the information sources required to facilitate this delivery, as well as details of the EIA team, the legislative and policy requirements, the programme, and risk management. Technical stakeholders will be important in informing the project’s environmental, engineering and routing work. Statutory environmental bodies, utility providers and others will have specialist knowledge that will inform the project design in different ways.

East Coast Hydrogen: The ECHP North – Phase 1 pipeline will form part of a more extensive future network promoted by Cadent and partners under the umbrella of ECH_2. It will be important to explain this wider impact and work together with our partners and stakeholders to deconflict potential issues, share best practice and lessons learnt. It will also be important to consider other hydrogen projects being promoted in the area to ensure differentiation and clarity for all stakeholders. This will be particularly important in the context of the DCO consenting process. Beyond ECH_2, the project can act as a flagship for the expansion of the hydrogen sector and its key role in decarbonising industry and moving the country towards net zero. The ECHP North – Phase 1 project will maintain close relationships with other hydrogen projects across the country and publicise news and consultations through a dedicated section on the website and via other communications channels, building on the strong and effective engagement.

Ofgem: The only external source of funding that we will receive at this stage will be from Ofgem via the NZASP Re-opener. We will provide regular updates to the appropriate Ofgem personnel and will produce formal regulatory Price Control Deliverables reports as set out in a Licence Condition. We can be flexible and work with Ofgem to determine the most effective approach to providing key project updates as the project progresses.

Hydrogen Developers: We will work with these businesses to find ways in which they can work together to build awareness and understanding of hydrogen and the region's decarbonisation agenda. For instance, the Humber Industrial Cluster aims to be the first net zero industrial cluster by 2040 and this will be reliant on hydrogen developers completing production projects in the region. Ensuring our communications are delivered in collaboration with hydrogen developers we will aim to provide consistent messaging around hydrogen development within the project footprint and assist in the wider education delivered to stakeholders and consultees of the decarbonisation transition towards hydrogen.

Hydrogen Customers: We will continue to develop relationships with the hydrogen customers within the footprint of this project. Further engagement with these customers will be required during the FEED stage to ascertain further engineering criteria, including details around the connection points, and engage on further requirements for additional levels of project commitment. As the DCO pre-application stage progresses, customers identified within the DCO proposals will be required to demonstrate their commitment to the project, to give confidence to stakeholders and consultees over the feasibility and credibility of the project.

7.4 Whole System Opportunities

The wider whole system benefits of decarbonising the energy system are well documented and understood. As are the obvious economic benefits of providing an economic net zero energy source for industry so that it can continue and grow to support the UK economy. Presenting a clear and confident roadmap to deliver hydrogen will allow investments to be made and mitigate the risk of businesses closing or relocating.

A further significant whole system benefit from this project is the enabling of zero emission power generation. To achieve the target of a net zero power system by 2035, as well as the installation of large-scale renewables and associated infrastructure, dispatchable zero emission power generation will also be required for security of supply, when the expected intermittency of renewables prevents their operation at the required levels to supply demand.

Given the current challenges with electricity infrastructure, which will continue and be exacerbated as more demand from transport and heat is electrified, as well as providing hydrogen for power generation to deal with intermittent renewables, there will be value in decentralised power production to deal with local network constraints.

Some system constraints can also be addressed by increasing demand in certain areas, and the availability of a hydrogen network facilitates solutions such as electrolysis, providing a route to market and storage for the low carbon hydrogen produced.

A further significant whole system benefit of this project is the reduction in additional demand that the electricity grid would have to accommodate. As a result of energy density and resilience requirements, there is a huge mismatch between the quantities of infrastructure required to supply each kW of peak demand on the electricity system compared to the gas network. The current total gas and electricity systems compare in the region of 15:1 in terms of length of network required to meet each kW of peak demand. The value of avoided electricity network build out, both in terms of cost and deliverability risk, will be a major factor in the UKs successful journey to net zero by 2050.

The whole system value of a hydrogen economy is detailed in a recent report by Imperial College: The Role and Value of Hydrogen in Future Zero-Carbon Great Britain's Energy System[22]

[22] Imperial College London (2023) The Role and Value of Hydrogen in Future Zero Carbon Great Britain's Energy System. Found Online: https://cadentgas.com/nggdwsdev/media/media/The-Role-of-Hydrogen-Imperial-College-London.pdf

8. Regulatory Treatment and Bill Impacts

This chapter confirms the eligibility of this project for funding under the Net Zero Pre-Construction Works and Small Net Zero Projects Re-opener (NZASP) mechanism and outlines the range of benefits and reasons to socialise the cost of this project across all gas users.

8.1. Regulatory Funding Justification

Given the uncertainty surrounding hydrogen investment, to support hydrogen project development and other associated innovation, Ofgem has established funding mechanisms within the RIIO-2 framework via the Network Innovation Allowance (NIA) and the Net Zero and Re-opener Development 'Use it or Lose it Allowance' (NZARD UIOLI). There are also three other routes to funding hydrogen projects including the Strategic Innovation Fund (SIF), the Net Zero Pre-Construction Works and Small Net Zero Projects Re-opener (NZASP) and the Net Zero Re-opener. Below we explore these mechanisms in detail to justify the most suitable regulatory funding mechanism for the proposed activities.

Network Innovation Allowance (NIA): We have been provided NIA funding of £32.5m across the five-year RIIO2 period. The allowance is intended to enable network licensees to undertake innovation projects that have the potential to address consumer vulnerability and/or focus on the energy system transition, which would not otherwise be undertaken within the price control. Licensees are also obliged to make a 10% TOTEX contribution towards all NIA funded projects.

Net Zero and Re-opener Development 'Use it or Lose it Allowance' (NZARD UIOLI): The NZARD UIOLI allowance provides £18.8m of funding that can be utilised across the five-year price control period. The allowance is intended to enable the necessary development work for net zero projects and promote the progression of low regret net zero facilitation capital projects within the gas sector. The allowance should be predominantly allocated to those net zero projects which may be low in materiality but high in impact and consumer value. Network licensees should not use the NZARD UIOLI for net zero facilitation capital projects that are expected to cost more than £2m, and such projects can instead utilise other regulatory mechanisms, such as the Net Zero Pre-Construction and Small Projects Re-opener (NZASP).

Strategic Innovation Fund (SIF): The SIF is designed to drive the innovation required to equip gas and electricity networks for a low carbon future. The SIF works as a competition-based mechanism, allowing networks to apply for funding against specific innovation "challenges" issued by Ofgem. Applications are required against three SIF 'phases', with successful applications for earlier stages not guaranteeing success in subsequent stages.

- Discovery Phase: Up to two months and funding capped at £150k
- Alpha Phase: Up to six months and funding capped at £500k
- Beta Stage: Between six months and five years with funding starting at £500k (which may be capped at a certain level).

The Net Zero Pre-Construction Work and Small Net Zero Projects Re-opener (NZASP): The NZASP was created to allow network 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. The materiality threshold for the Re-opener is £1m per project and the funding provided per project under the NZASP may not exceed the total of £100m. The mechanism can only be triggered by Ofgem following a detailed engagement phase to establish the needs case in principle.

Net Zero Re-opener: The Net Zero Re-opener is an Ofgem triggered mechanism designed to support larger scale net zero projects. The terms of the Re-opener are specified in the network's license, and it may be used where a Net Zero Development has occurred or is expected to occur, and the cost is not otherwise provided for in this licence.

Evaluating and Determining the Suitable Regulatory Mechanism: Overall, when considering the above mechanisms, and with the purpose of this submission to undertake Front-End Engineering and Design for North - Phase 1 of our ECHP, the NZASP Re-opener is the most suitable mechanism in this circumstance as it is designed to cover such early construction costs. When compared with the alternative available funding routes across the RIIO2 framework, while the overarching principles of this project can be deemed 'innovative in nature', and we will be upholding a 10% contribution across the project, it does not meet the strict definitions of an 'innovation project' in place for the NIA and SIF mechanisms. Likewise, with the characteristics of this project meeting the criteria of the Net Zero and Re-opener Development UIOLI, as explored, licensees should not use this where project costs are expected to be more than £2m. Hence, where £2m is not sufficient to cover all costs associated with early development work, network licensees may use the relevant RIIO2 Re-Openers, including the NZASP Re-opener.

Sharing of project costs via the use of the NZASP aligns with the principles established by the Green Gas and Hydrogen Levy and also follows the same principles deployed with other net zero projects and Uncertainty Mechanisms, including HyNet and the SIF.

Moreover, to meet the requirements of the NZASP Re-opener, there has been extensive pre-engagement undertaken with Ofgem, including the submission of a 'trigger document' covering the criteria of the 'Engagement Step' as outlined in the corresponding governance document. On the 23 January 2024 Ofgem confirmed that they were content that the needs case has been established in principle and that the NZASP Re-opener can be triggered.

8.2. NZASP Funding Mechanism and Eligibility

As explored above, the NZASP is the most suitable regulatory funding mechanism for the given activities, and as mentioned, the NZASP has a broad scope, with some examples of relevant projects including:

- Early development, design and general pre-construction work that will enable the achievement of Net Zero Carbon Targets.
- Front-End Engineering Design (FEED) studies, conceptual design pre-FEED and general feasibility work required for large capital projects.
- Net zero projects that exceed the £2m materiality cap of the Net Zero and Re-opener Development UIOLI (NZARD UIOLI) or are otherwise not suitable for the NZARD UIOLI.
- Net zero facilitation (green gas and hydrogen) projects and hydrogen projects that are required as part of the Hydrogen Grid Research and Development Programme, including projects that may be interpreted as innovative – where there is a clear need and it is appropriate for network consumers to fund.

Overall, with the purpose of the submission required to undertake Front-End Engineering and Design for Phase 1 of our ECHP North – Phase 1 project, and with the project due to exceed the £2m materiality cap of the NZARD UIOLI, the scope of the proposal is well-aligned to the NZASP criteria.

8.3. Regulatory Treatment

As raised above, the NZASP Re-opener is designed to provide the funding for FEED studies for capital projects that will enable the achievement of Net Zero Carbon Targets. Therefore, we propose the funding is treated in line with the structure of the NZASP and in the same manner as other similar projects. The given mechanism works to socialise costs across all consumers, and hence use the same process to what is used for the HyNet FEED study, utilising a pass-through mechanism between Cadent and National Gas NTS. Our expenditure would be outside of the Business as Usual (BAU) efficiency incentives built into the RIIO-GD2 framework, however we note that any funding arrangements should recognise the risk we are taking from cost overruns.

It is not appropriate or sustainable for networks to fund a significant proportion of the costs of delivering the UK government's net zero plans. We do recognise, however, the unique opportunity that the development phase of this project represents and are therefore committing a contribution of 10% of the FEED study costs.

8.4. Impacts on Consumers' Bills

There are significant geographical, temporal and sectoral differences between different groups of hydrogen customers. If the costs of early hydrogen infrastructure are passed onto specific users only, this will result in the following impacts:

- Dis-incentivisation of early movers
- Volatility of charges
- Requirement for an industry led charging methodology change

If costs for early hydrogen transportation projects such as our ECHP North - Phase 1 are shared across all gas users, there will be the following benefits:

- Sharing of gas network costs across hydrogen and methane leading to higher price stability for all customers
- Quicker decarbonisation: early industrial and power generation hydrogen customers are not dis-incentivised, thus, delivering government policy at pace. This leads to acceleration of market development for other low carbon hydrogen use cases (see below).
- Enables future re-purposing of natural gas pipelines to hydrogen as a follow-on opportunity once ECHP North - Phase 1 has been constructed which in turn reduces gas network decommissioning liabilities and stranding risk and extends economic life of gas network assets.

Low carbon hydrogen is critical to reaching net zero carbon emissions by 2050 and is widely acknowledged to have a significant role to play in the decarbonisation of the following sectors: heavy industry, transport (HGV, busses, trains, shipping and aviation), power generation and energy storage.

Therefore, with the case for socialising costs across all consumers outlined above, when considering the impact on consumer bills, the materiality threshold to trigger this Re-opener is £1m per project. Under the scope of this proposal, project costs are expected at £37.1m, with a maximum annual spend of no more than £12m. Based on a kWh allocation onto consumer bills, this would have an annual impact on a typical domestic gas bill of less than [sensitive] per annum.

When compared with the wider societal progress expected from this project, the incremental consumer cost we believe is well justified. The proposed project will support the realisation of extensive benefits to existing and future gas network users, allowing the potential for hydrogen transportation at scale across industry and domestic consumers, and act as a blueprint for decarbonisation across the rest of the UK.

9. Assurance

As a part of our assurance requirements required under Ofgem's Re-opener Guidance we will provide confirmation that this Re-opener is:

- Accurate and robust, and that the proposed outcomes of the Re-opener are financeable and present good value for consumers.
- There have been quality assurance processes in place to ensure the Re-opener is of a high quality and enables Ofgem to make decisions that are in the best interest of the consumers.
- The application has been signed off internally by the Net Zero Transition Committee (NZTC). This is an executive level committee that is chaired by the Chief Regulation Officer, within Cadent.

As part of the initial trigger process of the Re-opener, Ofgem asked that three assurance points are considered as part of the Re-opener submission. These were:

1. Cadent's consideration of a 10% private contribution. In accordance with paragraphs 2.10-2.12 of the Governance Document, we think it is appropriate for your application to include a network contribution given the innovative nature of the deliverables.

- Cadent has confirmed the position that it is willing to contribute 10% of the total cost as suggested in the Pre-Trigger document and has now confirmed this position in the Re-opener. This can be found in Section 5.7 and 8.3.

2. Given the materiality, we expect robust justifications for the costs.

- Section 5 includes robust justification of costs, including how the costs have been derived during Pre-FEED, how they have been benchmarked against HyNet. The HyNet project has given us invaluable insights and experience on how best to undertake FEED and consenting on a purpose-built hydrogen pipeline which has allowed us to build a robust cost profile for the next phase of work to be undertaken on ECHP North – Phase 1.
- An experienced Pre-FEED project team was assembled that have detailed knowledge to enable them to benchmark ECHP North – Phase 1 costs against other design frameworks and these have been reviewed and challenged with the Pre-FEED consultants to ensure that they are as robust as possible.

3. Provide further detail on the individual work packages, including justification for how each meets the scope of/is appropriate to fund via the NZASP Re-opener.

- Section 4 considers the individual work packages in detail and the scope of the work packages. This has gone through a robust internal assurance process to ensure that funding for these work packages is appropriate via the NZASP Re-opener submission.

10. Glossary of Terms

Acronym	Description
ALARP	As Low As Reasonably Practical
BAU	Business As Usual
BERR	Department for Business, Enterprise & Regulatory Reform
BoR	Book of Reference
CAPEX	Capital Expenditure
CBA	Climate Change Committee
CCC	Climate Change Committee
CCUS	Carbon Capture & Utilisation and Storage
CH_4	Methane
CO_2	Carbon Dioxide
CU(s)	Cornerstone User(s)
DCO	Development Consent Order
DESNZ	Department for Energy Security and Net Zero
ECH_2	East Coast Hydrogen
ECHP	East Coast Hydrogen Pipeline
EET	Essar Energy Transition
EIA	Environmental Impact Assessment
EPC	Engineer, Procure & Construct
ES	Environmental Statement
FEED	Front End Engineering Design
GI	Geotechnical Investigations
GIS	Geographical Information System
GSMR (1996)	Gas Safety Management Regulations
GT	Gas Transporters
GW	Gigawatt
GWh	Gigawatt Hour
H_2	Hydrogen
H_2O	Water
H2P	Hydrogen 2 Power
HAGI	Hydrogen Above Ground Installation
HAR	Hydrogen Allocation Round
HSE	Health and Safety Executive
I&C	Industrial & Commercial

IGEM	Institution of Gas Engineers and Managers
KW	Kilowatt
KWh	Kilowatt Hour
LCHS	Low Carbon Hydrogen Standard
LPA	Local Planning Authority
LTS	Local Transmission System
MoUs	Memorandum of Understanding
$MtCO_2e$	Million Tonnes of Carbon Dioxide equivalent
MW	Megawatt
MWh	Megawatt hour
NGN	Northern Gas Networks
NGT	National Gas Transmission
NIA	Network Innovation Allowance
NIC	National Infrastructure Committee
NSIP	Nationally Significant Infrastructure Project
NZARD UIOLI	Net Zero and Re-opener Development 'Use it or Lose it Allowance
NZASP	Net Zero and Small Projects
NZTC	Net Zero Transition Committee
OFGEM	Office for Gas Electric Markets
OPEX	Operational Expenditure
PD	Project Director
PIER	Preliminary Environmental Information Report (PIER)
PINS	Planning Inspectorate
QRA	Quantitive Risk Assessment
RIIO GD2	Revenue = Innovation + Incentives + Outputs Gas Distribution 2
SAF	Sustainable Aviation Fuels
SGN	Scotia Gas Networks
SIF	Strategic Innovation Fund
SMR	Steam Methane Reformation
SoCC	Statement of Community Consultation
SSSI	Site of Special Scientific Interest
T&S	Transport & Storage
TOTEX	Total Expenditure
TW	Terawatt
TWh	Terawatt Hour

11. Figures and Tables

List of Tables

List of Figures

12. ANNEXES

The Annexes are sent as separate files to this document.

ANNEX A: ECHP North – Phase 1 Project Schedule

ANNEX B: Storage Collaboration Letter(s)

ANNEX C: Signed MoUs

ANNEX D: Re-opener Survey

ANNEX E: CBA Slides

ANNEX F: Options Mapping and Scoring Card

ANNEX G: Detailed FEED & Consenting Schedule

ANNEX H: Detailed FEED & Consenting Cost Schedule

Cadent
Your Gas Network

Cadent Gas Limited
@CadentGasLtd
@Cadentgas
0800 389 8000
wecare@cadentgas.com

cadentgas.com