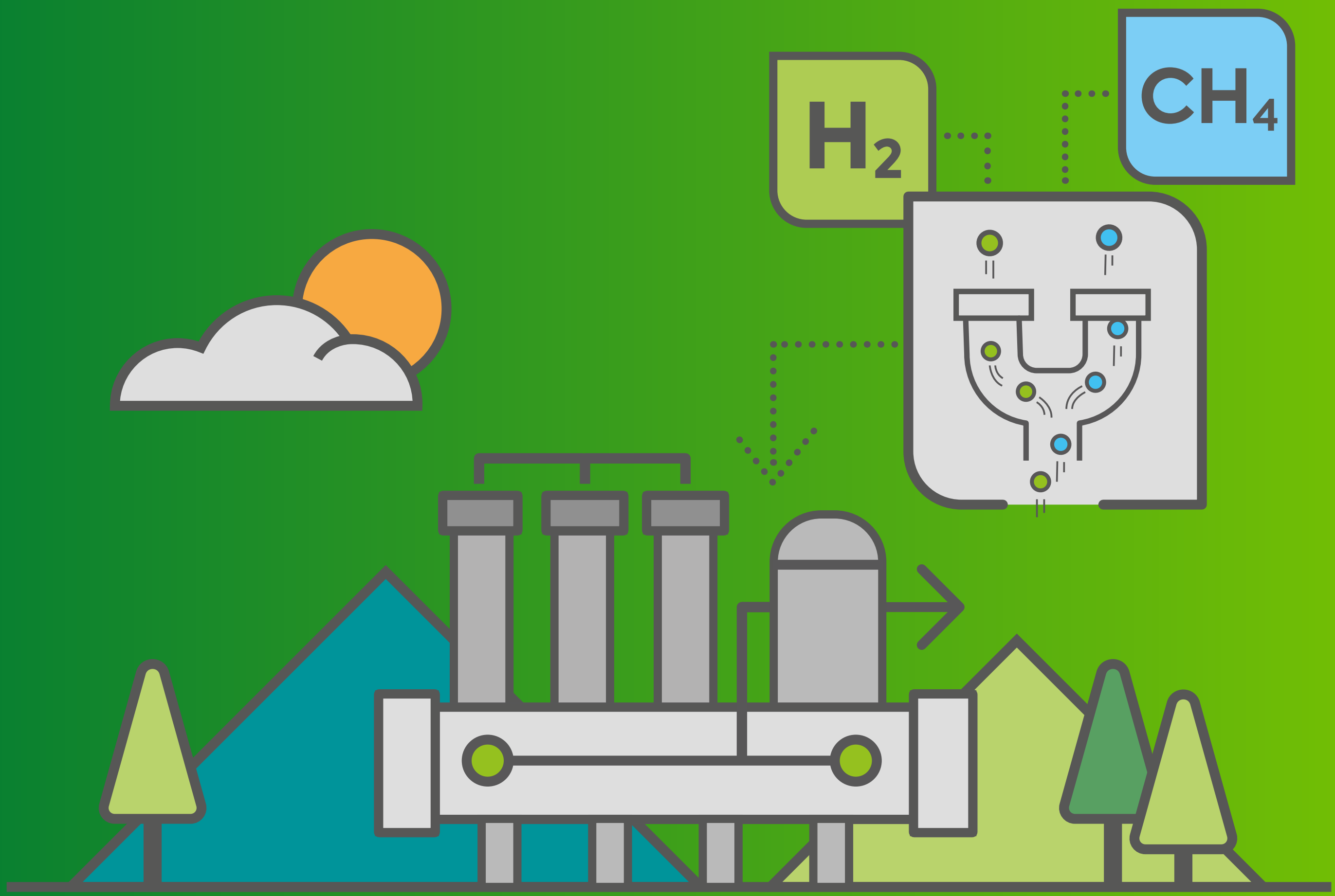
national gas



FutureGrid

Phase 2 Deblending

SIF Beta Project

Progress Report 2025

Contents

Foreword

Corinna Burger
Head of Innovation

At National Gas, we continue to be at the forefront of the UK's energy transition. Our commitment to innovation is central to enabling a cleaner, more resilient energy future, and the FutureGrid programme remains a cornerstone of that ambition.

The UK Government's focus on decarbonisation of power and industry supported by molecules sets a clear and ambitious target: to deliver cheaper, cleaner energy. This vision demands bold action across the energy sector, and National Gas are responding by aligning our innovation portfolio with national priorities. Through initiatives like our clean power focus group, and the development of clean transport and clean industry programmes, we are accelerating the transformation of our network to support a net zero future.

The Strategic Innovation Fund (SIF) continues to be a vital enabler of this work, supporting large-scale demonstration projects that push the boundaries of what's possible. The FutureGrid Deblending project, funded through SIF, is a key part of this journey.

Over the past year, the Deblending project has continued to make great progress. From detailed design and stakeholder engagement to the start of construction, we are now well on the way to demonstrating how we could use our networks to separate hydrogen from blended gases and used to fuel mobility – a critical step in enabling clean transport across the UK.

This year's work has focused on turning concept into reality. The facility is taking shape, and the hydrogen refuelling station has now been commissioned and has successfully refuelled its first vehicles – a major milestone for the project and a key part of our Clean Transport Stakeholder Event in July 2025. Alongside this, we've deepened our engagement with stakeholders across transport, energy and policy, and refined our rollout strategy to reflect the ever-evolving hydrogen landscape and the growing urgency to decarbonise hard-to-electrify sectors.

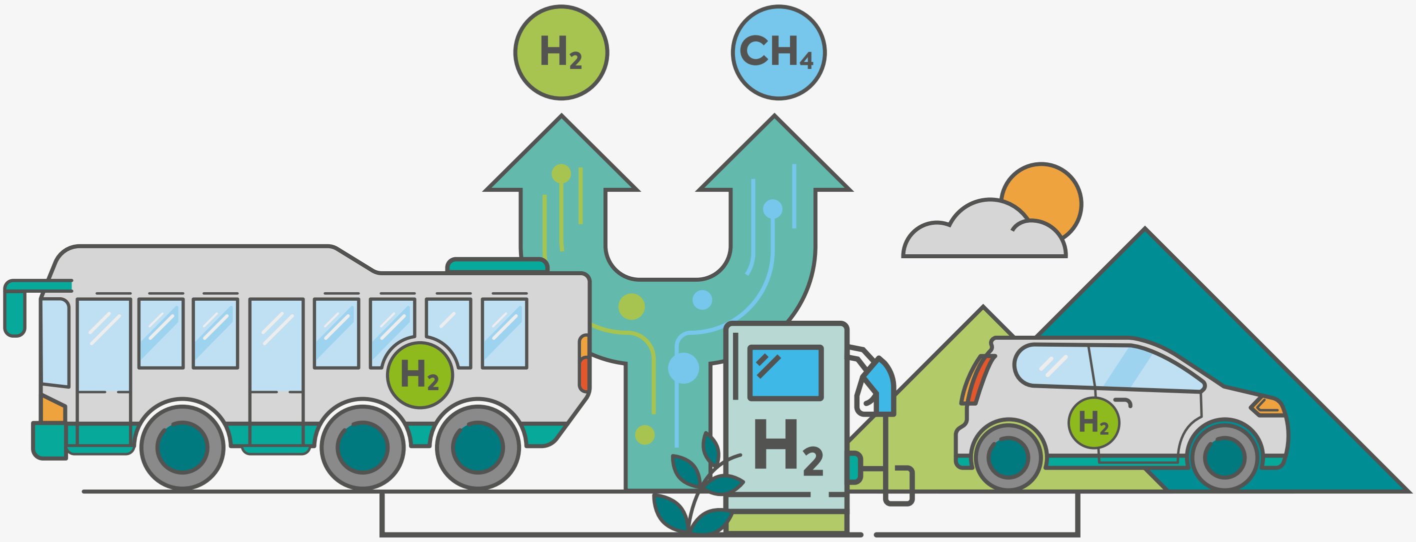
The project is not only showcasing technical innovation but also shaping the future of hydrogen mobility in the UK. By demonstrating the feasibility of deblending and purification technologies at scale, we are laying the groundwork for a more flexible and accessible hydrogen refuelling infrastructure – one that can be deployed across the country and integrated with the National Transmission System.

As we look ahead to commissioning and testing, I'm proud of the team's achievements and excited about what's to come. The project is helping to unlock the potential of hydrogen transport, and the insights generated will be critical in informing future policy, guiding infrastructure investment and supporting the development of a robust hydrogen economy. This work is not just about technology – it's about building the evidence base that will underpin the UK's clean energy future and ensure that our gas infrastructure continues to serve the nation in a low-carbon world.

Corinna with the FutureGrid FCEV.

Section 1

Executive summary



Project description

Project background

National Gas are undertaking an expansive 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 NTS customers such as power stations and industrial customers; however, the proliferation of hydrogen throughout the UK opens up opportunities to provide low-carbon energy to customers not previously served by the NTS. Of these, transport appears to provide particular opportunities due to the difficulty of decarbonising heavy transport such as heavy goods vehicles (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 which the NTS could play. The estimated cost of hydrogen in the scenarios explored showed that 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 provided the perfect location, with the capability to generate flow with natural gas and hydrogen blends, as well as having an experienced workforce and opportunities to demonstrate hydrogen vehicles. This project has been underway since September 2023, and this report details the progress and developments that have been achieved since the project started.

Project scope

The project focuses on three main areas:

Technology concept

This includes the design, fabrication, delivery, installation, commissioning and operation of the Deblending & 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 HRS (Hydrogen Refuelling Station) has been 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 to understand where the technology might be best deployed.

Future rollout and commercialisation

The hydrogen transportation industry remains nascent, and there is significant uncertainty around when and where demand might emerge. This project includes the scope to assess the most likely sectors and locations for future hydrogen demand and to 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.

In addition, the project explores the different commercial and operating models that could be used to govern the future operation of such a facility. This includes a number of different use cases based on the evidence gathered in the first phase of the Rollout Strategy.

Stakeholder engagement

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

FutureGrid Site and technology tour.

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 test 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 was completed in Q4 of 2024. Stage Gate 1 was successfully passed in June 2024. From summer 2024, the rollout strategy has been produced with further stakeholder engagement and discussions leading towards the start of the commercialisation strategy. Following its installation in December 2024, the HRS was commissioned and completed its first vehicle fill in July 2025.

Design

Design of the Deblending & Compression systems, test facility and HRS progressed throughout the first six 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 HRS progressed to plan, and the design of the Deblending & Compression systems was completed, albeit delayed by two months. HAZOPs 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.

In 2024, DNV began supporting Element 2 in the Hazardous Area design of their HRS to ensure it complies with the Spadeadam site standards. This allowed commissioning of the system and the first refuelling to take place in 2025.

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 because the outstanding design actions had little influence on the civils design.

The mechanical, civil and electrical phases of construction have proceeded as planned and are complete pending the installation of the equipment on site. HRS equipment has been delivered and installed on site with the adjoining pipework between HyET's compression system and the refuelling station installed in August 2025.

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, Enpro, to fabricate the full system. Electrochemical Hydrogen Compressor (EHC) fabrication was completed in April 2025, and the unit was shipped to the UK shortly thereafter. The fabrication of the Deblending unit is still ongoing; however, the estimated date of completion has slipped by approximately 4 months due to a challenging investment landscape for green technology developers causing cashflow issues for a key project partner.

Rollout strategy

The rollout strategy was completed and shared, incorporating key stakeholder input gathered during the first phase of the project. The strategy reflected the opportunities highlighted by stakeholders and the likely interaction of hydrogen transport users for aviation, rail, buses and HGVs. This was utilised to guide further stakeholder engagement and discussions leading towards the 2025 Clean Transport event and the beginning of the commercialisation strategy.

The report identified opportunities for hydrogen transport in the UK and the likely timelines this would be developed over. The hydrogen transport landscape is continually shifting, and in 2025, Cenex was engaged to further consider maritime, LGVs, passenger cars and mobile power to fully ensure the hydrogen future is captured.

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. This continued through 2025, with over 100 different stakeholders engaged.

Following on from the success of the 2024 stakeholder event, the FutureGrid team hosted a Clean Transport event in July 2025, to further gather a wide range of stakeholders together, show project progress and to demonstrate some of the advancements in the transport industry with tours of the facility and a showcase of hydrogen equipment. The event hosted workshops, gathering valuable data for the next stage of the project.

Challenges

The project has faced a number of challenges in the previous year.

Novel technology
Low Technology Readiness Level (TRL) projects face significant uncertainty in cost, schedule and performance due to novel designs and limited global examples, especially in hydrogen applications where legislation, safety standards and equipment certification are still evolving. While commissioning and testing more mature technologies like HyET's Electrochemical Compressor pose lower risks, newer systems, such as the deblending equipment, present greater challenges. HyET mitigates these risks through modelling, Factory Acceptance Testing and leveraging experience from previous demonstration projects.

Market uncertainty
Pipeline-based hydrogen refuelling faces significant uncertainty due to evolving regulations, technical complexity and unclear market demand. Projects like deblending rely on regulatory approval, which can delay progress. Even with approvals, the sector's early-stage development, uncertain infrastructure rollout and investment risks make long-term planning and commitment challenging. This lack of certainty means that potential investment into hydrogen transport projects has been slowed.

Industry buy-in
Industry buy-in for hydrogen transport remains difficult, as OEMs and fleet operators prioritise practical solutions over fuel type. Despite growing interest driven by net zero targets, supply chain issues, uncertain demand and slow UK infrastructure rollout – especially compared to Europe – continue to hinder progress. This creates a cycle of hesitation between refuelling station developers and vehicle manufacturers, which can only be broken through coordinated policy, investment and clear market signals.

Change in green investment landscape
Following the change in the US administration, and the halting of funding for many green projects, the investment environment for green technologies has cooled. Recent reductions in net zero funding across the industry have impacted HyET's financial position, delaying payments to ENPRO and construction of the DBU, which sits on the project's critical path. These delays are expected to push the master test plan and final reporting back by approximately four months, with funding timelines still unclear.

Learnings to date

Design dependencies and standard clarification
At the start of the Beta phase, final design submissions were scheduled simultaneously, but interdependencies between partners – such as DNV requiring inputs from HyET and Element 2 – led to delays. Additional revisions to the Hazardous Area Design and coordination with third-party OEMs highlighted the need for early alignment on site standards and clearer communication. These lessons reinforce the importance of upfront planning and coordination to improve efficiency in future multi-partner projects.

Logistical complexities
A discrepancy between consignee details and equipment ownership during the import of HyET's Electrochemical Hydrogen Compressor caused issues with duties and VAT. The ownership contract was amended to resolve the issues, and the lessons will be applied to the upcoming DBU delivery, where avoiding similar delays is critical due to its impact on the project timeline.

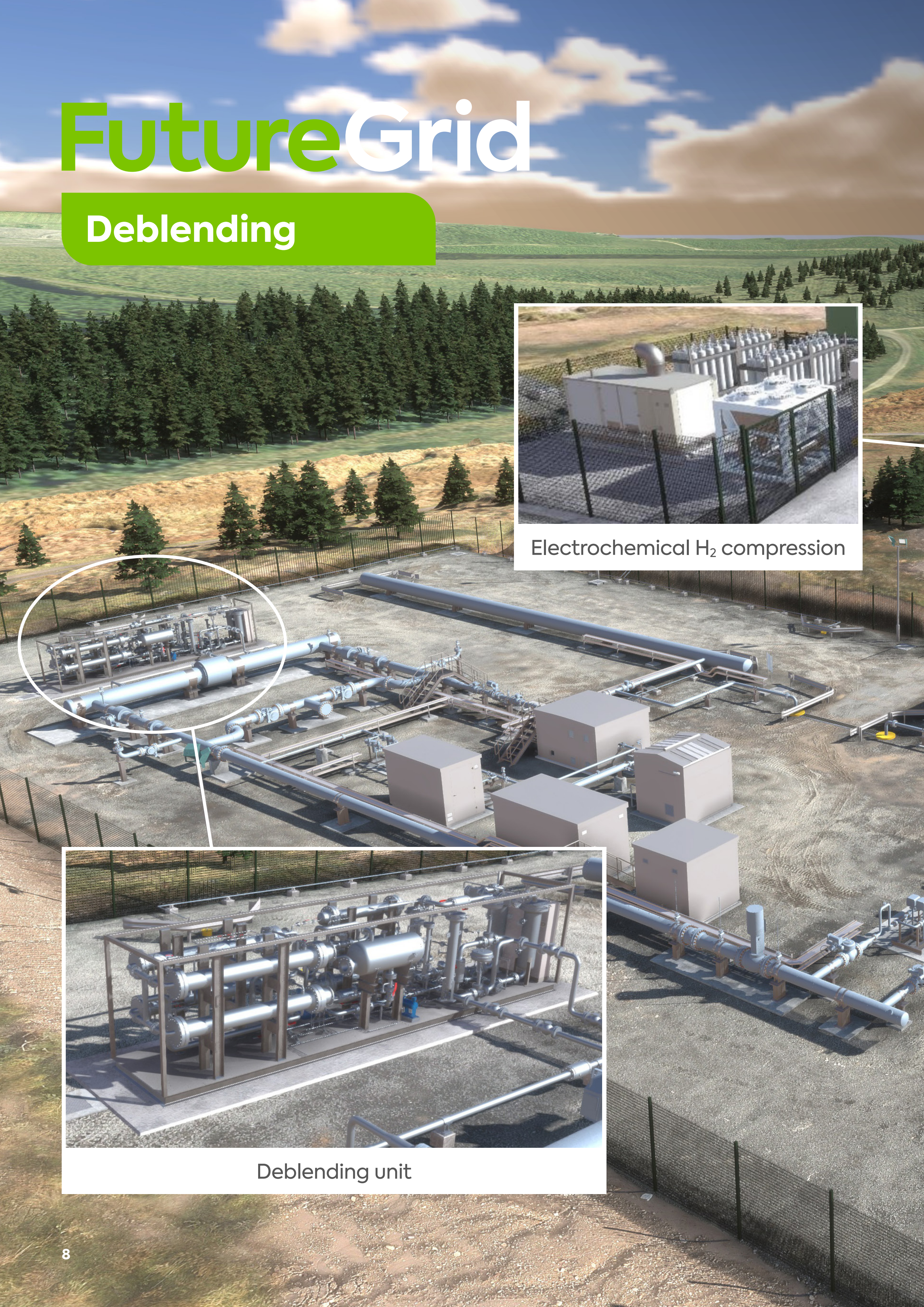
Design interactions
Commissioning of the HRS suffered additional delays due to the interactions between the design scope of three different partners as well as one subcontractor. Certain assumptions had been made around the interfaces between these scopes, but these were not always clarified. Future work involving multiple design partners would benefit from an 'Interface Register' to clarify any uncertainties.

> "From summer 2024, the rollout strategy has been produced with further stakeholder engagement and discussions leading towards the start of the commercialisation strategy."

> "These lessons reinforce the importance of upfront planning and coordination to improve efficiency in future multi-partner projects."

FutureGrid

Deblending



Electrochemical H_2 compression

Deblending unit

Hydrogen refuelling station

Section 2
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, while 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 HGVs 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 uptake 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 network decisions with the transport sector, to ensure delivery of an efficient energy system that 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.

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/or 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 NTS to enable delivery to transport applications, presenting 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. HRSs 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.

Deblending can also be utilised to support National Gas's Project Union ambitions (developing a 100% hydrogen pipeline backbone throughout the UK starting with the connection of industrial clusters). In this scenario, pipeline hydrogen may have a purity of circa 98 mol%, therefore further purification would still be required to service a refuelling station with fuel cell-grade hydrogen. As a result, the technology explored in the FutureGrid Deblending project could be utilised for both blended hydrogen networks as well as for 100% hydrogen networks.


The FutureGrid Test Facility at Spadeadam, Cumbria.

Progress to date

Project delivery

The Deblending for Transport project is split into work packages, each with associated milestones and deliverables. To facilitate project progressing and timekeeping, there are five stage gates laid out by UKRI that National Gas must meet and pass. They are as follows:

- **Stage Gate 1 – design sign-off – passed in April 2024**. Design system, compression and purification system, HRS 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 – passed in December 2024.** Groundworks, civils, mechanical and E&I works complete at Spadeadam. Site ready for the delivery of the HRS and Deblending assets.
- **Stage Gate 3 – deblending equipment installation – March 2026.** FAT and then SAT complete with reports issued for Deblending, Compression, Purification Systems and for the HRS system.
- **Stage Gate 4 – stakeholder demonstration – July 2026.** Testing complete as per test programme. Vehicle refuelling and operation complete as per plan.
- **Stage Gate 5 – project closure – September 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.

In May 2025, it became apparent that one of the major project partners, HyET, has been impacted by cash flow issues due to investments in hydrogen projects being scaled back globally. As a result, HyET have had to pause construction of the Deblending unit (the critical path item for the project). At the time of writing, HyET are looking to secure additional funding and are in advanced talks with a potential investor. It is anticipated that this will result in a critical path delay of approximately four months.

HyET's funding issues have also impacted the release of the Electrochemical Compressor from UK customs which completed fabrication in April 2025. Although not on the critical path, this has resulted in a delay in equipment commissioning. Once HyET receive confirmation of additional funding, the compressor will be released for delivery to Spadeadam.

Demonstration of hydrogen ICE and FCEV vehicles at FutureGrid.

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

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. **M1.3** Periodic report – project on target with budget; however, timetable delays due to partner funding issues. 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 the 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 finalised design for the deblending of the compression and purification system, signed off by DNV and NGT. **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).
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. **D3.3** Mechanical works. **D3.4** Electrical works. **D3.5** Instrumentation works. **D3.6** Completion of all preparatory on-site works.

Work Package	Milestones	Deliverables
Work Package 4 Fabrication of deblending 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. **M4.1c** Start of fabrication of skid frames deblending system and EC&P. **M4.2** Placement of HRS order. **M4.4** Refuelling station delivered to site.	**D4.1** Order of long-lead items for Electrochemical Compressor and deblending equipment. **D4.3** Construction of electrochemical compression equipment. **D4.5** Factory acceptance tests of electrochemical compression and purification equipment. **D4.8** Order of long-lead items for hydrogen refuelling station. **D4.9** Procurement/fabrication of all HRS equipment. **D4.10** Hydrogen refuelling station equipment delivered to site.
Work Package 5 Facility installation and commission.	**M5.2** Installation of HRS complete. **M5.4** Vehicles delivered on site. **M5.5a** Commencement of HRS area commissioning.	**D5.4** HRS installation. **D5.5A** HRS commissioning part 1.
Work Package 6 Equipment operation and monitoring.	Not started.	Not started.
Work Package 7 Future rollout and stakeholder engagement.	**M7.1** Commencement of modelling activities and completion of stakeholder engagement plan. **M7.2** Completion of future rollout mapping and preparation of stakeholder engagement materials. **M7.3** Preparation for stakeholder engagement completed and report on first phase stakeholder engagement learnings completed.	**D7.1** Stakeholder engagement plan developed. **D7.2** Report on stakeholder engagement. **D7.3** Report on future rollout 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 as the key driver for demand of the project. 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, show and tell events as well as LinkedIn posts, webinars, and conference exhibitions. This continuous and ongoing engagement ensures that we are planning for the future and understanding what our customers' and stakeholders' requirements are and how our network can meet their needs and challenges. Across the entire supply chain, we engage with a wide range of stakeholders, including hydrogen producers, refuelling operators, vehicle producers, fleet operators, regulators and international networks. The image below shows many of the stakeholders that have been actively engaged, including through bilateral discussions, attending the stakeholder events and/or taking part in stakeholder surveys.

Project partners

Cadent Your Gas Network
DNV
HyET Hydrogen
ERM
SGN
Northern Gas Networks
Wales&West Utilities

TSOs

apa
fluxys
GRTgaz
enagas
snam
Gas Networks Ireland

Automotive

JCB
Hyundai
BMW
IVe
Toyota
ULEMCo
Honda
Liebherr
Flannery
Vauxhall
Electra
First Hydrogen
Eddie Stobart
Stellantis
FutureZeroEmission
HVS
plantforce
Ford

Deblending

H2 SITE
OSMOSES
HITACHI
H_2GAR WG3
SKYRE

Refuelling and producers

HyHAUL
Protium
H2 energy
Intelligent Energy
aegis
Ryze Hydrogen
GeoPura
Fuel Cell Systems
Commercial Fuel Solutions
Future Fuels CRC
exolum
Air Products

Aviation and rail

UK Civil Aviation Authority
ZeroAvia
easyJet
Loganair Scotland's Airline
University of Birmingham | BCRRE
HydroFLEX
Cranfield University
Network Rail
Vanguard
The Hydrogen Boat Centre

Others

Department for Energy Security & Net Zero
Green Hydrogen Catapult
UK Research and Innovation
Net Zero Teesside
defra
Ministry of Defence
Advanced Propulsion Centre UK
Roland Berger
cenex
TÜV SÜD
East Coast Hydrogen

Our key engagement involves a wide range of activities that allow the sharing of key project aims and are timed in alignment with key project deliverables, enabling 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
A1	**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
A2	**In-person HyNTS launch event** • Update on project progress to date • Share of high-level findings from future rollout mapping • Workshops with each of the stakeholder engagement groups to discuss the challenges faced in the hydrogen transportation and refuelling industry • FutureGrid and Deblending site visit	04/24	In-person (Spadeadam)
A3	**Project progress webinar** Following publishing of the progress report – an open session to disseminate project progress, plans and an opportunity to ask questions.	09/24	Online
A4	**Clean transport forum** • Update on project progress to date • Disseminate findings from rollout mapping • Workshops with each of the stakeholder engagement groups • Deblending site visit • Vehicle and equipment demonstration	07/25	In Person (Spadeadam)
A5	**Progress webinar** • Update on project progress and test plan	09/25	Online
A6	**Commercialisation strategy brief** Share findings from final report summary, which is due to be published in April 2026.	02/26	Online
A7	**HyNTS project findings** Dissemination of final report and test findings.	07/26	Online
A8	**In-person closure deblending event** A closure event for stakeholders: • Project results • Next steps • Workshops with engagement groups • Visit to Deblending site	07/26	In person (Spadeadam)

Further information on the industry engagement activities can be found in Sections 3, 8 and 11.

Challenges

Challenge 1 – Novel technology

A major challenge of low TRL projects is the degree of uncertainty and a 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 certifying 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.

A lower risk is posed by commissioning and testing HyET's Electrochemical Compressor due to this equipment being more commercially mature and HyET having greater experience testing this equipment. The Deblending equipment, being of a more novel design for the HyNTS Deblending for Transport project, does pose a greater risk in terms of commissioning and testing success. HyET conduct modelling and Factory Acceptance Tests and utilise their experience from other demonstration projects to mitigate against these risks.

Challenge 2 – Uncertainty

The viability of pipeline-served hydrogen refuelling remains highly uncertain due to several interdependent factors. The success of projects such as deblending, purification, and compression hinges on regulatory approval for hydrogen integration into the gas networks. This process involves a complex and evolving landscape of regulatory changes, government decisions, and documentation updates, all of which contribute to uncertainty in project timelines.

Even if regulatory pathways are approved, the hydrogen transport sector remains nascent, with significant ambiguity around future demand, commercial viability, and risk. Stakeholder feedback consistently highlights key challenges: lack of clarity on government and regulatory support, uncertain infrastructure rollout timelines, and the unpredictable future cost of hydrogen. These factors collectively make long-term investment decisions in pipeline-based hydrogen refuelling infrastructure particularly difficult at this stage.

Challenge 3 – Industry buy-in

Securing industry buy-in for hydrogen transport remains a significant challenge, particularly among OEMs and fleet operators. While some stakeholders are enthusiastic about hydrogen, many are primarily focused on finding practical, reliable solutions – regardless of the fuel type. The push for net zero and the UK's 2030 targets have increased interest, but supply chain constraints for both vehicles and hydrogen, coupled with uncertain demand, continue to hinder progress.

Long asset lifecycles in sectors like aviation and maritime mean full hydrogen adoption is unlikely within the next two decades. Additionally, the UK has seen slower growth in hydrogen refuelling infrastructure compared to Europe, leading some vehicle manufacturers – such as BMW and Vauxhall/Stellantis – to deprioritise the UK market for hydrogen fuel-cell vehicles.

This lack of infrastructure and domestic hydrogen production creates a feedback loop of risk and hesitation. Refuelling station developers face uncertainty: investing in equipment without guaranteed demand, while OEMs hesitate to commit without a robust refuelling network. Breaking this cycle will require coordinated policy, investment, and clear market signals.

> "Hydrogen 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/or maritime transport).

Learnings

Learning 1 – Design dependencies and design standard clarification

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 HyET and Element 2 in order to inform their own design. This resulted in the deadline for DNV completing their design being pushed back by two months. This learning highlighted the importance of understanding design dependencies at the start of the project in order to make the critical path clearer and reduce the likelihood of project delays due to engineering design.

Significant delays were experienced in commissioning the HRS as a result of further HRS Hazardous Area Design work needing to be carried out by Element 2 following DNV's review of their original design. An understanding of the design standards that all project partners must use for the Spadeadam Site prior to any design work would have been beneficial in ensuring that work did not need to be revised. Also, verifying the design acceptance criteria for the Spadeadam site early on would have ensured that all design elements were considered. Element 2 also utilised subcontractors, which created inefficiencies in communication. Timely interactions between DNV and these subcontractors would help to improve efficiencies in receiving Request for Information responses.

The learnings mentioned above can help to facilitate efficient progress in the event of future multi-partner projects of a similar nature.

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. The equipment included:

- 2x water chillers with associated pipework and storage tanks
- Buffer tank and pump for deionised water system
- Vent stacks
- Instrument air
- Nitrogen for purging the system
- Hydrogen for start-up

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.

Learning 4 – Logistical complexities

A discrepancy between consignee details on Electrochemical Hydrogen Compressor (EHC) paperwork and equipment ownership has presented challenges in paying import duties and reclaiming VAT for the equipment when delivered to the UK. ENPRO's paperwork (HyET's third-party manufacturer) had stated DNV as the consignee; however, due to National Gas ownership of HyET's equipment, this would prevent DNV from reclaiming VAT. Contract transfer of ownership was amended to allow National Gas to pay import duties/reclaim VAT.

The lessons learned from the EHC process will be utilised for DBU delivery to prevent delays as a result of equipment import. Although the delays to the EHC did not impact the project critical path, delays to the DBU will; therefore, it's imperative that these lessons learned are utilised when importing the DBU equipment.

Learning 5 – Global net zero investment can impact OEM funding

Funding for net zero is often cyclical, and recent scaling back of net zero funding across industry has had knock-on effects to project partner (HyET) funding. HyET are looking to obtain additional funding; however, timelines for this are still not clear. This has had a knock-on effect on ENPRO payment and DBU construction timelines. With DBU construction on the critical path, delays will cascade on to the project master test plan and final reporting. At present, this is estimated to be a delay of around four months.

Section 3

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 with informing and showcasing the upcoming demand. ERM have produced a future rollout mapping report and in 2025 will present a further report detailing more specific locations and a commercialisation strategy.

As part of the mapping, there has been modelling work and stakeholder engagement. This has been in the form of in-person events, a survey, multiple 121s and modelling work conducted by ERM.

2024 stakeholder event

The 2024 stakeholder event was held at DNV Spadeadam on 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 including on the HyHaul project, the Bradford project and also from Aegis Energy on how they


Exploring dual-fuel NRMM at the FutureGrid Stakeholder Day 2025.

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 conducted 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.

2025 stakeholder event

The Clean Transport: Hydrogen Infrastructure for the Future event was held at DNV Spadeadam on 9 July 2025, building on the success of the 2024 event. This year's gathering benefited from significant project progress and an expanded stakeholder network, enabling more targeted workshops and a live demonstration of the FutureGrid Hydrogen Refuelling Facility.

The event welcomed over 70 stakeholders, with additional interest from those unable to attend. Attendees received updates on project milestones, rollout mapping, and commercialisation strategy, followed by industry insights from the Road Haulage Association (RHA), ULEMCo's Element 1 project, and Fuel Cell Systems' work on hydrogen refuelling. The afternoon featured two interactive streams: one group toured the FutureGrid site, viewing the deblending equipment and a range of hydrogen-powered vehicles – including dual-fuel excavators, a Hilux, a Mirai FCEV, a refrigerated lorry, a drone, and a mobile refuelling unit – with live refuelling demonstrations. The other group participated in focused workshops addressing sector-specific challenges. Groups rotated to ensure all attendees had the opportunity to engage with both the facility and the discussions. Workshop outcomes are detailed in the following section.

Workshop findings

The stakeholder workshops held during the 2025 Clean Transport Forum provided valuable insights into the challenges and opportunities facing hydrogen adoption across multiple sectors. Discussions highlighted both systemic barriers and practical recommendations for accelerating deployment:

- **Public sector:** Participants raised concerns about fragmented national strategy, unsuitable funding models, and the lack of representation for Northern Ireland. Opportunities for improvement include empowering local authorities, enhancing funding flexibility, and leveraging hydrogen's circular economy potential.
- **OEMs and equipment manufacturers:** Deployment is being slowed by policy delays and risk aversion. Stakeholders called for long-term projects, clearer market signals, and improved public education to counter misinformation and build confidence.
- **Road transport:** While hydrogen technology is considered mature, deployment is hindered by cost and regulatory uncertainty. Recommendations included setting realistic short-term targets and developing hydrogen valleys – clusters of refuelling infrastructure – to stimulate uptake.

- **Other transport sectors:**
  - Aviation: Faces supply uncertainty and unrealistic timelines, making planning difficult.
  - Non-Road Mobile Machinery (NRMM): Transition depends heavily on hire companies, with end users reluctant to accept disruption or increased costs.
  - Cross-cutting challenge: Workforce training and upskilling were identified as essential to scaling hydrogen adoption effectively.
- **Refuelling infrastructure:** Grid limitations and commercial risk are major barriers. Stakeholders proposed a target of 50 strategic hydrogen refuelling stations by 2030 ("50 in 5"), supported by modular units and proximity to the NTS. However, regulatory classification of hydrogen as hazardous and the lack of right-hand drive trucks for trials remain significant challenges.

The findings and discussions from the stakeholder workshops will directly inform the development of the hydrogen commercialisation strategy, ensuring it reflects real-world challenges and opportunities across sectors. By identifying key stakeholders – such as OEMs, fleet operators, public sector bodies, and infrastructure developers – the strategy can be shaped to address practical deployment needs, policy gaps, and market signals, helping to build a robust, inclusive roadmap for hydrogen transport in the UK.

Modelling work

ERM has submitted a future rollout mapping report as part of the work package 7 deliverable. Their approach for the modelling emphasises the use of clusters, the potential, and the 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:

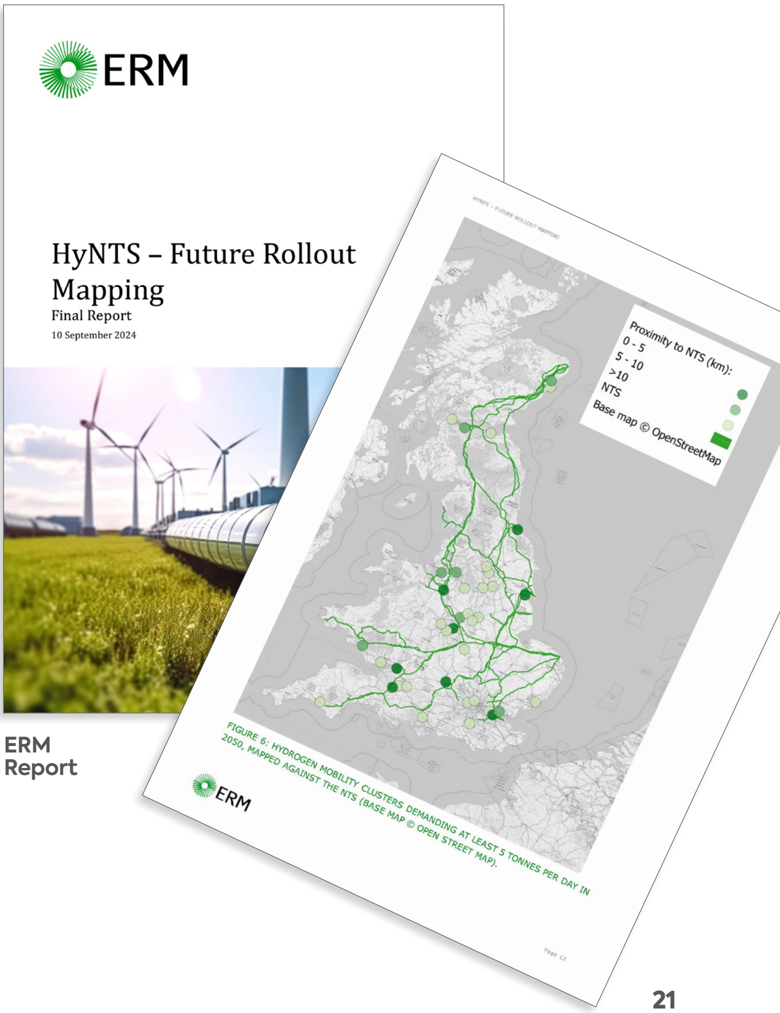
1. Modelling the viable uptake of hydrogen transportation.
2. Input from stakeholder engagement including the event and the survey.
3. Mapping hydrogen demand against the NTS.
4. Site shortlisting.

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 centralized hub, both from either a blended network (of up to 20% hydrogen in natural gas) and of a nominally 100% hydrogen network (where purification will still be required for fuel cell quality hydrogen).

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, which increases the reliability of the hydrogen supply, which has been shown to be one of the key risks identified by the industry currently.

The outputs of the rollout mapping were shared across the project's stakeholders and through engagements and events such as the Cenex Expos in 2024/2025 and various hydrogen conferences and discussions.

The ERM report focused on four main transport modes: aviation, rail, HGVs and buses and coaches. To ensure a full hydrogen transport landscape is captured, Cenex have been contracted to consider Light Goods Vehicles (LGVs), cars, maritime, Non-Road Mobile Machinery (NRMM), and mobile power (such as generators). Although these markets are likely to be small, their inclusion is essential for building a complete picture of hydrogen demand and ensuring stakeholder plans are accurately reflected. The findings from the Cenex report will be inputted alongside the initial rollout strategy and will play a key role in shaping the broader commercialisation strategy.



ERM Report

Knowledge dissemination

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

Conferences and engagement

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

Table 3: Dissemination activities

Date	Event	Overview
18 Sep 24	European Transport Conference	Attendance at ETC 2024, with networking and interactions
24-25 Sep 24	FutureGrid Tour	Visit from GasUnie and the IGEM young persons group
3 Oct 24	Ignite Labs Tyseley Visit	Visit to Tyseley Energy Park as part of Innovate UK's hydrogen programme
25 Oct 24	FutureGrid Tour	IGEM and IChemE visit to Spadeadam
29-30 Oct 24	EIS	National Gas exhibited at EIS, sharing the work undertaken during FutureGrid Phase 2 and the wider innovation team
12-14 Nov 24	FutureGrid site visits	Visit and tours from Ofgem, DESNZ, H2GAR, Pipeline Industry Guild and NGT IT team
18-19 Nov 24	HyET Visit	Visit and tour to HyET facilities with DNV and UKRI
21 Nov 24	Transport and Energy Forum – ZEMO	Conference focusing on the challenges of decarbonising transport for local councils
10 Dec 24	HIL Transport Conference	Panel discussion on scalability and challenges for hydrogen refuelling
29 Jan 25	UK H2 Mobility Working Group	Attendance of working group and informed about upcoming July stakeholder event
12 Feb 25	FutureGrid Tour	Procurement Team visit to Spadeadam
3 March 25	Bright Spark Podcast	UKRI podcast led by Beth Foster on the FutureGrid programme
4 March 25	SIF community forum	Group session to share best practice among SIF project partners
4-5 March 25	Engineering a Hydrogen Economy Conference	Opportunity to hear presentations on challenges across industry and how they are being overcome
6 March 25	UKRI – Zero Emission HGV and Infrastructure Demonstrator Programme Summit	An in-depth overview of the progress achieved across the programme's zero-emission projects. Opportunity to engage with key stakeholders to exchange insights and learnings from the work completed to date
13 March 25	FutureGrid Visit	NESO executive visit and tour
16 April 25	FutureGrid Tour	Tour of facility and introduction to NG strategies

Date	Event	Overview
29-30 April 25	Innovation Zero	Two-day expo at Olympia London, sharing information on FutureGrid and National Gas
30 April 25	H2 Mobility meeting	Attendance and presentation within meeting in London
30 April 25	Commercial Vehicle Show	Attended conference at NEC, sharing information on FutureGrid
16 May 25	HyHaul Meeting	Discussion around the HyHaul progress and integration with deblending rollout strategy
16 May 25	Hydrogen Boat Centre Meeting	Dissemination of Deblending project info and learnings on advancement in marine technologies
22 May 25	Hydrogen UK Transport Working Group Meet	Short presentation on the Deblending project and informed on July event
28 May 25	Cranfield University Meeting	Interaction with Cranfield University, tour of the hydrogen facilities and discussion on the work we are both doing, investigating collaboration
2 June 25	Deblending Newsletter	Newsletter sent out to 78 stakeholders
11 June 2025	Enagas Hydrogen Conference Meeting	Panel discussion covering blending and safety and discussion of FutureGrid facility
25 June 2025	FutureGrid Tour	Host of Geopura, with discussion on potential collaborations and green hydrogen production
8 July 2025	FutureGrid Tour	Visit from NG Innovation team to inform and learn about Phase 1 and Phase 2
9 July 2025	Clean Transport Stakeholder Event	Attendance of 70+ stakeholders with workshops, tours and demonstration for the Deblending project
16 July 2025	AVL Hydrogen Tech Day	Attendance at tech day for networking and interaction building
17 July 2025	HyPPO Swansea	Attendance for landscape scoping and networking
23 July 2025	Clean Transport Feedback	Feedback and workshop results sent out to all stakeholders
8 August 2025	HEA Transport Event	Attendance for networking and knowledge dissemination
12 August 2025	FutureGrid Tour	Visit from ESP Team to FutureGrid
13 August 2025	FutureGrid Tour	Visit from NGT board to FutureGrid
20 August 2025	Collection of Hydrogen Van for use on facility	Demonstration of Hydrogen Van and refuelling at FutureGrid
3-4 September 2025	Cenex 2025	Presentation and panel slot on the Energy Systems stage

There are further planned visits and conferences including:

- Progress webinar in September.
- Innovation summit Liverpool 2025 December.
- Many more FutureGrid webinars and tours.

Newsletter, webinars and steering groups

In order to keep stakeholders engaged and up to date on the Deblending project a newsletter has been disseminated approximately every four months. The first newsletter was disseminated in July 2024 with positive feedback from the stakeholders. A screenshot of it is shown on the right.

The below topics show the items covered in each newsletter along with the planned agenda items for the next year of newsletters.

Table 4: Newsletter topics

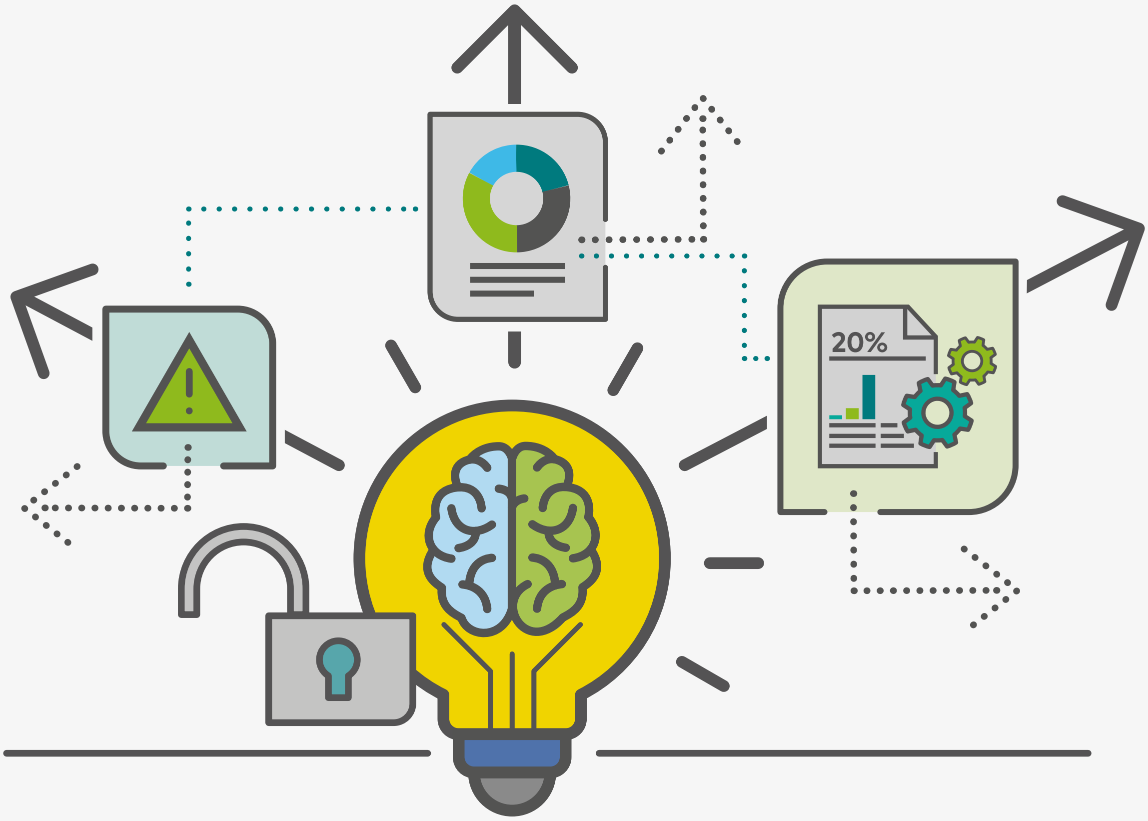
Timeline	Agenda items
July 2024	Build update / Survey results
October 2024	Build update / Academic vs commercial conference thoughts
January 2025	Build update / Toyota Mirai arrival at FutureGrid / Spotlight on aviation
May 2025	Build update / Clean transport event / Limitations of road transport electrification
August 2025	Build update / DBU arrival / Event and feedback
October 2025	Build update / Conference feedback
January 2026	Build update / Commercialisation strategy / Start of testing
April 2026	Testing progress / Strategy feedback
July 2026	Project report and dissemination / Closure event

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 steering group is made up of the project partners with a view to enabling focused and constructive discussions. This group combines the expertise of the partners for each part of the project and brings in knowledge from external stakeholder engagement from each partner.

The engagement in these meetings allows National Gas to discuss project progress, ideas, dissemination and the rollout/commercialisation strategies. The agenda and workshop prompt for the 2025 Clean Transport Event were developed through these meetings with key engagement planned for the event.

Section 4

Intellectual property (IP) rights generation



The results and research produced from this project are 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

In Q2 2024, detailed design was completed by HyET, Element 2 and DNV. HyET's focus was on the design of the Deblending & Purification system, and Element 2's design on the HRS, with DNV's design focusing on the interface between the existing FutureGrid facility, HyET's Deblending & Purification system and Element 2's HRS. DNV have completed site preparatory works at Spadeadam ready for the facility to receive HyET's assets. Element 2 have commissioned the HRS for standalone refuelling operation (no tie-in to HyET's equipment required) with final pipework installation planned for completion in September 2025 to tie into HyET's EHC. HyET have completed construction of the EHC, which has arrived in the UK. At the time of writing, the equipment is awaiting release from customs before it can be transported to, and installed at, Spadeadam. The Deblending & Purification system fabrication is ongoing.

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, which are currently being worked through to aid system design in preparation for system testing. Civil work for the Deblending & Purification system and HRS has been completed at DNV Spadeadam, with the commencement of electrical installation work.

Knowledge dissemination at industry conferences.

The maximum operating pressure of the FutureGrid facility has also been verified for use with hydrogen; learnings from this process will be valuable if and 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 of 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.

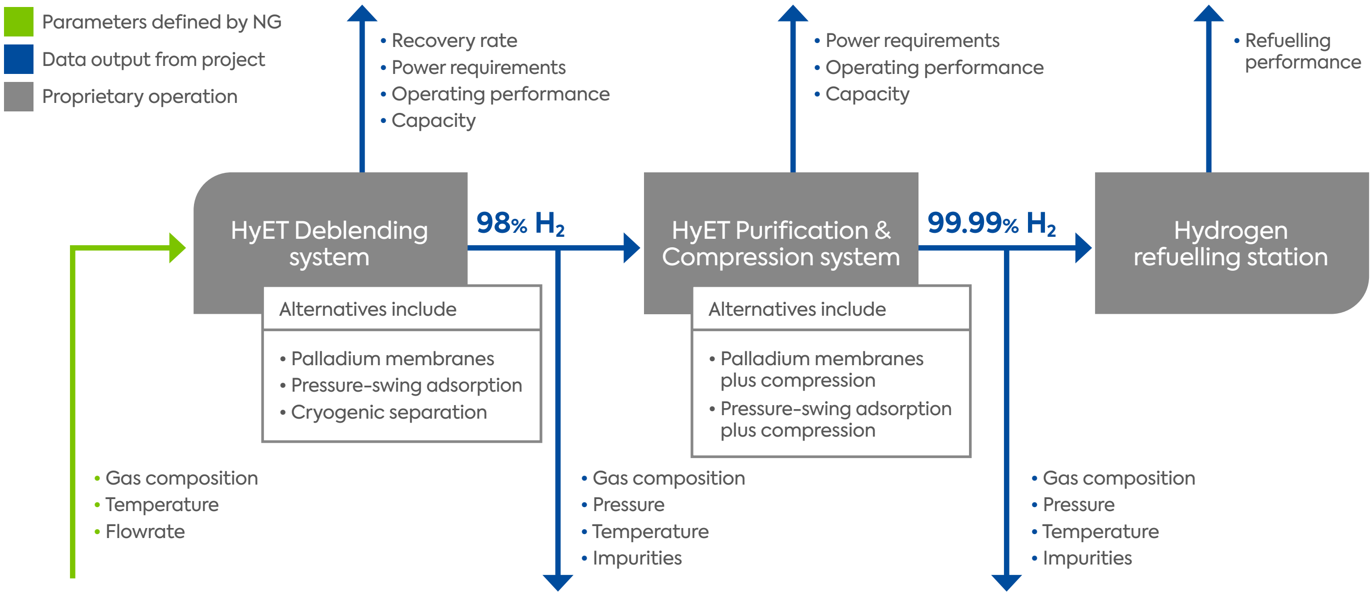
Due to the novel nature of the concept, there is not a well-established market for equipment to economically separate hydrogen from natural gas at high purity and pressure. Processes for each of these steps do exist; however, they are often undertaken at large scale within the chemical industry and therefore have often not been tested at smaller scale for 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, H2Site, a Spanish producer of palladium membrane systems, Skyre, another electrochemical purification technology provider as well as Honeywell, a producer of traditional pressure-swing and temperature-swing adsorption technology.

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) as well as the equipment footprint. 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.

Further work

Following completion of the FutureGrid site preparatory works, HAZOP actions, Deblending & Purification system, Factory Acceptance Tests and system installation, there will be a period of full system commissioning and testing. A number of 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, are shown in the following diagram on page 27 (Figure 1).

Figure 1: Key parameters and data output



National Gas are committed to enabling the industry to advance without prejudice towards partners, engaging with alternative OEMs and international TSOs. Through stakeholder engagement, OEMs are being engaged about the ongoing blending, deblending and Project Union development. The Deblending & Purification technology was relatively unknown and, as such, received less focus in the 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 provide the basis of design for future standardised designs and compare against alternative/ developing systems. Work has already begun with ERM to start developing the commercial demonstration for Deblending & Purification. Engagement with HyET, and utilisation of the test plan findings, will be imperative for this work.

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 ERM mapping, combined with the demand estimations from the Cenex report, explores the needs of each potential market segment and the ways in which a grid-supplied hydrogen supply could enable new decarbonised transport applications.

Together, this covers cars, buses, coaches, trains, aviation, HGVs, LGVs, maritime, NRMM and mobile power generation. Through mapping, it is possible to identify locations where the NTS could supply hydrogen to refuelling stations.. 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 up 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 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 during the testing phase, the next step will be to develop a concept paper for a commercial demonstration to supply real customers with NTS-supplied hydrogen. This will utilise previous work done, including 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 5

Data access details

Data access

Details on network or consumption data arising in the course of an NIC or 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: https://smarter.energynetworks.org

Link to the FEN portal: https://portal.futureenergynetworks.org.uk/

In addition to this, as part of the communication and engagement plan, NGT has held webinars and in-person events for the purpose of sharing knowledge throughout the duration of the project. We plan to continue these as the project continues.

These webinars and events will be open to all interested parties and shared through the newsletters and through LinkedIn. Our newsletters share the availability of our reports and webinars, providing opportunities for stakeholders and interested parties to request copies and further information.

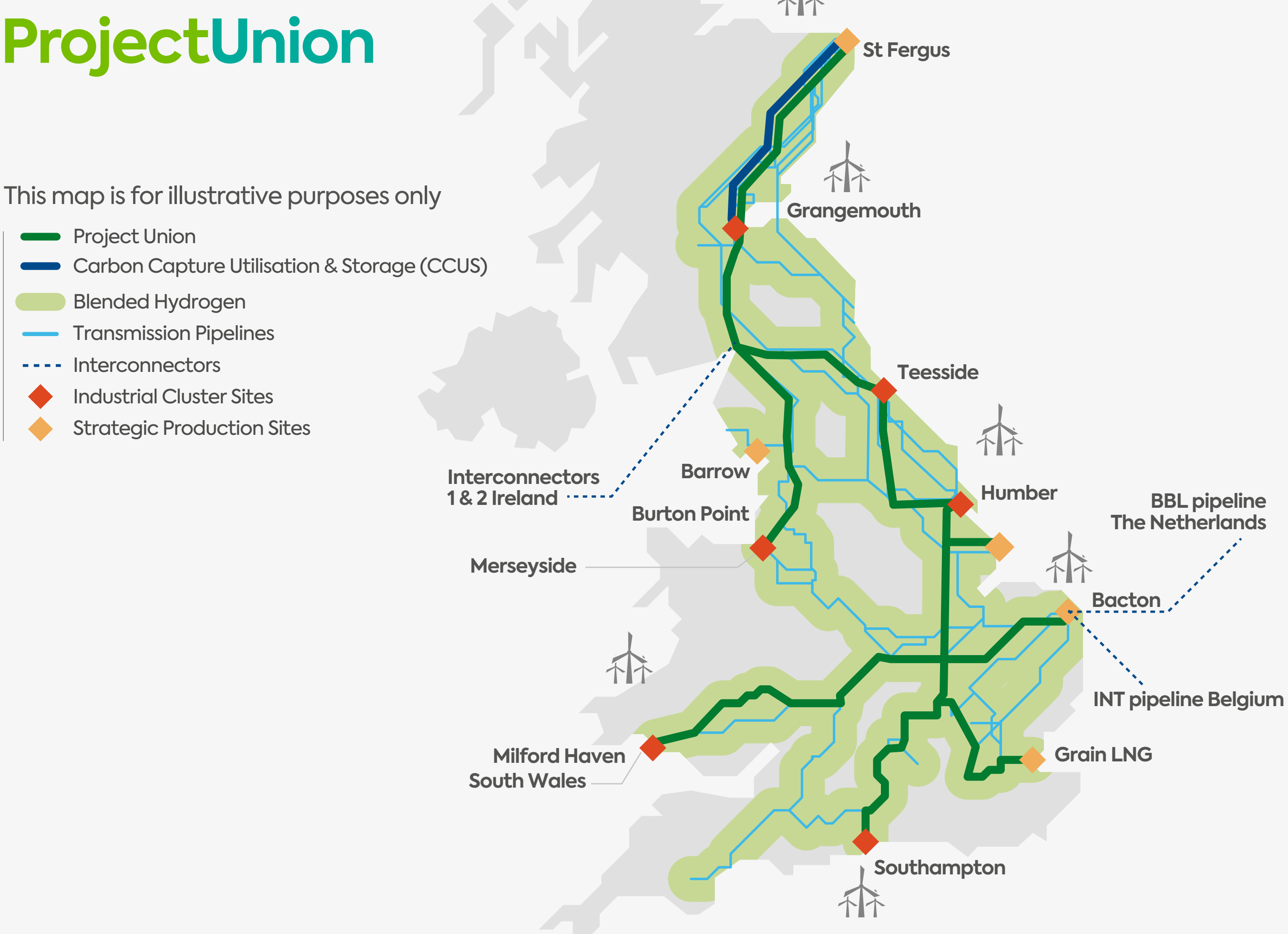
To assist in the sharing of information, we have also set up a shared email box in which any queries about the project can be addressed. The email is: futuregrid@nationalgas.com.

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

Section 6

Route to market / business as usual

Figure 2: The future of the NTS under the '3 molecule approach'



The future of the gas network

National Gas Transmission own and operate the 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 three parallel streams: strategic carbon capture from blue hydrogen production and industrial processes, 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 decarbonising our network, we see opportunities for Carbon Capture Utilisation and Storage (CCUS), particularly in Scotland as part of the SCO2TConnect project shown in dark blue on the diagram above. This is alongside a significant opportunity to build a hydrogen backbone connecting industrial clusters across the UK along with the introduction of blending up to 100% across the remainder of the network. As illustrated in the diagram above, the hydrogen backbone known as Project Union will consist of approximately2,500 km of hydrogen pipeline (as represented by the dark green line), which will be built in stages connecting the industrial clusters starting with East Coast Hydrogen between Teesside and Humber. In parallel to this, we expect hydrogen blends to be introduced to the network, with these increasing over the coming years, eventually achieving 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 ensure safe operation. Already underway is the development of this evidence for 5% and 20% hydrogen blend evidence supporting the development of hydrogen production and injection into the NTS. Ultimately, this will be followed by 100% hydrogen evidence to enable full decarbonisation. This must be parallel to the relevant policy updates that will ultimately allow rollout and construction across the network. In July 2025, DESNZ opened a consultation seeking stakeholder views on the potential strategic and economic value of blending hydrogen into the NTS.

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 a 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 the diagram below (Figure 3), 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 in turn requires the relevant policy changes to enable hydrogen and enable Project Union and hydrogen blends across our network.

There are assets that are not included in the FutureGrid facility which will likewise require evidence gathering on their operations. We will continue to close out these gaps through other innovation projects in our hydrogen safety case portfolio, which start to build the foundational technical evidence and any updates to standards and procedures, then 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 provide a vital role in full-scale demonstration of this new technology, with the 100% hydrogen metering project serving as an example of this.

Figure 3: Developing the technical evidence to transition the network

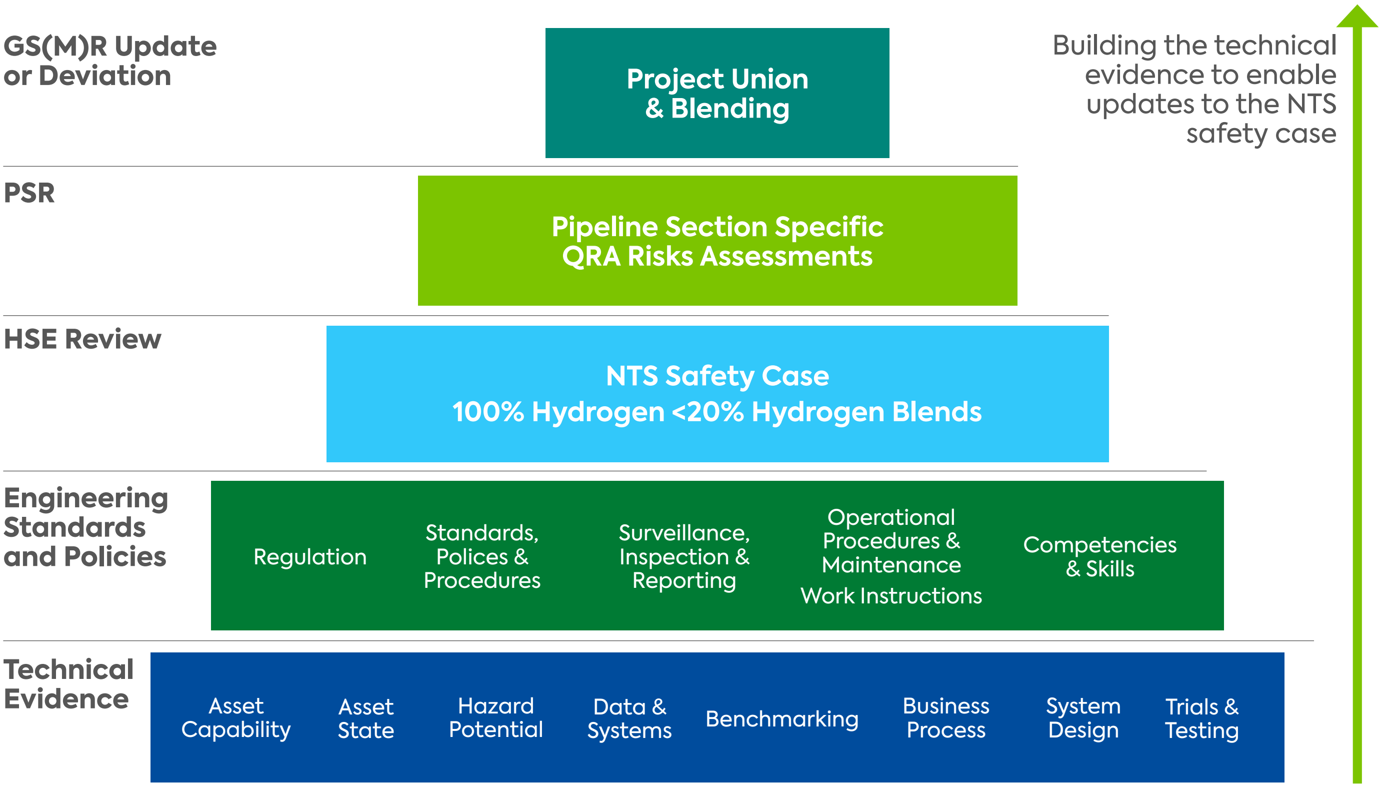
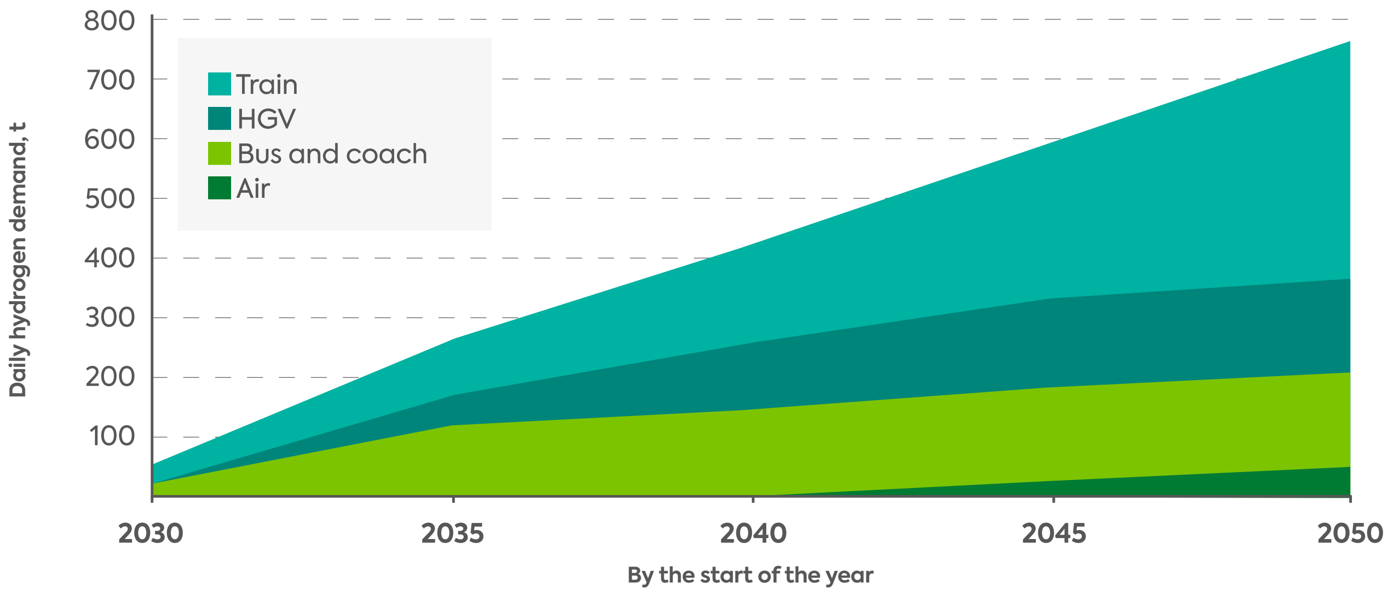


Figure 4: Expected daily hydrogen demand for selected transport modes



Blending

The demands for hydrogen refuelling need to align with the production and timelines set through blending and Project Union. The graph above (Figure 4), produced by ERM, provides an estimation of daily demand of hydrogen for the four heaviest-use transport modes between 2030 and 2050 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. Especially while the hydrogen transport landscape is so uncertain, continuous stakeholder engagement and policy/regulation recognition to understand the developing demand will be crucial in mapping out and predicting these locations.

Technology development

FutureGrid Deblending concept development

As discussed in Section 4 '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 at the scales to be tested during the project. 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 OEMs 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/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, H2Site, a Spanish producer of palladium membrane systems, Skyre, another electrochemical purification technology provider, and Honeywell, a producer of traditional pressure-swing and temperature-swing adsorption technology.

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 installations and compare against alternative and developing systems.

Market landscape

A number of Deblending technologies exist in addition to electrochemical hydrogen purification 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/disadvantages is provided in this section.

Pressure swing adsorption

- Process description: A 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, and 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 the gas back to the desired operating pressure.

Temperature swing adsorption

- Process description: A 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 depending 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) and 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, while some inorganic membranes are currently expensive and only available on a 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 7

Policy, regulatory and standard barriers

Technical uncertainties

Since the demonstration of deblending and refuelling at FutureGrid is out with the transmission system, it is not required to meet the same requirements and policies as the transmission system. However, it is expected that where possible, the same standards will be adhered to (for example, adherence to Pressure Systems Safety Regulations 2000, Pipelines Safety Regulations 1996, The Dangerous Substances and Explosive Atmospheres Regulations 2002 etc). 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 whether they would present a challenge to adhere to 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 also to both industry and stakeholders of the project.

As the hydrogen industry is an area of active research, with more frequent developments in knowledge and understanding compared to more mature industries, 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) has 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) having recently received a new revision. 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 HRSs. ISO, CEN (European Committee for Standardization), BS (British Standards), SAE (Society of Automotive Engineers) and the British Compressed Gases Association (BCGA) 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 (see Table 5 below) include, but are not limited to:

Table 5:

Standard reference number	Standard title
ISO 14687	Hydrogen fuel quality.
ISO 17268	Gaseous hydrogen land vehicle refuelling connection devices.
ISO 19880	Gaseous hydrogen – fuelling stations.
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.
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.
SAE J2719	Hydrogen Fuel Quality for Fuel Cell Vehicles.
BCGA Guidance Note 41	Separation Distances in the Gases Industry.

Broader policy requirements

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 aimed at driving the development of a 100% hydrogen system. This commitment will need to continue and develop to allow the hydrogen economy to grow.

Outputs from H_2 Mobility group

The UK H_2 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), Department for Business & Trade, Transport Scotland 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 through the UK H2 Mobility group 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 H_2 Mobility group has recorded some key policy requirements based on 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. In 2024, the UK H_2 Mobility group developed a set of "asks" of government to encourage uptake. These points were made to Shadow Minister for Transport, Bill Esterson, before the 2024 election. These asks included:

- Increase coordination between departments and develop a long-term plan for hydrogen mobility.
- Increase the scale and duration of funding available for UK projects.
- Develop an implementation plan for a hydrogen refuelling station network.
- Include hydrogen internal combustion engine vehicles in plans for hydrogen mobility.
- Streamline the planning process for hydrogen refuelling stations.
- Support the development of lower TRL hydrogen mobility technologies.

Through 2025, the group has focused on drafting the Risk Taking Intermediaries (RTI) document on the challenges under the Low Carbon Hydrogen Agreement, which will be later submitted to the government. In the meantime, further focus has been on knowledge dissemination between the working partners and government, recruitment of further working group members and updates on political status from Beyond2050. Participation within this group provides National Gas with a key opportunity to directly work to reflect on the policy changes and requirements needed to advance the hydrogen transport landscape alongside it's complimentary work for the introduction of blending and hydrogen into the gas network.

Broader policy requirements

While 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 setup 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. We have taken the approach that we expect the standards to which National Gas operate to be employed and adhered to alongside those required by DNV, who will be operating the FutureGrid facility and upon whose site the facility is located.

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 are operated to standards as this provides excellent assurance to the Safety Management System.

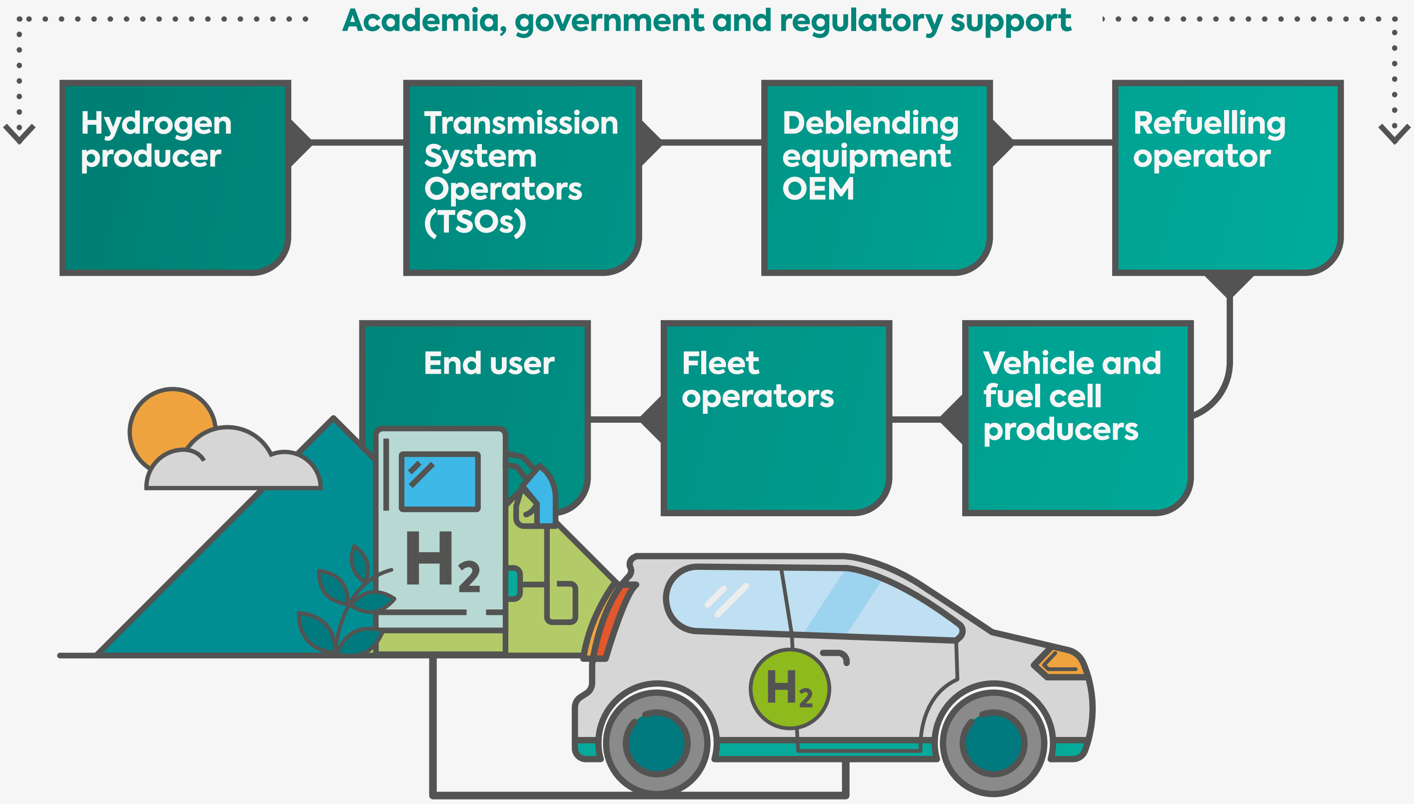
When considering the deployment of the project learning, National Gas will update any internal standards for hydrogen blends/Project Union as part of the Safety Case update that would be required in advance of this occurring on the NTS. The learnings from this project will go a long way towards informing the eventual standards updates, along with key industry-recognised standards and safety legislation. Further data that can be collected through the testing phase of the project can help inform the evidence documents for hydrogen blends and 100% hydrogen.

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 of the impact of hydrogen upon NGGT policies, management procedures, standards and work procedures. It was found that of the 554 relevant documents, 52% required no update, but 48% required changes classed as 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 8
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 impacted by the work and the results produced, and will be able to contribute valuable input into the project.

The below diagram shows the supply chain for the hydrogen transportation industry. Government, policy makers and input from academia 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 2 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, conversations and networking. 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 collaboration both between the project and stakeholders and between the stakeholders themselves.

The table below summarises the aims and goals for engagement for each of the stakeholder groups, identifying their interests and user needs. This has been updated and has evolved throughout the project's progression, taking into account the stakeholder survey and engagement so far.

Table 5

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 projects. • Understand longer-term plans for vehicle availability to the UK, to feed into deblending equipment rollout 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 rollout plans.
Academia	• Understand the research and input that academia can provide, with the assistance of technology developments alongside network and planning assessments. • Engagement to share learnings and publish papers for academic learning.

Stakeholder engagement

Results of stakeholder engagement

The 2024 progress displayed results from the 2024 stakeholder event surveys. During the 2025 Clean Transport event, these questions were asked again with the results shown below and compared to the results from 2024.

When surveyed on which transportation industries are most suited for hydrogen, the results were very similar to that of a year ago with again HGVs and buses and coaches coming out as the leaders. This is most likely due to the alternative decarbonised options not being suitable, but also the the advancements that have already been made in the industry, as well as visual government support, such as for the ZEHID and HyHaul projects.

Passenger cars remain the lowest still, more than likely due to the suitability of electric cars and the already large uptake, which may also remain suitable for light goods vehicles. Aviation remained low, as this has been repeatedly identified as one of the hardest transportation sectors to decarbonise.

Figure 5:
Transportation best suited for hydrogen
2024: 28 responses

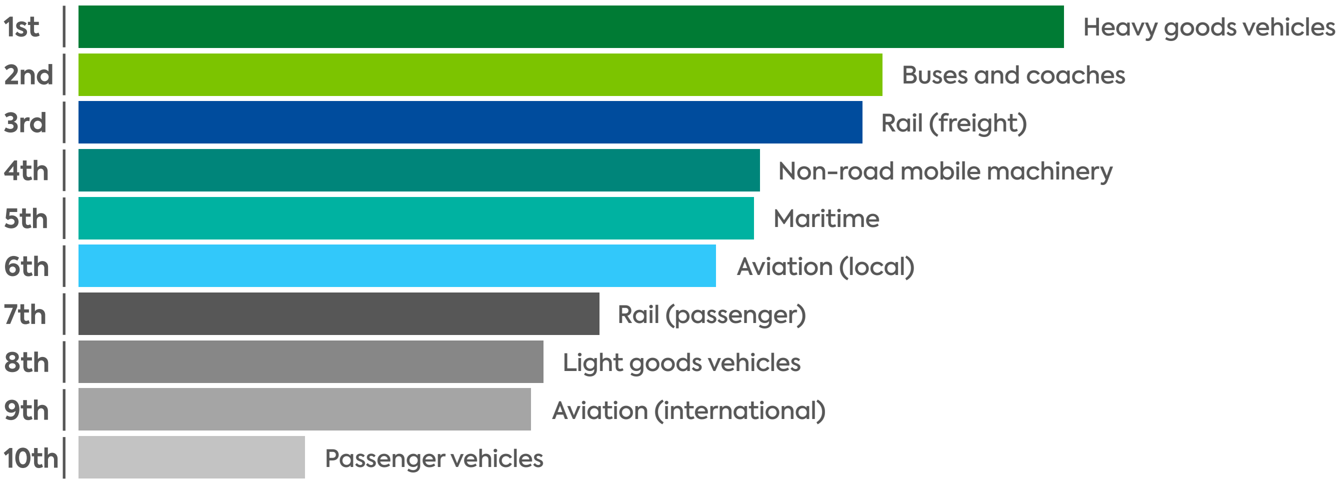
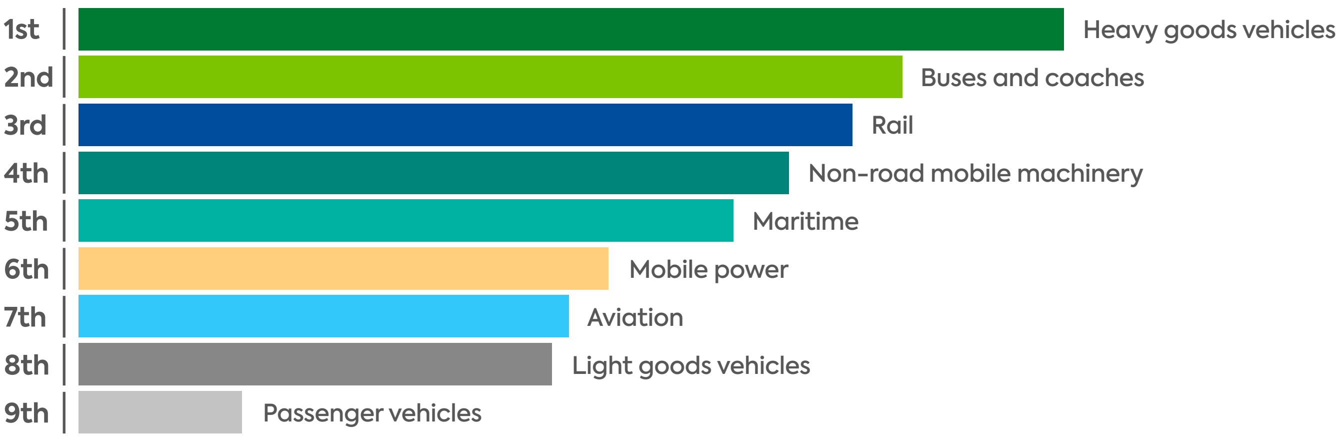


Figure 6:
Transportation best suited for hydrogen
2025: 60 responses



Attendees were asked to identify the primary barriers to the deployment of hydrogen transportation. Consistent with findings from 2024, cost remains the predominant concern, followed closely by commercial risk and the level of government and regulatory support. The persistence of these issues across both events highlights the need for continued focus and strategic intervention. On a positive note, safety and technological readiness are not perceived as significant obstacles, indicating that the industry is well-positioned for a transition to hydrogen. However, financial and policy-related challenges continue to impede progress.

Figure 7:
Blockers to the hydrogen transportation industry
2024: 28 responses

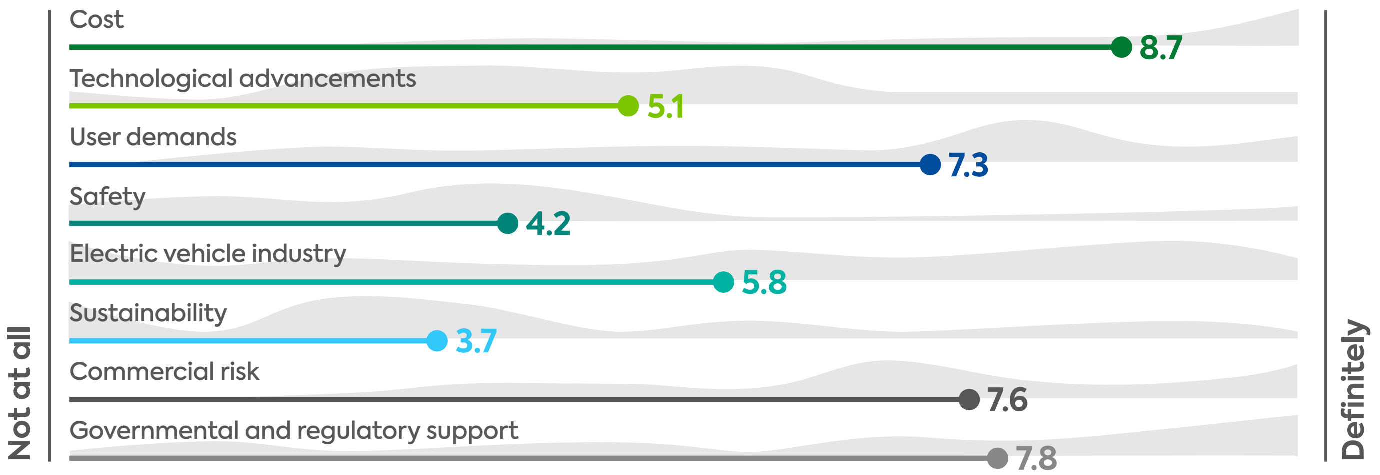
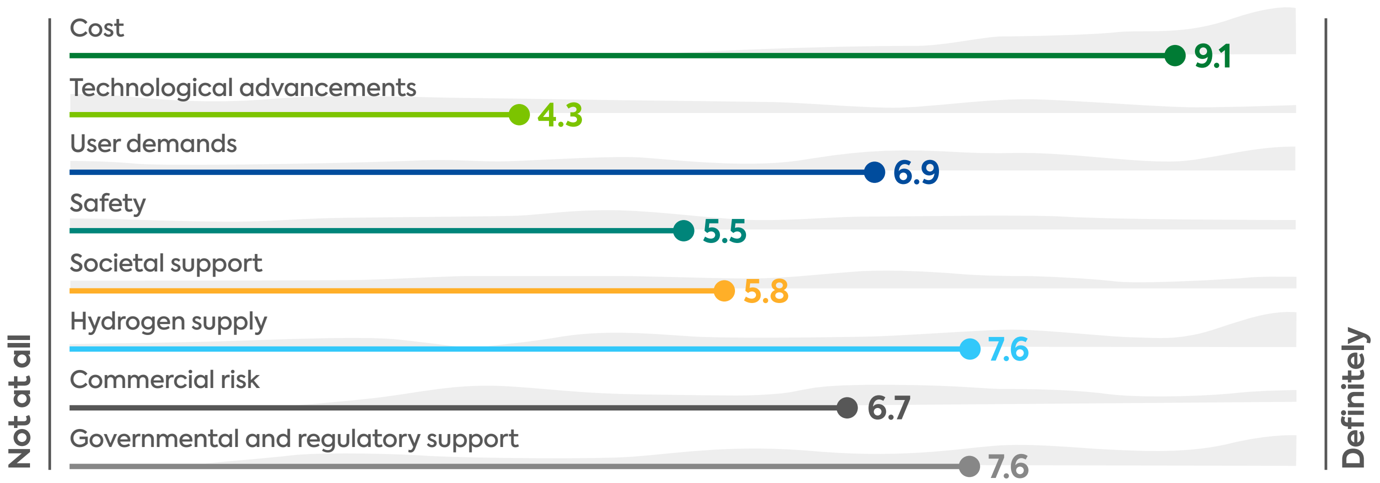


Figure 8:
Blockers to the hydrogen transportation industry
2025: 60 responses



The engagement forum also led workshops to split into Public Sector, Equipment Manufacturers, Road Transport, Other Transport and Refuelling. The workshops provided valuable insights into the current landscape of hydrogen development within the hydrogen sector, particularly focusing on challenges, opportunities, and strategic value.

Current Challenges
Participants highlighted several persistent barriers to progress. Notably, Northern Ireland (NI) has no HAR2 projects, leading to a perception that it is being overlooked in the national hydrogen strategy. This exclusion underscores a broader issue of regional imbalance in hydrogen planning. Funding models were also a major concern. The Regulated Asset Base (RAB) model was deemed unsuitable for hydrogen projects, while the Instrument model, though more promising, suffered from poor execution. These limitations have created uncertainty and hindered investment. In terms of policy, the cancellation of the Industrial Energy Strategy without a clear replacement has left a strategic void. While there have been frequent government announcements, they often lack the necessary financial backing to drive real change. Finally, the workshops revealed a disjointed national approach, with fragmented coordination across departments and regions. This lack of alignment is slowing down the development of a cohesive hydrogen infrastructure.

Opportunities for Improvement
Despite these challenges, several opportunities were identified to accelerate progress. Increasing investment liquidity through flexible funding mechanisms and risk-sharing models could attract more stakeholders and capital. Empowering local authorities with greater funding and autonomy was seen as a key enabler. Although competing priorities exist, local support could be unlocked with the right resources. Participants also suggested loosening HAR requirements, which would allow intermediate buyers to enter the market and stimulate activity. Additionally, there is a need to upskill the Department for Energy Security and Net Zero (DESNZ) to better understand and address NI-specific constraints.

Strategic Value of Hydrogen
Hydrogen was recognised as a critical component of the future energy landscape. Its potential to support a circular economy through local production aligns with sustainability goals and strengthens regional messaging.

The development of dedicated commercial clusters, particularly those involving local authorities, was seen as a scalable and targeted approach to deployment. However, cost sensitivity and public perception remain significant risks. If consumer costs are not managed carefully, there could be backlash that undermines public support. Finally, hydrogen's role in power applications was emphasised, especially its ability to provide long-duration energy storage (exceeding 100 hours), which surpasses the capabilities of conventional battery systems.

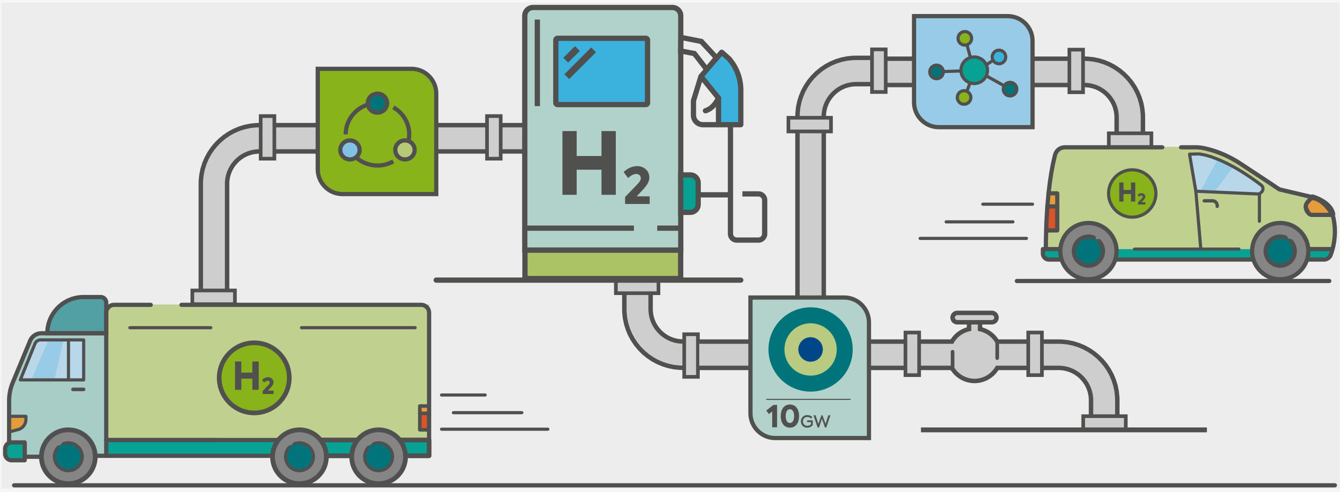
Further refinement of user needs

To ensure that the project and rollout mapping remain relevant and that our stakeholder and user needs continue to be understood, further engagement will be conducted. Working with ERM and Cenex, 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 rollout mapping in 2026.

FutureGrid FCEV after refuelling.

Section 9

Impacts and benefits



Benefit to vehicle operators

Hydrogen transport via the NTS will provide reliable supply to vehicle operators across the country. The existing UK HRS infrastructure is often faced with reliability issues, due to the often on-off nature of sites supplied by electrolysers, 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 by instilling confidence that supply will be there when needed. 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). Development of HRS infrastructure across the country will also aid in reducing the levelised cost of hydrogen by promoting additional hydrogen production, which will ultimately benefit vehicle operators by reducing vehicle running costs. Pipeline transportation of hydrogen will also help to promote hydrogen generation that may not be specifically intended for refuelling applications, but will help to promote the hydrogen economy and reduce hydrogen cost through economies of scale. Development of both nationwide hydrogen production and a hydrogen refuelling network will help to promote adoption of hydrogen vehicles as well as reduce vehicle running costs.

Benefit to gas system users

The UK Government has set a target to deploy 10 GW of low-carbon hydrogen by 2030. To help achieve this ambition, large-scale hydrogen production projects, such as East Coast Hydrogen, HyNeT and HySpeed, 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) while 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 the growth of the hydrogen economy and reduce the levelised cost of hydrogen. Hydrogen transport using the NTS will also support decarbonisation of gas consumers that are capable of accepting hydrogen blends.

Deblending facilities may look to connect directly to the NTS or develop a 'hub' that can service multiple nearby HRSs. This can benefit refuelling stations by reducing the need for multiple hydrogen deliveries per day or 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 levelised hydrogen cost further, and reduce safety implications by minimising the volumes of hazardous gas stored on site.

Section 10

Risks, issues and 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.

Through 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 project decision-making with a view to mitigating against these risks. Risks are assessed by all partners at quarterly risk review 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 were able to be identified, and included in the risk register.

> “Risk 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.

Top risks

Our top risks to the project at this stage of the project have been summarised in the table on the following page (p43). It includes a statement on the likelihood and also the commentary on actions being taken to manage these key risks.

Table 6: Risk summary

Risk Number	Risk
1 High	**Project partner cash flow issues** HyET have been hit by cash flow issues which have caused delays in the delivery of the DBU. Activities are ongoing to secure funding and prevent any further delays. This has been caused by global cutbacks in net zero funding, which includes HyETs investors. Delays of circa three months to the project critical path are anticipated as a result of the pause in fabrication as new funding is sought.
2 High	**Testing delays** The novel nature of the test configuration could result in 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.
3 Medium	**Enpro build quality is not up to standard** During the build of the EHC, HyET noted that there were a greater number of quality improvements to be made than anticipated following system fabrication. Given that the DBU is on the project critical path, fabrication standards must remain high in order to not impact equipment fabrication timelines and delay shipment of the unit. HyET are planning to increase the frequency of visits to Enpro's factory in order to provide more opportunity for quality assurance checks.
4 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.
5 Low	**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.

Risk profile

Using the risk register to record the risks as identified through the project, we are able to identify 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 the risk to be closed down. At the current status of the project, the risk profile is shown as below. The arrows indicate whether the number of risks in that category have gone up, gone down or stayed the same.

These statistics show that, overall, the number of risks has increased, with a rise in green and red risks. 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 down as mitigations and workarounds are identified.

Figure 9: Risk Register Statistics

UP
19
Green

NO CHANGE
18
Amber

UP
8
Red

NO CHANGE
26
Closed

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. This includes identifying opportunities for green hydrogen. Geopura is a local producer of green hydrogen and has been brought onboard as a supplier for DNV.
- 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 have already secured two FCEV cars through Toyota and the trial of a FCEV through Stellantis. There are further ongoing discussions for trialling other equipment, along with the demonstrations of excavators and lorries seen during the Clean Transport Event.
- 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 rollout 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.
- The future deployment of hydrogen transportation remains highly uncertain, with several companies having experienced funding challenges or entered administration over the past year. This volatility makes it difficult to forecast developments over the next 5, 10, or 20 years, as a clear and definitive pathway has yet to emerge.

> "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."

Deployment

System deployment

The innovative nature of the Deblending & Purification 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. A number of 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. The HyET technology has not been operated at NTS pressures prior to this project.
- 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 its 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 station. 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 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 remain above 5°C at all times to prevent freezing of the electrochemical membrane stacks. It is not clear how well this will be achieved while shipping the items to DNV Spadeadam as well as 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; however, 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 sought to mitigate 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.
- System testing will help to assess operating costs and equipment efficiency in order to inform cost of ownership and concept commercialisation.

Industry adoption

Industry-related challenges also exist, which may impact the success of Deblending & Purification adoption. A number of 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 4, aims to mitigate against this by identifying advantageous locations for potential HRS offtakes.
- The cost of hydrogen, and how 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 while 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 8, 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. The UK Government's consultation on 'Hydrogen blending into the GB gas transmission network' published on 23 July 2025 aims to address the implications for transmission system stakeholders, including gas consumers but also hydrogen producers, investors, storage operators, academics etc.

FutureGrid Test Facility

Section 11

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 newsletters etc.

Much of the engagement has already been discussed in Section 3 and Section 8 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.

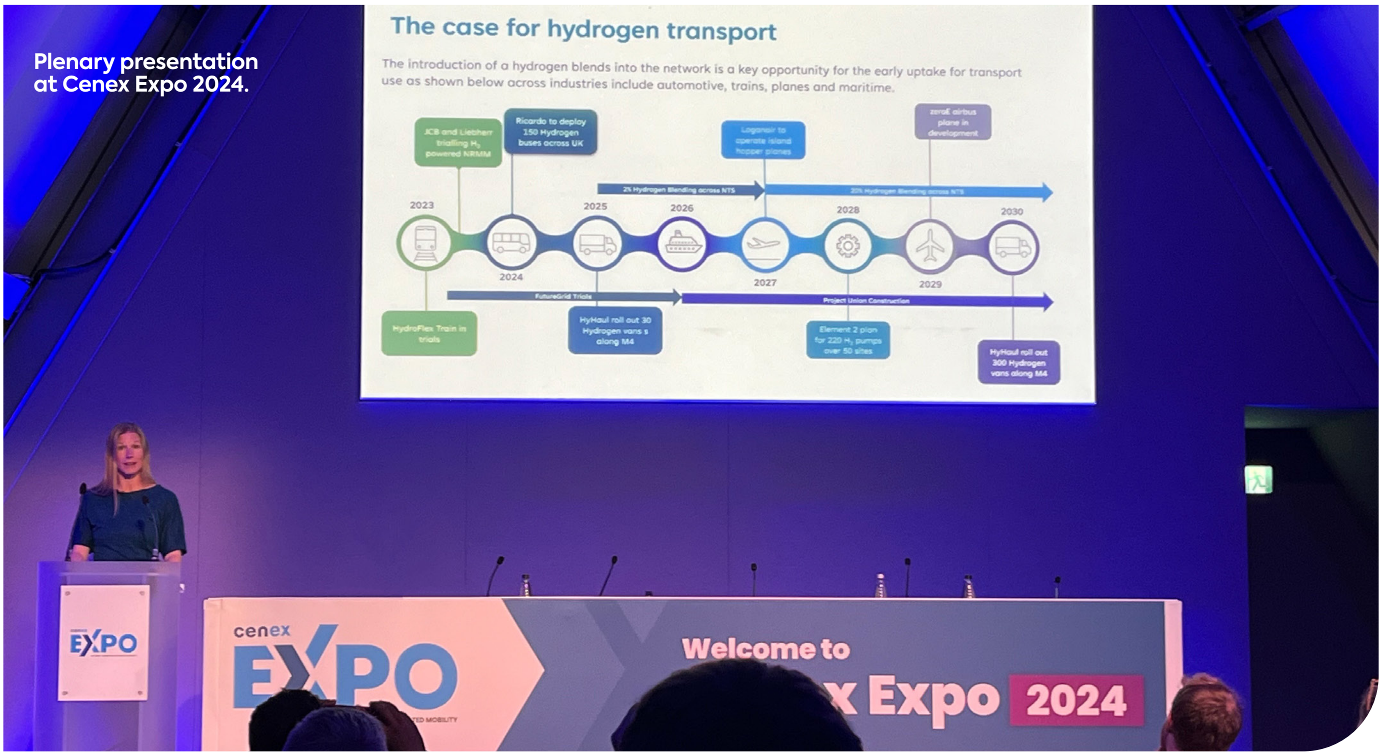
> "The ultimate goal of these engagement activities is to ensure that the HyNTS Deblending project is closely aligned with the market needs and stakeholder expectations, paving the way for successful commercialisation."

Steering group

A steering group was formed from the partners with the first formal meeting held in July 2024 with all partner leads either attending or sending a representative in their place. At the first meeting, a term of reference was agreed, which detailed the role of the steering group as follows:

- Championing FutureGrid Deblending for Transportation Project
- Approving key programme deliverables including the test plan
- Providing direction on strategy rollout and implementation
- Providing a point of escalation for significant risks 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 all partners to not only contribute to the project's work but also share their expertise and external experience to inform other parts of the supply-chain journey, raising any issues or insights they have gathered. It also allows meetings and spin-off meetings on specific topics such as the rollout mapping and feedback from the stakeholder events, where some partners have significant input that can adjust the inputs and outputs of the project.



Plenary presentation at Cenex Expo 2024.

Stakeholder group

As mentioned in the previous sections, through horizon scanning and utilisation of existing and new contacts, a comprehensive stakeholder group was established. Through the stakeholder event, surveys, newsletter and one-to-one conversations, the project has been promoted and the profile raised. The conversations have also allowed challenges 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 contacts and the industry also grow. Section 3 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 H_2 Mobility 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, a decision was made to work with the existing groups and the steering group to keep the FutureGrid project at the forefront of these groups, and to utilise the knowledge within the existing work groups and also 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.

Some of the groups that have bilateral engagements with key stakeholders include, but are not limited to:

- H_2GAR
- H_2 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)

External communications

As part of working in the open, external communications are an important part of information dissemination. Both the use of newsletters and LinkedIn are a great opportunity for broadcasting the work conducted and results produced at FutureGrid and the ongoing progress. It allows interactions 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 ultimate goal of these engagement activities is to ensure that the HyNTS Deblending project is closely aligned with 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 12

Costs and value for money

Table 7: Project finance summary – QRM7

	SIF funding requested	Total actual project spend	Total project contribution made (incl. contributions in kind) to date
National Gas	£1,206,316	£772,884	£126,000
DNV	£4,692,556	£1,750,504	£765,000
HyET	£3,983,875	£3,199,188	£604,775
Element 2	£891,360	£726,855	£99,040
ERM	£196,544	£100,000	£37,790
Cadent	£12,639	£8,809	X
NGN	£14,570	£10,156	X
SGN	£12,969	£7,268	X
WWU	£10,428	£9,039	£1,300

Project performance

The first year of the FutureGrid Deblending project 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. The majority 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 to expand on, there would have been additional costs of around £5m to deliver the project. This example, along with others funded under NIA that have also utilised the facility, demonstrates the importance of cost avoidance as a source of value for consumers, 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 the 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.

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.

Variation against original forecast

Project spend against the original forecast is presented at each quarterly review meeting. There have been a number of changes made to the spend profile throughout the project as part of our ongoing management of project delivery. These have included expediting payments to avoid delays in long-lead items, reconfiguring payment milestones to better reflect delivery of work, and delays to payments where work has not been delivered.

The project is currently behind its payment forecast due to delays to the fabrication of the Deblending Unit, which will have a knock-on effect on overall project timelines. Once clarity is provided on the delivery timeline for the Deblending Unit, the payment milestones will be reforecast to reflect the delivery timeline. All changes to payment milestones and project deliverables are captured in the Change Log.

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.

What has been achieved to date on Phase 1, and will be achieved with Phase 2, is far beyond any physical testing capabilities across the world. FutureGrid is a global first: a 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, interest has grown both nationally and internationally. Our collaborative networks run across the globe with deep and complex data and knowledge exchange, with the global players recognising the value of collaboration. This has brought significant attention to FutureGrid, presenting a fantastic opportunity to open the facility to collaborators to engage with us and utilise the facility to further their own technological needs.

This also provides 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 a number of potential customers regarding using the FutureGrid facility for bespoke testing, with some already conducted, such as the 100% metering 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 13

Special conditions

Special conditions summary

The below table summarises the special conditions that are specific for FutureGrid Phase 2. 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: Special conditions overview

Project-specific condition fulfilment				
Condition 1	No Spend Until SIF Contracts	Ensuring that no spend occurs on 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 the 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	Deblending Stage Gate 1 and 2 completed, working towards Stage Gate 3.
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	Underway for second progress report – with further discussion on content requirements to be had at QRM8.
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. It will also include 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 and Edinburgh Community Days 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	First video completed and uploaded. Deblending: click here Second video in production.
Condition 10	Consumer Engagement	Updating 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	Initial report provided and currently being updated – the frequency of future updates to be agreed.
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 a detailed plan.

Table 8: Special conditions overview (continued)

Project-specific condition fulfilment

Condition 12	Commercialisation Strategy	Updating the commercialisation strategy, focusing on what National Gas and Partners have considered for the commercialisation of FutureGrid.	G	Initial report provided and currently being updated.
Condition 13	Hydrogen	Updating the project's ability to obtain the required volumes of hydrogen and outlining the opportunities for the project to use green hydrogen. In addition, exploring how hydrogen trial projects can be used to help stimulate the development of the green hydrogen market.	G	DNV continuing engagement across the 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 facility in Spadeadam beyond the Beta Phase.	G	Initial report provided and currently being updated – the frequency of future updates to be agreed.
Condition 15c	Cost Reductions & Value-Adding Opportunities	Identifying opportunities to reduce project costs, increase contributions from project partner or identify further value which can be extracted from the project.	G	Initial report provided and currently being updated – the frequency of future updates to be agreed.
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 – over 100 stakeholders engaged with and collaborating with Toyota and Stellantis alongside partners and the Element 1 project.
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	Engaged with the HyHaul project and the ZEHID team from Dynamon alongside H2 Mobility.
Condition 17	Outline IPR Value to Supply Chain Providers (HyET)	Providing an outline of the IPR value from 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. Along with the specific transport -related activities, there have been activities carried out as part of Project Union which have been extensive and dynamic, covering a broad spectrum of stakeholders 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 wider project direction and building on the business case for pipeline-served deblending. 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 end-users and hydrogen refuelling 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.

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 both nationally and internationally. 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 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. There is open communication and knowledge sharing between others involved in deblending, including Skyre, Hitachi and H2Site.

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

The components used in 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 a number of 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. Utilisation of the facility for 100% metering testing on Phase 1.
3. Opened discussions with H2Site (Deblending equipment manufacturer) for potential future testing to demonstrate their equipment in a similar way to the existing HyET equipment.
4. Repurposing of the Phase 1 facility for a carbon capture project which is currently in the contracting phase.

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 and value-adding opportunities across the FutureGrid Programme, we can consider these in three categories as demonstrated in Figure 10 (p53):

Figure 10: Opportunity horizons

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 programme or potential demand/ requirements from external forces. As such, these are watchlist items, and when they become clearer, they are opportunities that will come 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 in 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 some of the lead times 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.

Progress against each of these opportunities is presented at the quarterly review meeting, alongside internal discussions to assess potential opportunities based on the portfolio of projects across Innovation. The table below shows opportunities that have been identified or developed over the course of the project.

Table 9: Summary of value-adding opportunities

	Opportunity description	Added value	Status
1	Use of the FutureGrid Test Facility to test 100% Hydrogen Meters with representative flowrates	Lower costs for testing	Complete
2	Leak testing whilst undertaking 100% Hydrogen Metering test	Additional data gathered	Complete
3	Leak testing during Deblending to assess preferential emissions	Additional data gathered	Sanctioned, awaiting test phase
4	Performance testing of novel gas detection technology	New technologies tested	Under review
5	Alternative deblending equipment to run in parallel during testing phase	Additional data gathered	Under review
6	Performance testing of novel gas sampling technology	New technologies tested	Under review
7	Use of hydrogen generators to power operations	Technology demonstration	Potential future opportunity
8	Use of hydrogen plant for site works	Technology demonstration	Potential future opportunity

Section 14

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:

FutureGrid@nationalgas.com

01926 65 3000

National Gas,
National Grid House,
Warwick Technology Park,
Gallows Hill,
Warwick,
CV34 6DA

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
CO_2	Carbon Dioxide	**NGN**	Northern Gas Networks
DBU	Deblending Unit	**NGS**	National Gas Services
DNV	Det Norske Veritas	**NG**	National Gas
EHC	Electrochemical Hydrogen Compressor	**NIA**	Network Innovation Allowance
EU	European Union	**NIC**	Network Innovation Competition
FAT	Factory Acceptance Test	**NTS**	National Transmission System
FCEV	Fuel Cell Electric Vehicle	**OFGEM**	Office of Gas and Electricity Markets
GB	Great Britain	**PIG**	Pipeline Inspection Gauge
GDN	Gas Distribution Network	**PPR**	Project Progress Report
H_2 GAR	Hydrogen Gas Asset Readiness	**QRA**	Quantitative Risk Assessment
HRS	Hydrogren Refuelling Station	**R&D**	Research and Development
HSE	Health and Safety Executive	**SAT**	Site Acceptance Test
HyNTS	Hydrogen in the National Transmission System	**SIF**	Strategic Innovation Fund
ICE	Internal Combustion Engine	**SME**	Subject Matter Expert
IPR	Intellectual Property Rights	**TSOs**	Transmission System Operators
IT	Information Technology	**TWh**	Terawatt hour
MOP	Maximum Operating Pressure	**UK**	United Kingdom

Warwick Technology Park
Gallows Hill, Warwick, CV34 6DA

nationalgas.com