FutureGrid

Project progress report

December 2022

Gas Transmission and Metering

Contents

Foreword

"2023 marks the final and most important year of FutureGrid Phase One. For the first time in the UK, we will operate a gas transmission pipeline with 100% hydrogen."

Antony Green
Hydrogen Director,
National Grid Transmission and Metering

According to the recent Progress Report from the UK Climate Change Committee, we won't hit our 2050 target with current measures alone. It's going to take ambition, innovation and determination to decarbonise the UK's energy system and secure the future of our economy and environment.

We've got a massive challenge ahead of us – we must lower our emissions to reach our Net Zero 2050 targets while ensuring we maintain energy supply to industry, we have resilience in power generation and our homes are kept warm.

Hydrogen has the potential to be a lower-carbon, cleaner alternative to natural gas, playing a key role in decarbonising our energy system. Our programme, Hydrogen in the National Transmission System (HyNTS), is building an evidence base to demonstrate how we can safely and efficiently transition our network.

FutureGrid has a pivotal role, building a hydrogen test facility at DNV's test and research centre in Cumbria, using decommissioned assets which have been in service with natural gas. This facility will demonstrate that our assets can transport hydrogen safely and reliably. The outputs will build our evidence base and unlock the opportunities for Project Union – a 2,000km hydrogen backbone across Great Britain.

The FutureGrid facility construction is nearing completion, with the majority completed in the past 12 months.

We're now preparing for the commissioning phase where the assets are calibrated and tested ready for operation. We'll then carry out a 100% natural gas test on the facility before we begin our hydrogen tests in 2023, moving from 2%, 5% and 20% hydrogen blends to 100% hydrogen.

We've had some challenges in the past year, in particular the global supply chain issues, caused in part by Covid-19. This has unfortunately caused some delay in construction. However, we've re-baselined our programme in agreement with Ofgem and are now focused on delivering the final testing stages of the project.

2023 marks the final and most important year of FutureGrid Phase One. For the first time in the UK, we'll operate a gas transmission pipeline with 100% hydrogen. This is a huge step forward in building a robust evidence base that the NTS has a key role in decarbonising the UK energy mix, bringing the transition to hydrogen one step closer.

Antony Green,
Hydrogen Director,
Gas Transmission
& Metering

Executive Summary

The National Transmission System (NTS) transports a significant amount of energy consumed within the UK. Critical research is key to advancing the UK's net zero 'heat challenge' to establish whether, and how, the NTS could be repurposed to transport 100% hydrogen.

Work is required to ascertain whether the NTS could maintain existing world-leading standards of safety and security of supply if converted to hydrogen. To address this challenge, Gas Transmission and Metering (GT&M) set up the Hydrogen in the NTS (HyNTS) programme of work to cover all hydrogen related projects with respect to the NTS.

GT&M has undertaken several desktop studies across the HyNTS programme which have confirmed, in principle, the possibility of using the NTS to transport hydrogen. However, there are hydrogen knowledge gaps that are fundamental to achieving the safe and reliable conversion of our network to hydrogen. The Health and Safety Executive – Science Division (HSE-SD) carried out an initial study and highlighted impacts such as leakage, venting and the effects of hydrogen on the mechanical properties of some NTS materials.

The main finding of this research was that practical demonstration is required on a variety of NTS assets, to understand the risks and mitigations. The FutureGrid Project aims to address this challenge.

The FutureGrid Project is funded through Ofgem's Network Innovation Competition (NIC). FutureGrid was registered in December 2020 and is expected to be complete by November 2023.

The project will build a replica of the NTS using decommissioned assets previously found on the network. The purpose of the project is to test these assets with varying blends of hydrogen, as well as 100% hydrogen, to prove their suitability and demonstrate that our existing network can successfully be operated with hydrogen.

Overall project progress

This is the second project progress report and focuses on the period from December 2021 – when the first report was published – up until December 2022.

The key achievements in this reporting period are as follows:

- Assets are now assembled.
- Assets have been remediated as required and made fit for service.
- Asset integrity tests have been completed.
- Detailed commissioning and testing plans are in place.
- Full triage of GT&M procedures has been undertaken.
- Activities have progressed in line with the communications plan.

The overall project completion date has been delayed from August 2023 to November 2023, due to an issue with the construction of the outer container (shell) of the recompression unit. This issue materialised in September 2022 and meant the recompression unit was delivered to site one month later than originally scheduled. As this is a critical path item it has delayed the overall project programme by more than one month.

Financial update

The total value of the project is £12m. However, this includes a significant amount of in-kind contribution and voluntary contribution. The total project funding estimated to complete the project is £10m, spent over a two-year period. In this reporting period there have been no changes in the total forecasted value since project direction was achieved. However, for various reasons, the project costs have changed for the different categories and the different years, but there has been no overall impact on costs.

Dissemination activities

A key goal of the project is to produce learning that can be disseminated as the project progresses. We created a communication plan at the start of the project, containing several regular activities that will be used to share progress and learning with key stakeholders. This plan is updated quarterly to incorporate stakeholder feedback.

The communication plan includes, but is not limited to, the following activities:

- Monthly Steering Group meeting with project partners
- Quarterly Network Steering Groups
- Quarterly subject matter expert (SME) forums for internal stakeholders
- Monthly articles (internal and external)
- Monthly podcasts
- Monthly webinars
- Monthly site tours
- Face-to-face hydrogen events
- Planned events for each hydrogen blend test.

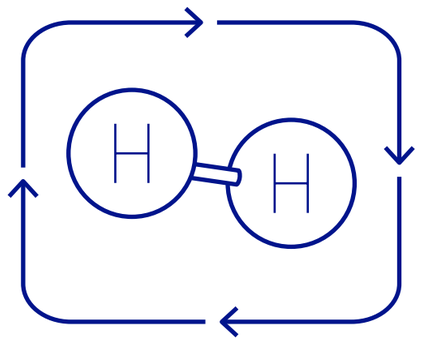
Business case and material change information

There have been no changes in the business case in this reporting period. However, the risk to the construction of the outer container (shell) of the re-compression unit materialised in September 2022. This has an impact on Ofgem deliverables 1.0 and 2.0, causing them to be delayed by up to three months. As a result, the changes to the completion dates of these deliverables have now exceeded one year in total since the Project Direction was issued in December 2020. Therefore, as described in the Gas Network Innovation Competition Governance Document V.3.1, this is declared a material change. All dates are based on the proposed programme extension submitted to Ofgem in November 2022 as part of a chance control for the project. This is pending approval from Ofgem but for the purpose of this report they are assumed to be approved.

FutureGrid
Overview and Timeline

FutureGrid is an ambitious programme to build a hydrogen test facility from decommissioned NTS assets at DNV's facility in Cumbria. It aims to demonstrate how the NTS can transport hydrogen and generate new knowledge and understanding of how these assets will perform as part of a future hydrogen system.

We'll carry out testing in two parts:

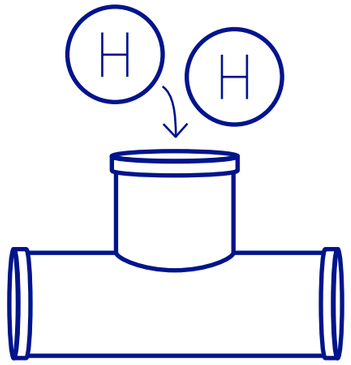


Offline hydrogen test facility

Representative decommissioned assets of different types, sizes, and material grades are being supplied to build the hydrogen test facility.

The facility will initially run on 100% natural gas to collect baseline data for the equipment and then move through 2%, 5%, 10% and 20% hydrogen / natural gas mixtures and then 100% hydrogen.

The facility will have a maximum flow of 1.76 MSm3/day generated by the use of the Recompression Unit (RCU).



Standalone hydrogen test modules

Standalone hydrogen test modules will operate alongside the main test facility, to provide data to feed into the main facility and address specific knowledge gaps which can't be included in the main test facility.

These tests include:
- Materials testing
- Pipe coating testing
- Fatigue testing
- Flange testing
- Asset leak testing
- Rupture testing.

Project partners:

DNV

DNV is the main delivery partner, responsible for building the test facility and developing the comprehensive master test plan across the range of decommissioned assets.

fluxys

Fluxys is the Gas Transmission Operator in Belgium and is contributing a substantial level of hydrogen research, to ensure an internationally collaborative approach.

HSE

HSE Science Division (HSE SD) is supporting the development of the test facility and subsequent master test plan, providing technical assurance and validation across the project.

Durham University

Durham University is sponsoring a secondment student to study the NTS asset gaps, focusing on the development skills and training courses along with Phase 2 & 3 of FutureGrid.

Northern Gas Networks

NGN is collaborating on the project to drive closer links with the H21 project, which is building a distribution test facility at DNV's Spadeadam Facility.

The University of Edinburgh

Edinburgh University is supporting the trials and developing technical papers and research from the project to enable dissemination, linking the H100 activities and FutureGrid/H21 activity to prevent duplication.

Safety case
There are fundamental differences between how natural gas and hydrogen behave. We need to understand how different concentrations of hydrogen impact our network so we can develop our safety standards. Through this project, we'll be able to assess the impact and update our safety case, indicating where we need to update procedures, quantitative risk assessments, hazardous areas.

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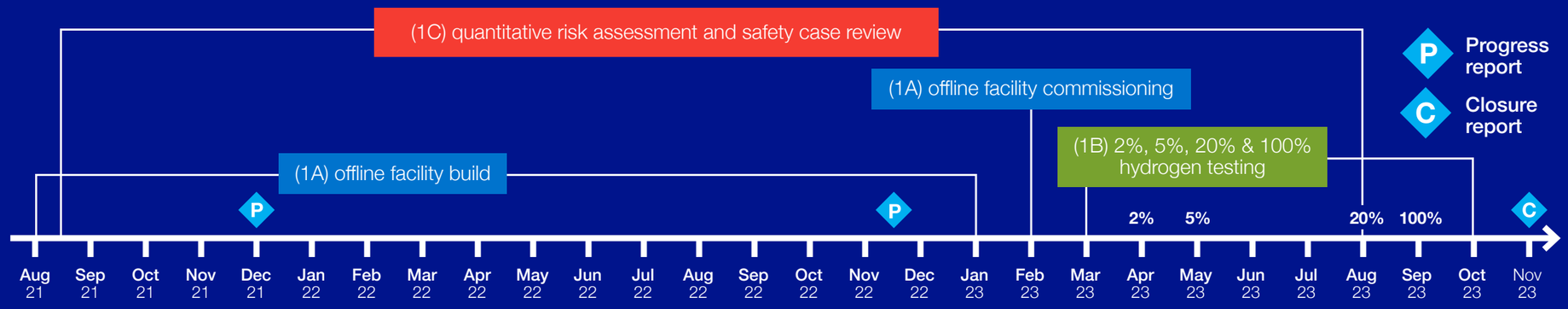


Offline Hydrogen Test Facility

Construction of our unique high-pressure hydrogen transmission test facility is almost complete.

The facility has been constructed from a representative range of decommissioned NTS assets of different types, sizes, and material grades. It will initially run on 100% natural gas capturing standard baseline data for all assets. Testing will then move through 2%, 5%, 10% and 20% hydrogen/natural gas mixtures, and then 100% hydrogen. The facility will have a maximum high flow of 1.76 MSm3/day and 0.36 MSm3/day through the low flow loop generated by using the recompression unit.

1. High-pressure storage
The high-pressure storage is constructed from 60 metres of 48” diameter pipe that acts as the gas storage reservoir for the test facility. Natural gas, hydrogen, or a specific blend of both, is stored in the high-pressure store at 70 bar (1015psi). This then connects to the facility and provides the gas required to flow around the facility.

2. Ball valve arrangement
Double block and bleed valve arrangement consisting of two 18” ball valves installed in series. A vent valve is installed on the pipe between the two ball valves. A smaller-diameter bypass pipe is installed around and interlinks the two ball valves. The bypass allows the gas pressure to be equalised each side of the valves, eliminating differential pressure in preparation for valve movements.

3. Ultrasonic meter
Twin stream ultrasonic meters used to calculate flow rates. Based on gas composition, density, pressure, and temperature. Flow rate is calculated by velocity of sound between two probes.

4. Customer offtake
The customer offtake consists of a range of assets which ensures the gas received by a Gas Distribution Network (GDN) or large power/industrial user, operates to the correct process conditions. This includes pressure reduction equipment, metering and gas quality facilities, pre-heating equipment and filtration equipment.

5. Block valve
The long-distance gas pipelines on the transmission network have isolation valves at regular intervals along their length. This will be used to demonstrate the capability of critical valves which are used to isolate sections of pipelines in event of an emergency or for maintenance.

6. Low-pressure storage
The low-pressure hydrogen reservoir is constructed from 36 meter, 36” diameter pipe which is located at the end of the facility flow loop. It will ensure there is sufficient volume of gas for the recompression unit to run efficiently.

7. Recompression unit
The recompression unit generates gas flows around the facility. This unit is bespoke to the FutureGrid facility, to operate with natural gas and hydrogen at a wide range of flow rates and pressures to replicate the National Transmission System.

8. Control room
The control room is where all the test data from the different assets can be monitored and recorded via supervisory control and data acquisition interfaces. It’s connected to the FutureGrid site via a series of communication links.

Project Manager's Report

Project background

FutureGrid is an ambitious project, comprised of decommissioned assets that have previously seen decades of service as part of the National Transmission System (NTS). The purpose of the project is to demonstrate the suitability of NTS assets to operate with a range of hydrogen blends up to 100% hydrogen. This will identify future investment requirements to enable the full conversion of the transmission system for hydrogen operation. The project is now due to complete in November 2023.

There are six project partners working collaboratively to deliver FutureGrid. Project steering groups have been established, involving all project partners.

Project overview 2021-2022

In this reporting period, major project milestones have been successfully delivered. FutureGrid is looking very promising, as it now advances through the final phase to completion. Asset inspections have been carried out to ensure functional safety when incorporated into the FutureGrid facility. This assessment identified a number of activities which need to be conducted (e.g. weld repairs and valve condition assessment). We worked in collaboration with DNV, Pipelines Maintenance Centre (PMC) and GT&M Operations to prepare the assets for the facility. This has been a key element of work and the learning from these works have been added to the overall project lessons learned.

The majority of the facility build has been delivered to plan. We have also pro-actively managed project risks throughout the project timeline by reviewing risks and mitigating where necessary. We were able to reduce the likelihood of most risks and eliminate them where possible through hazard identification, analysis and operability studies. However, despite our efforts the recompression unit has been delayed, causing a knock-on impact to the construction completion date. This has been caused by a supply chain issue relating to the outer shell which contains and protects the sensitive pressure containing equipment. This affected the overall project timeline by three months as it is a critical path item. This was reported to OFGEM as per change control submitted in November 2022.

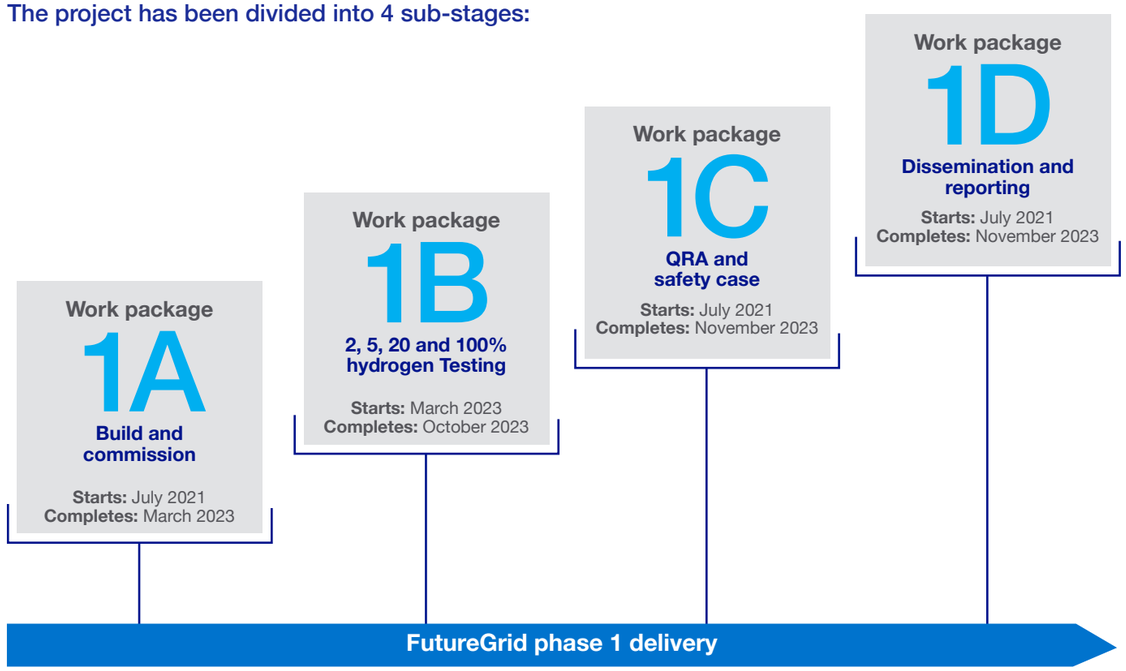
As part of the standalone tests, we have completed comparative asset integrity tests on the key assets. These were conducted at 70 bar with natural gas for five days, then with hydrogen for five days. We identified and remediated issues, such as small leaks on the small-bore pipework. These issues will be considered in the final recommendations of the project.

We commenced the lab permeation test and revised the methodology for the permeation tests on pipe coupons for a second time, as no hydrogen was detected for 40 days despite holding the sample under pressure. We are currently conducting the test using a more rigorous test method which should allow us to detect hydrogen of much smaller quantities. The permeation test is scheduled to be completed in February 2023. The rupture test is planned to be completed early 2023. Data from the standalone test will feed into the QRA section "Review of the over-pressure risk".

In collaboration with DNV, we have assessed 653 GT&M policies and procedures in this reporting period. The assessment found that 52% required no material change. 48% required change, and were further classified as high, medium and low. In addition to this, we have also created a hazardous area drawing for an existing GT&M above ground installation (AGI) and are in the process of completing this for a compressor site for blends of hydrogen and 100% hydrogen. Furthermore, we have created hazardous area drawings for the FutureGrid facility. We are expecting the remaining activities in the QRA section will be completed in the next reporting period.

For the dissemination phase of the project, our robust communication plan allowed us to conduct 25+ webinars, 5 podcasts, and publish 12 articles. Our communications plan is reviewed regularly to incorporate stakeholder feedback and focuses on a particular theme each month. In addition to this, we have conducted site visits for more than 300 people. These were for our internal teams, which are critical to the project and for key stakeholders (BEIS and OFGEM).

The project has been divided into 4 sub-stages:



The key achievements in the reporting period are as follows:

1. Asset integrity tests have been completed.
2. Assets have been remediated as required and made fit for service.
3. All assets are now installed and construction is nearing completion.
4. The facility is being prepared for commissioning and testing.
5. A full triage of GT&M procedures has been completed as part of the QRA development.
6. Extensive range of engagement activities delivered, including the return of in person events.

Project deliverables

The project deliverables were agreed when the project direction was provided in December 2020. Each of the deliverables was assigned an associated deadline and budget.

As the project has progressed, we've slightly revised the deadline and the associated budget, so they reflect the latest updates.

This table provides information of the latest status of deliverables:

Reference	Project deliverable	Revised deadline
1.0	Phase 1a – Groundworks and construction	January 2023
2.0	Phase 1a - Testing and commissioning	April 2023
3.0	Phase 1b – Testing 2% - 20% hydrogen	August 2023
4.0	Phase 1b – Testing 100% hydrogen and fatigue testing	October 2023
5.0	Phase 1c – QRA and safety case	November 2023
6.0	Knowledge dissemination	November 2023
7.0	Comply with knowledge transfer of the governance document	November 2023

In the period between the PPR submitted in December 2021 and this progress report we have submitted a change control to OFGEM in November 2022, as there was a material change in the project. This has been reviewed and accepted by OFGEM.

The change control highlights the following points:

- **Programme Updates:**
  A material change had occurred as per the Gas Network Innovation Competition Governance Document V.3.1 because the completion dates of Ofgem project deliverables 1 and 2 exceeded one year since the project direction was issued.

- **5% Blend:**
  The 5% Blend testing is being conducted under a separate NIA Project. In order to, take advantage of the cost and time savings it was considered practical to incorporate the blend testing into the FutureGrid testing project. This meant an extension to the overall FutureGrid programme. The additional timescales required on the FutureGrid programme have been submitted as part of the change control document.

- **5% Blend Testing NIA Project:**
  In a recent policy paper the European Commission suggested that a readiness for the acceptance of 5% hydrogen by volume could be the first step for European transmission network operators in a transition to hydrogen. GT&M sanctioned a NIA project to test 5% hydrogen. It was considered sensible for the FutureGrid project to incorporate a 5% test into the testing programme to ensure that the UK can continue to seamlessly trade gas with the European market. It is estimated this will provide a cost saving of £470,000 and will reduce the project timescale by one month than testing separately.

Governance

Meeting	Frequency	Description
Project progress meeting	Weekly	The progress meeting is held weekly ensuring the core Project Delivery Team remains focused on the project deliverables. It provides an opportunity to discuss any ongoing issues and identify potential threats and opportunities in future stages of the project. The weekly meeting is conducted with GT&M and the delivery partner (DNV).
Internal project review meeting (IPRM)	Monthly	The IPRM is conducted monthly within GT&M between the Project Manager, FutureGrid Manager and Hydrogen Director. The aim of this meeting is to discuss the costs, key programme dates, commercial risks and highlight any escalations.
Project Steering Group	Monthly	The Project Steering Group meets monthly, with all the project partners present. The discussion in this forum is to ensure the project activities conducted are relevant and feed into the seven Ofgem deliverables. Additionally, the project programme and costs are monitored in this meeting. It's also a platform to share any key learning within the group.
Risk review	Monthly	The monthly risk review is conducted between GT&M and DNV. The aim of this meeting is to update the risk register. The risk register contains the risks, mitigation measures, probabilities and impacts of each of the risks.
Network Steering Group	Quarterly	The Network Steering Group meets quarterly, with the project partners and other gas distribution networks present. The aim of this steering group is to provide an update of the project and it also provides a platform to share any key learning.

Project documentation management

A project SharePoint site has been created to facilitate document management. The documents are managed in a folder structure and access is provided to all project partners.

Risk management

The nature of FutureGrid as an innovation project brings varying levels of risk, due to the activities being undertaken. The project has adopted a continuous risk management approach to identify potential risks at an early stage and determine suitable mitigation measures. The extended list of risks has been documented in the risk management section.

In this reporting period most of the project activities have remained on track. However, it is worth noting that the project is being delivered against a backdrop of economic uncertainty. The combination of Covid-19 and the Ukraine crisis has caused volatility in the construction market and issues with the supply of components. A risk to construction of the outer container (shell) of the recompression unit materialised in September 2022, due to constrained supply chains still being affected by Covid-19. However, despite best efforts, this outer container was delivered one month later than originally anticipated.

As the recompression unit is a critical path item it has delayed the overall project programme. However, there has been a greater impact on follow-on activities, in particular commissioning, which has resulted in the timeline for Ofgem deliverables 1 and 2 being delayed by three months. This is due to the availability of specialist third parties, alongside considerations for other scheduling issues, such as site closure over holiday periods and weather considerations for commissioning activities.

Over the coming months, specific high-level risks being monitored will include:

- **The assets fail during test plan**
  As the assets were sourced from decommissioned NTS sites and have seen up to 40 years of service, there is a potential that these assets could fail unexpectedly during the testing phase of the project. We have worked in collaboration with our GT&M Ops, Pipeline Maintenance Centre and DNV to conduct asset inspections and asset integrity tests prior to site installation. These activities should reduce the likelihood of failure. However, as we have still not tested them as a whole system it is still one of the key risks to the project.

- **Weather**
  Most of the commissioning and testing activities are planned in the winter period. Historically, there have been occasions during this period in which the temperature does not meet required conditions or there has been excessive snow cover. This means delays may be encountered during some activities due to temperature. We are working with DNV to identify activities that can be conducted earlier to minimise any impacts of bad weather.

Additional materials testing

There is currently no working standard to govern the operation of hydrogen pipelines in the UK. In the absence of an officially adopted standard, GT&M, as well as most other international networks, is looking for guidance from ASME B31.12, the American standard that governs the operation of hydrogen pipelines in the US. This standard provides two methods for assessing the maximum operating pressure (MOP) for a pipeline operating in hydrogen service: Method A and Method B. Method A is more conservative but can avoid the need for additional testing, whereas Method B requires more evidence but can be used to justify higher operating pressures.

The pipelines selected for use on the FutureGrid main facility were assessed using ASME B31.12's Method A approach. We found for one particular X65 pipe section that the MOP of the facility would be limited to around 50 bar. To ensure the facility could be operated at the intended 70 bar MOP it was determined that we would need to expedite some elements of our HyNTS materials testing programme. This would make sure Method B testing had been completed on the X65 pipe samples by the commissioning of FutureGrid.

Additional material testing was commissioned through the NTS Materials Testing to Enable Hydrogen Injection into High Pressure Pipelines Project (NIA_NGGT0180). Testing began in early 2022 and in August a technical note was provided by DNV that set out the results so far and the implications for FutureGrid. In summary, the material samples had achieved the required toughness levels to operate the facility at 70 bar. However, testing must be completed on the weld metal samples before the final confirmation and this is expected in late 2022.

Project Partner Activities

Alongside the construction and delivery of Phase 1, the FutureGrid team has been working with project partners on other hydrogen development activities within the UK and Europe.

- **HSE:**
  Representatives from the HSE have provided peer review to the project on both the design report and materials testing. They will also be conducting reviews on the testing analysis and recommendations on the different blends of hydrogen. In addition to this, they will review the QRA report focused on the methodology, outputs, inputs, assumptions, justifications of these assumptions and how the results will be used.

  Outside of FutureGrid, the policy team in HSE has recently formed 'evidence review groups' covering the hydrogen innovation activities being undertaken by the networks. We have been working with the team to submit our recent hydrogen innovation projects for review.

- **Northern Gas Networks (NGN):**
  National Grid, NGN and the other UK networks have been coordinating hydrogen research activities at multiple industry groups – in particular, the Hydrogen Grid R&D Programme, sponsored by BEIS, which seeks to address any knowledge gaps within current UK hydrogen research.

- **Fluxys:**
  Fluxys has reviewed materials work to support FutureGrid and shared the findings of its own materials work. National Grid and Fluxys are both partners in the PIPELHYNE project, a collaborative European project assessing the impact of hydrogen on pipeline steels, as well as the effects of inhibitors.

- **Durham University:**
  Recently completed a student placement project that assessed the key effects of hydrogen on gas transmission infrastructure; and conducted a literature review to highlight knowledge gaps in the current research programme. This work will form the basis of a further six-month research project that will act as a gap analysis, highlighting where FutureGrid is filling these gaps.

- **Edinburgh University:**
  Recently started a placement project literature review linking SGN H100 activities with FutureGrid/H21 and other hydrogen pilots. This will help us identify knowledge gaps, avoid duplication, and develop crucial interfaces. This includes links across to H100 in Fife and other small hydrogen pilots around the UK. The work will help identify common problems and seek to transfer solutions between operators to inform a regulation pathway for decarbonisation, including the transportation and storage of hydrogen on shore and near shore

Next Reporting Period

During the next reporting period the following milestones will be achieved:

Commissioning

- Complete the hydrostatic testing and commissioning of the FutureGrid facility. The commissioning of the facility and first phase of testing will be conducted with 100% natural gas.

Testing

- Complete testing of the facility with natural gas and hydrogen blends (2%, 5%,10%, and 20%)

- Complete testing of the facility with 100% hydrogen.

Standalone testing

- Completion of standalone testing

- As of December 2022, the fatigue rig has undergone over 15,000 pressure cycles, which equates to over 40 years of operational life. At the end of the project (October 2023) the cycle data will be extracted and reported in the project closure report. However, the fatigue rig pressure cycling will continue throughout 2023 into 2024 up to the required 150,000 cycles, as a standalone test independent of the project.

QRA and safety case

- The overpressure testing will be completed. Additionally, the QRA and methodology review will be completed as part of the facility testing.

Dissemination and Close out

- A project closure report will be submitted to Ofgem.

- Engagement will continue through events and other activities as detailed in the communications plan.

Business Case Update

At the time of writing, there have still been no changes to the anticipated benefits to be gained by the project. The summary of the benefits case set out in the 2021 Project Progress Report is shown below.

The key financial benefits of the FutureGrid programme as set out in the NIC Full Submission Document are from 2 key methods:

- **Method 1 – Creation of world leading net zero test facility as a focus for hydrogen testing:** In order to gather the required understanding and knowledge of how a hydrogen NTS would operate, a number of the different types of assets and tests we would need to carry out could either be completed separately or combined on a single test facility. This projected benefit would see £20.5m saved against the cost of conducting all eligible tests separately.

- **Method 2 – Avoiding valve replacement as part of work to connect industrial clusters:** Currently the most likely scenario for hydrogen transition and adoption will be at industrial clusters. The NTS will be used to join several clusters together by 2040, for which plans are being developed in detail under Project Union. To facilitate this, safety critical assets such as valves would all need to be replaced for hydrogen operation if they are not proven to be compatible to operate safely with hydrogen blends up to 100%. FutureGrid unlocks the opportunity to prove this compatibility, with projected benefits of avoiding a proportion of valve replacement being at least £46.5m.

FutureGrid also presents an opportunity to reduce carbon emissions, with a total of 81m tonnes of carbon emissions expected to be avoided:

- **Unlocking the opportunity for the NTS to convert to 100% hydrogen by 2050:** We have assumed a linear reduction in demand towards 2050 as previously quoted in the ENA Pathways Report, reducing from 880 TWh in 2020 to 440 TWh in 2050. Assuming 440 TWh and a CO2 emissions per energy demand of 0.0549 kg/ft3 by converting the NTS to 100% hydrogen by 2050, we will reduce carbon emissions by 81m tonnes CO2 e.

- **Avoiding valve replacement as part of work to connect industrial clusters:** Removing the need for all valves to be replaced by proving their compatibility with hydrogen could see at least 100,000 tonnes of CO2 e being saved based on an initial part of the NTS transitioning to hydrogen.

Unlocking the Opportunities for Project Union

FutureGrid forms part of GT&M's Hydrogen Programme, which is focused on delivering strong foundation evidence that we can safely operate the National Transmission System with Hydrogen to accelerate the UK's transition to net zero by 2050.

In delivering the outputs from FutureGrid, we provide an enduring test facility that allows further research and asset testing to continue this evidence development. We also expect to be able to demonstrate the capability of a number of assets including our valves, which could be costly if all were to be replaced. This is a key element to unlocking Project Union and the benefits it can bring. In achieving its outputs, FutureGrid enables Project Union and the significant benefits it will bring to the UK economy.

Consumer-centric	
Levelling up and jobs	
Connectivity and efficiency	
Providing flexibility and optionality	
Market coupling	
Decarbonisation of industry and power	CO_2
Energy storage and resilience	H_2
Global leader in green innovation	
Energy independence	

£300m* annual GVA (2021 prices)

3,100* jobs at peak construction

Project Deliverables and Project Against Plan

Following feedback, we have streamlined the report by combining the project deliverable and progress against plan sections of the report. This section summarises the key progress to date as we come to the end of the build phase of the project and commence preparations for commissioning.

Project deliverables and progress against plan

The project deliverables and evidence agreed at the time of the project direction have been stated below. GT&M has also added checkpoints on the key deliverables. The purpose of the checkpoints is to ensure that all the results have been achieved for that specific test before we proceed. This is because returning to any deliverable after a checkpoint has been crossed will add additional costs and time to the overall project.

Some of the key deliverables have been split into a further phase since the project direction was provided. Those deliverables entailed important activities that were being carried out over a longer period. They were split further to align with the checkpoints required in the project. This should not have an impact on the overall deliverable timeline.

Ofgem deliverable ref 1.0: Groundworks and construction – January 2023
(original bid date: November 2021) **Status:** Ongoing

Evidence required:

- As built drawings – *Ongoing*
- Written scheme of examination – *Ongoing*
- DNV GL report of build activity and lessons learned – *Completed*

Latest update summary:

Overall, most activities in the construction stage have been conducted on time in this reporting period. However, delays in the delivery of the recompression unit have affected the duration of the construction programme by three months. This is due to the availability of specialist third parties, alongside considerations for other scheduling issues, such as site closure over holiday periods and weather considerations for commissioning activities.

We have worked in collaboration with DNV and implemented additional mitigation measures, such as restricting non-essential site visits to avoid any further delays. This has been successful, as all the construction activities are nearing completion without any additional delays.

This deliverable is associated with the activities to build and construct the facility, using decommissioned assets to replicate the NTS.

Preparatory phase

Key planning activities have been carried out to ensure the build/testing phases of FutureGrid can progress as efficiently as possible. This includes:

- **Standards:** A working group was established to set out the key standards and policies to be used for the facility build and testing (e.g. ASME B31.12). By working in collaboration, both parties demonstrated compliance adhering to set standards, policies and procedures. Compliance was demonstrated throughout the groundworks and construction phase, which ensured the FutureGrid build was accomplished safely and delivered efficiently within allocated budgets.
- **Design:** The FutureGrid design report has been drafted by DNV and submitted to GT&M and the HSE-SD for further review. Progress has been made in the following disciplines.
  - **Civils:** Many of the designs are now complete and implemented, with minor snagging works still outstanding. Following design approval, the compressor foundations are now constructed.
  - **Mechanical/gas engineering:** DNV has generated and incorporated a 3D design model for stress analysis alongside producing necessary calculations; the two designs have proven to compare with the data obtained. This will continue over the commissioning and testing period.
  - **Electrical designs:** Designs are now complete. DNV is coordinating with Electricity North West to upgrade site infrastructure. As a possible contingency for the electricity supply issue, a temporary generator may be used.
  - **Control and Instrumentation:** Designs are completed, meaning control and instrumentation wiring panels have also progressed to completion. Work is now complete on the analyser kiosk which supports gas quality analysis for the FutureGrid facility. Flow computers have been configured and meters calibrated ahead of commissioning.
- **Asset inspections:** DNV has carried out a detailed inspection report on all assets, with recommendations that have now been completed and incorporated into the FutureGrid facility. This technical report consists of visual inspections, magnetic particle inspections followed by more thorough ultrasonic testing to confirm mechanical soundness and help identify any defects. Testing has identified assets that cannot be incorporated into the facility in their current condition. This ranges from assets that simply require cleaning, through to assets that do not have sufficient integrity to safely test with hydrogen. Although the assets are being repurposed due to being at the end of their working life, the quantity and severity of these defects has been more than originally anticipated.
- **Asset remediation:** Planned maintenance has been carried out on some of the decommissioned assets so they can be safely operated within the FutureGrid test facility without compromising the project ethos of representing the NTS. GT&M's PMC team rectified defective Cameron isolation ball valves so they can be operated with optimal safety. Other examples include planned preventative maintenance procedures, including testing and certifying primary and secondary protective devices. DNV, supported by GT&M, has ensured all pressure vessels supplied adhere to current PSSR examination specifications for safe operation.
- **Asset replacement:** Where assets have been identified as not having the required integrity or functionality, remediation is not an option. The FutureGrid team has used the contingency plan in such instances. Testing of the original sections of pipeline supplied revealed compromised integrity, showing minute cracks that had been noted during magnetic particle inspection tests, thus being recognised as a valuable observation. The learning outcomes were cascaded through different departments across the wider GT&M business.

- **Procurement:** The recompression unit has been ordered and the design is being refined to ensure it is compliant with hydrogen design codes. However, an identified risk (as referenced on page 38) has resulted in a delay to the overall project programme of one month.

- **Review of metering:** The NTS flow computers have been transported to DNV's laboratories. There, the software configurations are being examined to determine if modifications are required to calculate the flow rate of the gas blends. Following an inspection of the meters to be incorporated into the facility, issues such as corrosion have rendered some meters unusable for the gas blend testing. GT&M has since purchased two flow meters: a modified ultra-sonic flow meter capable of working with up to a 30% hydrogen blend; and a new 100% natural gas flow meter, representative of what is currently used on the NTS. These flow meters will be compared to orifice plate meters on the FutureGrid facility, to replicate the parts of the NTS where metering upgrades have not yet taken place.

Build phase

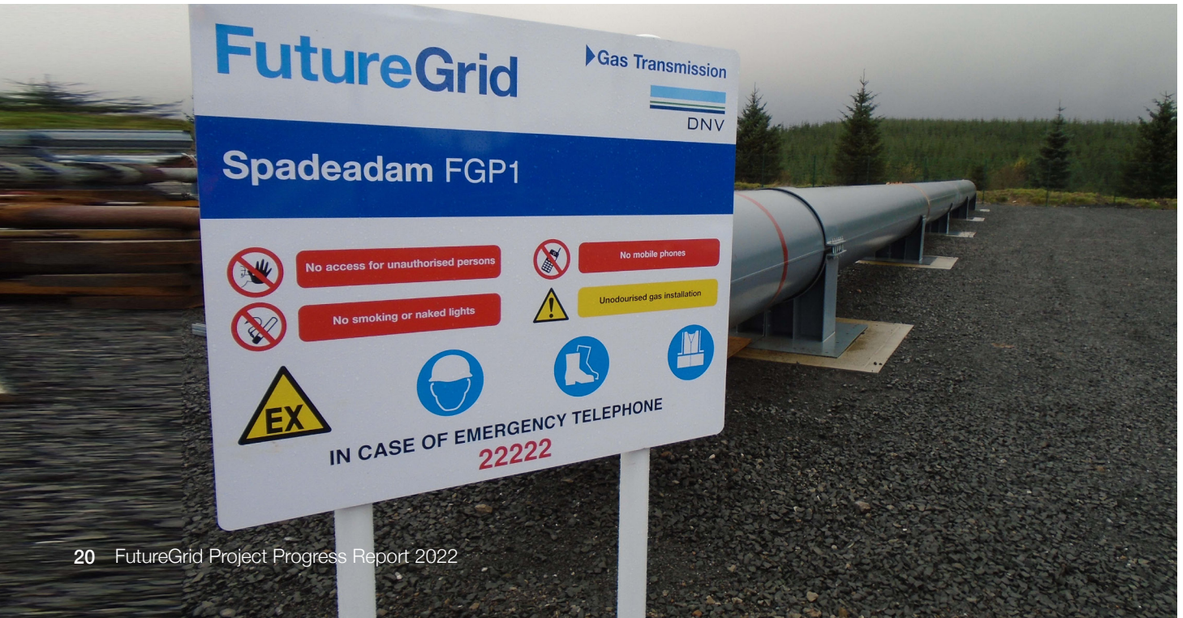
DNV has finished groundworks and construction is mostly complete. The FutureGrid site is now representative of the National Transmission System. The 48" high pressure reservoir is now connected via 18" inlet pipework into the new FutureGrid site, and all isolation valves and associated pipeline assets are now welded in position and ready for commissioning. The FutureGrid control room is nearing completion. This will act as the location for human/machine interfaces and the focal point for the main supervisory control and data acquisition interfaces. Following factory acceptance test approval, the LMF compressor is now installed on its new concrete base and currently being set to site specifics. The new flow meters have now been installed and are also ready for commissioning.

Progress has been made regarding the installation of site water supply which also provides a feed for FutureGrid's fire ring main. Drainage, along with ducting works, is now complete, which has ensured the supporting infrastructure required for the facility has proceeded according to plan. Electrical infrastructure works are still progressing.

Planned works

To ensure the build and commissioning phases are completed in the next 12 months, the following will be carried out:

- Testing of metering and gas quality assets.
- Hydrostatic testing of relevant assets and compilation of commissioning documents.
- Commissioning of the FutureGrid flow facility.



Ofgem deliverable ref 2.0: Standalone testing and facility commissioning – April 2023
(original bid date: Jan 2022) **Status:** Ongoing

Evidence required:

- Successful completion of testing and commissioning processes with supporting documentation – *In progress*
- Dissemination of facility design and layout to allow detailed development of Phase 2 and 3 interactions. The design will not be completed until the build has been completed – *Completed*

Latest update summary:

As the overall programme has been affected due to delays on the recompression unit, this deliverable has also been affected. We have created a detailed commissioning plan and envisage the activities will be conducted within the required timescales. We have successfully completed all the standalone integrity tests. The other standalone tests are on track to be completed in the next reporting period.

Commissioning

Commissioning is now in progress and the calibration of the two ultrasonic meters has been completed, ready for them to be installed into the facility. The two orifice plates have been calibrated at the DNV flow centre and installed into the metering skid ready for the first flow tests. The Danalyzer has passed its performance evaluation test and is able to measure natural gas, with up to a 100% hydrogen blend. The test plan has been developed and approved. Some standalone leak testing has been completed, with the data currently being analysed. Reports will be shared as soon as they are available. The hydrostatic test is due to be completed in February. This will ensure the site is safe, by pressuring it up to 1.5 times maximum operational pressure. Calibrations on the site instruments have been carried out. The configurations on the flow computers have been completed ready to undergo a full metering system calibration as per GT&M ME2 procedures.

The Master Test Plan defines the set of tests which are to be conducted over the course of the project. The aim is to ensure as much relevant information as possible is extracted, so we can understand the assets' hydrogen compatibility. The data gathered will be analysed in detail and used to evidence the changes in operation for gas transmission assets in hydrogen service.

The Master Test Plan has been refined over the course of the project. The aim of this has been to better reflect the details of the build and the requirements identified by stakeholders, such as Future Fuels CRC Australia providing independent review. This includes recent revisions to the operating flow rates to allow for comparisons across the two modes of operation.

There was much discussion around the location and nature of monitoring equipment on the test facility. It was determined that strain gauges would be the most appropriate tools to measure vibration during operation. Also, while subject matter expert (SME) knowledge can give an indication of good monitoring locations, it was decided to leave some aside until commissioning, so that vibration hotspots can be identified using a portable accelerometer.

Test procedures for the standalone tests were also developed and refined during this period. For example, the leak test on the 48" ball valve was modified to measure the leak rate from one side of the valve and out through the cavity vent. This allowed us to determine the leakage rate across one seal at a time, rather than simply the valve as a whole.

Standalone tests

Permeation testing
The methodology for the permeation tests on pipe coupons has been revised, based on initial test findings. Testing was first conducted by creating a test cell, where a machined 3mm thick disk of pipeline base metal was subjected to 70 bar of hydrogen pressure, with any hydrogen being detected at atmospheric pressure on the other side of the disk. Despite holding the sample under pressure for 40 days, no hydrogen was detected, so it was proposed to move to a more rigorous test method.

The new test method involves machining a more complex sample shape, in which the sample contains an inner void that's pressurised with high-pressure hydrogen and is then held within a sodium hydroxide solution. Any hydrogen permeating into the solution will change the electrical potential of the solution, which will be registered by the attached potentiostat. This should allow for detection of much smaller quantities of hydrogen.

Pipe coating and CP testing
This testing is dependent on the completion of the permeation testing.

Fatigue testing
During this period, the fabrication of the fatigue test module was completed. This includes eight different weld types, which were selected after two SME workshops to ensure the test is as representative as possible.

Fatigue cycling began in September and, as of December 2022, the module has undergone more than 15,000 pressure cycles, equivalent to approximately 40 years of operational life. The cycle time is currently around 6.5 minutes, although this could be reduced to around five minutes, as one of the four pumps used to operate the facility is out of commission. It's expected this will add approximately two weeks to the overall test time, but it won't have an impact on the wider project.

Non-destructive testing of the welds was conducted before the test began. This will be repeated 5 times during testing to highlight any discrepancies that would suggest a degradation of the material.

Flange testing
During this period, two flanges, one ring-type joint (RTJ) and one raised face (RF) were leak-tested. These were tested in one system and subjected to a five-day hold with natural gas at 102 bar, followed by a five-day hold with hydrogen at 102 bar.

There was no leak measured for either joint under either test. This supports the growing evidence that if equipment is leak-tight with natural gas, it will remain so with hydrogen.

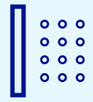
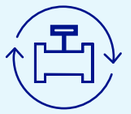
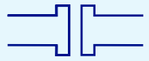
Asset leak testing
During this period all planned asset leak tests were completed. The regulator skid was found to leak excessively, possibly due to transit. The skid was refurbished by PMC and it was leak-tested once more before being moved to the main facility.

The results of the leak tests were in line with expectations and previous evidence that was gathered by the gas distribution networks. Assets that were leak-tight with natural gas remained so with hydrogen. However, those that leaked with natural gas leaked to a greater degree with hydrogen. The difference between natural gas and hydrogen is generally proportional to the size of the leak (i.e. a bigger leak will show a greater difference between natural gas and hydrogen). This will be a very useful finding in making assets on AGIs hydrogen-ready.

Rupture test
During this period, the test procedure for the rupture test has been developed. This deviates from a traditional rupture test, as it will use mechanical means to rupture the pipe, rather than an explosive charge, to allow for delayed ignition. This is to simulate a worst-case scenario for a high-pressure gas release and to allow the capture of overpressure and thermal radiation data.

During the next reporting period all standalone tests, with the exception of the fatigue testing, will be completed. The results will be shared according to the communication plan.

Reason for revised date: Dates for the standalone testing have shifted to prioritise the construction of the main facility. Permeation testing dates have shifted due to a change in test method, and the completion of leak tests was delayed to remove the need to repeat tests for the regulator skid.

Standalone hydrogen test module	End date	Status	Progress to date
Material permeation testing 	Jan 2023	Ongoing	Initial methodology revised and tests completed with no permeation detected. Test methodology revised again with more rigorous test, currently ongoing.
Pipe coating and CP testing 	Jan 2023	Not started	Not started. This will follow the permeation testing
Fatigue testing 	Oct 2024	Ongoing	Weld procedures agreed with SMEs and design finalised. Rig constructed and commissioned. Testing ongoing, 10,000 pressure cycles achieved so far
Flange testing 	Aug 2022	Complete	Tests complete showing no leakage on either flange type
Asset leak testing 	Oct 2022	Complete	Tests complete including additional tests after asset refurbishment. Data currently being analysed but initial results are in line with expectations
Rupture testing (only the build of the test rig – testing falls under Ofgem deliverable 4.2) 	Feb 2022	Ongoing	Test procedure developed, preparatory works are ongoing

Hydrogen testing

Testing on the offline hydrogen test facility is due to start in 2023, with several preparatory activities undertaken throughout 2022. This is to ensure the facility is designed, constructed, and commissioned to provide the most suitable conditions for the varying hydrogen blends to be tested.

To operate the flow facility at a representative NTS pressure of 70 bar, additional materials testing was required on the line pipe designated to be used to construct the facility. This materials testing is nearing completion by DNV at its facility in Columbus, Ohio. The initial indications from the testing is that we can operate the facility at 70 bar while complying with the ASME B31.12 Method B approach.

The first test to be completed will be using 100% natural gas, which is representative of process conditions on the NTS.

100% natural gas will be the baseline for all future testing and ensures the site is safe to operate. The data from this test will be analysed and used as a baseline where the results of hydrogen and hydrogen blend tests can be compared.

There are four key blends we are testing on the FutureGrid facility: 2%, 5%, 20% and 100% with a pause at 10% to allow for meter calibration. The duration of each test is shown below:

Hydrogen concentration	Natural Gas concentration	Duration
2%	98%	4 weeks
5%	95%	4 weeks
20%	80%	4 weeks
100%	0%	4 weeks

The facility will be paused at 10% hydrogen and 90% natural gas concentration for 2 weeks to allow for the assets to be calibrated before continuing with 20% hydrogen testing.

We are now also including a 5% blend test in our test programme. This has pushed out the remaining programme deliverables by four weeks to allow for these tests to be carried out. This has been submitted as a change control to Ofgem for the change in programme, with it being funded via the NIA mechanism.

The additional 5% hydrogen blend test has arisen from policy developments in Europe, which could affect the use of hydrogen on the continent and, by extension, the UK through our two gas interconnectors. In a recent policy paper draft, the European Commission suggested that readiness for the acceptance of 5% hydrogen by volume could be the first step for European transmission network operators in a transition to hydrogen. Therefore, it was deemed sensible for the FutureGrid project to consider the inclusion of a 5% test into the project plan. This ensures that the UK can continue to seamlessly trade gas with the European market.

Between each of the hydrogen blend tests we have included a ‘go/no-go’ checkpoint. This allows the project partners to make sure all tests for the various blends have been completed, and that no re-tests are required before the facility is prepared for the next blend test. It is imperative we ensure all tests are completed, including any re-tests, as it will be costly and time-consuming to revert the facility back to a lower hydrogen blend later. It would also be counter to the project sustainability ethos, as it would require the 100% hydrogen blend to be vented, so a 5% blend could be tested.

Ofgem deliverable ref 3.1: Testing 2% hydrogen – May 2023
(Original bid date: October 2022) **Status:** Not started

Evidence required:

- Completion of 2% H2 tests identified by the master testing plan, including launch and close-out events – *To be completed in the next reporting period*
- Identification of future test requirements as a result of the findings – *To be completed in the next reporting period*
- Results collated, documented and validated for impact on next phases of hydrogen development activities – *To be completed in the next reporting period*

Latest update summary:
The testing deliverables are dependent on the groundworks and construction being delivered on time. The delays experienced here have affected the timeline for testing, as described on page 10.

The first of the hydrogen tests will be 2% hydrogen with 98% natural gas. This low concentration of hydrogen is being tested to reflect the assumption that blends will be needed to facilitate a hydrogen transition of the NTS. No significant changes to operation are expected at this point, and most assets should function with little to no impact from the 2% hydrogen blend test.

The full set of results from this test will be captured in the detailed report produced by DNV and will form a chapter in the FutureGrid Closure Report. A brief ‘go/no-go checkpoint’ report will be issued promptly, confirming which tests have been completed and including details on the initial observations. This report will inform the decision for the **go/no go checkpoint – 2% hydrogen blend tests complete, no additional tests required.**

Ofgem deliverable ref 3.2: Testing 5% hydrogen – June 2023

(Original bid date: N/A) **Status:** Not started

Evidence required:

- Completion of 5% H2 tests identified by the master testing plan, including launch and close-out events – *To be completed in the next reporting period*
- Identification of future test requirements as a result of the findings – *To be completed in the next reporting period*
- Results collated, documented and validated for impact on next phases of hydrogen development activities – *To be completed in the next reporting period*

Latest update summary:

The associated timescales of the deliverables described in the NIA sanction paper are currently on track.

Through collaborations with European partners, the FutureGrid team has kept a watchful eye on policy developments in Europe. These could affect the use of hydrogen on the continent and, by extension, the UK through our two gas interconnectors. In a recent policy paper draft, the European Commission suggested that readiness for the acceptance of 5% hydrogen by volume could be the first step for European transmission network operators in a transition to hydrogen. This would mean that gas entering the National Transmission System (NTS) through the interconnector could have up to 5% hydrogen blended with natural gas.

The FutureGrid team liaised with OFGEM in November 2022. It was decided that the 5% project would be set up as a separate NIA project with its own deliverables and funding mechanisms. However, in order to take full advantage of cost and time savings, the 5% testing is incorporated within the FutureGrid test plan. The NIA project was sanctioned on November 2022. It is estimated that it will provide a cost saving of £470K and will reduce the project timescale by one month.

The project has been divided into the follow four deliverables:

- **NIA Deliverable 1** Test plan review and sign-off – 12 December 2023 to 13 February 2023
- **NIA Deliverable 2** Asset preparation and 5% hydrogen 95% natural gas fill of high-pressure reservoir – 8 May 2023 to 25 May 2023
- **NIA Deliverable 3** (also known as NIC Deliverable 3.2) 5% hydrogen blend test on the facility – 26 May 2023 to 22 June 2023. go/no go decision point for the test facility to progress to 10% meter validation test 23 – 26 June 2023
- **NIA Deliverable 4** Data analysis and review for 2% and 5% hydrogen including report – 26 July 2023 to 27 September 2023

The 5% hydrogen blend test as part of this NIA project will be conducted after the 2% hydrogen blend test, and before the 10% meter calibration test. This is the most efficient and effective option, allowing for a small amount of gas to be vented in order to take the concentration of the facility from 2% to 5% hydrogen.

As for all hydrogen blends tested on the FutureGrid facility, the 5% hydrogen blend test will be conducted over four weeks, with time to prepare the tests and fill the facility, before analysis of the results afterwards. As the 5% hydrogen blend test forms part of the wider FutureGrid Phase 1 testing programme, an initial set of observations will be reported as part of the NIA governance. The full technical report and analysis will be provided at the NIC project closure. This allows these results to be adequately interrogated alongside the full set of hydrogen blend test results and a full set of observations and outcomes can be recorded. This report will inform the decision for the **go/no go checkpoint – 5% hydrogen blend tests complete, no additional tests required.**

Ofgem deliverable ref 3.3: Testing 20% hydrogen – August 2023

(Original bid date: October 2022) **Status:** Not started

Evidence required:

- Completion of 20% H2 tests identified by the master testing plan, including launch and close-out events – *To be completed in the next reporting period*
- Identification of future test requirements as a result of the findings – *To be completed in the next reporting period*
- Results collated, documented and validated for impact on next phases of hydrogen development activities – *To be completed in the next reporting period*

Latest update summary:

The testing deliverables are dependent on the groundworks and construction being delivered on time. The delays experienced here have affected the timeline for testing, as described on page 10. In addition, the 5% blend test has increased the overall project timescales.

The second of the hydrogen tests will be 20% hydrogen with 80% natural gas. Before we reach this 20% blend in the facility, we will pause at 10% hydrogen with 90% natural gas. This is to allow for a shorter duration test to be conducted, to calibrate and assess the meters and flow computers. The blend will then increase to 20% hydrogen with 80% natural gas. The 20% hydrogen blend test is expected to show changes to the thermal and flow characteristics of the gas. However, these are expected to be relatively small and won't change the overall operation of the system.

The full set of results from these tests will be captured in the detailed report produced by DNV and will form a chapter in the FutureGrid Closure Report. A brief 'go/no go checkpoint' report will be issued promptly, confirming which tests have been completed and including details on the initial observations. This report will inform the decision for the **go/no go checkpoint – 20% hydrogen blend tests complete, no additional tests required.**

Ofgem deliverable ref 4.1: Testing 100% hydrogen – October 2023

(Original bid date: February 2023) **Status:** Not started

Evidence required:

- Completion of 100% H2 tests identified by the master testing plan inc. launch and close-out events – *To be completed in the next reporting period*
- Identification of future test requirements as a result of the findings – *To be completed in the next reporting period*
- Results collated, documented and validated for impact on next phases of hydrogen development activities – *To be completed in the next reporting period*

Latest update summary:

The testing deliverables are dependent on the groundworks and construction being delivered on time. The delays experienced here have affected the timeline for testing, as described on page 10. In addition, the 5% blend test has increased the overall project timescales.

The third of the hydrogen tests will be 100% hydrogen. To achieve net zero by 2050, we need to transition the NTS to transport 100% hydrogen. This testing is vital to understand how the assets perform and what modifications could be required, including any further work. It is envisaged that the facility will require some modifications as we transition to 100% hydrogen.

The full set of results from this test will be captured in the detailed report produced by DNV and will form a chapter as part of the FutureGrid Closure Report. A brief 'go/no go checkpoint' report will be issued promptly, confirming which tests have been completed and including details on the initial observations. This report will inform the decision for the **go/no go checkpoint – 100% Hydrogen tests complete, no additional tests required.**

Ofgem deliverable ref 4.2: Testing 100% hydrogen fatigue testing – October 2023

(Original bid date: April 2023) **Status:** Ongoing

Evidence required:

- Completion of fabrication and hydrostatic pressure test of the standalone fatigue test module using a selection of pipeline welding procedures. This will be completed during the next reporting period.
- Commence pressurising the test module with hydrogen and hold at pressure to enable permeation of the hydrogen into the pipe wall. Begin the pressure cycling of the test module. This will be completed during the next reporting period.
- Completion of the required number of pressure cycles and completion of the test.
- Results collated, documented and validated for impact on next phases of hydrogen development activities – t*o be completed in the next reporting period*
- Identification of future test requirements as a result of the findings – t*o be completed in the next reporting period*

Latest update summary:

Complexities associated with construction and commissioning have occurred alongside the pressure cycle times being longer than originally expected. As this is over 150,000 cycles a slight increase makes a significant difference.

Fatigue testing commenced in August 2022 and, as of November 2022, more than 12,000 pressure cycles have been completed. This is more pressure cycles than most NTS pipeline have been subjected to during its operational life. Due to complexities associated with the construction and commissioning of the bespoke test module, the fatigue testing will continue into 2024. Also, the time taken for each full pressure cycle (approximately 6.5 minutes) is causing the overall test time to increase from 18 months to 24 months.

Ofgem deliverable ref 5.0: QRA and safety case – November 2023

(Original bid date: March 2023) **Status:** Ongoing

Evidence required:

- Overpressure testing on secondary off-line NTS test facility – *to be completed in the next reporting period*
- Validation of results into existing QRA model and any mitigations reviewed (updated QRA and mitigation log) – t*o be completed in the next reporting period*
- High level review of NGGT's policies and procedures documented – *completed*
- Prepare a commented version of the safety case – *to be completed in the next reporting period*
- Updated asset assessment and hydrogen risk review – *to be completed in the next reporting period*

Latest update summary:

The policies and procedures review is now complete. Fatigue testing began in October and is currently ongoing. The overall project timelines have increased by 3 months due to the delays from the recompressor unit this means the delivery of the QRA has also extended by 3 months.The review of hazardous areas for two samples NTS sites is ongoing.

The workstream was reviewed and it was identified that there are six key areas that the testing outcomes will impact:

1. **Procedure review:**
   Categorisation of GT&M procedures as high, medium, low impact with a report detailing the methodology findings and next steps for each.

2. **Hazardous assessment of transmission system**: Assess impact of hydrogen on Major Accident Prevention Document (MAPD). Provide an updated hazard assessment of the transmission system (HATS) for the NTS pipelines, based on the network transporting hydrogen instead of natural gas.

3. **Quantitative risk assessment:**
   Record and update the Hazard Assessment Methodology Manual (HAMM) where deviations are required for assets transporting hydrogen.

4. **Hazardous area impact:**
   Hazardous area drawings will be produced for a typical compressor station and AGI at 20% and 100% hydrogen and compared to existing natural gas drawings.

5. **Overpressure risk:**
   This is hazardous range associated with a potential pipeline incident. The work is to identify whether the existing methodology can be adapted for 100% hydrogen. If needed, develop an appropriate methodology for risk analysis and emergency planning purposes.

6. **GT&M safety case:**
   Assess GT&M safety case (policies, procedures, and work instructions) and recommended modifications with respect to the impact of hydrogen. Review will involve GT&M safety team and SMEs.

Outcomes this period

- **Policy and procedure review:** The draft policy and procedure review has estimated that a full update of the GT&M document suite will require 6,130 days of effort, or approximately 27.5 years.

Policy and procedure review

We have identified 653 GT&M documents from the Safety Management System (SMS)) to be assessed. Of these, 99 were not applicable meaning they were out of scope, withdrawn, or there was no document received or available. Therefore, 554 were assessed to determine if they needed to be updated and to identify the scale of the updates required.

Of the 554 documents assessed, 179 were considered to require no change (e.g. documents relating to civils, document control etc), 108 were deemed to require very minor changes, 154 require medium changes, and 113 require a high degree of change.

DNV has estimated the required effort needed to update each document, based on the length, type and level of change. These figures include stakeholder workshops, recalculations, process changes and re-drafting of diagrams. In some cases this would also include computer modelling and scenario planning.

Progress next period

The next reporting period aims for the completion of the hazardous area impact assessment to accompany the completed hazardous area drawings. The procedure review will be finalised after being circulated within GT&M. The literature review and design for the overpressure risk test will be completed. The QRA and safety case elements will be progressed with the involvement of internal GT&M SMEs.

Ofgem deliverable ref 6.0: Knowledge dissemination – November 2023

(Original bid date: April 2022) **Status:** Ongoing

Evidence required:

As described in Section 5 'Dissemination' of this submission, the team will deliver a variety of dissemination activities throughout the project period. These will be completed at regular intervals during the project lifecycle and on closure – *in progress*

Latest update summary:

This deliverable is in relation to the knowledge shared throughout the project and will be completed when the project is completed. Impacts on deliverable 4.2 have also affected this deliverable.

From the outset of FutureGrid, we have adopted a ‘digital first’ approach to engagement and dissemination. We want to be as open and inclusive as possible for stakeholders across the UK and provide collaborative opportunities internationally. We have challenged ourselves to bring FutureGrid to life for as many people as we can, whether that’s through virtual sessions, walkthroughs, digital models, or on-site visits. This has proven very successful, even with the disruption caused by Covid-19 and its ongoing impact on the way everyone works. By maintaining our ‘digital first’ approach, we have ensured continued resilience for our engagement activities, knowledge dissemination, and collaboration. As our colleagues and stakeholders have navigated the new ways of working, we’ve been able to introduce more face-to-face engagement both on site and at events.

A highlight of 2022 has been attending the Energy Innovation Showcase in Glasgow, where we debuted our new digital model exhibition. We had a joint innovation stand alongside the other gas networks where we showcased the latest developments in our innovation programme. The FutureGrid digital model was the central feature of our section.

The digital model provides an opportunity to showcase the final facility plan using 3D modelling. This allows users to interact and learn more about the specific assets, including what the purpose of the asset is, what testing we will be doing on it and key statistics such as technical specifications, age of the asset and where it was sourced from. The model received excellent feedback and we plan to continue to develop this, to help bring the facility to life for those that can’t visit in person. We have plans in 2023 to take this model to further events and are also reviewing the options available to make it accessible online.

Throughout 2022, we have continued to build on the strong foundation we established for engaging with our stakeholders and disseminating information about the project. We’ve continued to engage with industry forums such as Gas Goes Green and the Hydrogen Research and Development Group, working with the Gas Networks, BEIS, Ofgem and other key industry bodies. We’ve developed the Quarterly Network Steering Group which brings together representatives from the Gas Networks and project partners to focus on the development of FutureGrid both in Phase 1 as part of the NIC, but also to explore the future opportunities being developed through the Strategic Innovation Fund (SIF) process.

The success of our mixed media approach to engagement on the digital platforms has seen us build on our key pillars of engagement, with a fourth pillar ‘FutureGrid feature’ added. These are key channels that allow us to be accessible to all stakeholders both nationally and internationally. Throughout 2022, we’ve been able to support these with the introduction of face-to-face engagement opportunities such as in-person conferences and workshops. The four key pillars of engagement for FutureGrid are:

Our engagement approach

FutureGrid Explore

FutureGrid Explore comprises webinars and in-person events focused on key topics relating to the FutureGrid project. These interactive events allow stakeholders to learn more about the project and participate in relevant discussions. These have continued to receive very positive feedback, with several stakeholders joining live and catching up with the recordings after the event. Highlights from the past year include:

Maintaining the National Transmission System (NTS) – March 2022
This FutureGrid Explore webinar looked at the ways that we currently maintain the National Transmission System (NTS), and how FutureGrid will help us understand what future maintenance may look like.

► **Watch here**

Our compression and deblending challenges – July 2022
This FutureGrid Explore webinar considered the challenges associated with hydrogen compression and deblending. Dave Hardman (Strategic Innovation Specialist) and Lynsey Stevenson (Hydrogen Innovation Engineer) gave an overview of some of the innovation projects we’re looking at to help us overcome these challenges.

► **Watch here**

FutureGrid Feature

FutureGrid Feature articles are focused on the key topics our stakeholders are interested in. They tackle some of the big questions around the hydrogen transition and provide more information on the fundamentals of what this could mean to us all. Key feature articles we’ve shared over the past year include:

Decarbonisation and net zero policy – what does it mean? – January 2022
In 2021, the UK government published several critical documents that will heavily influence the delivery of a net zero energy system. In this feature article we talk about what this means for us and how we are responding to deliver a net zero future.

► **Watch here**

What is a UK hydrogen backbone? – August 2022
We’re looking at repurposing existing pipelines within our network to create a hydrogen backbone for the UK. But what exactly is a hydrogen backbone? In this feature article we talk about what the backbone means and how it benefits the UK.

► **Watch here**

FutureGrid InFocus

FutureGrid InFocus gives stakeholders the opportunity to hear from those working on the FutureGrid project, whether that be the direct team or colleagues supporting the project. FutureGrid InFocus is a blog series providing insight and updates around the progress of the project as it's happening. We’ve continued to develop this series, providing a more personal perspective on the opportunities of hydrogen and how FutureGrid is unlocking these. Among our latest blogs are:

The different phases of FutureGrid – May 2022
Find out more about how we plan to expand the FutureGrid programme to enhance our knowledge of transporting hydrogen across our network in this FutureGrid InFocus blog, written by Haroon Khan (FutureGrid Project Manager).

► **Watch here**

What are the opportunities of a hydrogen gas network? – July 2022
Find out more about the opportunities that hydrogen presents in the energy industry in this FutureGrid InFocus blog written by Tom Neal (FutureGrid Manager).

► **Watch here**

FutureGrid Chat

FutureGrid Chat is a podcast series that brings together key experts across the project and wider industry, to talk about the big questions in hydrogen and how FutureGrid supports this. With the rise in podcasts in the net zero space, we’ve continued to develop these, bringing in a wider range of voices to cover the key topics our stakeholders have told us they want to hear more about. The latest podcasts in our series are featured below:

All about the NTS – April 2022
Kirsty McDermott (Senior Welding Engineer), Shaun Bosomworth (Senior Delivery Engineer) and Daniel Knowles (Hydrogen Engineer) discuss the characteristics of the National Transmission System (NTS), both now and in the future.

► **Watch here**

FutureGrid and other innovation projects – July 2022
In this episode of FutureGrid Chat hosted by Lloyd Mitchell (Hydrogen Engineering Lead for FutureGrid), Peter Martin and Robert Best (Hydrogen Innovation Engineers) discuss some of the innovation projects they are working on that support FutureGrid.

► **Watch here**

To see all of the webinars, articles, blogs and podcasts, please visit our website: nationalgrid.com/FutureGrid and go to the ‘Events and Resources’ section

Physical on-site visits have grown over the past year as Covid-19 restrictions have eased and we've been able to welcome more people to site around the construction activities. This has been a key element to sharing our story and being able to demonstrate what FutureGrid will achieve.

A key part of site visits is also to bring together technical experts from both our organisation and the wider industry to gain their insights, particularly where we may have technical challenges or be considering a range of options for configuring assets. As we continue the project, we will pursue both physical and virtual tours to ensure the widest range of stakeholders can access the facility and understand the work that we are doing.

Pairing physical and virtual site visits alongside our broad range of digital engagement has generated very positive feedback from our stakeholders. We continue to canvas opinion and look for new ways to engage as we move into the testing phase of FutureGrid.

We've continued our wider engagement across the UK regions and on an international stage, maintaining our pivotal role in collaborative efforts such as the Hydrogen Gas Asset Readiness (H2 GAR) group with several of the European transmission system operators (TSOs). Here we've shared our progress and are working closely with our international counterparts on a wide range of technical programmes. These are designed to accelerate our hydrogen programme and benefit from sharing a wealth of knowledge and research on the impacts of hydrogen on transmission assets. In addition, we've showcased FutureGrid at a range of industry events.

Including:

- IGEM North East and Yorkshire Innovation Day June 2022
- UKOPA Annual Conference May 2022
- YPPE hydrogen event July 2022
- Energy Innovation Summit Sep 2022
- 10th Pipeline Maintenance and Integrity Management Oct 2022
- GERG Board visit November 2022.

Ofgem deliverable ref 7.0: Comply with knowledge transfer of the governance documents – November 2023 (Original bid date: April 2022) **Status:** Ongoing

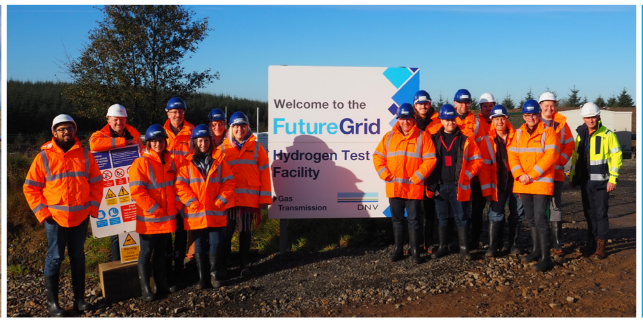
Evidence required:

- Annual project progress reports which comply with the requirements of the governance document – *In progress*
- Complete Close-Down Report which complies with the requirements of the Governance Document – *To be completed in the next reporting period*
- Evidence of attendance and participation in the annual conference as described in the governance document – *In progress*

Latest update summary:
This deliverable is associated with the activities that will be conducted as part of the project's governance. There is an overall delay in the project and this deliverable will be completed once the project is completed. The project remains in compliance with the knowledge transfer activities associated in V.3.1 of the Gas Network Innovation Competition (NIC) governance document.

The project is registered on the ENA Smarter Networks Portal **https://smarter.energynetworks.org/projects/nggtgn04/** where there are links to the Ofgem website for the screening submission and full submission pro-formas, alongside a copy of this project progress report. Further relevant documentation will be added when it becomes available.

As outlined throughout this report, we continue to work collaboratively with the UK Gas Networks and wider industry to share and disseminate all knowledge and learning from the FutureGrid project. To access our latest reports and see our full range of engagement including webinars, articles, blogs and podcasts please visit **nationalgrid.com/FutureGrid**.



350+ people have visited the FutureGrid site to-date

More than **25** webinars led or presented at by FutureGrid

5 podcasts created

12 blogs and articles released

Progress Against Budget

As part of the programme update in 2021 the project spend was reallocated to suit the revised project programme. With the materialisation of the risk of delay due to the recompression unit, the programme and costs have been adjusted to reflect the change in time. Please note there have been no changes in the overall revised costs from the original NIC budget.

The planned contingency spend has increased throughout 2022 as additional works have been identified for certain decommissioned assets to bring them to the relevant standard for inclusion in the facility. As these activities are only just coming to a close the costs have not yet been charged, therefore at the time of writing, contingency spend is £0. There is still contingency remaining as we progress into the commissioning and facility testing phases to support any further issues that may arise.

The table below provides an overview of the original NIC budget, revised budget, project forecast and actual spend up to November 2022. These figures are tracked via our SAP system and financial records for the project.

FutureGrid Phase 1 budget and spend to date:

	Original NIC Budget	Revised Budget Nov 2021	Revised Budget Nov 2022	Total Expected Spend by Nov 2022	Total Actual Spend by Nov 2022	Variance	% Variance
Labour	£5,303,769	£5,201,157	£5,263,849	£3,689,799	£3,558,712	£131,087	3.55%
Equipment	£4,229,006	£4,443,221	£4,356,642	£3,152,211	£3,103,814	£48,397	1.54%
Contractors	£65,020	£65,020	£65,020	£23,347	£0	£23,347	100%
IT	£10,000	£10,000	£10,000	£10,000	£10,000	£0	0%
Travel and expenses	£50,400	£50,400	£84,287	£46,787	£39,186	£7,601	16.25%
Contingency	£420,159	£308,556	£308,556	£0	£0	£0	0%
Other (Comms)	£160,000	£160,000	£150,000	£46,603	£41,794	£4,808	10.32%
Totals	**£10,238,354**	**£10,238,354**	**£10,238,354**	**£6,968,746**	**£6,753,507**	**£215,239**	**3.09%**

Commentary on budget line items:

- **Labour** – The actual spend is 3.55% less than expected due to the delay in the project programme pushing out some activities. In the total revised budget for November 2022 the labour has slightly increased compared to November 2021. This is reflective of the programme extending requiring more effort, but has been offset with reductions in equipment spend.
- **Equipment** – The actual spend is 1.54% less than expected due to the delay in the project programme and unexpected delays in the purchase of the re-compressor unit. The total revised budget for November 2022 equipment has slightly decreased compared to November 2021. As above this is due to the programme extending requiring cost to be reduced to cover additional labour spend.
- **Contractors** – The contractor spend has been less than anticipated due to the overall delay in the project programme, which has pushed the costs for HSE into 2023.
- **IT** – The IT budget was spent in 2021, as per the communications plan, with no further spend allocated.
- **Travel & Expenses** – The travel & expenses costs are recorded centrally on our internal SAP system and are reallocated to the project on a quarterly basis. Costs which have been incurred to date are within budget.
- **Contingency** – Due to the nature of the contingency pot, we do not forecast specific spend, instead we record when spend is incurred. Therefore, the variance in spend is 0%.
- **Other (Communications Spend)** – The actual spend for communications activities (the only costs in the 'other' category) is 10.32% less than expected. This is in part due to activities associated with communications spend moving into 2023. In addition, we've focused on driving efficiencies by completing a larger proportion of communications activities in house. This continues to drive down costs and has allowed us to reduce the budget by £10,000 to date, which has been reallocated to labour to cover additional costs.

Project Bank Account

A separate Project Bank account has been created as per the Ofgem NIC Governance 3.1 to manage all associated transactions for the FutureGrid NIC. The project bank account is monitored monthly as part of the project progress review. Transactions from the main National Grid account are mirrored quarterly to the bank account and reconciled via our SAP financial system and internal project management system to ensure accuracy.

Copies of the bank account statement are provided directly to Ofgem and due to confidentiality and data protection are not made available as part of this Project Progress Report. A summary of the key information is included below. Note all values have been rounded to nearest £1000.

Bank account transactions

As summarised in the 2021 Project Progress Report, the bank account statement clearly shows the following transactions from National Grid (NG):

- Compulsory Contribution **£819,287.52** (80% from NG)
- Voluntary Contribution **£100,000**
- Funds from the underspend on Project CLoCC* **£904,760**

* Project CLoCC is a previous NIC project which had an underspend. As part of the 2021 Funding Award from Ofgem, the money to be paid into the bank account has been reduced to allow for the Project CLoCC underspend to be put directly into FutureGrid. Therefore National Grid has transferred this money into the FutureGrid account.

In addition there is a transaction from our partner Northern Gas Networks (NGN):

- Compulsory Contribution **£204,821.88** (20% from NGN)

Since the 2021 Progress Report, the bank account received all 12 of the monthly payments as part of the Ofgem Funding Award for FutureGrid, with payments received totalling **£8,169,025.92**.

Deductions totalling **£4,889,397.9** have been made from the bank account as part of the bank account mirroring process to cover costs incurred up to September 2022 on the FutureGrid project including:

- DNV Costs
- NGGT Internal Costs
- Additional Contractor Costs

As of the end of November 2022 the bank account balance is: £5,318,030.37

The October and November invoices were delayed in being processed which has meant the next bank account mirror has been delayed till the new year.

Interest rates

The bank account is a non-interest-bearing account; therefore, no interest is gained on the balance and there is expected to be a shortfall in funding awarded as a result.

Learning Outcomes

The knowledge gained during this project can be implemented for similar future projects, so they can be delivered more efficiently and effectively.

We have had quarterly workshops between GT&M and DNV to discuss the lessons learned in the project. These are tracked throughout the project and are mentioned where relevant on the monthly governance meetings. The aim of this process is to benefit future phases of the project and other similar projects. These lessons are shared internally within GT&M and with DNV.

The key lessons learned in this reporting period are:

Asset maintenance: Planned maintenance has been carried out on some of the decommissioned assets to ensure safe operation within the FutureGrid test facility without compromising the project ethos of representing the NTS. GT&M's PMC team rectified defective Cameron isolation ball valves to ensure optimal safe operation. Other examples include planned preventative maintenance. This was due to early engagement with the relevant internal teams and meant the assets were all serviced and ready for installation earlier than planned.

Meters: During the FutureGrid build phase the instrumentation engineer identified a way of adding an additional meter in the facility, which enhanced the testing by cross-referencing between the existing meters, meaning all flow rates can be measured on all tests.

Decommissioned assets: During the conceptual detailed design phase, it was found that some of the decommissioned assets required some further maintenance. This posed a challenge in the redisposition of existing assets and arrangements to suit the project. Part of the agreed remediation for the future is the need for detailed assessments of assets during decommissioning planning and works.

Spares: Delays were experienced while ordering spares to support the build phase of the project, mostly due to supply-chain issues. For the future, following confirmation of required assets in the project's spares list, orders will be made to prevent the occurrence of long lead times.

Communications plan: Detailed plans for Future Grid communication works were principally based on monthly themes. Following feedback received from various stakeholders, the detailed communications plan for FutureGrid is now developed as a three-month look-ahead to reflect gathered interests and support received from both internal and external stakeholders.

Collaboration: To support the qualification of FutureGrid pipelines, there was reliance on information from materials related innovation projects during the project design phase. This created new knowledge requirements. In a bid to address this limitation, the agreed remediation is to expand the knowledge pool, to have more engagement with innovation SMEs and similar projects completed in the past. This will bridge the knowledge gap for projects done in future phases.

Material change due to delay associated with Recompression Unit

The biggest impact to the project programme has been caused by supply chain constraints associated with the recompression unit. Although the project has had to contend with a significant amount of unforeseen events, a real learning point in the future will be to include more float in projects to minimise the likelihood of procurement delays reoccurring.

5% blend test inclusion

The 5% blend testing was conducted as a separate NIA project. It was considered sensible for the FutureGrid project to incorporate a 5% test into the testing programme to ensure that the UK can continue to seamlessly trade gas with the European market. It is estimated this will provide a cost saving of £470,000 and will reduce the project timescale by one month opposed to testing separately.

Diverse multiskilled project team

The FutureGrid project team have a wide variety of knowledge and experience between them and as the team has evolved it has been enhanced by the inclusion of team members who offer a new perspective. This has added value to the project by augmenting what will be achieved throughout the commissioning and testing phases of FutureGrid.

We plan to continue to conduct regular lessons learned workshops throughout the project and will continue sharing the outcomes with the gas networks and wider industry. In addition to this, we will also take note of any lessons from similar projects that are shared with us, to develop our knowledge and understanding.

Risk Management

Our structured approach to risk management has resulted in developing a risk register – the highlighted key risks detailed in the project risk assessment matrix set out the risk, risk management and mitigation plans. The project team has documented the risks associated with the project and assessed them in terms of likelihood and impact. Proactive control of the risk register throughout the project will take place monthly as an agenda item of the project reviews, making sure the status against the mitigations is understood, re-assessed, and actioned by the project leads.

Key risks and issues from the monthly reviews are escalated to the Steering and Stakeholder Groups to ensure understanding and, where required, undertake further action. The risks are grouped into three main categories: health and safety, technical delivery, and project risks.

The risk register has been attached to Appendix.

Risk in 2021 compared to 2022:
In this section, we describe the top five risks in the previous reporting period and how we have worked proactively to close or reduce their likelihood. We also highlight their latest status.

- **Delays on delivery of recompressor unit – closed:** We managed this risk throughout the reporting period by implementing early mitigation measures for e.g. in April 2022, a risk materialised when the supplier couldn't procure control and instrumentation equipment due to global shortage of chips. We acted swiftly and sourced the parts from alternative suppliers, reducing any potential lead times.

  However, as previously stated in this report, a risk to the construction of the outer container (shell) of the recompression unit materialised in September 2022. This was due to constrained supply chains LMF (the recompression unit manufacturer) has exhausted all mitigation options to reduce the impact and minimise the delay. Despite best efforts, the outer container was delivered a month later than originally anticipated.

- **The assets may not have the required condition to support build the test rig – closed:** In order to close this risk, we worked diligently with DNV, PMC and GT&M Operations to prepare the assets for the facility, by conducting assessments and remediation works. We have successfully conducted these activities and the build of the facility is now completed.

- **Welding procedures not provided to DNV in a timely manner causing delay to fabrication of the fatigue test module – closed:** We have worked tirelessly with our internal teams and conducted visits to our archives to attain weld procedures of different ages used on the NTS. We were able to source the procedures in a reasonable time, which did not cause a significant delay to the fabrication of the fatigue test module. The module is now fabricated, and the risk can be closed out.

- **COVID-19 and Brexit causing volatility to the construction industry – reduced:** There was a potential risk that there is volatility in the construction industry due to Covid-19 and Brexit. We have reduced this risk by procuring the long lead items well in advance of when they are required. This has helped reduce the risk where possible.

The top five risks in this reporting period are as follows:

- **Assets fail during the master test plan:** We conducted inspections on the assets to confirm their suitability for incorporating them into the facility. We also carried out several standalone tests which identified that there have been unexpected leaks on the assets that could affect the test results.

  It is our understanding that these leaks are due to the ageing condition of the assets and because they were decommissioned several years before the FutureGrid project began, no regular maintenance was required. This allowed us to create a mitigation and maintenance plan for these assets, prior to installation, to mitigate this risk.

  As part of this plan, key components of the assets were replaced, and essential maintenance was conducted such as checking the operation and re-greasing the valves. These works will be added to the recommendations section at the end of the project. However, these assets have not been tested as a whole system and there is a potential risk that they may fail during the testing phase which means that there would be additional timescales and costs to the project.

- **Weather risk may impact commissioning and testing programme:** In line with the latest project programme most of the commissioning and testing activities are planned in the winter period when cold weather is common. This could conflict with the timing of the hydrostatic test as this activity cannot be carried out in freezing conditions.

  In addition to this, there is a chance that storms such as the previous "Beast from the East" may occur. In this instance, all site activities are likely to be stopped due to hazardous weather conditions. If this occurs, there is a potential for delays to some of the testing and commissioning activities. The project timelines are tight, and this will affect the project programme. To mitigate this risk, we are working collaboratively with DNV to identify activities that could be carried out either side of the winter period, with minimal effect on the overall project programme.

- **Availability of key internal and third-party resources during commissioning and testing phases:** There is a possibility that we experience issues with the assets and associated instrumentation during these phases and it is likely that we would require key internal and third-party resources to help manage these issues. There is a risk that they may not be available at the earliest opportunity which may affect the overall project programme. We are mitigating this risk by utilising internal engagement methods such as the SME discussion forum and GT&M's Operations liaison plan. In addition to this, we have allocated operational resources and third-party resources for two to three days at the start of each hydrogen blend, as any unexpected issues will most likely occur during that time.
- **DNV's electrical site upgrades:** There was a major risk in this reporting period that the electrical site upgrades required may not be conducted on time due to several factors. This is critical work and any delays to this work package could result in a delay to the overall programme, leading to increased project costs. This risk has reduced over this reporting period as we have progressed well, and we are confident that we should not encounter any delays, as the works are scheduled to be completed before the commissioning of the facility.

- **Risk of recompression unit at commissioning:** The recompression unit was delivered to site on 30 November. This unit has been designed to operate with natural gas and hydrogen. In addition to this, the recompressor has undergone factory acceptance tests (FAT) and site acceptance tests (SAT). However, there is still a potential risk that the recompression unit could encounter unexpected issues during commissioning.

  As it is a critical path item, any delays may impact the overall FutureGrid programme. We are monitoring this risk and we have plans for LMF (the recompression unit manufacturer) to be present during the different stages of commissioning and testing. In addition to this, the SAT and FAT conducted previously should further mitigate this risk.

We are managing the risks by working collaboratively and escalating them to the various project steering groups for mitigation.

Test Plan

The main testing planned during the FutureGrid project will be carried out on the offline hydrogen test facility, which has been constructed from a range of decommissioned assets. These assets have been in service with natural gas for several years on the NTS. Using these assets will provide the most accurate representation of the existing network, to test and trial key blends of hydrogen. These are:

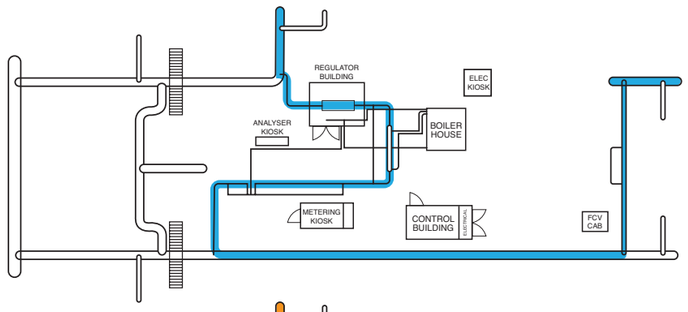
- 2% hydrogen
- 5% hydrogen
- 20% hydrogen
- 100% hydrogen

Once construction of the facility is completed, several activities need to be undertaken before the hydrogen blend tests can be carried out. This is known as the commissioning phase, where all the assets are calibrated, tested, and reviewed. As part of this, a hydrostatic test is undertaken, in early 2023. Once this is completed, the facility will undergo a final test where 100% natural gas will be injected into the facility, to test that it is fully functioning and to provide a baseline case for assessment.

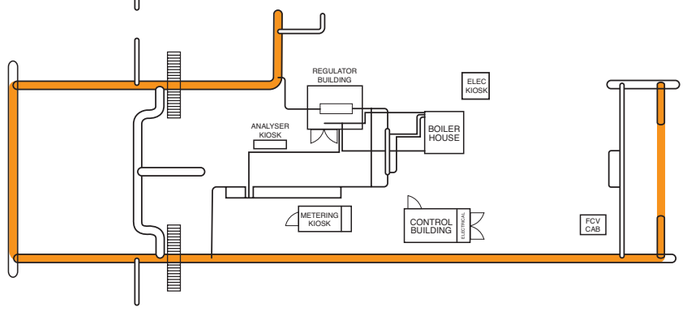
Once the facility has successfully passed this rigorous commissioning process, it is ready to flow with hydrogen.

The main test programme will focus on evaluating the performance characteristics of the most common type of pipe (LSAW pipe), size (36" diameter), material grade (X60), as well as the class rating of the different assets (e.g. valves, filters) which is #600.

Low flow rate



High flow rate



What are we testing?

2% hydrogen

The first hydrogen blend that will flow through the FutureGrid facility will be 2% mixed with 98% natural gas. This is due to the market foreseeing the introduction of smaller scale blends while production begins to scale up.This creates demand for hydrogen produced and enables changes to Gas Safety (Management) Regulations, known as GS(M)R, to be made which allows blending on the NTS.

5% hydrogen

A 5% hydrogen blend with 95% natural gas will now be incorporated into the phase 1 FutureGrid test programme The EU has released a decarbonised gas package, which proposes all TSOs must be able to accommodate up to a 5% blend. It's our ambition to keep aligned with this, as we are interconnected with Europe. The potential for variable hydrogen blends in the early stages of blending requires a safety margin. A 2% blend would likely be the first, so a 5% blend would provide a safety margin.

Pause at 10% hydrogen

The accuracy of meters at 10% hydrogen will be tested since the equation of state used to calculate density may change.Therefore, the calculations in the flow computer may need modification to calculate density correctly.

20% hydrogen

The last blend is 20% hydrogen with 80% natural gas. This has been chosen because it represents the highest level of blending that existing consumer appliances can handle without modification. This may dictate the maximum blend compatible with the NTS without needing modification.

100% hydrogen

The final test will use flows of 100% hydrogen and no natural gas. When we repurpose our network to 100% hydrogen these results will further our understanding of working with hydrogen and how it interacts with our assets. This will enable the development of appropriate processes, procedures, and safety standards, which are required to operate our network safely.

How are we operating the testing?

The recompression unit generates gas flows around the facility. This unit has been designed for the FutureGrid facility, to operate with natural gas and hydrogen at a wide range of flow rates and pressures to replicate the NTS. This allows us to simulate various flows across the facility that are representative of our network.

We have sourced a complete offtake arrangement, complete with metering equipment. This is used to bill the customer and reduce the pressure to make sure the end user gets billed correctly and receives the right supply pressure of gas. The FutureGrid facility also has an AGI block valve which simulates the isolations that would commonly be required on the NTS. Various tests will be performed across the facility that are routinely carried out by technicians working on our network.

Flow rates shown in the table below will be applied at all blends, starting with 100% natural gas as a standard, then moving up to 100% hydrogen.

Throughout the testing we will be concentrating on vibration, noise, and permeation across the facility. The leak monitoring that will be completed will be compared to natural gas.

The facility will flow at 7 constant rates up to 1.76mSCm/day with low flow rates representing a smaller offtake and high flows replicating a larger offtake:

Low flow rate

Flow 1 – 0.12mSCm/day

Flow 2 – 0.24mSCm/day

Flow 3 – 0.36mSCm/day

High flow rate

Flow 4 – 0.36mSCm/day

Flow 5 – 0.82mSCm/day

Flow 6 – 1.28mSCm/day

Flow 7 – 1.74mSCm/day

FutureGrid

Phase 2 Development

Once FutureGrid Phase 1 has been built and tested, there are further phases planned to adapt the FutureGrid facility and allow for the technical demonstration of more complex equipment. These demonstrations are essential to understanding how a hydrogen NTS would operate. It will also mark the natural evolution of the facility, moving from providing evidence for existing assets to developing new technology required for hydrogen operations.

In the last 12 months significant progress has been made against four key projects. These will be incorporated into the FutureGrid site to allow the facility to test and develop both complex and new technologies, which will be essential for a hydrogen NTS. These projects include:

- **SIF HyNTS Compression**
- **SIF HyNTS Deblending and Purification**
- **SIF HyNTS Pipeline Dataset**

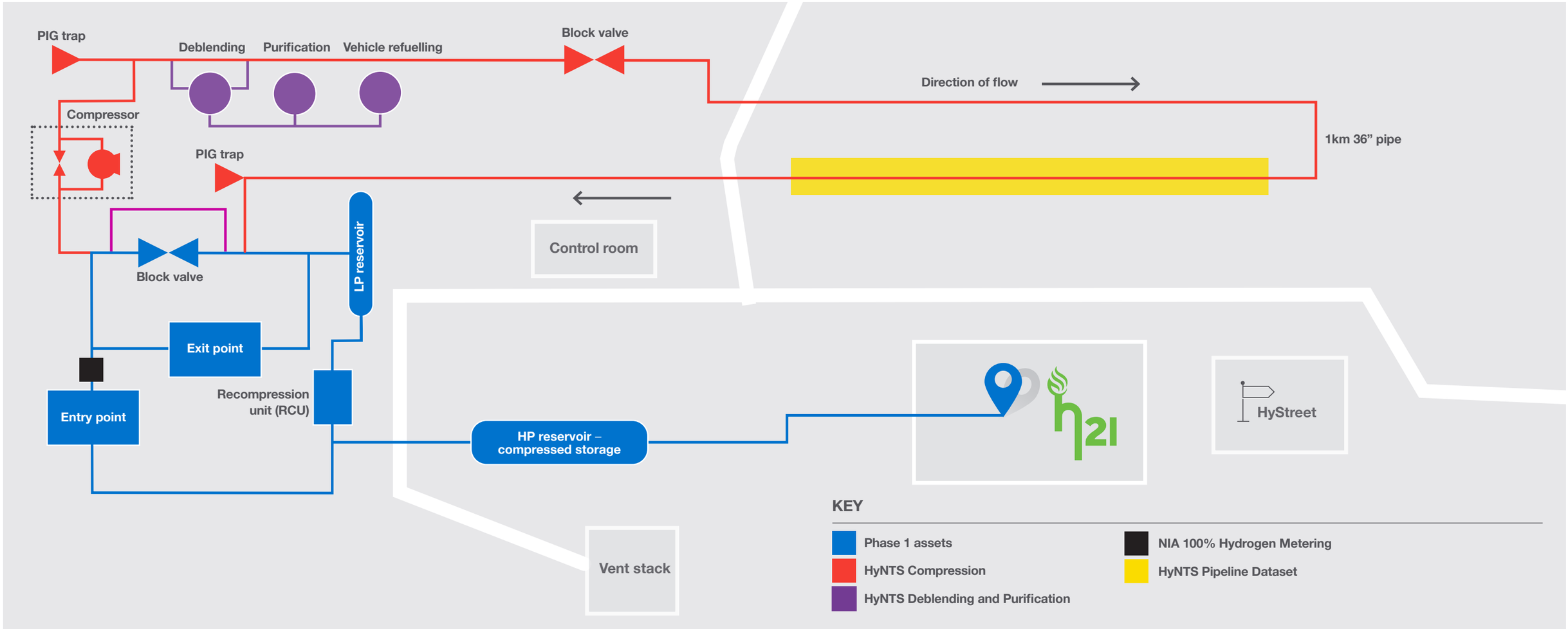
- **SIF HyNTS Compression**
  This project investigates the key challenges associated with compression of hydrogen using existing national transmission system (NTS) assets. This project has two key aims:
  - Demonstrate the hydrogen blend the existing compression fleet can operate at with minimal modification.
  - Demonstrate the level of modification needed to be made to an existing compressor in order for it to operate with 100% hydrogen.

- **SIF HyNTS Deblending for Transport Applications**
  This project aims to provide an offline demonstration of gas separation or 'deblending' technology on a gas network scale. The project aims to develop a skid-mounted, mobile solution to demonstrate hydrogen fuelling from the NTS for the future transport network.

- **NIA HyNTS Pipeline Dataset**
  This project aims to develop the methodology for asset information attainment and assessment against the repurposing requirements for hydrogen. As pipeline data may not cover all aspects required for hydrogen application, an in-line inspection (ILI) pipeline inspection gauge (PIG) that can capture a greater level of detail about our existing pipelines is to be developed and deployed. The FutureGrid site will be modified to allow new ILI PIGs to be developed for use with hydrogen.

All three of these projects are currently in the alpha stage of the SIF process with the beta delivery phase submissions being planned.

- **NIA 100% Hydrogen Metering**
  This project aims to develop a metering and gas quality system capable of operating at 100% hydrogen and at variable blends.



Section 14

IPR

IPR generated or registered during reporting period

The results and outputs from the testing on both the standalone hydrogen test modules and offline hydrogen test facility will generate IPR throughout the duration of the project, in addition to outputs relating to the safety case. As outlined in our IPR position in the NIC bid, there is no opportunity to commercially exploit this IPR.

We are committed to making all results freely available in the public domain to facilitate and accelerate knowledge dissemination. This information will be made available through reports and information releases throughout the duration of the project and will be available on our website www.nationalgrid.com/FutureGrid. As a result, there has been no IPR registered as a result of this project and as such, no royalties generated.

Background IPR exists within the equipment used to construct the FutureGrid test facility and will remain the property of the supplier(s) as part of the commercial product. Knowledge and experience from the DNV and HSE-SD from other NIA and NIC funded projects will constitute background IPR. It will be fed into FutureGrid and, according to the respective governance arrangements, will be freely available to be accessed by the FutureGrid project. There is also background IPR in relation to the hydrogen research provided by Fluxys as part of its in-kind contribution to FutureGrid.

Section 15

Data Access Detail

The project partners will be able to access the data via a shared access platform. Relevant documentation which contains key learning will be shared within the various governance groups mentioned in Section 3.

Details on how network or consumption data arising in the course of a NIC or NIA funded project can be requested by interested parties, and the terms on which such data will be made available by GT&M can be found in our publicly available “Data sharing policy relating to NIC/NIA projects” at: www.nationalgrid.com/gasinnovation

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

In addition to this, as part of the communication and engagement plan, GT&M has held webinars for the purpose of sharing knowledge throughout the duration of the project. We plan to continue these events as the project continues. There are also specific events planned for the completion of different blends of hydrogen. These webinars and events will be open to all interested parties.

We have also set up a shared email box in which any queries about the project can be addressed. The email is: futuregrid@nationalgrid.com. The website www.nationalgrid.com/futuregrid also contains presentations, videos, files, and images relevant to the project which can be accessed by interested parties.

Section 16

Material Change Information

As highlighted in the FutureGrid 2021 Progress Report, there were several deliverables that were at risk of being material changes (as defined in the Network Innovation Competition Governance document v3.1). These risks have been closely monitored and mitigated where necessary throughout the past 12 months to minimise the likelihood and associated consequences of their occurring.

Due to COVID-19 causing global volatility to supply chains, there was a potential risk that delays could materialise in the construction phase of the project. The Project Risk Register captured this key risk and detailed the mitigations in place which were collaboratively monitored regularly to reduce their potential impacts.

Unfortunately, the risk to the construction of the outer container (shell) of the recompression unit materialised in September 2022. The manufacturer, LMF, has exhausted all mitigation options to reduce the impact to the programme which has minimised the delay. Despite best efforts this outer container will cause more than one month delay to the re-compression unit delivery.

This has a knock-on impact to Ofgem deliverables 1.0 and 2.0, causing them to be delayed by up to three months, due to the availability of specialist third parties required to complete critical activities. In addition, considerations for other scheduling issues, such as site closure for Christmas and weather impact for commissioning activities, have added to the delay.

As a result, the changes to the completion dates of Ofgem Project Deliverables 1.0 and 2.0 have now exceeded one year in total since the Project Direction issued in December 2020. Therefore, as described in the Gas Network Innovation Competition Governance Document V.3.1, this is declared a material change. This has been reported to Ofgem and was approved in November 2022, with all dates quoted in this report reflecting that change.

Section 17

Accuracy Assurance Statement

This report has been prepared in accordance with the Network Innovation Competition Governance Document (v3.1) published by Ofgem. The report has undergone a review and challenge from the FutureGrid Steering Group. This has also been reviewed and signed off by Gary Tomlin, the Project Sponsor for DNV.

NGGT
Senior manager sign-off:

I can confirm that the process followed to compile and review this report is compliant with the control requirements outlined above and the report is robust, accurate and complete.

Name: Antony Green

Position: Hydrogen Director

Signature: A. Green

Date: 12 December 2022

Get In Touch with the FutureGrid Team

We're always happy to discuss the project, hear your views and ideas, and share our learning from the project. Our FutureGrid Team comprises eight team members, in addition to our project sponsor:

Antony Green
Hydrogen Director and FutureGrid Project Sponsor

Tom Neal
FutureGrid Manager

Shaun Bosomworth
Senior Delivery Engineer

Haroon Khan
Project Manager

Simon Avery
Hydrogen Engineer – Operations & Maintenance

Lloyd Mitchell
Hydrogen Engineer – Materials

Dan Knowles
Hydrogen Engineer – Electrical & Instrumentation

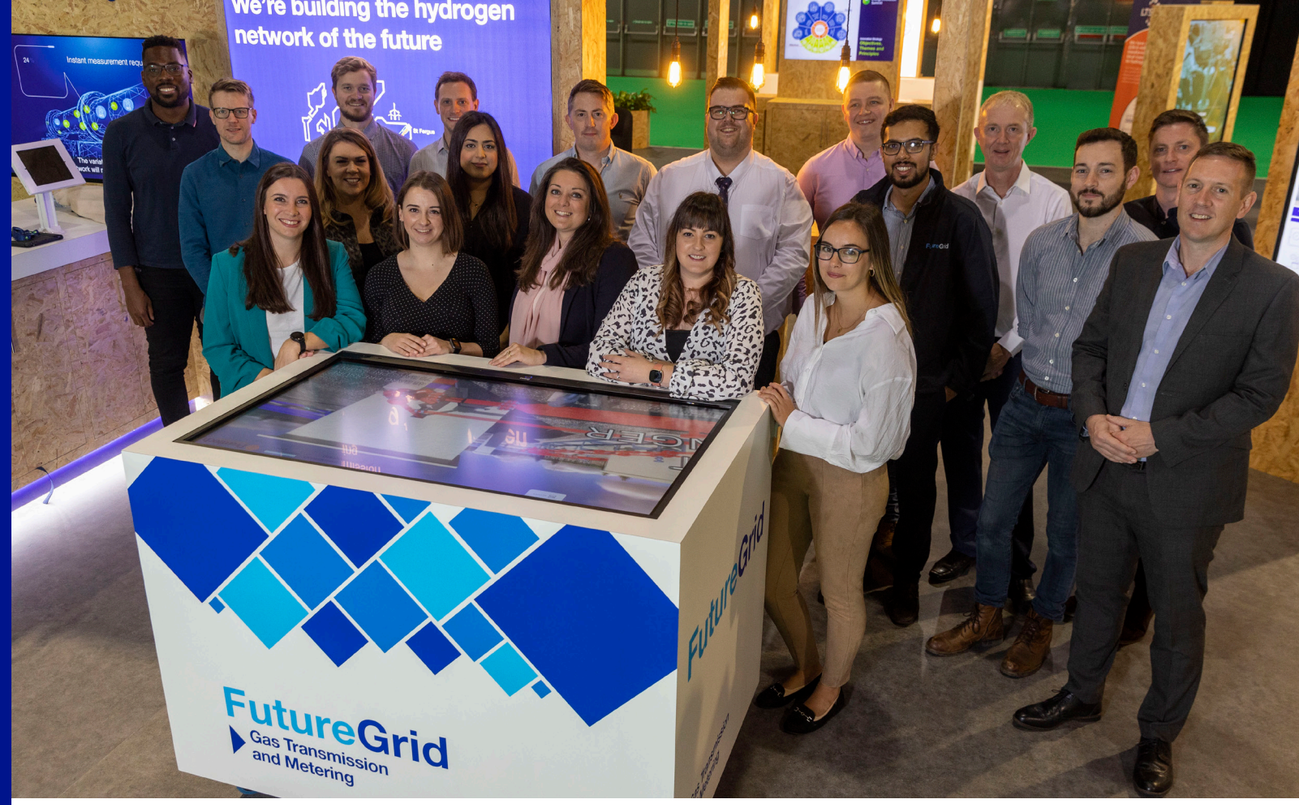
David Anowu
Graduate Hydrogen Engineer

If you want to get involved and find out more about FutureGrid there are many ways you can get in touch.

Email us at FutureGrid@nationalgrid.com

Find out more information and access all project documentation and our full range of engagement including webinars, articles, blogs and podcasts www.nationalgrid.com/FutureGrid

Follow us on the 'Innovation at National Grid' page on LinkedIn www.linkedin.com/showcase/innovation-at-national-grid



Get Involved with innovation

We are always looking to hear from you about new innovation opportunities and your ideas to help us achieve our net zero targets.

There are many funding options available for innovation projects:

Network Innovation Allowance (NIA)
funding is accessible throughout the year to run smaller scale projects. It provides opportunities for innovation programmes to be developed across the gas industry.

The Strategic Innovation Fund (SIF)
is the replacement for the Network Innovation Competition (NIC). It's intended to support innovation activities that contribute to the achievement of net zero and deliver real benefits to both network companies and consumers.

Get in touch
If you'd like to be added to our mailing list, or have a question or idea you'd like to discuss, just email
box.GT.innovation@nationalgrid.com

We are looking for projects that:

- Accelerate the development of a low carbon energy sector
- Demonstrate customer value
- Directly impact the gas network
- Share learning and intellectual property
- Avoid duplication
- Are innovative – requires a project to demonstrate effectiveness.

FutureGrid

Appendix 1

Acronym Key

Acronym	Definition	Acronym	Definition
AGI	Above ground installation	**MPI**	Magnetic particle inspections
ASME	American Society of Mechanical Engineers	**NIA**	Network Innovation Allowance
BEIS	Department for Business, Energy & Industrial Strategy	**NIC**	Network Innovation Competition
CLoCC	Customer Low-Cost Connections	**NG**	National Grid
CO2	Carbon dioxide	**NGGT**	National Grid Gas Transmission
DNV	Det Norske Veritas	**NGN**	Northern Gas Networks
DNV GL	Det Norske Veritas and Germanischer Lloyd	**NTS**	National Transmission System
ENA	Energy Networks Association	**OFGEM**	Office of Gas and Electricity Markets
EU	European Union	**Ops**	Operations
FAT	Factory acceptance test	**PIG**	Pipeline inspection gauge
GDN	Gas distribution network	**PMC**	Pipeline Maintenance Centre
GSMR	Gas Safety Management Regulations	**PPR**	Project progress report
GT&M	Gas Transmission and Metering	**PSI**	Pound per square inch
HAMM	Hazard Assessment Methodology Manual	**PSSR**	Pressure Systems Safety Regulations
HATS	Hazardous assessment of the transmission system	**QRA**	Quantitative risk assessment
H2 GAR	Hydrogen gas asset readiness	**R&D**	Research and development
HSE	Health and Safety Executive	**RF**	Raised face
HSE-SD	Health and Safety Executive – Science Division	**RTJ**	Ring type joint
HyNTS	Hydrogen in the National Transmission System	**SAT**	Site acceptance test
ILI	In-line Inspection	**SCADA**	Supervisory Control and Data Acquisition
IPR	Intellectual property rights	**SIF**	Strategic Innovation Fund
IPRM	Internal project review meeting	**SME**	Subject matter expert
IT	Information technology	**TSOs**	Transmission system operators
LMF	Leobersdorfer Maschinenfabrik	**TWh**	Terawatt hour
LSAW	Longitudinal submerged arc-welding pipe	**UK**	United Kingdom
MOP	Maximum operating pressure	**UT**	Ultrasonic testing

Appendix 2

Risk Register

FutureGrid Programme Tracker

Risks and Mitigations

Risk ID	Status	Category	Phase	There is a risk that	Because of	Leading to	Likelihood 1-5	Impact 1-5	Risk Score (Pre mitigation)	Mitigation	Likelihood 1-5	Impact 1-5	Risk Score (Post mitigation)	Nov-22 Update - Risk Score
1	Closed	Assets	1a	Some assets may not be available at the right time to support the build of the test rig.	Regulatory funding mechanisms not allowing the decommissioning plan to start until April-21.	Delays in the removal and build phase of the test rig.	4	5	20	a) Potential for funding during the final year of RIIO 1 to be made available for decommissioning. b) Discuss plans with the Decommissioning Strategy team c) Plan where possible to have assets which have already been decommissioned from GT&M sites d) Potential to use Local Transmission Assets which have been decommissioned. e) Update the decommissioned assets tracker	2	5	10	
2	Open	Assets	1a	The assets may not be of the required condition to support the build of the test rig.	Assets being left in a state of either disconnected and open to atmosphere, disconnected and un-maintained or isolated and un-maintained.	The need to source other suitable assets to support the build of the test rig.	4	5	20	a) Undertaking site condition surveys of the assets identified. b) Ensure construction teams in NGGT know that the assets are needed for FutureGrid and to decommission correctly to allow re-use c) Attend site during decommissioning activities	2	5	10	10
3	Closed	Assets	1a	Assets will be damaged in transport between NGGT site and Spadeadam	Loading and unloading onto haulage trucks	Assets will be damaged beyond use on the test facility	2	5	10	a) NGGT will only appoint qualified haulage contractors who are used to lifting and moving NTS equipment around the country b) Lifting procedures checked by NGGT staff at site and with DNV staff at destination	1	5	5	5
4	Open	Assets / Master Test Plan	1a, 1b	The design does not meet the requirements of the master test plan	Both parts have been developed in isolation	Being unable to complete the master test plan on time	3	5	15	a) Design review meetings throughout the design/build stage of the project b) Detail master test plan c) Use DNV technical authorities	1	5	5	5
5	Closed	Build	1a	The civil aspect of the build is delayed	Unknown ground conditions / discovered items / unstable ground	Cost and time increase of the build stage	2	4	8	a) Ground sampling carried out in the area of the test facility before build b) Utilise records and site visits to understand the best location for the facility	1	4	4	
6	Open	Build	1a	There is a risk that the assets will be incorrectly installed or damaged during installation	Following incorrect procedures / a lack of experience in building transmission assets	Potential delays in the programme and costs to reinstall assets	2	5	10	a) Use of a competent DNV and third parties for installation b) Follow agreed specifications and procedures for installation	1	5	5	5
7	Open	Comission	1a	Unable to commission the whole rig	Inability to hydrotest against some of the assets	Extra work to remove assets and fit spools/blanks to hydrotest on. Extra time and work	4	4	16	a) Input from subject matter experts both in GT&M and DNV b) Clear, well-planned and thought-through commissioning plan	2	4	8	8

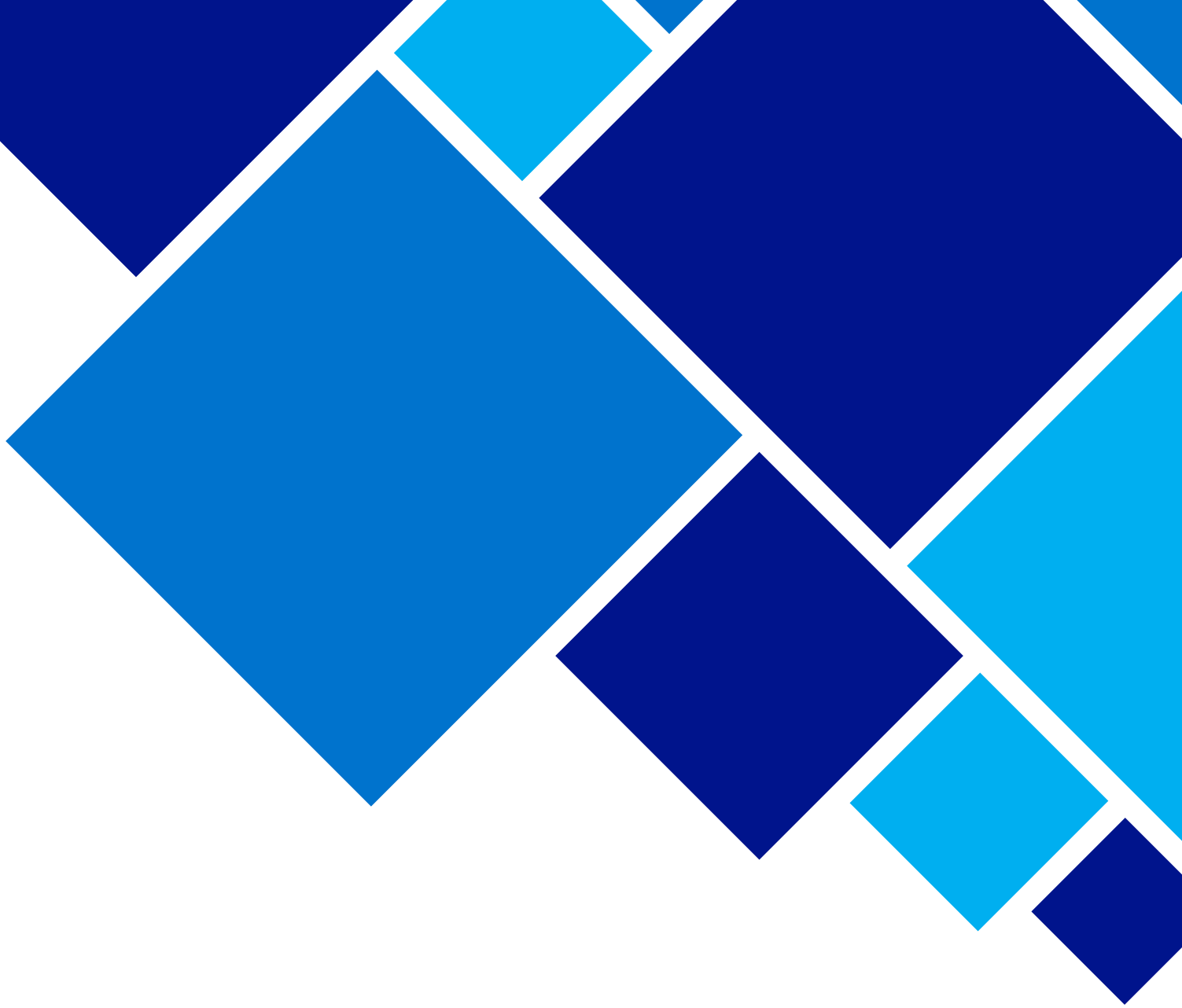
Risk ID	Status	Category	Phase	There is a risk that	Because of	Leading to	Likelihood 1-5	Impact 1-5	Risk Score (Pre mitigation)	Mitigation	Likelihood 1-5	Impact 1-5	Risk Score (Post mitigation)	Nov-22 Update - Risk Score
8	Open	Health and Safety	All	Safety incident on site preventing further work to be completed	Safety incident – various cause, slips/trips/falls, PPE issues etc...	Project not able to deliver deliverables	2	5	10	a) Detailed safety assessments to be undertaken as per standards and policy b) PPE and correct working methodologies to be ensured throughout project c) Safety log to be kept and addressed to ensure any near-misses are corrected	1	5	5	10
9	Closed	Master Test Plan	1b	We cannot achieve the desired flow rates	Constraint by volume and speed of recompression for continuous testing	Some tests will not be completed during the project	2	4	8	a) The size and flows in the test rig will be specified during the design stage and any concerns flagged early in the project b) Downstream demand can be utilised to create flow in the test facility c) Suitability of recompression to match assets	1	4	4	
10	Open	Master Test Plan	1b	The test facility could be damaged during the test plan	Following incorrect / no procedures during the tests	Damage to the test facility, time and cost to repair	3	5	15	a) Develop and follow site procedures and safe control of operation process b) Input from subject matter experts both in GT&M and DNV c) Maintenance plan for the test facility	1	5	5	10
11	Open	Master Test Plan	1b	The assets fail during the master test plan	Being decommissioned from the NTS	Cost and time increase of the project	3	5	15	a) All assets fitted to the test facility will have their history recorded and be a good quality before installation b) Where history is not known, assets will undergo pressure testing to confirm usability c) Asset remediation strategy formed	2	5	10	15
12	Open	Project Management	All	Suitable resources aren't available for parts of project from NGGT	Other operational and project demands	Delays in project delivery	3	4	12	a) Clear and communicated resource plan and resource management in place b) Agreement and backing from senior leadership team c) Encourage subject matter experts to understand more about the project and its impacts through objectives d) Understand resource demand on staff and share with individuals	2	4	8	8
13	Closed	Project Management	All	A lack of support from the gas distribution networks	Poor communication from GT&M	A loss of shared learning and collaborative working	3	4	12	a) Engagement with the GDNs from the beginning b) Invite representatives to update meetings and events c) Statements of support for the project d) Work with GDN teams throughout the project	1	4	4	
14	Open	Project Management	All	A critical GT&M team member moves off the project	Leaves the company, promotion or new job, resource required on urgent issue	A loss of technical expertise	3	4	12	a) Skills and competencies to be understood across the team b) Critical skills duplicated where possible c) Where not possible detailed documentation to be kept in order for project to continue	2	4	8	8
15	Closed	Supply	All	Remote location of Spadeadam prevents regular senior and stakeholder review on site reducing contact and buy-in to the project	Issues with remote connection (4G)	A loss of shared learning and collaborative working	4	4	16	a) Remote virtual access to the site is going to be key and needs to be reviewed as the location is unlikely to have good cellular coverage b) Early scheduling of meetings to ensure they are prioritised	2	4	8	

Risk ID	Status	Category	Phase	There is a risk that	Because of	Leading to	Likelihood 1-5	Impact 1-5	Risk Score (Pre mitigation)	Mitigation	Likelihood 1-5	Impact 1-5	Risk Score (Post mitigation)	Nov-22 Update - Risk Score
16	Closed	Assets	All	Additional funds are required to support the decommissioning activities.	Either additional site mobilisation events are required, or an uplift in cost is incurred for 'careful' removal of assets.	An increase in costs for removal of assets.	3	5	15	a) Engage and discuss options with investment management and decommissioning teams b) Discuss options to reduce costs with Capital Delivery (i.e. reduction in cold-cuts)	1	5	5	
17	Open	Build and MTP	All	Tests will fail in the schedule and there will not be time to carry out a re-test in Phase 1	Unexpected failure with the normal operation of the asset	No results for that asset until a future point in time.	2	5	10	a) Depending on the size of the failure and the 'why it failed' tests may be able to be run again within the timeframe of Phase 1; however if it is a more significant failure then the re-test may need to be planned in for Phase 2	1	5	5	10
18	Closed	Assets	All	Asbestos may be present in some assets	Older assets	Delays and costs to project	3	5	15	a) GT&M will conduct all reasonable endeavours to provide DNV any information available for asbestos in assets b) If there is a requirement to hinder the flange joint, it will be discussed with NGGT	1	5	5	
19	Closed	Build	All	Delay in Contracts	Delay in start date	Delay in Programme	5	5	25	Regular liaison with DNV	4	5	20	
20	Open	Build	All	NORM (Naturally occurring radiative material) may be present	Unsure NORM might have been unaccounted for during decommissioning	NORM being present	3	3	9	GT&M to liaise with Ops and Cap. D Teams	2	3	6	
21	Closed	Build	1a	Weld procedure are not provided to DNV in time	Unavailability of legacy weld procedures	Delay in welding	3	4	12	a) FG Team liaising with internal GT&M teams	3	4	12	
22	Closed	Build	All	Land may not be available	RAF Permissions	Delay in construction	3	5	15	Good relationship between DNV & RAF	1	5	5	
23	Open	Assets	All	Analyser may not be available from other project	Delays on other project	Unavailability of asset for FG	4	5	20	a) Constant liaison with Leigh Palmer	2	5	10	
24	Open	Assets	All	USM (Ultrasonic Meters) and Boilers may not be suitable for Hydrogen blend above 20%	USM – transducers not suitable boiler	Unavailability of asset for FG	4	5	20	a) GT&M-DNV to contact OEM to confirm suitability	2	5	10	
25	Closed	QRA	All	Procedural documents may not be suitable or available for DNV	Availability and suitability	Delays in QRA	4	5	20	a) GT&M in liaison with Policy SME	2	5	10	
26	Closed	Assets	All	36" pipe may not be suitable for the fatigue test rig	Coupon testing report states it may not be X60	Unsuitable for rig	4	5	20	a) GT&M SME verifying data. DNV in liason also	2	5	10	
27	Closed	Build	All	Recompressor rig delays	Delay in delivery date	Delays in rig	5	5	25	a) DNV in constant liaison with LMF	4	5	20	20
28	Closed	Build	All	Material testing delayed	Delays in delivery of materials (spool pieces) at Colombous laboratory	Delay commissioning of facility	4	5	20	a) Regular liaison with DNV	2	5	10	
29	Open	Build	All	Covid-19			4	5	20		3	5	15	5

Risk ID	Status	Category	Phase	There is a risk that	Because of	Leading to	Likelihood 1-5	Impact 1-5	Risk Score (Pre mitigation)	Mitigation	Likelihood 1-5	Impact 1-5	Risk Score (Post mitigation)	Nov-22 Update - Risk Score
30	Closed	Build	All	Control Cabin is not available from Redcar	Delays on Redcar project	Control cabin not being available for the project	3	5	15	DNV have alternative options available with different aesthetic	2	5	10	
31	Closed	Build	All	3D Modelling delayed	Delayed site visit	Delay in report	2	5	10	Constant liaison with premtech	1	5	5	
32	Open	Build	All	Boiler house not working at 20% hydrogen blend		Delays and costs to project	3	5	15	a) GT&M will conduct all reasonable endeavours to provide DNV any information available for asbestos in assets b) If there is a requirement to hinder the flange joint, it will be discussed with NGGT	1	5	5	
33	Open	Build	All	Cycle time of fatigue rig		Delay testing	3	4	12	Armstrong will be on site new blend commissioning	1	4	4	4
34	Open	Build	All	Transformer is delayed	Liaison with Electricity Distribution provider	Delays on commissioning facility	4	5	20	Escalation to Senior Management	3	5	15	20
35	Closed	Build	All	Design report is delayed	External specialist subcontractors	Delay in review of report and commissioning of facility	3	4	12	DNV working collaboratively with their contractors.	2	4	8	
36	Closed	Build	All	Land may not be available	RAF Permissions	Delay in construction	3	5	15	Good relationship between DNV & RAF	1	5	5	
37	Open	Commission	All	Operations, SMEs and 3rd Party availability in commissioning	Unavailability	Delays on commissioning and testing of the facility	4	5	20	Early liaison with parties and a plan	3	5	15	15
38	Open	Commission	All	Commission and testing plan are delayed	Resources are focused on build stage	Shorter duration for GT&M internal teams to review and comment	4	5	20	Early liaison with GT&M internal teams. Regular liaison with DNV	2	5	10	10
39	Open	Commission	All	Risk of recompression unit at commissioning:	Unexpected issues	Delays on the testing and commissioning programme	4	5	20	1) LMF on site during commissioning 2) S.A.T and F.A.T	3	5	15	20
40	Open	Commission	All	Delay in Delivery of Gas	Global shortage	Delay in Testing programme	3	5	15	DNV are managing contracts with supplier	1	5	5	10
41	Open	Commission	All	Severe weather conditions may impact commissioning and testing phase	Possible winter storms based on previous years	Delay in commissioning and testing programmes	4	5	20	GT&M and DNV are liaison to mitigate the risks where possible	4	5	20	20

Notes

Notes



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