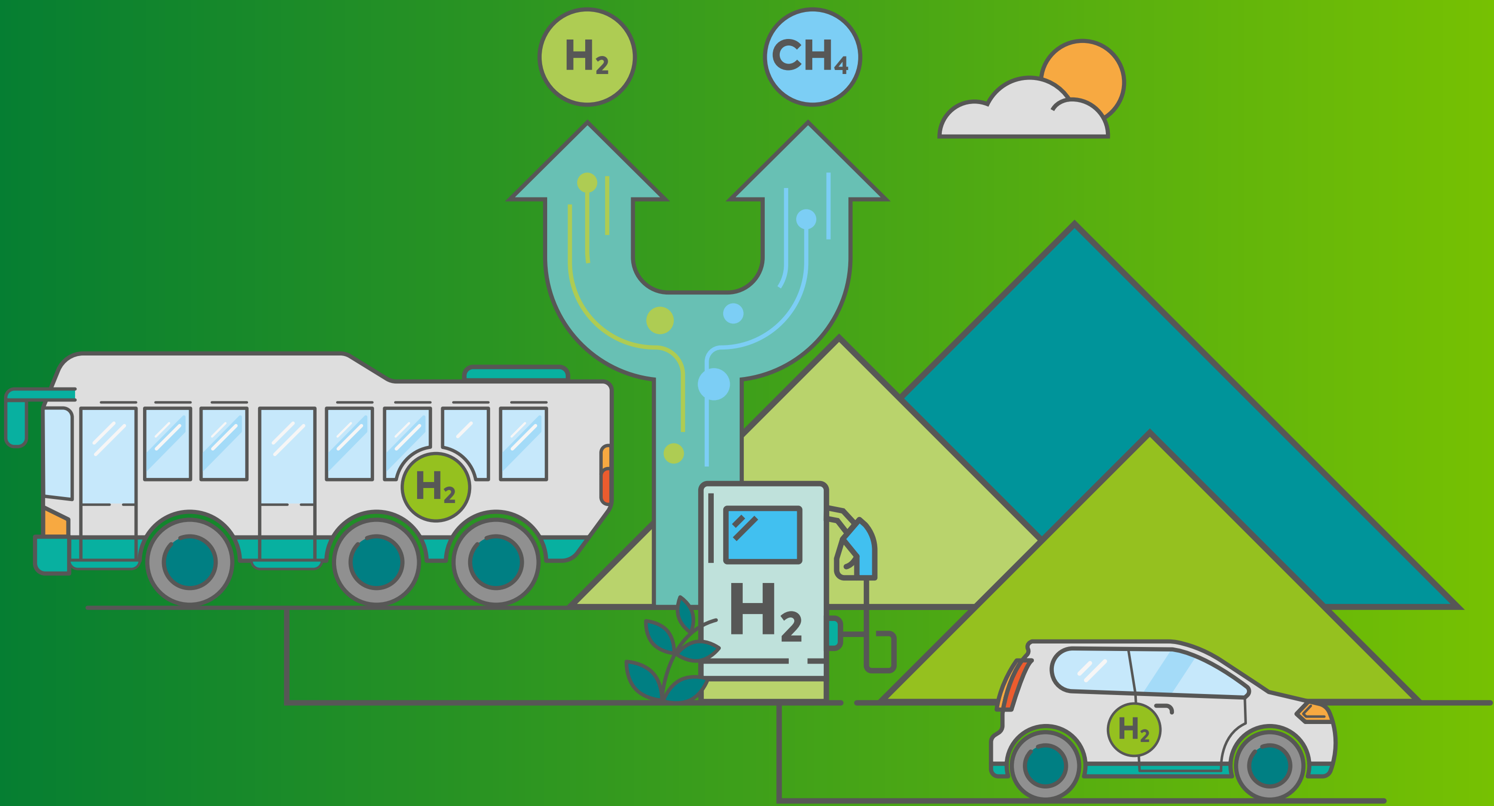
national gas



FutureGrid

Phase 2 Deblending

SIF Beta Project

Progress Report 2024

Contents

Section 1

Foreword

National Gas is the backbone of Britain's energy system today. We deliver energy where and when its needed. We're also playing a leading role in the transition to net zero and a clean energy future.

In July, the UK Government announced their plans to establish a 'Clean Power 2030 Mission Control' to help achieve decarbonisation and provide Britain with cheaper, clean power by 2030.

To align ourselves with the Government's ambitions, we are combining our wider energy transition portfolio with existing innovation projects and newly generated project ideas, to accelerate National Gas' decarbonisation efforts to meet the net zero targets. We have started by setting up a Clean Power 2030 focus group, which I will direct alongside my role leading the Innovation team. It is then our ambition to develop similar programmes focusing on delivering clean industry and clean transport for the UK.

Innovation will play a pivotal role in helping us deliver these ambitious programmes, and our existing funding mechanisms – the Network Innovation Allowance (NIA) and the Strategic Innovation Fund (SIF) – will continue to support with the delivery of key innovation work.

The SIF is the replacement for the previous Network Innovation Competition (NIC) and supports innovative activities that contribute to achieving net zero, by providing funding for larger-scale demonstration projects.

We previously utilised NIC funding to deliver FutureGrid Phase 1, a flagship project to build a high-pressure hydrogen test facility from decommissioned network assets, to carry out a range of tests in various network conditions and with different blends of hydrogen and natural gas. Phase 1 demonstrated that our assets can transport hydrogen safely and reliably. The results of the testing are extremely positive and provide an indication that there are no major blockers to repurposing our network to transport hydrogen.

We're now using SIF funding for the next stage of this research – FutureGrid Phase 2. This has been split into two ground-breaking beta projects: Compression and Deblending.

Corinna Jones
Director of Clean Power and Innovation

The deblending project is helping the UK prepare for the transition to cleaner, greener energy, by testing ways to separate hydrogen from blended gases, for use in vehicle fuelling. The project will showcase the full deblending process, from separating blended transmission gases using electrochemical processes, through to refuelling hydrogen vehicles. The project will also develop low-cost mobile solutions for deblending and purification that can be deployed around the UK.

Since starting in September 2023, we've made significant progress on the project. We've focused primarily on creating the detailed designs of the deblending and compression facility, as well as the hydrogen refuelling station. Alongside this, we've conducted thorough stakeholder engagement activities and developed the rollout strategy, both of which will be revisited throughout the duration of the project. Construction has now begun on the facility, starting with the required groundworks, including the installation of hard standing, concrete plinths, and fencing.

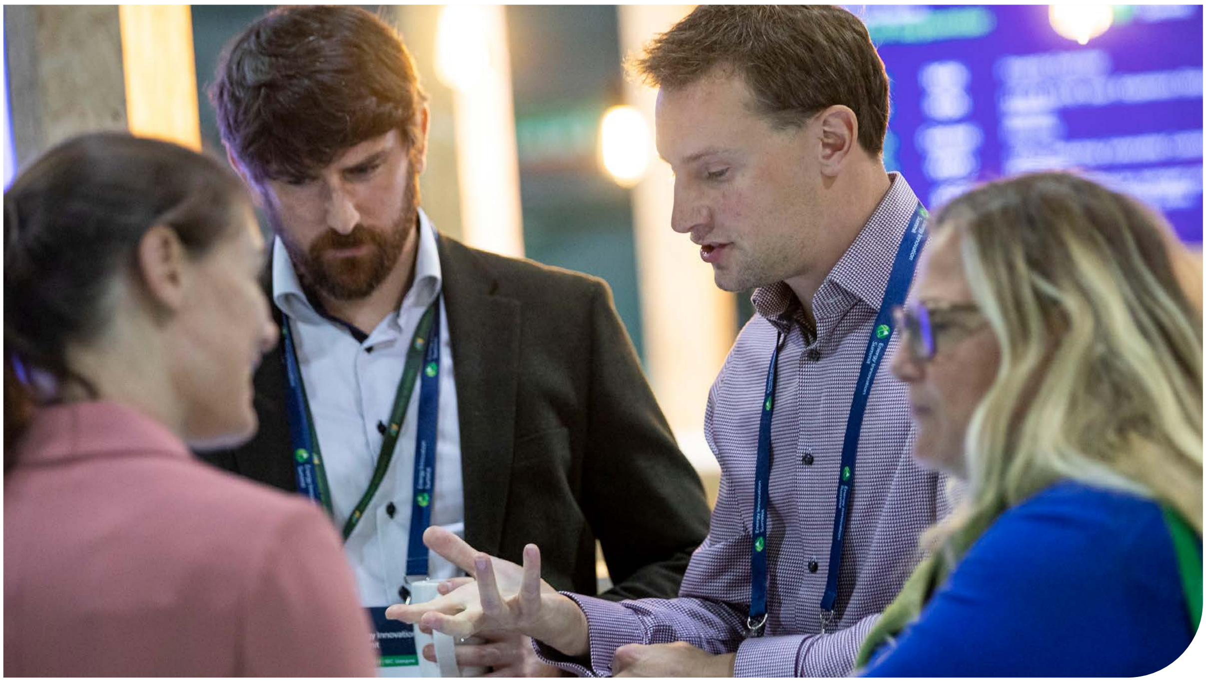
Following this, we're looking ahead to the completion of the necessary siteworks, the delivery, installation and commissioning of the hydrogen refuelling station and the refuelling of the first hydrogen vehicle at the facility, ahead of testing beginning next summer.

Alongside this, the FutureGrid Deblending project team are leading our activities on building the clean transport programme, bringing together stakeholders from across the transport sector to develop solutions for automotive, rail, marine and aerospace. This also includes looking at how refuelling systems, synthetic fuel production and transportation could be supported by the National Transmission System.

Decarbonising our network is a significant but exciting challenge, one that FutureGrid Phase 2 is at the heart of. I'm looking forward to seeing how the project evolves and develops over the next year and beyond.

Section 2

Executive Summary



Project description

Project background

National Gas are undertaking an extensive programme of work to repurpose the gas transmission system to operate with hydrogen, as well as expanding the network with new hydrogen pipelines where necessary. This programme focuses primarily on existing National Transmission System (NTS) customers, such as power stations and industrial customers, however the proliferation of hydrogen throughout the UK broadens opportunities to provide low-carbon energy to customers not previously served by the NTS. Of these, transport appears to provide wider opportunities due to the difficulty of decarbonising heavy transport such as HGVs, Trains, Buses, and Aircraft.

This opportunity was explored in the HyNTS Deblending SIF Discovery and Alpha phases, which highlighted the scale of the opportunity and the role that the NTS could play. The estimated cost of hydrogen in the scenarios explored, showed the hydrogen provided through the NTS could be cost-competitive with other decarbonised transport solutions, when considering full lifecycle costs. A particular technology concept was considered, utilising electrochemical hydrogen separation technology, to separate hydrogen from natural gas blends (where required) and purify it to fuel-cell grade.

Following the evidence generated in the earlier project phases, a full-scale demonstration was proposed to prove the concept and generate valuable evidence to understand where it might be best applied. The existing FutureGrid facility provides the perfect location with the capability of generating flow with natural gas and hydrogen blends, as well as having an experienced workforce and opportunities to demonstrate hydrogen vehicles.

Project scope

The project focuses on three main areas:

Technology concept

This includes the design, fabrication, delivery, installation, commissioning, and operation of the Deblending and Purification system. The project will demonstrate the full-scale technology concept, which includes the flowing of natural gas and hydrogen blends, separation of the hydrogen and recirculation of the natural gas, purification of the hydrogen and compression of the hydrogen. In addition, a Hydrogen Refuelling Station (HRS) is being constructed to fuel vehicles for operation on site.

Valuable data will be collected to better understand the optimal operating conditions and limitations of the system. This will be used to refine future system designs and understand where the technology might be best deployed.

> “Transport appears to provide particular opportunities due to the difficulty of decarbonising heavy transport such as HGVs, Trains, Buses and Aircraft.”

Rollout mapping
The hydrogen transportation industry remains nascent and there is significant uncertainty around when and where demand might emerge. This project includes scope to assess the most likely sectors and locations for future hydrogen demand and map these against the NTS to highlight potential opportunities. This will be used to shape future engagement and identify locations for a first commercial concept demonstration.

Stakeholder engagement
National Gas sits in a unique position to support the development of hydrogen vehicle opportunities in the UK. Our stakeholder engagement programme brings together stakeholders from across the value chain and helps identify opportunities for collaboration to support the development of hydrogen transportation in the UK.

Project progress

Progress to date

The project has progressed significantly since its launch in September 2023. The first six months focused primarily on the design of the Deblending & Compression systems, as well as the design of the facility. The stakeholder engagement and rollout strategy workstreams continued in parallel and will be revisited throughout the project. From Spring 2024, construction began on the new facility, and this is broadly complete as of September 2024. Stage Gate 1 was successfully passed in June 2024.

Design
Design of the Deblending & Compression systems, test facility, and Hydrogen Refuelling Station progressed throughout the first 6 months of the project. Due to dependencies on the design of the Deblending & Compression systems, the test facility design had to be delayed, however this did not impact the project timelines, as DNV began the civils construction at risk.

The design of the Hydrogen Refuelling Station progressed to plan, and the design of the Deblending & Compression systems was completed, albeit delayed by two months. Hazard and Operability (HAZOP) studies were conducted for each of the individual designs, as well as a full system HAZOP which was conducted in person in Stockport, facilitated by DNV.

Construction/fabrication
Construction of the test facility was split into three broad phases: civil, mechanical, and electrical. The civil phase of construction, including the construction of new hard standing, concrete plinths and fencing, was undertaken before the final design was complete. However, this was considered low risk, as the outstanding design actions had little influence on the civils design.

The mechanical and electrical phases of construction have proceeded as planned and are complete, pending the installation of the equipment on site.

Fabrication of the Deblending & Compression systems has been ongoing since Spring 2024. This is being managed by HyET, who are fabricating the electrochemical ‘stacks’ and working with a system integrator to fabricate the full system.

Rollout strategy
The completion of the rollout strategy was delayed, to ensure there was sufficient time to incorporate stakeholder input gathered during the first phase of the project. The strategy went through several iterations to ensure it reflected the opportunities highlighted by stakeholders, and the likely interaction of hydrogen transport users and the NTS.

The report identified opportunities for hydrogen transport in the UK and the likely timelines for development. Of particular interest was the opportunity regarding rail transport, which was not considered in previous analyses. The hydrogen transport landscape is continually shifting and so it was agreed that the report would be revisited in a years’ time.

Stakeholder engagement
In the first phase of the project, there was significant effort dedicated to identifying stakeholders for NTS supplied hydrogen for transport. The value chain was divided into segments and multiple stakeholders for each segment were sought, to ensure the project represented a broad range of views.

In April 2024 the FutureGrid team hosted a stakeholder engagement forum at the Spadeadam site to bring these stakeholders together and gather valuable data on industry views for the future of hydrogen transport. The event was a big success for the project, with over 30 stakeholders in attendance and valuable data gathered and shared with the attendees.

Phase 2 development

Now that Phase 1 testing has been completed there are additional phases planned to adapt the FutureGrid facility and allow for further development. These are essential for understanding how a hydrogen NTS would operate. Designs are well underway at the time of publishing for Phase 2 Compression and Deblending.

FutureGrid

Deblending

FutureGrid

Compression

Section 3
Project Summary

Project Objectives

SIF Challenge Round 1 – Zero Emission Transport

The Strategic Innovation Fund (SIF) aims to fund network innovation that will contribute to achieving Net Zero rapidly, and at lowest cost to consumers, whilst aiding in the growth of the UK energy market. Zero Emission Transport has been identified as a crucial area in which innovation will be required to achieve national net zero targets.

Consumers need reliable, cost-effective transportation that is readily available when demanded. Personal transportation preferences are shifting, as new trends emerge in transport which include e-mobility, new public transportation links, as well as national and international changes in supply chains for goods. Alongside these consumer needs, there are also strategic targets for deep decarbonisation of the transport sector which will have significant implications for the electricity networks (and may also have implications for the gas networks). Preparing the networks to enable large-scale deployment of battery electric vehicles (BEVs) while keeping costs to consumers affordable and equitable, is critical. The introduction of hydrogen-fuelled heavy goods vehicles is likely to create novel technical challenges across roads, rail, and ports, such as effectively managing integration of electrolysis across the electricity networks and hydrogen transportation infrastructure.

The Zero Emission Transport Innovation Challenge aims to:

- Develop the technologies, infrastructure, and processes required to support and accelerate at-scale up take of zero emission transport options.
- Investigate the services that could be provided from electrified transport infrastructure and users to reduce system costs and the means of delivery.
- Maximise the opportunities of integrating zero emission transport energy provision with the energy sector, for instance for constraint management or maximising use of renewables.
- Coordinate strategic energy networks decisions with the transport sector, to ensure delivery of an efficient energy system which also meets the needs of transport users.
- Provide greater certainty on the options, costs, and timelines for energy network infrastructure availability which supports zero emission transportation.

> "Blending into the existing gas network may help to provide market-building benefits for the hydrogen economy, especially ahead of larger-scale hydrogen transport and storage infrastructure being available to connect producers with a wider range of end users."

The opportunity for Deblending

Hydrogen transport can support decarbonisation of the UK economy, particularly in 'hard to electrify' sectors. It can be used as a feedstock to replace existing processes (such as using hydrogen for Direct Reduced Iron production for the steel industry), for heating (either for industrial, commercial, or domestic applications), for the power industry (for electricity grid power and grid balancing) and for the transport industry (decarbonising road, rail, aviation, and maritime transport).

The National Transmission System (NTS) provides a resilient supply of high-pressure natural gas and National Gas are exploring hydrogen injection into the NTS to support decarbonisation during the transition to 100% hydrogen pipelines. Blending into the existing gas network may help to provide market-building benefits for the hydrogen economy, especially ahead of larger-scale hydrogen transport and storage infrastructure being available to connect producers with a wider range of end users.

Deblending (removing hydrogen from a blended gas stream) could prevent hydrogen reaching sensitive consumers (where customers cannot accept an increase in hydrogen content in their natural gas) and/or provide very precise blends of hydrogen to those who may be sensitive to fluctuations. The HyNTS Deblending project focuses on the deblending of gases from the NTS, to enable delivery to transport applications, which presents a new customer segment for National Gas. Without this technology, refuelling of transportation assets will be limited to the use of locally produced hydrogen, until the gas networks can transport 100% hydrogen. This will limit large scale hydrogen infrastructure availability and therefore the speed of transition for the transport industry. Hydrogen refuelling stations today are often hampered by constraints on hydrogen delivery, frequently having to shut due to a lack of supply. Permanent pipeline connections for hydrogen supply provide greater certainty for hydrogen refuelling operators, reducing their commercial risk.

Progress to date

Project delivery

The Deblending for Transport project is split into work packages which have both milestones and deliverables associated to them. To ensure the project is on target, there are five stage gates laid out by UKRI that National Gas must meet and pass. They are as follows:

- **Stage Gate 1 – passed in April 2024.** Design system, compression and purification system, hydrogen refuelling station and the overall site design all to be complete. Final HAZOP to be completed and distributed once signed off by chair.
- **Stage Gate 2 – Site Construction Complete - Postponed to January 2025.** Groundworks, civils, mechanical and E&I works complete at Spadeadam. Site ready for the delivery of the HRS and Deblending assets. This has been postponed to January due to delays in testing of the deblending equipment, however due to the commissioning time, it is not expected to delay the following stage gates or project timeline.
- **Stage Gate 3 – Deblending equipment installation - June 2025.** FAT and then SAT complete with reports issued for Deblending, Compression, Purification Systems and for the HRS system.
- **Stage Gate 4 – Stakeholder Demonstration - February 2026.** Testing Complete as per test programme. Vehicle refuelling and operation complete as per plan.
- **Stage Gate 5 – Project Closure - May 2026.** All reporting activities complete including demonstration activities, commercial demonstration and the stakeholder and strategy reports complete. All the project governance to be completed, signed off and approved by OFGEM/UKRI.

Below is the summary of the work completed so far, split by Work Packages with the milestones and deliverables that have either been completed or are ongoing by National Gas and the partners.

Table 1 – Summary of work completed

Work Package	Milestones	Deliverables
Work Package 1 Project Management and Dissemination.	**M1.1** Project kick off and commencement of project activities. **M1.2** Periodic Report – project running to timetable and project on target with budget. As per this report.	**D1.1** Draft dissemination plan setting out targeted audiences and planned engagement approaches.
Work Package 2 Detailed design and preparation for deblending facility within FutureGrid.	**M2.0a** Start of detailed design for deblending and compression/purification. **M2.0b** Start of detailed design for FutureGrid connection. **M2.1** Completion of the HRS design including the refuelling station design completed and signed off by DN and NGT. **M2.2** Completion of detailed design for deblending and testing and data collection protocols. Including finalized design for the deblending of the compression and purification system, signed off by DNV, and... **M2.3** FutureGrid design and construction plan complete with all HAZOP and safety assessments passed. This includes all design and planning work completed to enable the construction of the deblending facility and HRS.	**D2.1** – preliminary design for refuelling station. **D2.2** – preliminary design for deblending system. **D2.3** – preliminary design for compression/purification of gas. **D2.4** – FutureGrid preliminary site design. **D2.5** – Detailed design for refuelling station. **D2.6** Detailed design for deblending and purification/compression systems. **D2.7** FutureGrid entire site design and construction plan. **D2.8** Master test plan. **D2.9** Safety implications in design of deblending facility (including HAZID and HAZOP). NGT.
Work Package 3 Mechanical, civil and E&I works at FutureGrid.	**M3.1** Commencement of preparatory works on site including signing of subcontract and order of parts. **M3.2** Completion of civils ready for start of construction.	**D3.1** Groundworks. **D3.2** Civil works.
Work Package 4 Fabrication of de-blending and HRS equipment offsite and delivery to site.	**M4.0** Order of long lead items for electrochemical compressor and deblending equipment. **M4.1a** Start of fabrication of deblending. **M4.1b** Start of fabrication of EC&P.	**D4.1** Order of long lead items for electrochemical compressor and deblending equipment.
Work Package 5 Facility installation and commission.	Not started.	Not started.
Work Package 6 Equipment Operation and Monitoring.	Not started.	Not started.
Work Package 7 Future roll-out and stakeholder engagement.	**M7.1** Preparation for stakeholder engagement completed and report on first phase stakeholder engagement learnings completed. **M7.2** Completion of future roll-out mapping.	**D7.1** – Stakeholder engagement plan developed. **D7.2** – Report on stakeholder engagement. **D7.3** – Report on future roll-out potential.
Work Package 8 Commercial feasibility and regulation.	Not started.	Not started.
Work Package 9 Decommissioning.	Not started.	Not started.

Industry engagement

The FutureGrid Deblending project is heavily reliant on the hydrogen transportation industry. Engagement presents opportunities for strategic partnerships and stakeholder driven development, which is crucial in aligning the Deblending Project with the consumer needs and regulatory expectations. This ensures a responsive and inclusive drive towards a key challenge of the hydrogen transportation industry.

Across all the work done at National Gas, consumer and stakeholder engagement is at the heart. This includes one-to-one meetings, steering groups, and show and tell events, as well as LinkedIn posts, webinars, and conference exhibitions. This continuous and ongoing engagement ensures that we are planning ahead , and understanding what our customer and stakeholders' requirements are and how our network can meet these needs and overcome any challenges. Along the full supply chain, we engage with a wide range of stakeholders from hydrogen producers, refuelling operators, vehicle producers and fleet operators, to regulators and international networks. The image below shows all the stakeholders that have actively engaged, including 1 to 1 conversation, attending the stakeholder event and/or taking part in a stakeholder surveys.

Project partners

TSOs

Automotive

Deblending

Refuelling and Producers

Aviation and Rail

Others

Our key engagement involves a wide range of activities that allow the sharing of key project aims and are aligned to key project deliverables, allowing stakeholders to provide feedback and input that can directly influence the project outcomes. A breakdown of some of the key engagement activities are shared below:

Table 2 – Key engagement activities

Engagement	Meeting timing	Meeting format
Stakeholder engagement kick-off Introduce the HyNTS project, including: • Aims of the project • Project timelines • Share agenda for in-person HyNTS launch event	02/24	Online
FutureGrid Hydrogen Transport Engagement Forum An opportunity to meet all stakeholders, get their buy-in to the project and feed-in any learnings they have from other projects. • Update on project progress to date. • Share high-level findings from future roll-out mapping (first draft by end of Feb 2024) • Workshops with each of the stakeholder engagement groups to set out the plan for engagement throughout the project and discuss any initial learnings they have that can feed into the project. • Deblending site visit	04/24	In-person (Spadeadam)
Stakeholder engagement survey Shared survey gathering insights into supply chain concerns, risks and challenges	06/24	Online
First FutureGrid Deblending newsletter Update on project progress, sharing of survey results and call for input.	07/24	Online
FutureGrid Hydrogen Transport Engagement Forum A follow up event: • Update on project progress. • Share roll-out mapping findings and project demonstration plan. • Workshops with engagement groups • Visit to Deblending site	07/25	In person (Spadeadam)
Update on FutureGrid demonstration project. Note, testing to be carried out between June and Dec 2025.	11/25	Online
HyNTS Project Findings Share findings from final report summary (D8.4), which is due to be published in April 2026.	05/26	Online
In-person Closure Deblending Event A closure event for stakeholders: • Project Results • Next steps • Workshops with engagement groups • Visit to Deblending site	06/26	In person (Spadeadam)

Further information on the industry engagement activities can be found in Sections 4, 9 and 12.

Challenges

Challenge 1 – Novel technology

A major challenge of low technology readiness level (TRL) projects is the degree of uncertainty and lack of understanding of the cost and schedule risks, due to the development of novel designs. Few examples of the technology may exist globally at the intended scale; therefore design, procurement and certification of equipment may be slower than more well-established technologies. Use of low TRL designs in hydrogen service presents additional challenges due to the immaturity of the hydrogen sector. Progress is still being made to develop hydrogen legislation, understand the safety implications of operating with hydrogen and certify equipment for use with hydrogen.

Once a low TRL design has been designed and built there are still uncertainties surrounding commissioning and scalability of the technology. Technology performance must be assessed (both the immediate performance and long-term) as well as operating efficiencies (especially with variable gas compositions, gas rates and the potential presence of contaminants). Section 10 discusses project risks in further detail.

Challenge 2 – Uncertainty

The deblending, purification and compression project depends greatly on the regulatory approval of the hydrogen transition into the gas networks. This requires a series of long and short-term tasks to be carried out, including regulations, governmental decisions and document changes, all of which increases uncertainty on timescales. If this is approved and proceeds, there is still a large amount of uncertainty with regards to demand and risk, as it is very much a new industry. When the stakeholders were surveyed on the biggest challenges to the hydrogen transportation industry, the response overwhelming stated the uncertainty around infrastructure, timelines, and the cost of hydrogen.

Challenge 3 - Industry buy-in

With new industries, there is often concern about industry buy-in. With the current drive for net zero and the recent government announcement for a target of 2030, the demand for hydrogen transport is as important as ever. Despite this drive, there are key issues within the industry including supply chain issues for both vehicles and hydrogen and demand. Timelines can cause a challenge for transportation industry buy-in. The lifespan of transportation such as aeroplanes and ships, means that a full transition to hydrogen fuelled transportation is unlikely to happen within the next two decades.

There has also been a stunt in growth in refuelling within the UK, especially in comparison to the rest of Europe. This has led to a lack of industry buy-in, particularly from vehicle developers, for example BMW, who do not view the UK as an upcoming market for their hydrogen fuel-cell cars. A similar lack of hydrogen production means there is concern and risk for hydrogen refuellers if they invest in equipment and stations, but there is a lack of demand, or they are unable to meet demand.

Learnings

Learning 1 – Design dependencies

At the start of the Beta phase of the project, final designs were planned to be returned by all project partners on the same date. This did not account for the interdependency between some of the project partner's designs. As design work progressed, it became clear that DNV required the completed designs from both HyET and Element 2, to inform their own design. This resulted in the DNV design completion deadline being pushed back by 2 months. This learning highlighted the importance of understanding design dependencies at the start of the project to make the critical path clearer and reduce the likelihood of project delays due to engineering design.

Learning 2 – Scope clarity

During project development it became apparent that some ancillary equipment had been missed from the original Deblending & Purification System design. It was essential to add this unbudgeted equipment, which therefore increased project costs.

This learning highlights the importance of clearly defining the scope of each partner during the inception of the project. Partners were operating with different assumptions and therefore a session to clarify assumptions would have flagged any potential gaps.

Learning 3 – Equipment lead times

In the initial phase of the project, it was noted that certain long lead items presented a timeline risk to the project. National Gas agreed to expedite payment for these items which successfully prevented this timeline risk from materialising, as some lead times had extended from their original quoted value. However, less complex assets which were on a shorter lead time were not subject to the same scrutiny and it was found later in the project, that many had their lead time similarly increased. It is therefore clear that quoted lead times cannot be assumed as fixed and all lead times on the critical path must be scrutinised appropriately.

Section 4

Knowledge creation & dissemination

Future rollout mapping

As part of the Deblending project, Work Package 7 includes stakeholder engagement and future rollout mapping. This involves identifying potential locations for a first commercial demonstration of deblending technology, by considering the scale and geographical distribution of future hydrogen transport demands in relation to the NTS.

This rollout mapping is being led by ERM, with support from stakeholder engagement that helps to inform and showcase the upcoming demand. ERM have produced a future rollout mapping report and in 2025, will present a further report detailing more specific locations and roll out.

As part of the mapping, we have undertaken modelling work and stakeholder engagement activities. This has been in the form of an in-person event, a survey and modelling work by ERM.

Stakeholder event

The stakeholder event was held at DNV Spadeadam on Tuesday 16 April 2024. The objective of the event was as follows:

- Understand the potential for deblending to support the transportation sector.
- Understand the requirements for hydrogen delivery from key players in the industry.
- Learn from industry as we develop a plan for commercial demonstration.
- Build strong relationships to drive hydrogen transportation forward.

The event was well attended with over 30 attendees from all aspects of the hydrogen transportation supply chain. Along with presentations from ERM on their rollout mapping methodology, there were also presentations from some of the stakeholders from the HyHaul project, the Bradford project and also from Aegis Energy, on how they plan to deliver essential infrastructure for the energy transition. The stakeholders were given the opportunity to tour the FutureGrid facility, ask questions and explore the progress and plan for the Deblending project. The event also included workshops asking key questions about the challenges and risks that the stakeholders see as blockers to hydrogen transportation. The results were shared with all stakeholders and with ERM after the event, for feedback into the rollout mapping strategy.

Stakeholder Survey

A survey was sent out to 64 stakeholders in mid-June to garner further insights from those that were unable to attend the stakeholder event, but also gather feedback following the event. The survey asked questions, which were produced in collaboration with ERM, on challenges, risk, a hub and spoke model and cost. There were 27 responses from industries including Hydrogen Refuelling, Regulations, Gas Networks, End Users and local government. The responses were fed back directly to ERM for use in the rollout mapping report as well as shared back out to the stakeholders via the July newsletter.

Modelling work

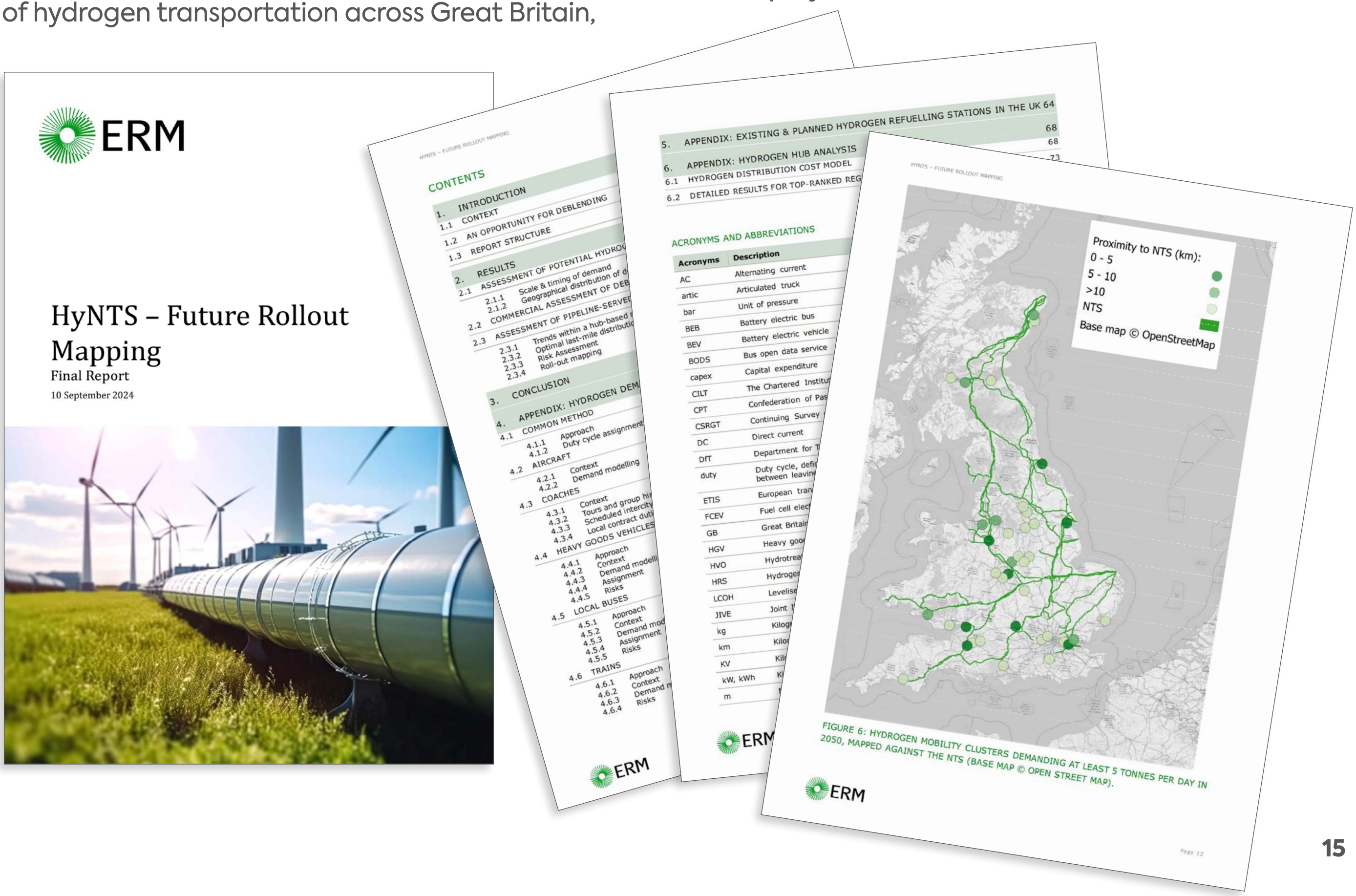
ERM has submitted a future rollout mapping report as part of the work package 7 deliverable. Their approach for the modelling emphasizes the use of clusters, and the associated potential and practicalities. The modelling focuses on the uptake of hydrogen transportation across Great Britain, mapped against the NTS, showing geographical distribution of large potential hydrogen demand.

The demand and modelling were mapped through the following tasks:

1. Modelling the viable uptake of hydrogen transportation.
2. Input from stakeholder engagement including the event and the survey.
3. Mapping hydrogen demand against the NTS.
4. Site shortlisting.

The report considers the possibility of serving future hydrogen transport demands by pipeline distribution in two formats: directly connecting demands to the NTS and tube trailer distribution from a centralised hub. The conclusion stated that there is a case for pipeline distribution of hydrogen in the long-term, but that deblending may need to be subsidised in the medium-term. The report stated that beyond the commercial case, there are several other benefits to distribution via pipeline, including pipeline distribution to access hydrogen supplied from multiple sources, increasing the reliability of the hydrogen supply which has been shown to be one of the key risks seen by the industry currently.

The outputs of the rollout mapping will be shared through different veins in the project. The stakeholders will be informed through the Deblending Newsletter and through stakeholder events. The findings will also be shared through webinars along with information from the entirety of the project.



Knowledge dissemination

A key part of the project involves the dissemination of the information and findings from the project. This takes several forms that are detailed below.

Conferences and Engagement

Conferences and Exhibitions provide an opportunity to reach a wide and varied audience that may not be familiar with the FutureGrid projects, as well as allowing others to discover more information and join our stakeholders. Working within the larger hydrogen team, the uniqueness of the FutureGrid site also allows for visits to the facility for further learning. Below is the engagement log showing interactions.

Table 3 – Dissemination activities

Date	Event	Overview
20/09/2023	FutureGrid Tour	Visit from DESNZ and overview of project given.
11/10/2023	FutureGrid Tour	Visit from European Pipelines Research Group (EPRG) and overview of project given.
17/10/2023	HyNTS Compression Subject Matter Expert Visit	Visit from NGT internal Compression team to engage on project.
24/10/2023	FutureGrid Tour	Visit North Sea Transitionary Authority (NSTA) and overview of project given.
25/10/2023	HyNTS Compression Gas Network Control Centre Visit (GNCC)	Visit from NGT GNCC team to engage on project.
27/10/2023	FutureGrid Tour	Visit from Osaka Gas and overview of project given.
01/11/2023	Energy Innovation Summit	Presentation given on HyNTS Compression and participation in panel.
14/11/2023	HyNTS Compression System Operator Visit (SO)	Visit from NGT SO team to engage on project.
14/11/2023	Asset Engineering Team Visit	Visit from NGT Asset Engineering team to engage on project.
15/11/2023	FutureGrid Tour	Visit from Marchwood Power and overview of project given.
16/11/2023	FutureGrid Tour	Visit from Storenegy and collaboration opportunities discussed about project.
21/11/2023	FutureGrid Tour	Visit from Pipeline Industries Guild and overview of project given.
22/11/2023	North Sea Transitory Office Lunch and Learn	Overview of project given and how it provides evidence for Project Union.
08/12/2023	Blog Post	Blog post on Linked-In about project.
06/02/2024	FutureGrid Tour	National Gas graduates and Procurement team visit to FG site.
07/02/2024	FutureGrid Tour	Visit from MPI (Strategy Consultant to council).
08/02/2024	FutureGrid Tour	Visit from Scotland and North Area GT Operations.
25/02/2024	FutureGrid mentioned in Daily Telegraph article	Visit from NGT internal Compression team to engage on project.

Table 3 – Dissemination activities (continued)

Date	Event	Overview
28/02/2024	FutureGrid Tour	Visit from No 10 Special Advisors and overview of project given.
29/02/2024	Blog post	Blog post on LinkedIn about 100% testing.
07/03/2024	FutureGrid mentioned in The Times Business Article	Ongoing work at Spadeadam including 100% H2 testing highlighted.
12/03/2024	FutureGrid Tour	Visit from NGT Insurance and Legal Teams.
04/03/2024	H2Site Tour	Visit to Deblending H2Site in Bilbao.
12/03/2024	FutureGrid Tour	Visit from NGT insurance and Legal Teams.
21/03/2024	H2 Mobility Event	Overview given of Deblending project to H2 Mobility Working Group.
16/04/2024	Stakeholder Engagement Event	FutureGrid event for Deblending with 30+ attendees for project launch and engagement event.
23/04/2024	HyET Visit in Arnhem	Visit to Arnhem to explore the Deblending technology with HyET.
30/04/2024	Innovation Zero, London	Exhibiting at Expo for both FutureGrid Phase 1 and Phase 2.
09/05/2024	Attendance at the Gas Industry Awards	Highlighting and networking for the ongoing work at FutureGrid.
14/05/2024	Construction Conference	Attendance by FutureGrid team to inform on Phase 1 and Phase 2.
14/05/2024	FutureGrid Tour	Visit from NESO, the CVDT team and the Decommissioning Team to inform and learn about FutureGrid Phase 1 and 2.
13/06/2024	Stakeholder Engagement Survey	Survey sent out to 67 stakeholders with responses from 26.
13/06/2024	FutureGrid Tour	Visit from PIL India and Indian Regulators.
11/07/2024	FutureGrid Filming	Visit from B1M team for filming for YouTube programme.
23/07/2024	FutureGrid Tour	Visit from OFGEM Engineering Team including OFGEM chair.
24/07/2024	Phase 1 Webinar	Introduction of the Phase 1 Closure Report.
August 2024	Phase 1 Webinars	Five further webinars, both internally and externally on the materials, next steps, results, etc. of Phase 1.
14/08/2024	FutureGrid Tour	Visit from Ofgem Policy Team.
04/09/2024	Cenex Conference	Plenary presentation and panel slot on the Future of the Gas Grid for Hydrogen Transportation.

There are further planned visits and conferences including:

- Attendance at the European Transport Conference 2024
- Energy Innovation Summit, Liverpool 2024
- Many more FutureGrid Webinars and tours.

Newsletter, Webinars and Steering Groups

To keep stakeholders engaged and up to date on the Deblending Project, a newsletter has been produced that provides information about the progress of the project, the ongoing rollout mapping, as well as developments within the industry. The first newsletter was disseminated in July 2024 and received positive feedback from the stakeholders. A screenshot is shown here:

As shown in the engagement log, we have held webinars for Phase 1 and have also given introductions to Deblending in the form of podcasts and LinkedIn articles. As the project progresses, further articles and webinars will be conducted.

Alongside the dissemination from the project, information from the stakeholders and the project partners will be fed back into the project via the steering group and newsletter feedback. The first steering group meeting was held in July 2024 and will be held quarterly, to allow knowledge sharing and guidance on the development of the project.

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national gas

News Letter
Edition 1

Deblender

Deblending Hydrogen for Transportation

Welcome to Deblender

...your go-to source for the latest updates on HyNTS FutureGrid Deblending project! As part of this regular update from the FutureGrid team we will be sharing project progress, stakeholder engagement activities, industry news as well as sharing stakeholder and partner updates.

Please feel free to share this with colleagues that may be interested in hydrogen deblending activities.

Stay tuned for the next installment of Deblender and get in touch if you have news you want to share with our stakeholder community.

Onsite Build Progress

Onsite Build Progress
Significant strides have been made in our onsite build project. We are pleased to announce the successful installation of concrete pads and road crossings, marking a major milestone in our construction timeline. With all designs now finalised, the construction phase is progressing smoothly and on schedule.

We are on track for the installation of the HRS (Hydrogen Refueling Station), which is expected to be operational by November. This will be a key development in advancing our infrastructure and meeting our project goals. Stay tuned for further updates as we continue to make headway towards build completion.

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Section 5

Intellectual Property (IP) Rights Generation

The results and research produced from this project is critical for expanding and demonstrating the viability of hydrogen deblending for transportation and other fuel cell industries. Although the technologies and mapping utilised by the partners will remain their property, much of the data both inputted and outputted will be made available to stakeholders and supply chain providers.

Deblending system design

Work to date

To date, detailed design has been completed by HyET, Element 2 and DNV, with site preparatory works and Deblending & Purification system fabrication ongoing at the time of writing. HyET's focus has been on the design of the Deblending & Purification system, Element 2's focus on the design of the HRS, and DNV's design focusing on the interface between the existing FutureGrid facility, HyETs Deblending & Purification system and Element 2's HRS.

Long lead items identified by the design work were ordered in Q4 2023 to ensure delivery in time for system installation and testing. A multidiscipline HAZOP was completed in March 2024, including discipline engineers from HyET, Element 2, DNV and National Gas. The HAZOP identified 57 actions that are currently being worked through, to aid system design in preparation for system testing. Civils work for the Deblending & Purification system and HRS has been completed at DNV Spadeadam with the commencement of electrical installation work.

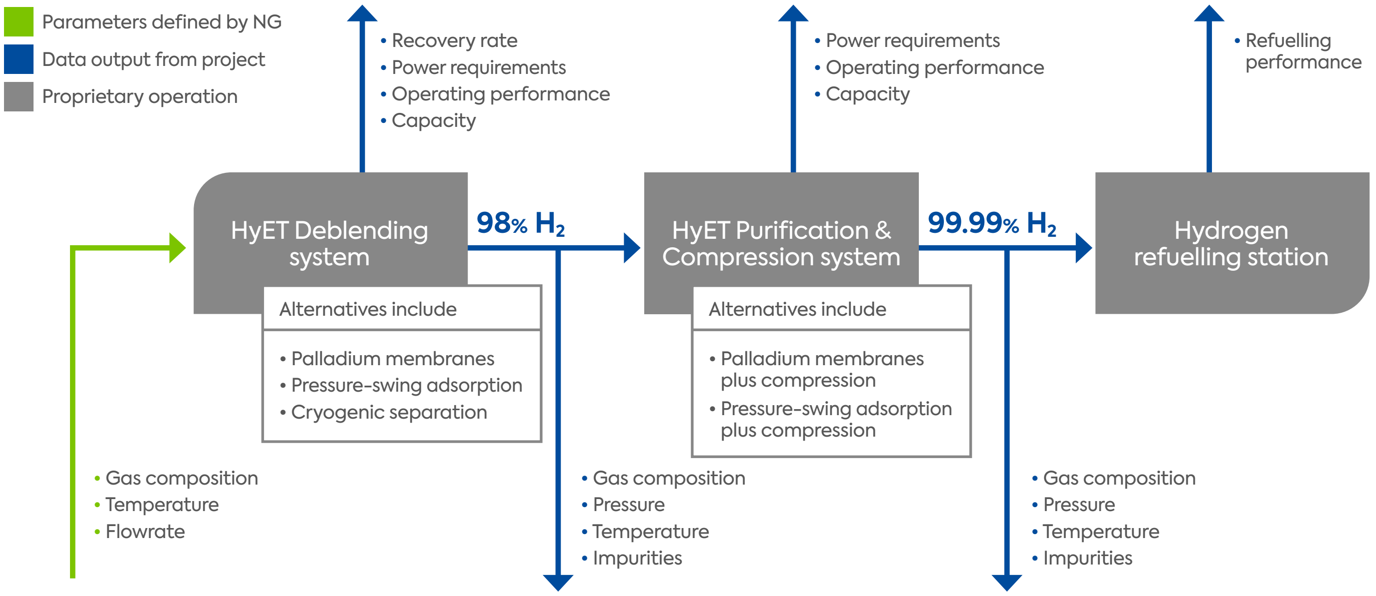
The maximum operating pressure of the FutureGrid facility has also been verified for use with hydrogen; learnings from this process will be valuable if/when future pipelines are repurposed for use with 100% hydrogen or hydrogen blends. Functional tests of the facility and its assets have also been completed as part of FutureGrid Phase 1 testing.

Due to the nature of the SIF Beta project funding, it is essential that any learnings support the development of a wider, competitive hydrogen refuelling landscape in the UK. It is therefore important to utilise the design work from the Deblending for Transport project, to develop a standardised design for future use. A competitive hydrogen refuelling market already exists within the UK and as a result, the components used for these operations are typically standardised and bought 'off the shelf', with design and construction following a similar pattern to traditional liquid refuelling stations. It is expected that any implementation of the deblended hydrogen refuelling concept would use a competitive tender process to select a refuelling station operator to partner with. As a result, the detailed design of the HRS has presented few difficulties.

Due to the novel nature of the concept, there is not a well-established market for equipment to economically separate hydrogen from natural gas at high purity and pressure. Processes for each of these steps do exist, however they are often undertaken at large scale within the chemical industry and therefore are not suited to the smaller scale transport applications. Other manufacturers have been engaged however, through our ongoing stakeholder engagement programme, to provide alternative technologies for hydrogen separation and purification. These include Osmoses, an American developer of membrane separation technologies for hydrogen, Hitachi, a Japanese multinational with considerable experience developing process plant, and H2Site, a Spanish producer of palladium membrane systems.

A significant benefit of the chosen Deblending & Purification system design is the two-stage nature of the design (i.e., the Deblending system and Purification system can be standalone). Bulk deblending may not be required depending on the decision made by UK government on hydrogen blending in the gas network, however the standalone Purification module still allows purification and compression of hydrogen up to fuel cell grade quality and pressures with a lower-grade 100% hydrogen feed.

Figure 1 - Key parameters and data output



Further work

There will be a period of full system commissioning and testing, following completion of the FutureGrid site preparatory works, HAZOP actions, Deblending & Purification system Factory Acceptance Tests and system installation. Several parameters will be monitored and analysed to verify system performance. Some of these key parameters, and which parts of the system will provide the data output, is shown above.

National Gas are committed to enabling the industry to advance without prejudice towards partners, engaging with alternative Original Equipment Manufacturers (OEMs) and international Transmission System Operators (TSOs). Through stakeholder engagement, OEMs are being kept informed about the ongoing blending, deblending and Project Union development. The Deblending & Purification technology was relatively unknown, and as such, received less focus in industry. This has changed significantly, and interest has grown, allowing OEMs to look more closely at Deblending feasibility.

It has already been agreed with these alternative suppliers that, following project deliverable 7.5 (Commercial demonstration 'requirements specification'), National Gas will provide detailed specifications for the development of a commercial demonstration, to allow them to develop competing proposals to ensure cost competitiveness. The data indicated in the figure above will be crucial to providing the basis of design for future standardised designs and compare against alternative/developing systems.

Rollout mapping

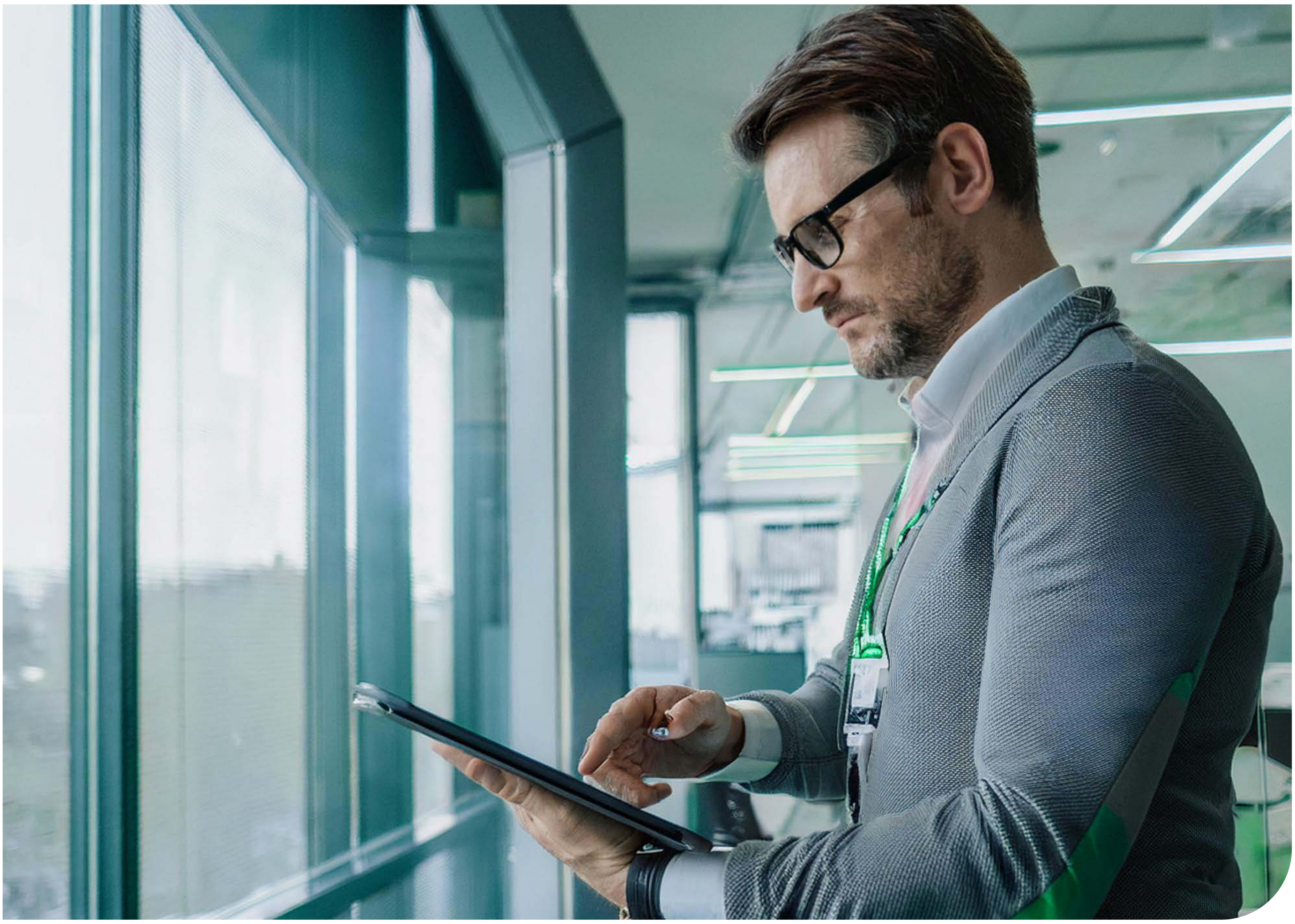
As part of the rollout mapping deliverable for the project, ERM devised a method for mapping demand, clusters, potential and practicalities of deblending for transportation. The mapping explores the needs of each potential market segment and the ways in which a grid-supplied hydrogen supply could enable new decarbonised transport applications. Through mapping, identification of locations where the NTS could supply hydrogen to refuelling stations can be made. Demand has been grouped into clusters which would either be served by a direct NTS connection or supply a larger regional fuelling hub, which would itself supply hydrogen to smaller demand centres. Assessing these two supply models opens additional possibilities for hydrogen refuelling based on regional requirements. The modelling undertaken in this assessment helps us better understand the potential market segments for NTS supplied hydrogen and allows us to better target our engagement to develop a robust and realistic commercialisation strategy.

Once the hydrogen deblending concept has been successfully demonstrated with operational data and experience gathered, this will be used to develop a concept paper for a commercial demonstration to supply real customers with NTS supplied hydrogen. This will utilise previous work done including the D7.3 to identify suitable locations, D7.2 (and ongoing consumer engagement) to identify interested stakeholders, and wider hydrogen development work within National Gas to map this against timelines for the deployment of hydrogen on the NTS. The concept paper from ERM will include both a high-level technical design for the facility, utilising the experience of operating the FutureGrid Deblending system, and a commercial framework for the operation of the facility with details of each party involved.

Section 6

Data Access Details

Stakeholder feedback



Details on network or consumption data arising in the course of a Strategic Innovation Fund (SIF) or Network Innovation Allowance (NIA)funded project can be requested by interested parties, by emailing: .box.GT.innovation@nationalgas.com.

National Gas already publishes much of the data arising from our NIC/NIA projects at: smarter.energynetworks.org

In addition to this, as part of the communication and engagement plan, NGT has held webinars for the purpose of sharing knowledge throughout the duration of the project. We plan to continue these events as the project continues. There are also specific events planned for the completion of different blends of hydrogen. These webinars and events will be open to all interested parties. We have also set up a shared email box in which any queries about the project can be addressed. The email is: futuregrid@nationalgas.com.

The website nationalgas.com/futuregrid also contains presentations, videos, files and images relevant to the project which can be accessed by interested parties.

Section 7

Route to Market / Business As Usual

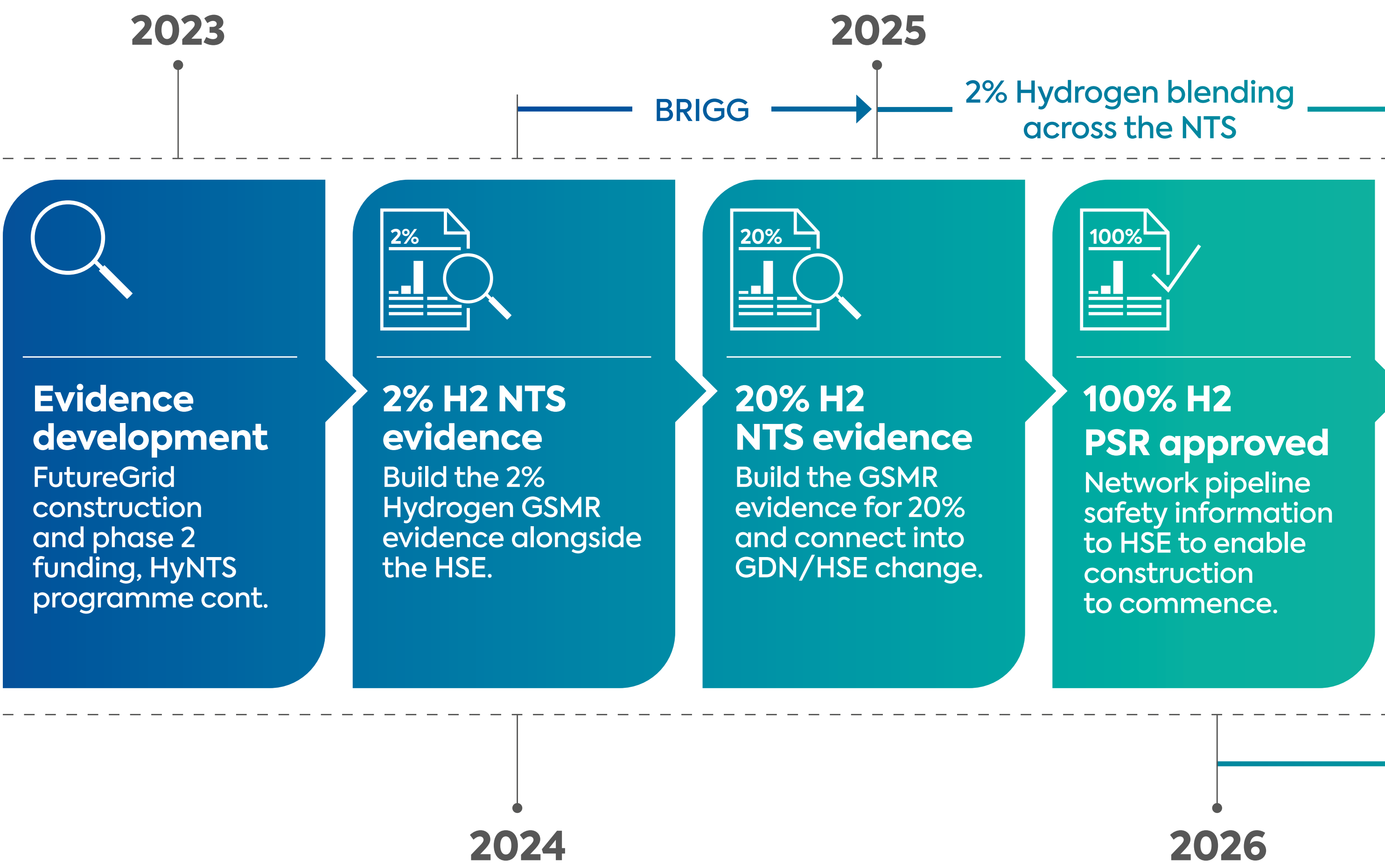
The Future of the gas network

National Gas Transmission own and operate the National Transmission System (NTS), with the duty of delivering natural gas wherever it is needed across Great Britain. Gas is currently a critical part of Britain's energy needs, keeping households warm and providing essential power throughout the year. National Gas plans to transition the NTS to operate with hydrogen, to continue this role into the future. This will be achieved via two parallel streams: enabling blended hydrogen up to 20% to be transported across the network and by repurposing a strategic backbone to operate with 100% hydrogen as part of Project Union.

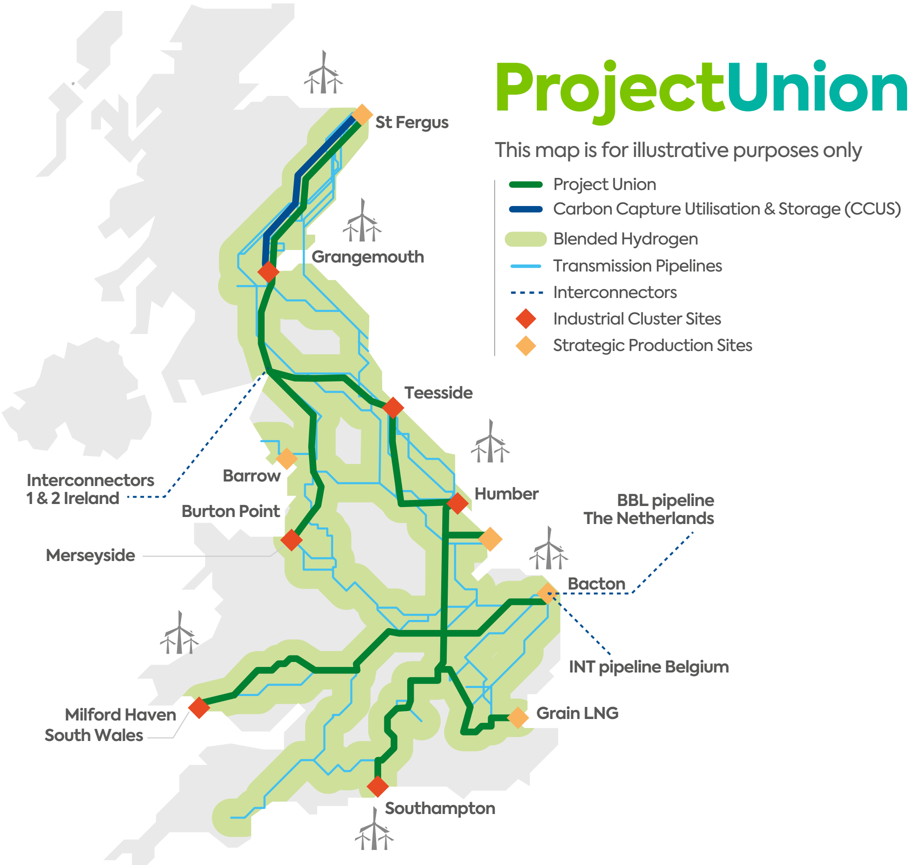
As we look to decarbonise our network, we see opportunities for Carbon Capture Utilisation and Storage (CCUS) alongside significant opportunities to build a hydrogen backbone, connecting industrial clusters across the UK, alongside the introduction of blending up to 100%, across the remainder of the network. As illustrated in the diagram (see page 23), the hydrogen backbone known as Project Union will consist of approximately 2500 km of hydrogen pipeline (as represented by the dark green line), which will be built in stages connecting the industrial clusters. In parallel, we expect hydrogen blends to be introduced to the network with these increasing over the coming years, eventually achieving a 100% hydrogen network (as represented by the green shaded area).

A key component of transitioning the network to hydrogen is building the evidence and safety case to ensure we can operate a hydrogen network to the same robust level of safety that we do today. A comprehensive programme of work is already underway to tackle the key knowledge gaps and ensure that sufficient evidence is available to enable safe operation of the network.

Figure 2 – Blend evidence timeline



The timeline below indicates the development of this evidence with 2% and 20% hydrogen blend evidence supporting the development of hydrogen production, followed by 100% hydrogen evidence to enable full decarbonisation. This is followed by the relevant policy updates were needed, and the ultimate rollout and construction across the network. These dates indicate at what point the network could take hydrogen at those levels and is still subject to the resultant supply and demand of hydrogen, through our network:



2027

2029

20% Hydrogen blending across the NT S

20% H2 GSMR implemented
Blending across the UK gas networks up to 20% enabled.

100% H2 operational evidence and approval
Operational evidence provided and approved for Union.

Project Union Live
First year of hydrogen network commission and management.

100% H2 GSMR implemented
Aligned to the Hydrogen Town delivery.

Project Union construction

2028

2030

The FutureGrid project has greatly enhanced the understanding of how the UK's NTS would operate with hydrogen blends and 100% hydrogen. FutureGrid forms part of wide range of innovation projects that play a key role developing the technical evidence for the transition of the network to hydrogen. As illustrated in Figure 4, the evidence gathering activities form the foundation of our transition strategy, which in turn drive the engineering standards and policies that are required to operate the network. This feeds into the HSE safety review, which requires the relevant policy changes to enable hydrogen and hydrogen blends to be transported across our network, and ultimately enable Project Union.

FutureGrid Compression will facilitate our understanding of how our compression systems would operate with hydrogen blends (with minimal modifications) and with 100% hydrogen – with major modifications. The demonstration being carried out is essential to the development of the evidence which will underpin our blended hydrogen safety case and our Project Union safety case. The timeline for the development of the parallel workstreams is shown in Figure 3, below.

This learning will be essential to support the identification and selection of compression options as part of Project Union. The learning and evidence from this project will support the repurposing of existing compression systems up to a 25% Hydrogen blend, and determine the strategic equipment modifications required (e.g., the compressor impeller) at 100% hydrogen. Repurposing the compression assets for continued operation with a hydrogen blend and/or with 100% hydrogen, as part of Project Union, will be the most direct opportunity to integrate the knowledge and innovation which is being developed as part of this project.

There are assets which are not included in the FutureGrid facility which will likewise require evidence gathering on their operations. We will continue to close these gaps through other innovation projects in our hydrogen safety case portfolio, which start to build the foundational technical evidence and any required updates to standards and procedures. Further specific Quantitative Risk Assessments (QRAs) will inform and enable Project Union and Blending. There will continue to be a requirement for new innovative technology to be developed, to support any differences in how a hydrogen NTS will operate. The FutureGrid facility will continue to play a vital role in the full-scale demonstration of this new technology, with the 100% Hydrogen metering project an example of this.

Figure 3 - We've recently changed from focusing on 2% as the first step to 5%

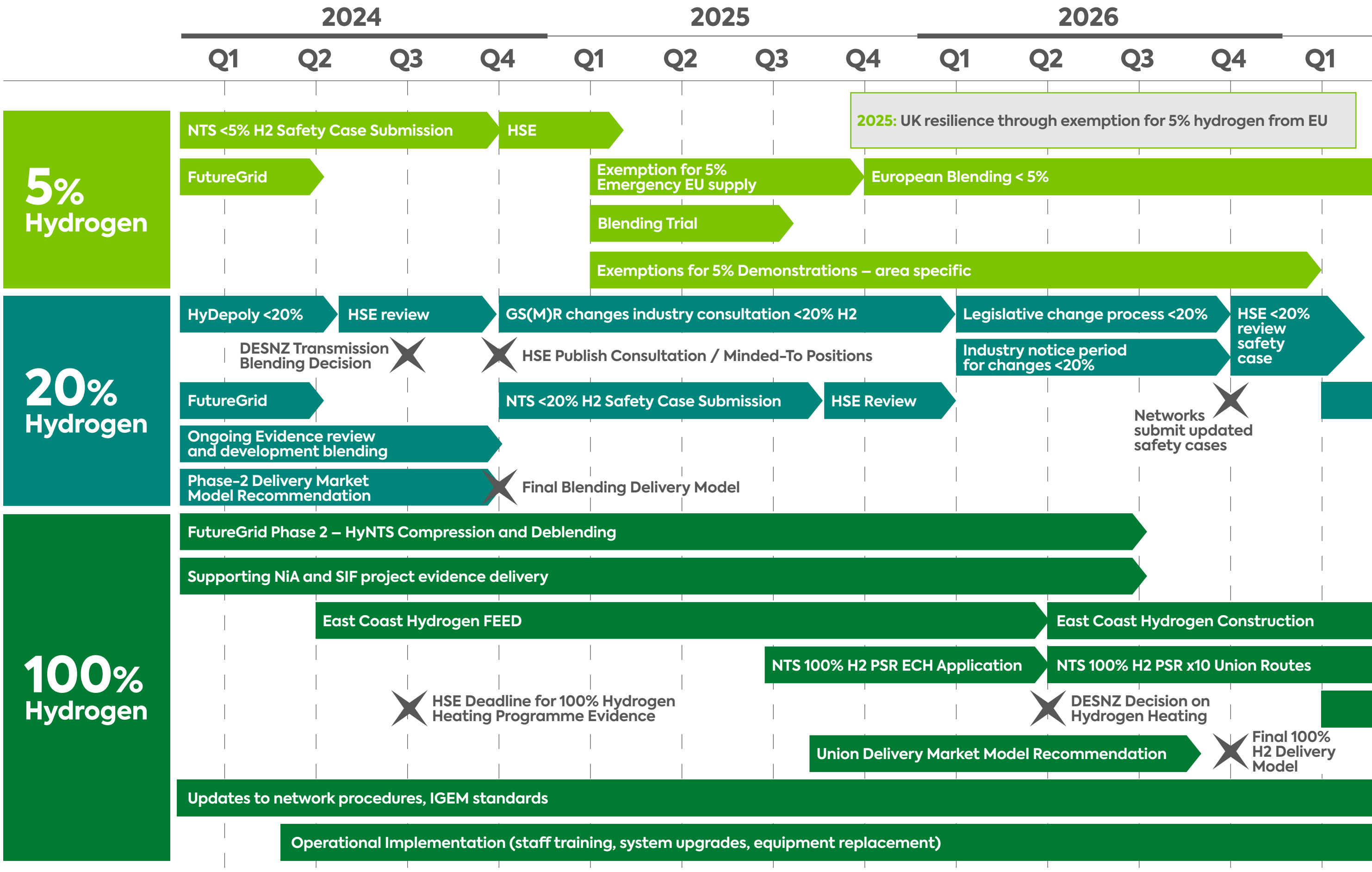
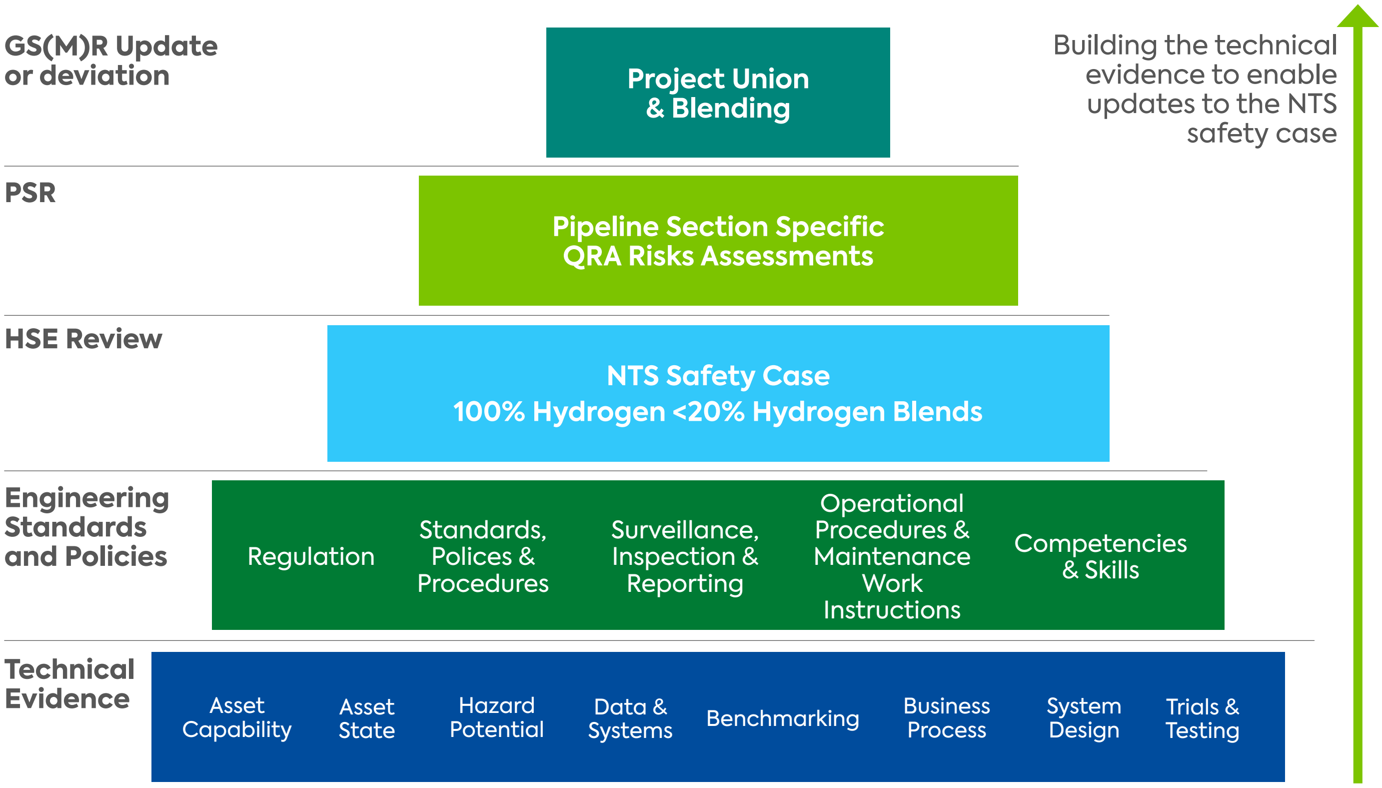


Figure 4 - Foundation diagram (Our approach to delivering the NTS Safety case)



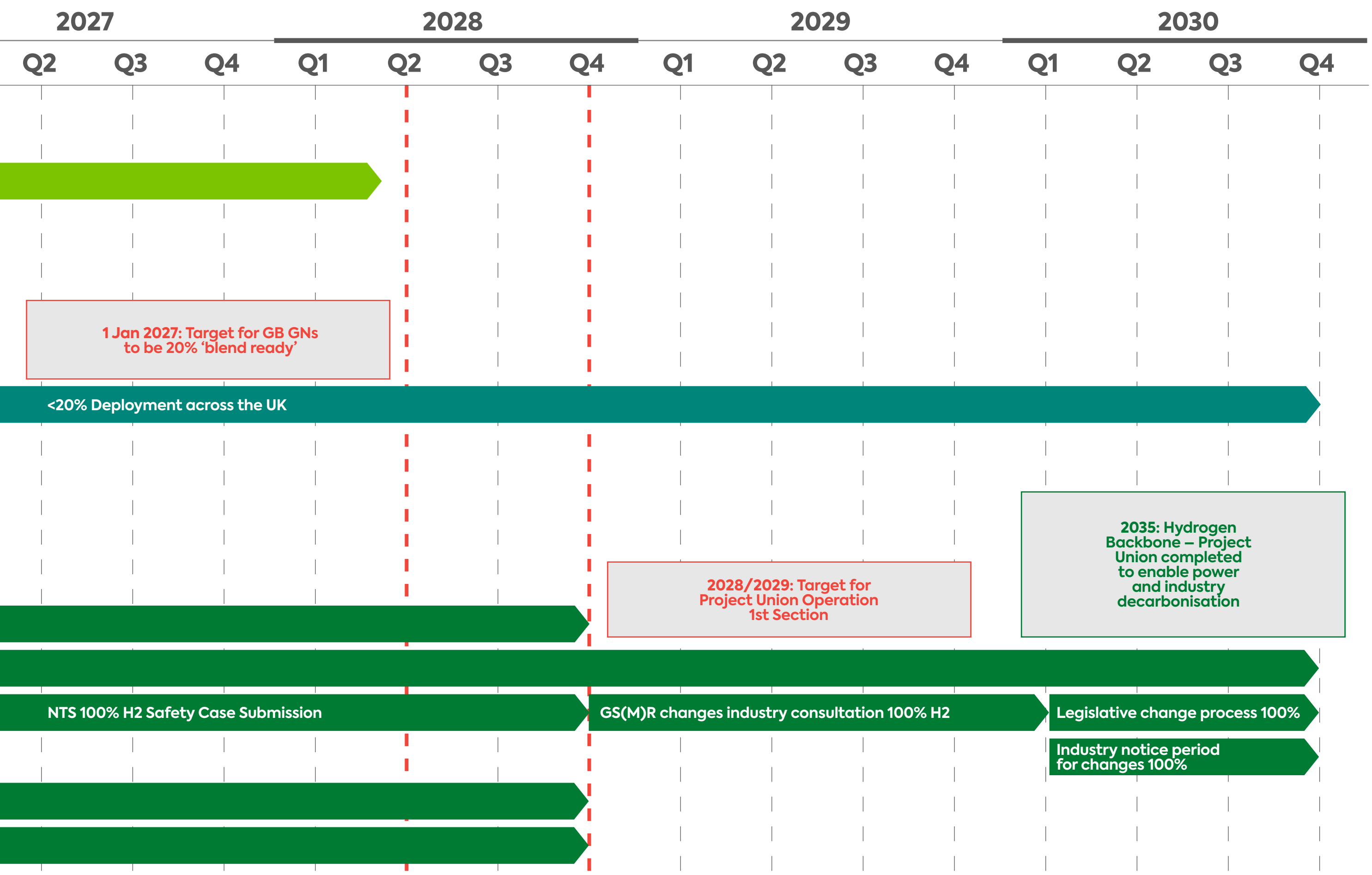
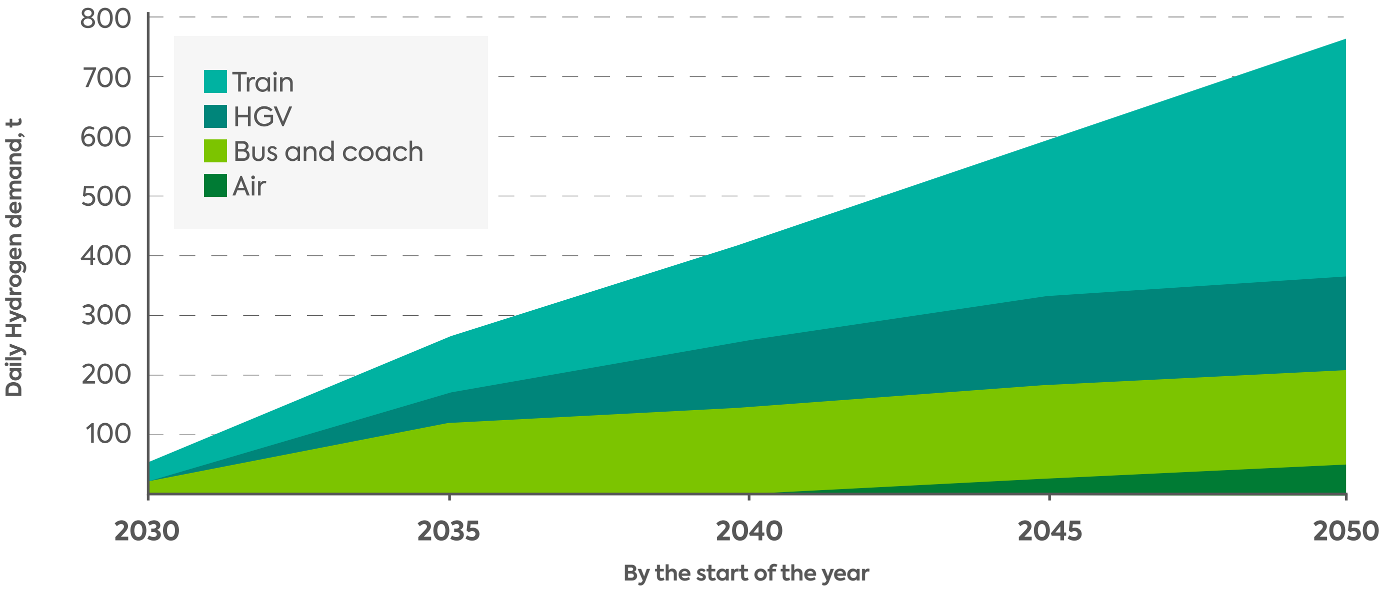


Figure 5 - Daily demand of hydrogen by mode and year (UK).
Source: ERM HyNTS Future Rollout Mapping report



Blending

The timelines in Figure 3 (page 24) show the estimated scales for blending into the UK. The demands for hydrogen refuelling need to align with the production and timelines set through blending and Project Union. Figure 5, above, provides an estimation of daily demand of hydrogen by mode and year for the UK.

As highlighted in the ERM report, the most efficient means of securing a future role for existing gas networks in hydrogen supply for transportation, is to be core to the hydrogen distribution system as it develops, while ensuring the most attractive supply locations are those already on the higher-pressure gas network.

Technology development

FutureGrid Deblending concept development

As discussed in Section 5 'Further Work', the HyET design is novel in nature and there is not a well-established market for equipment to economically separate hydrogen from natural gas at high purity and pressure. Processes for each of these steps do exist, however they are often undertaken at large scale within the chemical industry, and therefore are not suited to the smaller scale transport applications. The Deblending & Purification technology was relatively unknown and as such received less focus in industry. This has changed significantly, and interest has grown, allowing OEM's to more closely look at Deblending feasibility. The input and output data obtained by the FutureGrid Deblending & Purification project will be crucial to provide the basis of design for future standardised designs and to compare against alternative and developing systems.

Stakeholder engagement will be key to understanding the capabilities of other technologies for use in this application. Through our ongoing stakeholder engagement programme, OEMs with alternative technologies have already been engaged. These include Osmoses, an American developer of membrane separation technologies for hydrogen, Hitachi, a Japanese multinational with considerable experience developing process plant, and H2Site, a Spanish producer of palladium membrane systems.

It has already been agreed with these alternative suppliers that, following project deliverable 7.5 (Commercial demonstration 'requirements specification'), National Gas will provide detailed specifications for the development of a commercial demonstration, to allow them to develop competing proposals and ensure cost competitiveness. The data indicated in the figure above will be crucial to providing the basis of design for future standardised designs and installations, and comparing against alternative and developing systems.

Market landscape

In addition to Electrochemical Hydrogen Purification, several Deblending technologies exist at varying stages of development and commercialisation. These technologies include, but are not limited to, Pressure Swing Adsorption (PSA), Temperature Swing Adsorption (TSA), Vacuum Swing Adsorption (VSA), membrane separation, cryogenic separation, and metal hydrides. A brief description of each of the technologies listed above, their maturity and technology advantages and disadvantages will be described in this section.

Pressure Swing Adsorption

- Process description: Cyclic process where a gaseous mixture is passed over an adsorbent material that selectively adsorbs one component at high pressure, then desorbs it at low pressure to separate the gases.
- Maturity: PSA is very mature and is used for purification in many industrial processes.
- Pros: PSA systems can reach high purities (of 99.9+%) which is applicable for almost all hydrogen uses, PSAs can operate at close to ambient temperatures.
- Cons: PSA requires significant space as the unit footprints tend to be large, due to the intended pressure drop as part of the process compression is required to return gas back to the desired operating pressure.

Temperature Swing Adsorption

- Process description: Cyclic process where a gaseous mixture is passed over an adsorbent material that selectively adsorbs one component at low temperature, then desorbs it at high temperature to separate the gases.
- Maturity: PSA is very mature and is used for purification in many industrial processes.
- Pros: TSA is able to achieve higher purity hydrogen compared with PSA and VSA.
- Cons: Large equipment footprint for auxiliary heating/cooling and heating/cooling requires significant energy input.

Vacuum Swing Adsorption

- Process description: A variant of PSA where desorption is achieved by reducing the pressure further below atmospheric using a vacuum rather than depressurising to atmospheric conditions.
- Maturity: Mature and used in industry but less common than TSA or PSA.
- Pros: VSA can achieve higher hydrogen recovery rates than other adsorption bed technologies.
- Cons: Need for vacuum pumping equipment.

Membrane Separation

- Process description: Thin films with selective permeability that allow certain gas molecules to preferentially diffuse through based on their size/solubility in the polymer. Films may be made from polymeric materials, metals, or inorganic materials such as graphene.
- Maturity: Polymer membranes are most mature, metal membranes (such as palladium) are at early stages of commercialisation and inorganic membranes are at very early stages of development.
- Pros: Polymer membranes are economically competitive due to their low production costs and ease of fabrication into modules with a large area/volume ratio, palladium membranes can be alloyed with different metals to develop specific characteristics depending on the use case (in membranes it is alloyed with silver to develop sulphur resistance and resistance to hydrogen embrittlement), some inorganic membranes can have high chemical, thermal, and mechanical stability.
- Cons: Polymeric membranes do not give a sharp separation between components and therefore cannot produce highly pure hydrogen, palladium membranes have a low stability/durability, some inorganic membranes currently high have cost and are only at small scale.

Cryogenic Separation

- Process description: Utilises liquefaction of gases by refrigeration to very low temperatures and then fractional distillation to separate components based on their different boiling points.
- Maturity: Very mature with extensive use in industry.
- Pros: Can achieve high levels of hydrogen purity (99.9+%) and very high hydrogen recovery rates.
- Cons: High capital cost for design and installation, high energy intensity as cryogenic temperatures require significant energy input to achieve.

Metal Hydrides

- Process description: Desired molecules in the feed gas are stored within the metal/metal alloy. The metal can be tailored to only store the desired molecule and exclude pollutants.
- Maturity: Low TRL; they are yet to be exclusively used for purification.
- Pros: Metal hydrides combine hydrogen purification and storage – creating a synergy that can't be achieved by other purification methods.
- Cons: Metal hydrides have been trialled in labs and a few demonstration projects, but the technology still needs to mature before commercial uptake.

Section 8
Policy, Regulatory & Standard Barriers

Technical uncertainties

Since the demonstration of deblending and refuelling at FutureGrid is separated from the transmission system, it is not required to meet the same requirements and policies. However, it expected that where possible the same standards will be adhered to (for example adherence to Pressure Systems Safety Regulations 2000 and The Dangerous Substances and Explosive Atmospheres Regulations 2002). Where this isn't possible, it is expected that risk assessments and documentations will detail any expectations. Any standards or deviations made can feed directly into lessons learned from the project, to understand the context of whether they would be a challenge to follow on the live network and may require modification, or whether they are simply a feature of the demonstration project. It is imperative that the network assets, the deblending equipment and the refuelling equipment can be operated to the relevant standards, as this provides excellent assurance to the Safety Management System and to the industry and stakeholders of the project.

As the hydrogen industry is an area of active research, we are seeing more frequent developments in knowledge and understanding compared to more mature industries. This means that policy, regulation, and standards are being updated more frequently to reflect this. Although they may not be a barrier to the project at present, it will be imperative to stay abreast of developing policy, regulatory and standard requirements as the project progresses. The Institution of Gas Engineers & Managers (IGEM) have produced several supplements to existing standards specifically addressing operation with hydrogen (IGEM/SR/25 Supplement 1, IGEM/TD/1 Supplement 2, IGEM/TD/3 Supplement 1 and IGEM/TD/13 Supplements 1 and 2). ASME B31.12 (Hydrogen Piping and Pipelines) has typically seen revisions every 3 – 5 years, with some standards such as ISO 19887 (Gaseous Hydrogen — Fuel system components for hydrogen fuelled vehicles) currently undergoing review prior to their first issue. Although unlikely to directly impact the project, it will be important to monitor any changes to the Gas Safety (Management) Regulations (GS(M)R), as well as any new or updated Gas Industry Standards, which may impact the future rollout of the technology. Standardised guidance exists for some deblending technologies (ISO/TS 19883 - Safety of pressure swing adsorption systems for hydrogen separation and purification) therefore, it will be important to be aware of the development of standards for other purification technologies if developed.

The FutureGrid HRS is expected to adhere to the standards in place for existing operational HRS's. ISO, CEN (European Committee for Standardization), BS (British Standards) and SAE (Society of Automotive Engineers) produce standards that apply to hydrogen refuelling. As the standards for hydrogen refuelling are well established it is anticipated that they will not present a barrier to the project. Relevant HRS standards include, but are not limited to, ISO 14687 (Hydrogen fuel quality), ISO 17268 (Gaseous hydrogen land vehicle refuelling connection devices), ISO 19880 (Gaseous hydrogen – fuelling stations) and ISO 19885 (Gaseous hydrogen — fuelling protocols for hydrogen-fuelled vehicles); BS EN 17124 (Hydrogen fuel – product specification and quality assurance for hydrogen refuelling points dispensing gaseous hydrogen) and BS EN 17127 (Outdoor hydrogen refuelling points dispensing gaseous hydrogen and incorporating filling protocols); SAE J2600 (Compressed Hydrogen Surface Vehicle Fueling Connection Devices), SAE J2601 (Fueling Protocols for Gaseous Hydrogen Vehicles) and SAE J2719 (Hydrogen Fuel Quality for Fuel Cell Vehicles).

Outputs from H2Mobility group

The future rollout and implementation of deblending-led hydrogen refuelling will require barriers in policy and regulations to be overcome. This is both in relation to the introduction of hydrogen into the gas transmission system and for the industry drive for hydrogen transportation. In 2023, the Government outlined their plans to allow for blending hydrogen into the gas distribution network. This policy decision will need to be extended to transmission i.e. Government will need to agree blending into the transmission network. Once agreed, there will need to be changes to key legislation, such as GS(M)R and the UNC to facilitate the policy change and to make sure the policy is implemented.

To progress 100% hydrogen, Government will need to agree the need for the strategic development of a hydrogen network. Once agreed, legislation will need to be developed that facilitates the ongoing development of a hydrogen market that utilises the 100% hydrogen infrastructure.

In addition, there will need to be policies in place that allow for the development of hydrogen production and demand side measures that promote hydrogen consumption. The utilisation of the network for hydrogen blends and 100% hydrogen relies on a sufficiently mature hydrogen economy to be developed to ensure that there is sufficient hydrogen produced/consumed to allow for blends/100% hydrogen to be deployed. As there are not currently large volumes of hydrogen produced anywhere in the UK, the hydrogen market will require suitable policies that encourage and stimulate the development of the low carbon hydrogen market.

The development of the Hydrogen Transport Business Models (HTBM – to be published in 2025) and the process to develop an initial hydrogen network via the Hydrogen Allocation Round are examples of policy that look to drive the development of a 100% hydrogen system. This commitment will need to continue and develop to allow the hydrogen economy to grow.

The H2 mobility group provides opportunities for the discussion and direction of policy requirements. The group includes representatives from the Department for Transport (DfT), Department for Energy Security and Net Zero (DESNZ) and the Welsh Government, among others that can influence and drive policy adjustments and requirements. National Gas also has good communications with the Office of Gas and Electricity Markets (Ofgem). Engagement on requirements is raised with these departments on the following topics:

- **DfT** – policy and regulation related to using hydrogen as a fuel for mobility.
- **DESNZ & Ofgem** – to feed into a decision on blending hydrogen into the NTS.

The H2 Mobility group has recorded some key policy requirements based off concerns raised from the members that suggest moving away from focusing on further research and development, but instead using the existing knowledge to provide a government-led strategy for hydrogen refuelling through the following requirements:

- The need to reduce upfront cost of hydrogen.
- The current low availability of hydrogen
- Ability to produce cost-effective hydrogen.
- Provide resilient hydrogen refuelling station infrastructure.

Through involvement with these working groups, National Gas is helping to support the requirements that are needed for both introduction of blending and hydrogen into the gas network, but also the support needed for the hydrogen transportation industry.

Broader policy requirements

Whilst as a business National Gas work to a rigorous set of policies and procedures that ensure we fulfil our legal and moral duties to the communities in which we operate, this project is operating in a slightly different set up. It is not connected to the National Transmission System and will not be 'transporting gas'. As such, it will not be governed by the legislation for that. However, it will be located within a COMAH site and legislation that governs activities on those sites must be satisfied. Therefore, we expect that the standards to which National Gas operate, are to be employed and adhered to.

Where these standards cannot be adhered to, we expect risk assessment and documentation to detail any exceptions. This approach ensures we can extract maximum learning from the project. Any standards that cannot be followed for this project can be understood in the context of whether they would be a challenge to follow on the live network, and may require modification, or whether they are simply a feature of the full-scale demonstration. Further work may be required if current standards cannot be followed. It is imperative that the network assets can be operated to standards, as this provides excellent assurance to the Safety Management System.

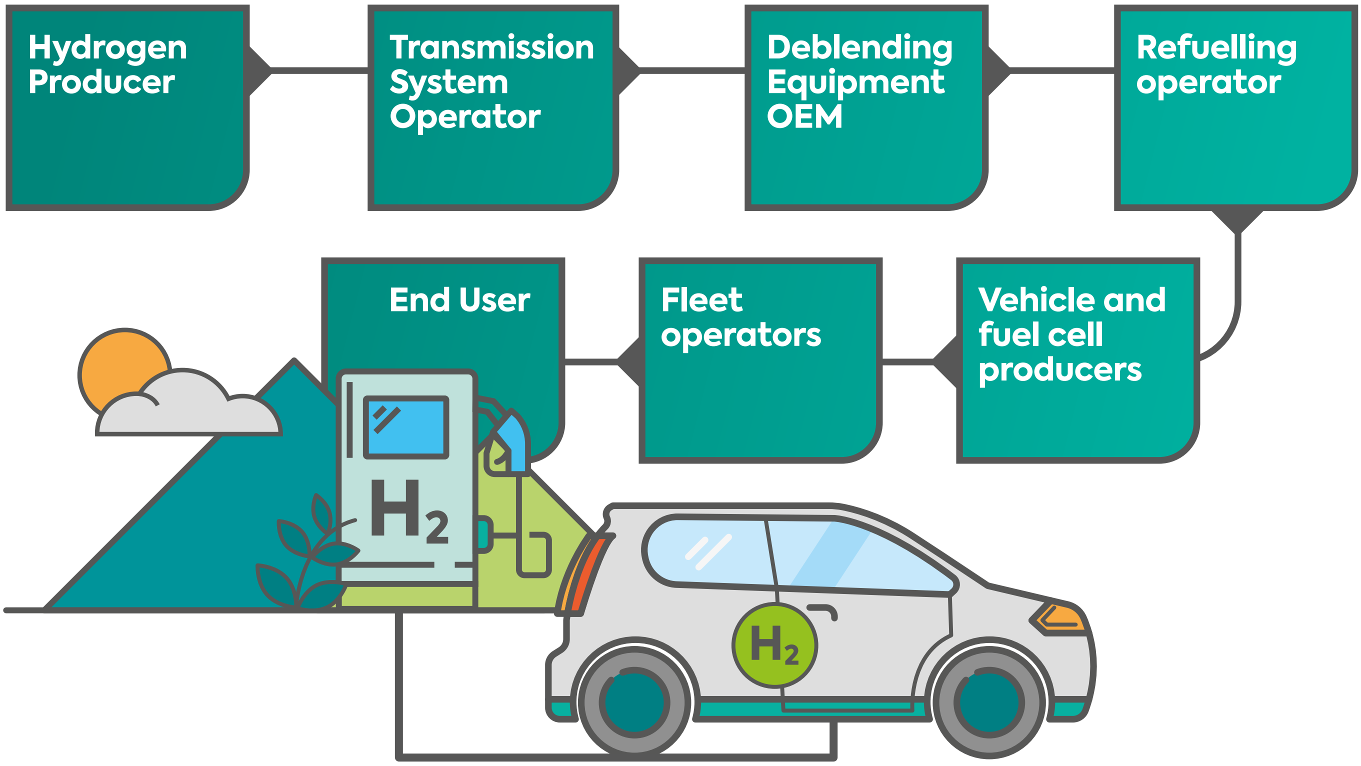
When considering the deployment of the project learning, National Gas will update any internal standards for hydrogen blends/Project Union as part of the Safety Case update that would be required in advance of this occurring on the NTS. The learning from this project will go a long way to help inform the eventual standards updates, along with key industry recognised standards and safety legislation.

There are many pieces of safety legislation that apply to hydrogen with regards to storage, transport, and use. As part of the FutureGrid Project Phase 1C, an assessment was undertaken on the impact of hydrogen upon NGGT policies, management procedures, standards and work procedures. It was found of the 554 relevant documents, 52% required no update, but 48% required changes classed as requiring high or medium levels of update. This is just within NGGT, so provides insight into the wider requirements for the industry.

Externally, there are some key legislation documents that relate to the safety of hydrogen that will require adhering to and possibly updating:

- the Planning (Hazardous Substances) Act 1990 and Planning (Hazardous Substances) Regulations 2015.
- Dangerous Substances and Explosive Atmosphere Regulations (DSEAR) 2002.
- Pipeline Safety Regulations 1996.
- G(S)MR Regulations.
- Notification of Installations Handling Hazardous Substances Regulations 2002.
- Control of Major Accident Hazards Regulations 2015.
- Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2004.
- Alternative Fuels Infrastructure Regulations 2017 SI 2017/825.

Section 9
User Needs



Hydrogen refuelling value chain

Value chain structure

To understand the stakeholder and user needs, it is important to understand the full extent of the supply chain, as those users will be those impacted from the work and the results produced, along with being able to contribute valuable input to the project.

The illustration above shows the supply chain for the hydrogen transportation industry. Government and policy makers sit across the whole supply chain, involved in making key decisions and pushing the hydrogen transport agenda.

Each part of the supply chain depends on the previous link, but also without the requirement from the end users and fleet operators, the initial links will struggle with a business case for the additional demand. Part of the use case for deblending is that the hydrogen would already be part of the gas network, and therefore the transport industry opens an opportunity for another workstream.

Key stakeholders

Section 3 summarised a list of all the stakeholders that have engaged in the project, broken down into each part of the supply chain. The stakeholders were identified by focusing on the key players in each industry, determined through research using conferences, news and press releases and through existing work and conversations. Regular updates and discussions with our stakeholders allow us to keep them informed on the progress and efforts of the project, along with allowing the sharing of information and progress between the stakeholders themselves. This prevents duplication of communications and discussions and allows for collaboration between both the project and its stakeholders and the stakeholders themselves.

The table below summarises the aims and goals for engagement for each of the stakeholder groups, identifying their interest and user needs. This has been updated and evolved throughout the project progress to date, considering the stakeholder survey and engagement so far.

Table 4 – Aims and goals for stakeholder groups

Stakeholder Group	Goals of engagement
H_2 refuelling station operators	• To test and develop the business case for deblending. • To develop technical specifications for commercial deblending system. • To develop interest in deployment of technology beyond the demonstrator, in particular for a first commercial demonstration.
H_2 producers	• Raise awareness of potential blending/deblending market for hydrogen to feed into production locations. • Understand plans for production and interest in blending/deblending.
Deblending equipment OEMs	• Raise awareness of the potential market of deblending for mobility to encourage development of NTS applicable development equipment. • Share learnings on specifications for equipment, to facilitate their plans for technology development. • Develop an understanding of alternative deblending technology options to inform the concept for a first commercial demonstration.
Vehicle manufacturers	• Engagement to bring vehicles to demonstration project. • Understand longer term plans for vehicle availability to the UK, to feed into deblending equipment roll-out plans.
Other international TSOs	• Share learnings from other gas network TSO activities that are relevant to this project.
Government departments	• Inform them of project learnings and developments, to feed into decisions around NTS hydrogen blending
Fleet Operators	• Understand long term plans for use of hydrogen transportation in their relevant industries. • Share learnings in development and customer demand.
Vehicle manufacturers	• Engagement to bring vehicles to demonstration project. • Understand longer term plans for vehicle availability to the UK, to feed into deblending equipment roll-out plans.

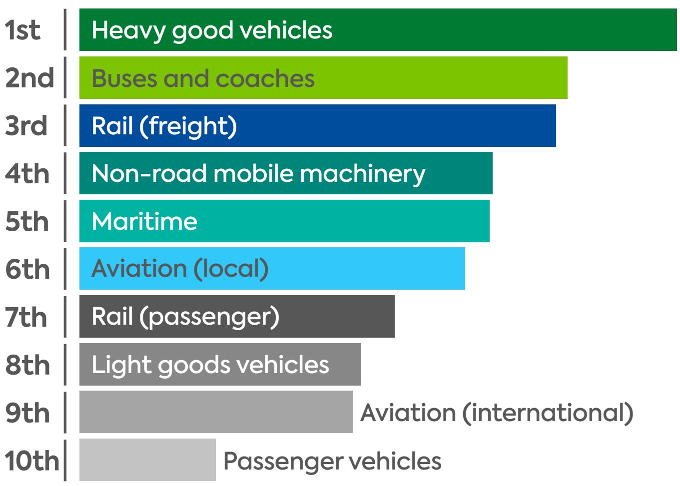
Stakeholder engagement

Results of stakeholder engagement

As shown in the previous sections, there has been significant stakeholder engagement conducted to date. Some of the questions and results are displayed in this section:

When questioned which transportation industries are most suited for hydrogen, heavy good vehicles and buses were pinned as the top two industries. This is as expected, as currently these have seen the most open and visible advancement. With the uptake of EV cars, it is unsurprising that passenger vehicles are not expected to have a large uptake with regards to hydrogen.

Figure 6 – Most suitable for hydrogen (survey response)



During the stakeholder event, and again through the survey, stakeholders were questioned as to what they saw as the blockers to the rollout of deblending served hydrogen refuelling. As seen from Figure 7 on the right, Cost was overwhelmingly the biggest concern, followed tightly by commercial risk and governmental policy. This reinforces the challenges highlighted in Section 3 of this report. It was encouraging to see that the technological advancements and concern over safety and sustainability were ranked as the lowest concerns as blockers to deblending led refuelling.

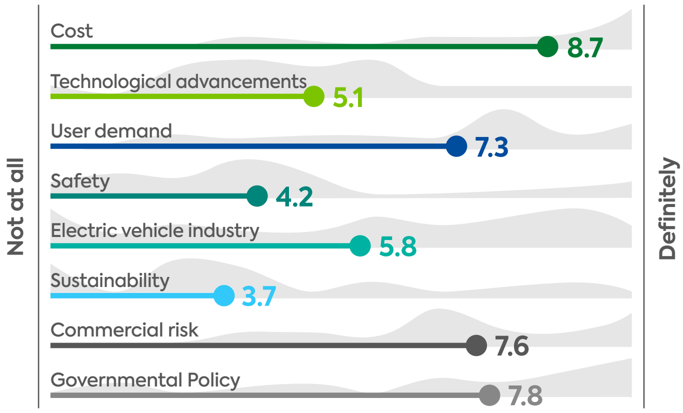
The engagement forum also led workshops to discuss some of the key enablers and risks for the rollout of deblending served hydrogen. The results can be seen in Table 5 below.

Table 5 – Rollout of deblending served hydrogen, key enablers and risks

Enablers
Strong incentives
Map with all refuelling stations
Clear market signals and market consistency
Link with the EV strategy
Vehicle range
Policy strategy and government support
Public perception and support

Blockers
Deblending bottleneck
Purity and the liability around this
Reliability of the service
Safety case
Scalability
Timescales
Network capacity
Low investment
Longevity of Hydrogen as an energy vector
Underutilised Assets
Cost
Ongoing maintenance

Figure 7 – Blockers to rollout



Using the information gained from the stakeholder engagement, the rollout mapping and future planning of the project can be directed and improved to ensure that, where possible, our stakeholders concerns are addressed, and their ideas utilised.

Further refinement of user needs

To ensure that the project and rollout mapping remains relevant and that our stakeholder and user needs continue to be understood, further engagement will be conducted. Engagement scope will be broadened to include a wider pool of hydrogen production, hydrogen demand and hydrogen storage projects. Further interactions with the Gas Distribution networks will be undertaken. Working with ERM, we will continue to monitor the market and sector and will update the rollout mapping report, to ensure that all information is up to date and relevant prior to the final roll out mapping in 2026.

Section 10

Impacts & Benefits

Refuelling station concept by Element 2

The concept being demonstrated through the FutureGrid Deblending, should it be rolled out as planned, provides numerous benefits to UK PLC. Both with regards to the users of hydrogen vehicles and the wider energy system.

Benefit to vehicle operators

The decarbonisation of transport in the UK is well underway, however there are many sectors which have been identified as difficult to decarbonise and are not well served by available technologies. Hydrogen provides an alternative pathway for these use cases and can provide a lower cost of operation, or more convenient solution, for these sectors.

Hydrogen transport via the NTS will ensure reliable hydrogen supply to vehicle operators across the country. The existing UK HRS infrastructure is often faced with reliability issues which will be negated if a supply is readily available from the NTS. Reliable supply will help to improve adoption of hydrogen vehicles and aid the expansion of vehicle fleets.

For manufacturers that do not currently have a hydrogen fleet, it may promote innovation and the incentive to develop hydrogen vehicles. Hydrogen refuelling will also support net zero initiatives for operators and support sustainability optics.

An accessible hydrogen supply will also aid the expansion of the UK HRS infrastructure which will provide vehicle operators with greater convenience when travelling, by reducing the distances required to refuel (an issue faced by early adopters of Battery Electric Vehicles).

Initial analysis has shown that central production and pipeline delivery of hydrogen can reduce the cost to consumer by over £2 per kg, depending on the application. This cost saving would have a major impact on the operating expenses of transport-heavy businesses. Furthermore, development of HRS infrastructure across the country will also aid in reducing the levelized cost of hydrogen, by promoting additional hydrogen production, ultimately benefitting vehicles operators.

Benefit to gas system users

The UK Government has set a target to deploy 10 GW of low carbon hydrogen by 2030. To help to reach this ambition, large-scale hydrogen production facilities, such as Gigastack, HyNET and Acorn, are planned to be deployed within the coming decade.

Blending hydrogen into the National Transmission System (NTS), with the capability to deblend high purity hydrogen at NTS offtake points, would create an opportunity to use existing NTS infrastructure to distribute hydrogen produced at these large-scale facilities, to hydrogen offtakers across the UK (often long distances from centralised facilities) at low cost. Deblending will also support users that must maintain existing gas composition (e.g., a power station with a specific gas turbine specification) whilst allowing hydrogen to be transported to other users of the NTS.

As with vehicle operators, a reliable hydrogen supply will benefit users of hydrogen from the NTS and encourage development of hydrogen consuming facilities, which will aid growth of the hydrogen economy and reduce the levelized cost of hydrogen. Hydrogen transport using the NTS will also support decarbonisation of gas consumers that can accept hydrogen blends.

Deblending facilities may look to connect directly to the NTS or develop a 'hub' which can service multiple nearby HRS's. This can benefit refuelling stations by reducing the need for multiple hydrogen deliveries per day or by significantly reducing the distance a tube trailer may need to travel. Refuelling stations may also require smaller buffer storage as a result, thereby reducing the overall levelized hydrogen cost further, and reduce safety implications by minimising the volumes of hazardous gas stored on-site.

Furthermore, any additional hydrogen demand provides incentives to increase supply and ultimately achieve the economies of scale which will be required to have a fluid and effective hydrogen market in the UK.

> "Hydrogen transport via the NTS will ensure reliable hydrogen supply to vehicle operators across the country."

Realisation of benefits

There remains uncertainty around how, when and where these benefits will be realised. The report on Future Rollout Potential, deliverable 7.3 of the HyNTS Deblending project, provides an assessment of expected emergence of demand for hydrogen refuelling in the UK. Certain sectors such as rail freight show promise, however likelihood and timeline of this demand is dependent on government policy.

Supply also shows significant uncertainty. National Gas have indicative timelines for the conversion of the gas transmission system to hydrogen, however this is again dependent on government policy. Blending of hydrogen is more likely in the near term, however this depends not only on government policy, but also on the available supply of hydrogen. The drivers for these different areas of uncertainty will continue to be explored throughout the project.

To progress through this haze of uncertainty, it is therefore prudent to develop a technology concept that is scalable and can be deployed in several different scenarios. Deliverable 8.3 will address this and work with stakeholders to ensure that all credible scenarios are covered by the proposed concept.

Section 11

Risks, Issues & Constraints

Project delivery

Utilising the gas network and deblending hydrogen for use in fuel cells and combustion engines is a novel practice and as such, there are numerous risks that need to be accounted for. This is not just related to technological and developmental risks, but also commercial and regulation risks that may hinder the advancement of the hydrogen transportation industry and even the use of hydrogen within the gas network.

There are also more project specific risks, related to the development and running of the project that include project timelines, equipment damage, weather impacts etc.

Utilising a risk register, it is possible to monitor and record the risks as they arise throughout the project lifetime, ensuring that risks are captured and used to inform the project. These are assessed by all partners at quarterly risk specific meetings as well as being reviewed with each QRM and stage gate. Where necessary, the project plan is adjusted as required, to account for any changes in risks, issues, or constraints. Through the conduct of HAZOP and HAZID meetings, further risks and issues are able to be identified and included in the risk register.

Top risks

Our top risks to the project at this stage of the project have been summarised in the table below. It includes a statement on the likelihood and the commentary on actions being taken to manage these key risks.

Table 6 – Risk summary

Risk Level	Risk
High	**Certification for the deblending unit will delay delivery to Spadeadam** There is a risk that the certification will not be provided in the required timescales due to the testing required on the unit prior to export and any other unforeseen issues that may cause a delay in the delivery to FutureGrid which in turn affects the project timeline. To assist in delays, an ATEX specialist contractor has been appointed by HyET to provide support by expediting work with the notified body. DNV has also provided contacts for additional support.
Medium	**Long lead items don't arrive in the required timescales** There is a risk that long lead items are not delivered in the required timescales due to not being ordered till day 1 of the beta project. Any delays on critical items could have an impact on the overall project programme and timescales. At the start of the project, the items were itemised, and payment expedited to allow procurement at the earliest opportunity. Whilst the project is still waiting for some items, partners are confident that the timescales will be met.
Medium	**Commissioning and Testing Delays** The novel nature of the test configuration could result in the unexpected delays to commissioning and testing. Cold weather presents an additional challenge which impacted the FutureGrid Phase 1 programme and could be experienced during Phase 2. There is ongoing design work between the partners which aims to mitigate this risk. In addition, the test programme has been adjusted to account for "extreme" weather conditions.
High	**The technology being proposed does not work** This is the first time the technology has been demonstrated at transmission pressure and scale, having previously only been demoed at smaller scale. Equipment will be tested before the signing off of the Factory Acceptance Testing. HyET is also developing an in-house test system which will simulate the load in live operation.
Medium	**The equipment arrives onto site damaged** Due to the sensitive nature of the HyET equipment, there is a risk that it could be damaged in transit. This is in particular for the membranes, which cannot be exposed to excessively low temperatures, and must be kept above 5'C at all times. HyET's engineering team is currently exploring options for the transit options to ensure a safe delivery.

Figure 8 – Project risks identified as of Q3 2024

Risk Register Statistics

UP	UP	DOWN	NO CHANGE
17 Green	**17** Amber	**2** Red	**17** Closed

Risk profile

Using the risk register to record the risks as identified through the project, we can monitor how the risk profile changes throughout the development of the project. As a risk arises, it is logged on the risk register and given a rating: red, amber, or green relating to high, medium, or low risk. The risks are reviewed at regular intervals and mitigations considered, which can cause the risk rating to change, or for the risk to be closed. At the current status of the project, the risk profile is shown as below. The arrows indicate that the number of risks in that category has gone up, gone down or stayed the same.

These statistics show that overall, the number of risks have increased, but the number of red (or high) risks has reduced. It is expected that the number of risks would increase as the project develops and more issues or risks are identified, however it is also expected that many more will be closed as mitigations and workarounds are identified.

> "Using the risk register to record the risks as identified through the project, we can monitor how the risk profile changes throughout the development of the project."

Other constraints

There are some key constraints that have been identified as the project has developed, and from lessons learnt from the Phase 1 project:

- Phase 1 struggled with the availability of large quantities of hydrogen to fill the FutureGrid facility. This constraint has been identified as being a potential issue for Phase 2, and as such DNV have worked to identify other suppliers of Hydrogen.
- Due to the slow uptake of hydrogen vehicles in the UK, there is not a wide range of hydrogen vehicles available for the demonstration part of the deblending project. National Gas has worked with Element 2 initially, to secure vehicles for the project, and there are ongoing discussions for trialling alternative types of vehicles such as telehandlers and excavators.
- The deblending technology being utilised in this project has not previously been proven at large scale. This project is an opportunity to trial the technology and work with HyET to develop further deblending opportunities.
- Through ERM's roll out mapping, it has been identified that there are significant constraints to the hydrogen transport industry particularly in relation to fuelling direct from the network. This includes proximity of clusters to NTS and slow uptake of hydrogen transportation in the UK.

Deployment

System deployment

The innovative nature of the Deblending & Purification system has the potential to provide significant advancements in the industry's knowledge of Deblending system capability but will present technical challenges due to its novelty. Several potential challenges are outlined below:

- Gas separation technology has historically only been used in specific chemical industrial processes and has never been trialled on a variable gas network.
- During commissioning it must be proven that the system can produce fuel cell grade purity hydrogen at the intended mass flow rates (200 kg/day bulk separation and 40 kg/day purified hydrogen at HRS supply pressure). Due to this being the first installation of this scale, it may be possible that these key performance indicators are not achieved.
- The system must demonstrate that it can perform with variations in operating conditions (as would be the case on the NTS). This may be variation in flow, temperature, pressure, gas composition and contaminant concentrations.
- This type of technology has not previously been connected to a refuelling pump. Issues with variable operating conditions as mentioned above may impact HRS performance.
- It will be important to understand the run-length of the technology between maintenance events. This will factor into the operating costs of such a system and its commercialisation success.
- If demand varies at the HRS, the impact to the potential on/off nature of the Deblending & Purification system needs to be understood.
- The system must always remain above 5°C, to prevent freezing of the electrochemical membrane stacks. It is not clear how well this will be achieved whilst shipping the items to DNV Spadeadam, as well as when operating the facility. Mitigations have been put in place, such as a back-up generator if there were to be a power outage at Spadeadam.
- At present it is not clear where ownership of a Deblending & Purification system would sit when rolled out to the Business-as-Usual NTS, if under the ownership of National Gas experience of operating such systems is low.
- Procurement of long lead items may impact the timeline for full system testing. Logistics in the current economic climate have become more challenging in recent years. The project has aimed to mitigate against this by ordering long lead items as early as practicable.
- There is insufficient hydrogen available at Spadeadam for the desired amount of deblending to demonstrate a scalable solution.

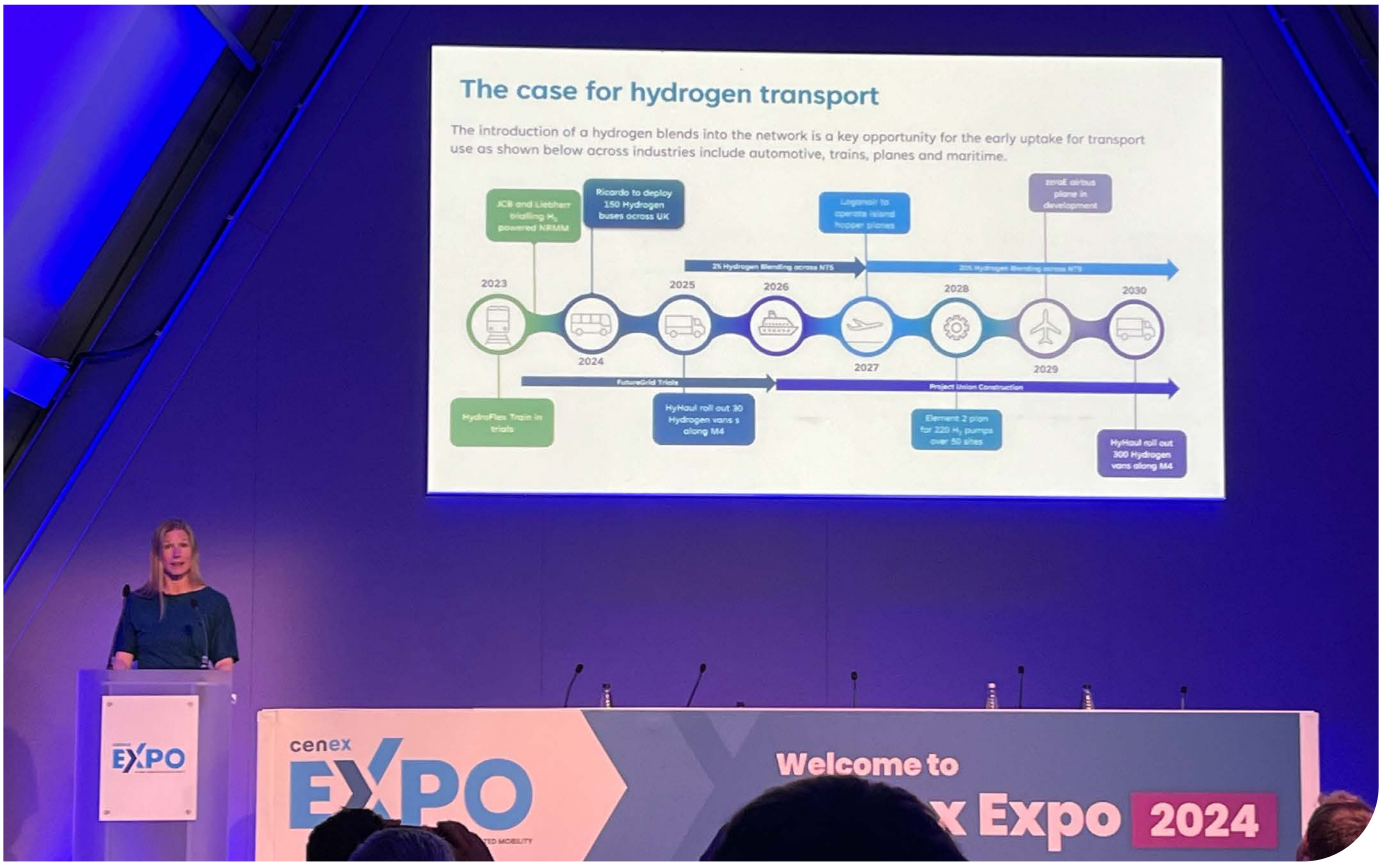
Industry adoption

Industry-related challenges also exist which may impact the success of Deblending & Purification adoption. Several potential challenges are outlined below:

- A significant challenge related to the Deblending portion of the Deblending & Purification system is whether the UK government choose to adopt hydrogen blending into the NTS. If hydrogen blending is not adopted, the Purification aspect of the system is anticipated to still be required to achieve fuel cell grade purity when utilising hydrogen from a dedicated 100% hydrogen pipeline.
- Due to the immaturity of the hydrogen economy, it is not clear whether sufficient hydrogen supply will exist for the reliable rollout of Deblending & Purification systems across the NTS.
- Similarly, it is not clear whether there will be sufficient hydrogen demand to promote the development of Deblending & Purification systems. Rollout Mapping, outlined in Section 5, aims to mitigate against this by identifying advantageous locations for potential HRS offtakes.
- The cost of hydrogen, and how the government will support this, will impact industry adoption both from a production standpoint but also indirectly from a consumption standpoint. The cost of hydrogen will be greater whilst the hydrogen economy is less mature. The UK government are looking at revenue support for hydrogen producers through the Hydrogen Production Business Model, although this is yet to be finalised.
- Stakeholder engagement, outlined in Section 9, has identified that public perception for transportation continues to be a challenge. Safety concerns still exist for the use of hydrogen; a factor which led to public hesitancy to the development of hydrogen villages in Whitby, Redcar, and Ellesmere Port.
- If blending is adopted, stakeholder engagement will also be important in assuring customers that may not wish to receive a blended hydrogen stream that their gas will be hydrogen free. Equally for those that wish to receive a purified hydrogen stream, it will be important to verify performance of Deblending & Purification systems.

Section 12

Working in the Open



It is critical that the work conducted for this project is conducted transparently, involving stakeholders to guide and inform throughout the lifecycle of the project with a concrete communication and dissemination strategy.

This involves utilising a steering group, a stakeholder group and engaging working groups, to produce content for conferences, site visits, lunch & learn sessions, podcasts, webinars and blog posts etc.

Much of this engagement has already been discussed in Section 4 and Section 9 with regards to the dissemination and communications.
In this section, the formation of the groups that have helped drive the communications and collaboration are detailed.

Steering group

A steering group, made up of the project partner leads, was formed, with the first formal meeting held in July 2024. The first meeting agreed a term of reference which detailed the role of the steering group as the following:

- Championing FutureGrid Deblending for Transportation Project.
- Approving key programme deliverables including the test plan.
- Providing direction on strategy roll-out and implementation.
- Providing a point of escalation for significant risk and issues, including cross-organisational challenges and unexpected difficulties or blockages as they arise.
- Supporting the stakeholder engagement where possible.
- Supporting the required governance with stage gates, QRMs and dissemination as required.

This quarterly meeting allows the partners to provide input on the work within the project, and also to use their expertise outside the project work, to input information on other parts of the supply chain journey, raising any issues or insights that have been garnered. It also allows for meetings and spin-off meetings on specific topics, such as the rollout mapping and the test plan, where some partners have significant input that can adjust the inputs and outputs of the project.

Stakeholder group

As mentioned in the previous sections, through horizon scanning and utilisation of existing and new contracts, a comprehensive stakeholder group was established. Through the stakeholder event, surveys, a newsletter and one to one conversation, the project has been promoted and promoted. These conversations have also allowed for challenge and questions to be raised around the project deliverables and methodology, for both the technical work and also the rollout mapping. The stakeholder group is continuously growing as key contacts and the wider industry also grows. Section 4 details the activities that are used for communicating publicly about the project.

Working groups

Within the industry, there are several working groups in existence that are driving progress and innovation. Specifically for hydrogen in the gas networks, the H2GAR working groups cover a wide range of topics with Working Group 3 leading on blending and deblending. The H2Mobility group focuses on hydrogen transportation. Both groups include the leading and key players in the industry and consider the issues and progress within the sector. With these and other existing working groups, it has been a challenge to garner members for a further Deblending for Transportation steering group, and so a decision has been made to work with the existing working groups to keep the FutureGrid project at the forefront of these, and to utilise the knowledge within the existing work groups and the Steering Group, to inform and guide the work on the project. This also allows other National Gas Innovation team members to feed into their associated working groups and increase transparency and dissemination of the Deblending for Transportation Project.

> “The ultimate goal of these engagement activities is to ensure that the HyNTS deblending project is closely aligned with the market needs and stakeholder expectations, paving the way for successful commercialisation.”

Some of the groups that have bi-lateral engagements with key stakeholders include, but not limited to:

- H2GAR
- H2 Mobility
- Hydrogen in Aviation (HIA) Alliance
- The Aggregated Hydrogen Freight Consortium
- The Energy Intensive Users Group (EIUG)
- Maritime UK’s Maritime Hydrogen Group
- UK Major Ports Group (UKMPG)
- The British Ports Association (BPA)
- Association of British Foods
- Chemical Industries Association.

External communications

As part of working in the open, external communications are an important part of information dissemination. LinkedIn is a great opportunity for broadcasting the work conducted and results produced at FutureGrid and the ongoing progress. It allows for audience interaction and reposts, encouraging engagement with parties that may not be aware of the work, and gives them opportunities to get in touch to find out more.

The aim of these engagement activities is to ensure that the HyNTS deblending project is closely aligned with the market needs and stakeholder expectations, paving the way for successful commercialisation. The feedback and partnerships cultivated through these engagements are critical to refining the business solutions that will define hydrogen deblending going forward.

Section 13
Costs & Value for Money

Table 7

	SIF funding requested	Total actual project spend	Partner in-kind contributions
National Gas	£1,206,316	£367,137	£28,900
DNV	£4,692,556	£1,053,024	£228,431
Hyet	£3,983,875	£3,199,188	£305,900
Element 2	£891,360	£581,400	£99,040
ERM	£196,544	£100,000	£7,238
Cadent	£12,639	£4,596	X
NGN	£14,570	£5,298	X
SGN	£12,969	£3,792	X
WWU	£10,428	£4,716	£1,300

Project performance

The first year of the FutureGrid Deblending project has focused on the preparation of the test facility for the installation and operation of the hydrogen deblending and purification equipment. Significant time has been spent on the design and safety assessment of the facility. Most of the funds spent to date relate to the procurement of equipment and services to produce the Deblending, Purification & Compression, and HRS systems.

The project leverages the existing FutureGrid Phase 1 facility to reduce the overall cost required to test the novel technology concept and utilise the learnings from prior operation of the facility. If this facility was not available for expansion, there would have been additional costs of around £5m to deliver the project. The ability of other NIA funded projects to utilise the facility demonstrates the importance of cost avoidance as a source of value for the consumer, and this should not be underestimated.

Despite the significant uncertainties associated with a large engineering research project, which carry inherent risks of overspend and extended timelines, the project is adhering to budget and is on schedule, demonstrating the effective management and planning of team. This approach not only underscores our commitment to efficiency but ensures the avoidance of any costs for consumers.

When the project bid was originally submitted, a project forecast plan was included and used as a baseline for financial forecasting. When the project commenced, we conducted detailed planning sessions and realised that some minor changes would be required to the payment plan as it had shifted to milestone-based payments. This was relayed to UKRI at the quarterly project meeting.

We have been tracking the forecast vs actuals for each reporting period and have been comparing it with the forecast stated in the baseline and at each respective quarter. The changes in forecasts vs actuals in Q1 and Q2 were mainly because long lead orders were brought forward to reduce risk. Since the forecasts conducted in Q3, there have been no significant variations between the planned and actual spend.

In this reporting period there is no unspent SIF funding to be returned to the consumers. Likewise, there have been no additional revenues earned related to the Project that will be returned to consumers.

Commercialising the facility

As the FutureGrid facility has expanded from a test loop to a more comprehensive facility, the capabilities and testing capacity of the facility have grown. This is expanded even further with the creation of the new Compression test loop, which adds additional functionality to an already unique test site.

What we have achieved to date on Phase 1, and will achieve with Phase 2, is far beyond any physical testing capabilities across the world. FutureGrid is a global first, unique and trailblazing facility at the heart of the green energy revolution, leading the way for the UK on a global stage.

As the Phase 1 project has developed, so too has interest on both a national and international stage. Our collaborative networks run across the globe with far deeper and complex data and knowledge exchange, with the global players recognising the value of collaboration. This has brought significant attention to FutureGrid which as such, presents a fantastic opportunity to open the facility for collaborators to engage with us and utilise the facility to further their own technological needs.

This presents a great opportunity to the UK consumer, the ultimate funder of the Ofgem Innovation Frameworks, that has helped to bring these ambitious large-scale facilities to life. How can we generate value and a return on this investment?

We have already been approached by several potential customers regarding using the FutureGrid facility for bespoke testing. These are being explored as a means of generating additional value for UK consumers; either through reducing testing costs, access to valuable data or direct returns.

In the special conditions report we have provided details of a proposed plan and how this would be implemented. In this reporting period, this is being agreed with UKRI as part of the quarterly project monitoring discussions.

Section 14

Special Conditions

Special conditions summary

The below table summarises the special conditions that are specific for FutureGrid Phase 2, including the Deblending and Compression projects. Together with this table, there are reports that detail how each of the special conditions have been met. Summaries of the reports can be found beneath the table.

Table 8

Project specific condition fulfilment

Condition 1	No Spend until SIF Contracts	Ensuring that no spend occurs on Compression or Deblending before the SIF contracts are signed.	C	This was fulfilled with contracts signed ready for the project start in September 2023.
Condition 2	Financial Contribution reported by NGT	Reporting on the financial contributions made to the projects as set out in the applications.	C	This was completed as part of the project start-up with financial contributions made to bank account.
Condition 3	Meeting Arrangements	Participating in all meetings arranged/ invited to by Ofgem, UKRI and DESNZ.	G	Engaging with all meetings set out to date and preparations underway for dissemination conferences including Innovation Zero and EIS.
Condition 4	Stage Gate Scoping	Scoping the requirements and success criteria for each stage gate within the Projects.	G	Process agreed and preparations completed for Deblending Stage Gate 2 and nearing completion for Compression.
Condition 5	Dissemination of Annual Progress Report	Uploading annual progress reports to ENA's Smarter Networks Portal, along with dissemination to a wider audience.	G	Annual progress report 2024 complete and circulated.
Condition 6	Impact Monitoring & Evaluation Plan	Producing an Project Impact Monitoring and Evaluation Plan. This will outline how the Project will monitor and evaluate the delivery of the benefits, along with quantifying and qualifying the realisation of the benefits, also including the approach for reporting this to Ofgem.	–	To be started at the end of the project phase.
Condition 7	SIF Community Forums	Attending and contributing to SIF community forum events.	G	Ongoing requirement, attended Newcastle Community Day in February along with Project Partners.
Condition 8	Policy, Regulation and Standards	Updates at each quarterly meeting on any regulatory, policy and standards barriers along with any change requirements which may impact beta phase delivery. In addition, providing (within annual progress reports) an update on any of the above barriers requiring changes/derogations.	G	Ongoing monitoring and discussion of impacts – nothing significant to note but continue to monitor.
Condition 9	Updated 60 second videos	A 60 second video summarising the project.	C	Videos completed and uploaded. Deblending click here Compression: click here
Condition 10	Consumer Engagement	Update on the consumer engagement plan developed by the project team every six months including highlighting engagement and interaction with energy consumers and any impact the projects may have on them or future energy consumers.	G	Ongoing as part of the project union consumer engagement. 100s of stakeholders contacted covering energy systems, consumers, working groups, supply chain.

Key

–	Not started	C	Complete	G	On Track	A	At Risk	R	Delayed

Table 8 – continued

Project specific condition fulfilment				
Condition 11	Post Beta Phase Roadmap	Providing a roadmap for activities post-Beta Phase, focusing on how and when Deblending will become business as usual within the NTS and potentially other GB gas or electricity networks.	G	Dual pathway approach to blending and 100% hydrogen through Project Union demonstrating feasibility, with ERM delivering detailed plan.
Condition 12	Commercialisation Strategy	Updating on the commercialisation strategy, focusing on what National Gas and Partners have considered for the commercialisation of Compression.	G	Currently under development and due to be discussed in June QRM.
Condition 13	Hydrogen	Updating on the projects ability to obtain the required volumes of hydrogen and outlining opportunities there are for the project to use green hydrogen. In addition, how hydrogen trial projects can be used to help stimulate the development of green hydrogen market.	G	DNV continuing engagement across diverse supply chain to seek the volumes required and seek green hydrogen opportunities supported by NG.
Condition 14	Maximising Future Value of Facility	Maximising, for all consumers, the future value of all activities occurring at the FutureGrid Test facility in Spadeadam beyond the Beta Phase.	G	Engagement with potential stakeholders is ongoing throughout the project and updates are provided regularly at the QRM.
Condition 15c	Cost reductions & value adding opportunities	Identify opportunities to reduce project costs, increase contributions from project partner or identify further value which can be extracted from the project.	G	NGT is pushing opportunities to enhance facility value. This includes identifying other NIA projects which can be delivered more efficiently due to FutureGrid.
Condition 15d	Engagement with potential demand users	Regular engagement with potential demand users who would provide refuelling stations should the Project's proposed solution be successful.	G	Ongoing engagement – Tees Valley Hydrogen support, JCB want to collaborate to demonstrate and BMW see the project as a blueprint for the world.
Condition 16	Engagement with successful ZEHID projects	Regular engagement with the successful Zero Emission HGV and Infrastructure Demonstrator (ZEHID) Projects, once they are announced by Innovate UK and / or the Department for Energy Security and Net Zero (DESNZ).	G	The FutureGrid team have engaged with the ZEHID partners and are looking at opportunities for collaboration.
Condition 17	Outline IPR value to supply chain providers (HyET)	Providing an outline of the IPR value form the Project to supply chain providers manufacturing the equipment in the project.	G	Value outlined with clear demarcations on IP which demonstrate the diversity of procurement opportunity and limited exclusive benefit to HyET.

Key

–	Not started	C	Complete	G	On Track	A	At Risk	R	Delayed

Special Condition 10 – Consumer engagement

To comply with special condition 10, the FutureGrid project has implemented comprehensive consumer engagement strategies. These include regular updates and transparent documentation ensuring all stakeholders are informed about project progress and developments. Phase 2 compression has utilised the Project Union engagement plan to identify and involve many stakeholders. The activities carried out as part of Project Union have been extensive and dynamic, covering a broad spectrum of stakeholder's integral to the energy systems' landscape. Throughout the project, hundreds of stakeholders, including energy system experts, consumer representatives, members of various working groups and supply chain entities have been actively involved. This extensive interaction has been crucial in shaping the project direction and building on the business case for compression.

As engagement continues throughout the duration of the project, NGT will broaden the scope of stakeholder engagement and immediate next steps to include engagement with:

- A wider pool of hydrogen Production, hydrogen Demand and hydrogen storage projects.
- Co-ordination between NGT and Gas Distribution Networks (GDNs) at a regional level to understand interdependencies and forecasts of supply and demand between Project Union and regional network plans.
- Following completion of pre-FEED route optioneering, engagement with key statutory stakeholders (e.g., environmental stakeholders) to share approach to constraints analysis and future route refinement.

For the Deblending project, there will be ongoing engagement both with existing stakeholders but also as part of the broader Project Union engagement strategy. This strategy covers all elements of the transition of the network to hydrogen and the impacts and considerations required. Combined with the transport specific engagement of the deblending project, we can anticipate more refined outputs that contribute essential knowledge to the hydrogen transition plan.

Special Condition 12 – Commercialisation strategy

As the Phase 1 project has developed, so too has interest on both a national and international stage. Our collaborative partnership with HyET and Element 2 works towards producing infrastructure that could be rolled out across the network for the refuelling of vehicles.

Due to the novel nature of the concept of the deblending steps, there is not a well-established market for equipment to separate hydrogen from natural gas at high purity and pressure. Processes for each of these steps do exist, however they are often undertaken at a large scale within the chemical industry and therefore are not suited to the smaller scale transport applications. Initial concepts explored in hydrogen deblending research suggested that this process would only be suited for major gas consumers with high purity requirements, such as power stations. However, the development of new, more scalable, technologies has opened new opportunities for hydrogen deblending.

The HyET technology was chosen to demonstrate this concept, after significant market research had been conducted, due to its inherent advantages including the very high output purity and lower power requirements due to the combination of the purification and compression step.

For the refuelling, Element 2 is just one manufacturer of Hydrogen Refuelling equipment. A competitive hydrogen refuelling market already exists within the UK with growth seen in the last few years. Element2 were chosen as partners for the HyNTS Deblending project, however others include Shell Energy, Motive Fuels and ITM Power.

The components used for these operations are typically standardised and bought 'off the shelf' with design and construction following a similar pattern to traditional liquid refuelling stations. It is expected that any implementation of the deblended hydrogen refuelling concept would use a competitive tender process to select a refuelling station operator to partner with.

The sharing of the input and output data allows the system tested in the FutureGrid Deblending project to be compared to alternative available and developing deblending systems.

Special Condition 14 – Maximising future value for the facility

The FutureGrid facility will continue to act as a key enabler for demonstrating innovative technology for the NTS today or supporting different needs as NGT repurposes its network for Net Zero. The best commercial use of the facility time is a combination of developing the safety case for repurposing the NTS via Project Union, the identification of critical new technology, which will be required to operate a net zero network, and third-party testing. There is also a key role for the FutureGrid facilities to play in the development of skills through real-life training opportunities and demonstrations that the facility can provide. Via these workstreams, FutureGrid will help to develop a diverse supply chain, with skilled and competent engineers helping to deliver net zero opportunities at a lower cost. There have been several NIA projects that have been demonstrated at FutureGrid or are upcoming, that form part of the evidence-based safety case for integrating hydrogen across the NTS. Below is some of the value that has been realised to date:

1. Initial promotion and engagement on the facility is generating interest with national and international asset manufacturers and gas networks.
2. Opened discussions with Baker Hughes and Solar (Compressor manufacturers) who were initially very reluctant to even discuss repurposing of equipment. Potential for future testing and similar benefits realisation with lower repurpose v replace costs.

As discussed in more detail in the Special Condition 14 Report, there are several factors that will determine the potential areas where value could be generated, how much value there could be, and how this value is best returned.

Special Condition 15c – Cost reductions & value adding opportunities

When we consider cost savings across the FutureGrid Programme, we can consider these in three categories as demonstrated below:

Figure 9

Opportunities realised

These are opportunities and value that has been realised and as such a saving can be attributed, whether that is through the FutureGrid Programme or associated hydrogen work such as an NIA project saving money.

Opportunities under review

These are opportunities that are currently being identified and developed. These could be early-stage opportunities for the end of the project or could be those in-flight options and opportunities to cut costs for upcoming activities.

Potential future opportunities

These are opportunities that are hard to fully articulate until more is understood about the program or potential demand/requirements from external forces as such these are watchlist items and when they become clearer, they are opportunities that will become under review.

This logical categorisation provides a platform to allow for easy demonstration and tracking of opportunities across the portfolio. They allow us to focus on those areas where cost savings are more likely, to ensure that these are realised and allow us to continue to seek further opportunities. Due to the nature of the programmes of work, there may be periods where there is little movement on the opportunities, as they require the next stage of activity to begin. This allows us time to plan and ensure that the opportunities are maximised wherever possible.

An example of opportunities realised has been in the contracting and project kick off phases. Legal negotiations around contracts are a challenge, so a change in methodology was done for phase 2 and this was achieved by aligning the project partners across both projects The savings are outlined below:

- **FutureGrid Phase 1 Cost**
  £128k
- **HyNTS Compression submission estimate**
  £100k
- **HyNTS Deblending submission estimate**
  £50k
- **Actual total across both**
  £124k (£79k/£45k)
- **Saving**
  £26k

Section 15

Material Changes

In this reporting period there have been no material changes to the project.

Contact Details

For further information about the project and to request a copy of the full technical report (please note restrictions apply to free access), please get in touch with the team:

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Note: all links on the page can be accessed on the digital version of the report available at nationalgas.com/FutureGrid

Appendix 1

Acronym Key

Acronym	Definition	Acronym	Definition
AGI	Above Ground Installation	NDT	Non-destructive Testing
ALARP	As Low As Reasonably Practicable	NGN	Northern Gas Networks
ASME	American Society of Mechanical Engineers	NGS	National Gas Services
CO_2	Carbon dioxide	NG	National Gas
DNV	Det Norske Veritas	NIA	Network Innovation Allowance
ENA	Energy Networks Association	NIC	Network Innovation Competition
EU	European Union	NTS	National Transmission System
FAT	Factory Acceptance Test	OFGEM	Office of Gas and Electricity Markets
GB	Great Britain	PIG	Pipeline Inspection Gauge
GDN	Gas Distribution Network	PMC	Pipeline Maintenance Centre
GSMR	Gas Safety Management Regulations	PPR	Project Progress Report
H2 GAR	Hydrogen Gas Asset Readiness	PSI	Pound per Square Inch
HAMM	Hazard Assessment Methodology Manual	PSR	Pipeline Safety Regulations
HATS	Hazardous Assessment of the Transmission System	PSSR	Pressure Systems Safety Regulations
HSE	Health and Safety Executive	QRA	Quantitative Risk Assessment
HSE-SD	Health and Safety Executive – Science Division	R&D	Research and Development
HyNTS	Hydrogen in the National Transmission System	RF	Raised Face
ILI	In Line Inspection	RTJ	Ring Type Joint
IPR	Intellectual Property Rights	SAT	Site Acceptance Test
IPRM	Internal Project Review Meeting	SCADA	Supervisory Control and Data Acquisition
IT	Information Technology	SIF	Strategic Innovation Fund
LMF	Leobersdorfer Maschinenfabrik	SME	Subject Matter Expert
LSAW	Longitudinal Submerged Arc-Welding Pipe	TSOs	Transmission System Operators
MAPD	Major Accident Prevention Document	TWh	Terawatt hour
MOP	Maximum Operating Pressure	UK	United Kingdom
MPI	Magnetic Particle Inspections	UT	Ultrasonic Testing


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