FutureGrid

Project progress report

December 2021

nationalgrid

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Foreword

"FutureGrid is a key part of the HyNTS programme, building a hydrogen test facility from decommissioned assets to demonstrate our network can safely transport hydrogen."

Antony Green
Hydrogen Director,
National Grid Gas Transmission

To reach Net Zero by 2050, we need to find new ways to decarbonise industry, and heat the UK's homes and businesses. If we truly want to reach a Net Zero decarbonised future, we need to replace methane with green alternatives like hydrogen.

As a nation, we're currently heavily reliant on methane gas in our homes and businesses with, for example, 85% of households using gas for their heating. The problem is that heating, cooking and industrial processes account for 37% of UK CO_2 emissions. So, if we're to lower those emissions and reach the national target of Net Zero by 2050, we need an alternative to natural gas.

Hydrogen has the potential to be that lower-carbon, cleaner alternative to methane, but we still need to do further research and testing to understand how it could work within the current energy system.

Our HyNTS programme (Hydrogen in the National Transmission System) is focused on understanding how we can safely and efficiently transition our network to hydrogen. FutureGrid is a key part of this programme, building a hydrogen test facility from decommissioned assets at DNV's facility in Cumbria to demonstrate that our assets can transport hydrogen safely and reliably.

Since starting in April 2021, the project has made great progress, with a detailed design of the facility in place and a comprehensive testing plan has been set out. We've refined and developed our plans, modifying our design and approach to suit the decommissioned assets we have available to build the facility. We've also updated our test plan so we can make sure the project delivers the required results on the impact hydrogen has on our assets. We also updated it during the Covid-19 pandemic to reflect the latest international developments.

We have made adaptations to our delivery programme, to mitigate against a challenging and ever more complex environment for procuring assets that are critical to the project delivery. Mobilising a project of this scale during the Covid-19 pandemic has proven to be and continues to be our biggest challenge. Our project delivery plan has minimised delays and we are continuously striving to further mitigate this risk. These challenges include increasing lead times and costs, which we have sought to minimise wherever possible. As a result, FutureGrid is now set to complete in August 2023, with the project timeline and funding updated where relevant.

As we near the end of 2021, the initial groundworks are complete. We've excavated the site and installed the initial stone layer required. We've completed a road crossing from the high-pressure hydrogen reservoir to supply hydrogen to the facility and the site has been fenced in. As we move into 2022 the construction of the facility will be completed, with the facility tested and commissioned, ready for the hydrogen testing to begin in 2023.

Antony Green,
Hydrogen Director,
National Grid Gas Transmission

Executive summary

As National Grid Gas Transmission (NGGT) we own, manage, and operate the high-pressure gas national transmission system (NTS) in Great Britain (GB).

Our network, which consists of approximately 7,600km of high-pressure pipelines, as well as 500 above-ground installations and 24 compressor stations, currently transports around two thirds of the energy used in the UK today.

For that reason, lives, businesses and industry rely on natural gas and on our network. Over time, there needs to be changes in gas usage as we move to Net Zero, but one thing remains the same; we need to ensure that the future decarbonised energy system is safe, reliable, efficient and delivers value to our customers.

Converting our NTS to carry hydrogen would minimise disruption and reduce the amount of expensive infrastructure needed to build a new hydrogen transmission network. But this solution is not without its challenges…

The NTS is a unique and complex network which uses steel pipes to transport natural gas at high pressures. We need to fully understand the impact that high-pressure hydrogen exposure could have on the pipes, and other assets, before the network can be converted. Extensive testing and detailed trials are needed to establish what modifications we may need to make, to safely transport hydrogen.

Under the banner of HyNTS – Hydrogen in the NTS – we have already run several projects looking into the physical capabilities of the NTS, in relation to hydrogen transportation. These projects have not just looked at the impact hydrogen could have on our pipework, but on all associated equipment such as compressors and valves, as well as the ways that a hydrogen network may need to operate differently in the future.

The FutureGrid project is testing the suitability of the NTS to transport hydrogen, by constructing an offline hydrogen test facility, representative of our network, which will be used to test decommissioned assets at a range of different hydrogen concentrations (including 2, 20 and 100%).

The project has been awarded funding through Ofgem's Network Innovation Competition (NIC), and is expected to be complete by August 2023.

Overall project progress

This is the first project progress report. It covers work undertaken from the initial project registration in December 2020 to the end of December 2021.

The key achievements in the reporting period are as follows:

- Bilateral contract (DNV-NGGT) has been completed
- Groundworks have been completed
- Several standalone tests have been completed
- Build is being progressed
- Quantitative Risk Assessment (QRA) is being progressed

The overall project completion date has been delayed from April 2023, as initially stated in the bid document, to August 2023. This additional time is to allow for the required modifications to the decommissioned assets being used to construct the facility to ensure a cost effective build. In addition to this, there are ongoing supply chain constraints due to the implications of both Covid-19 and Brexit.

Financial update

The total value of the Project is £12.7m. However, this includes a significant amount of in-kind contribution. The total project expenditure over the 2 year period will be £10.2m. For this reporting period, there have been no changes in the total forecasted spend since the OFGEM project direction was issued. However, the project spend has been realigned against the different spend categories alongside the project timeline which is detailed on page 9.

Dissemination activities

During the early stages of the project, we have focused on producing learning which can be disseminated at a later date. A communication plan was created at the start of the project, which looks to share project progress and updates through a variety of channels. This plan is updated quarterly, to ensure all communication activities carried out are suitable and in-line with the current project timescales.

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)
- Quarterly podcasts
- Multiple hydrogen in person events
- Planned events for each hydrogen blend test

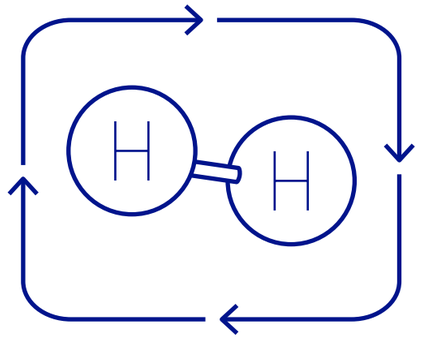
Business case and material change information

There have been no changes in the business case and no material changes to report in this reporting period. It is not envisaged that there will be any changes in the next reporting period.

FutureGrid

FutureGrid is an ambitious programme to build a hydrogen test facility from decommissioned assets at DNV's facility in Cumbria. It aims to demonstrate how the National Transmission System (NTS) can transport hydrogen.

We'll carry out testing in two parts:

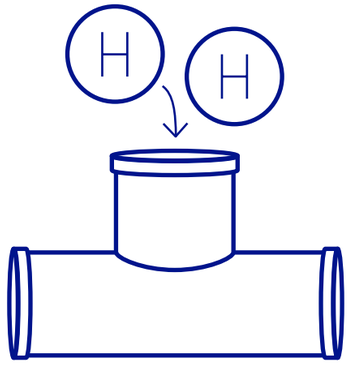


Offline hydrogen test facility

A representative range of decommissioned NTS 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%, 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 the data required to feed into the main facility.

These tests include:

- Materials testing
- Pipe coating testing
- Fatigue testing
- Flange testing
- Asset leak testing
- Rupture testing

Safety case

There is a fundamental difference between how natural gas and hydrogen behaves. 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 and mitigating over-pressure risks.

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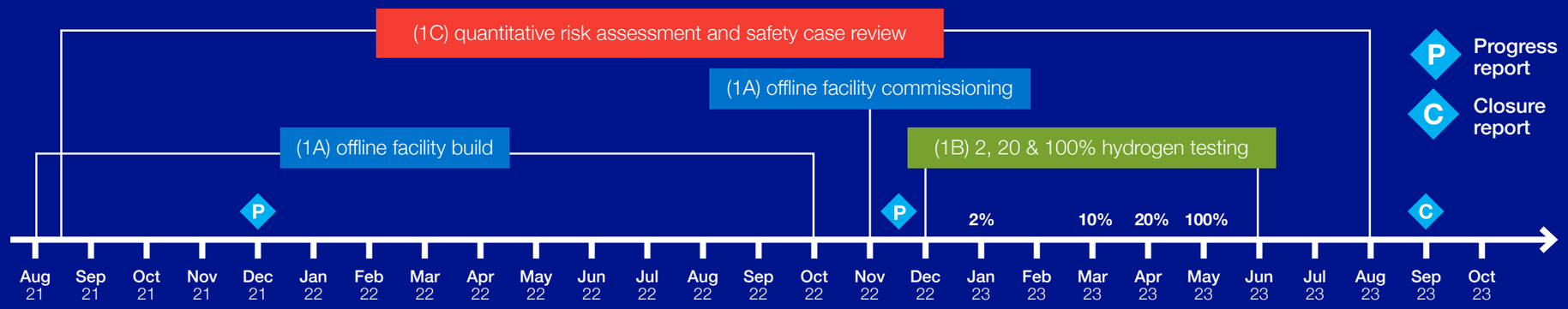


Project partners:

DNV

DNV are 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 are the equivalent Gas Transmission Operator in Belgium and are contributing a substantial level of hydrogen research, to ensure a internationally collaborative approach.

HSE

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

Durham University

Durham University are 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 are 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 are 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.

Project manager’s report

Project start up

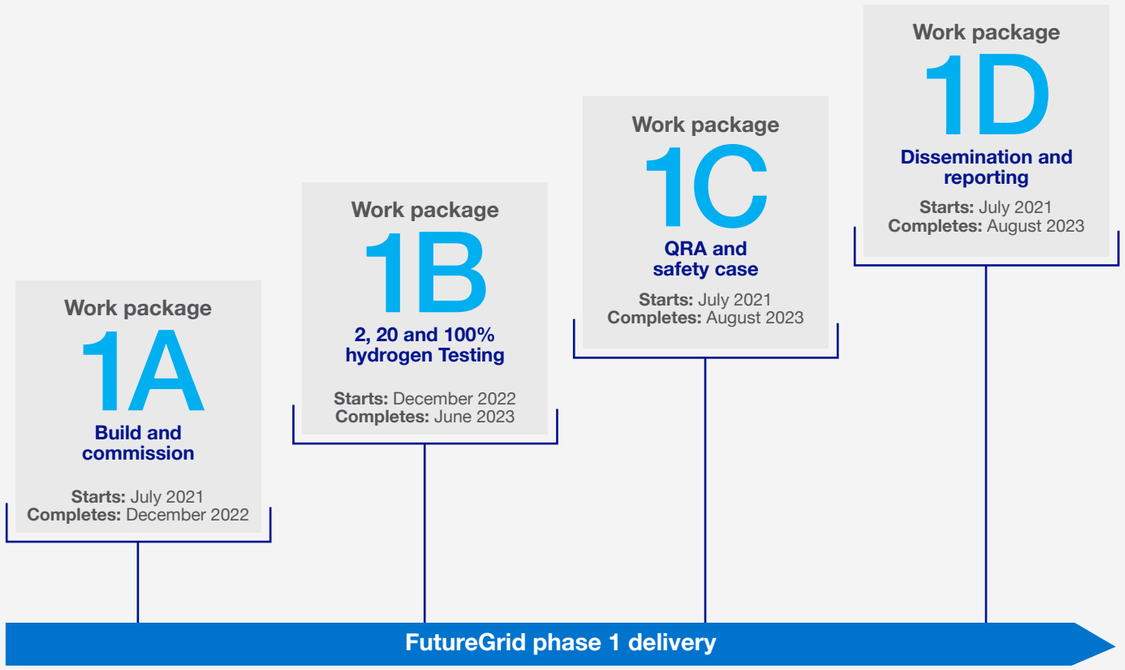
In readiness to start the project we completed key activities including resourcing the project team, establishing the project governance and reviewing the project plan. We now have a full team in NGGT, working closely with the DNV project team and in collaboration with our other partners to deliver the project. We considered a range of factors, including working remotely to ensure the team has been able to successfully deliver the work required to date, and have contingencies in place should Covid impact our ability to meet face-to-face in the future.

We’ve established clear lines of governance to ensure robust delivery of the project, including establishing risk review meetings, monthly steering groups and internal project reviews. The programme has been updated to reflect further work on the facility design and test plan. This has resulted in timelines of the Ofgem deliverables being updated and the costs being reallocated to ensure the project is delivered in the most efficient manner.

As identified in the FutureGrid NIA project, using decommissioned assets (which have been in service on the network) is key to building a facility that represents our network. We worked extensively with our internal teams to coordinate with the RIIO-2 decommissioning programme to identify several options for assets. We have successfully retrieved these assets and are in the process of conducting the necessary works ready for inclusion in the facility.

This report is structured around our key deliverables and provides an update on the progress that has been made and our plans for the next reporting period.

The project has been divided into 4 sub-stages:



The main achievements in this reporting period are as follows:

1. The governance groups for the project have been established. This means that different progress meetings and steering groups have been put in place.
2. Ground surveys and groundworks have been completed. The latter activity was crucial, and required before unfavourable weather for groundworks set in.
3. Several standalone tests that were detailed in the master test plan have been completed. The knowledge obtained from these tests will be applied to the full facility test. Key learning is also being shared with other interested parties as the tests are being completed.
4. The build stage of the project is being progressed as planned. The assets were initially inspected to determine their suitability for the build. Some of these assets required remediation work and some were rejected as the cost of remediating them would be significantly more than sourcing alternative assets.
5. The QRA has started and is planned to be completed over the full duration of the project. The full list of NGGT procedures are being reviewed and sites for QRA review have been selected.
6. A bilateral contract (DNV-NGGT) and multiparty contract (all project partners) have been signed: The bilateral contract was signed first, followed by the multiparty contract. The scope of works and the project plan was also reviewed as part of the contract reviews.
7. A communication plan was put in place so we could share learning with interested parties, together with the progress of the project. We also created events, podcasts and articles providing the latest updates in this reporting period.

Project deliverables

The dates and the funding alignment of the project deliverables have been amended since the project direction was provided in December 2020. The timescales of the deliverables were changed as the project plan was further developed, allowing the activities to be conducted in the most efficient way. The changes to the Project Deliverables have not exceeded one year, which means no material change has occurred. The NIC funding allocation has been amended to match the updated project programme and there has been no impact on the overall costs.

Updated Ofgem project deliverable deadlines:

Reference	Project deliverable	Revised deadline
1.0	Phase 1a – Groundworks and construction	November 2022
2.0	Phase 1a - Testing and commissioning	December 2022
3.0	Phase 1b – Testing 2% - 20% hydrogen	May 2022
4.0	Phase 1b – Testing 100% hydrogen and fatigue testing	August 2023
5.0	Phase 1c – QRA and safety case	August 2023
6.0	Knowledge dissemination	August 2023
7.0	Comply with knowledge transfer of the governance document	August 2023

Project manager's report

Contracts and procurement

Two separate contracts have been established for the FutureGrid Project. As the main project partners, NGGT and DNV coordinate via the bilateral contract. This covers the scope of works and commercial arrangements between the two parties. The wider FutureGrid consortium (covering all project partners) coordinate via the multiparty contract.

Governance

Meeting	Frequency	Description
Project progress meeting	Weekly	The progress meeting is held weekly ensuring the core project delivery team remain 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 meetings are conducted with NGGT and the delivery partner (DNV).
Internal project review meeting (IPRM)	Monthly	The IPRM is conducted monthly within NGGT 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 is conducted monthly where all the project partners are present. The discussion in this forum is to ensure the project activities conducted are relevant and feed into the seven OFGEM deliverables. The project programme and costs are also monitored in this meeting. It is also a platform to share any key learning within the group.
Risk review	Monthly	The monthly risk review is conducted between NGGT and DNV. The aim of this meeting is to update the risk register, which contains the risks, mitigation measures, probabilities and impacts of each of the risks.
Network Steering Group	Quarterly	The Network Steering Group is conducted quarterly between the project partners and other gas distribution networks. 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 has been created to facilitate document management 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 novel activities that are 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.

The project is being delivered against a backdrop of economic uncertainty. The combination of Brexit and Covid-19 has caused volatility in the construction market and issues with the supply of components. This is having an impact on many levels and has increased the overall risk profile of the project as a whole.

Specific high-level risks currently being closely managed include:

- **Supply chain:** suppliers have mentioned experiencing global material shortages due to Covid-19 and the increased customs requirements. This has the potential to both lead to delays, increases in material prices and unavailability of some components. Mitigation measures such as contacting suppliers well in advance and anticipating longer lead times for materials and services are in place.
- **Resourcing:** while most of the project team can work remotely, the construction of the test facility requires active staff working onsite and sometimes in close proximities. This increases the propensity for the virus to spread, thereby resulting in a mass group having to isolate and consequently delaying construction. The site has had measures in place such as social distancing, mask-wearing and keeping teams separate when indoors.

Next reporting period

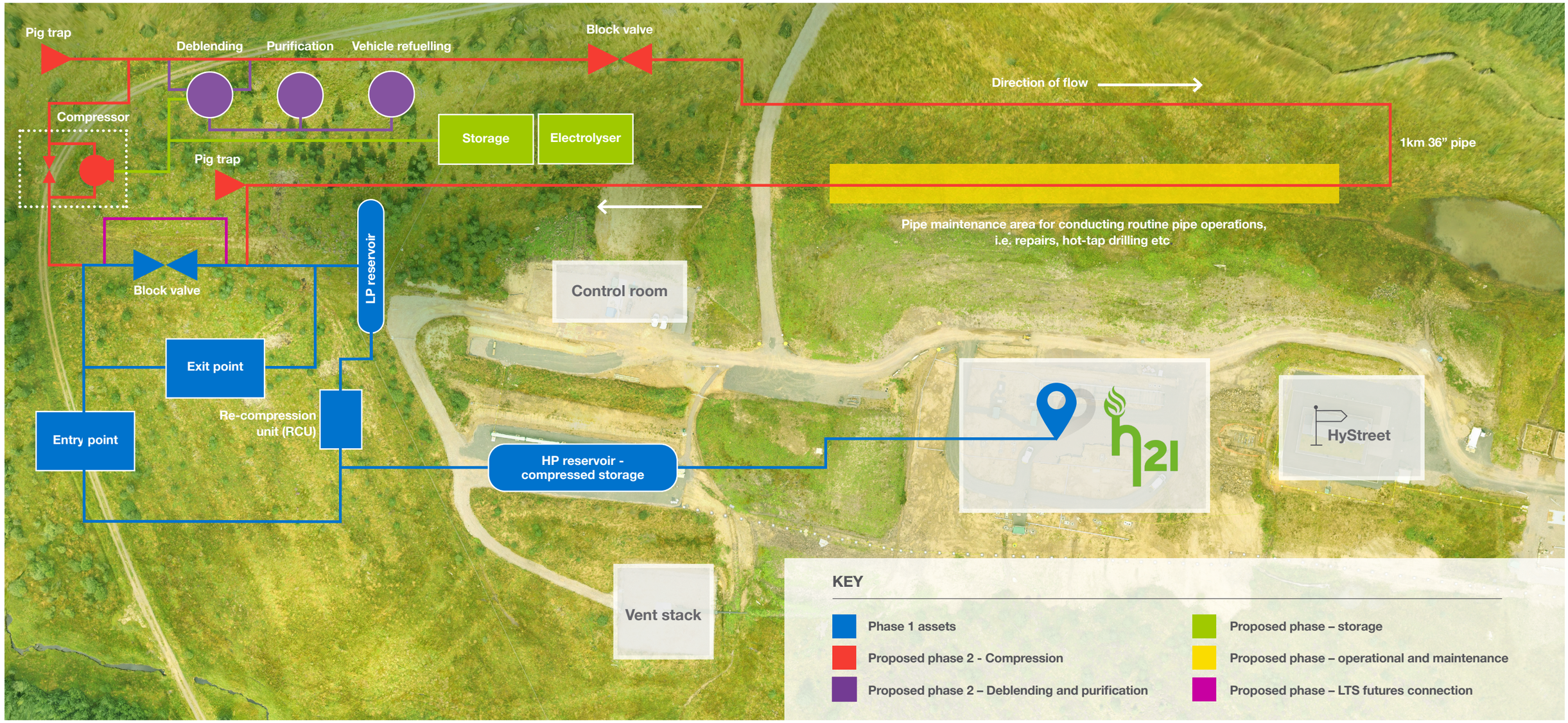
During the next reporting period the following milestones will be achieved:

- Complete any required remedial works on the existing NTS assets to be used in construction.
- Complete construction, hydrostatic testing and commissioning of the FutureGrid facility. The commissioning of the site and initial operation is to be completed using natural gas.
- The facility will be ready for the introduction of hydrogen.
- Standalone tests will have been completed. The results of these tests will have fed into the tests planned to be carried out on the flow facility, for example the permeation testing and the leak testing. Key learnings from the standalone tests will have been shared with interested parties.
- The testing of the fatigue test module will have commenced. Due to the nature and duration of this testing this will continue to the next reporting period.
- Hazardous area impact assessment and NGGT procedure review will have been completed under the QRA work package.
- Engagement will continue through events and other activities as detailed in the communications plan.

FutureGrid

FutureGrid development at DNV's Hydrogen Test Facility

The image below shows the Hydrogen Test Facility at DNV's Research and Development Centre in RAF Spadeam. You can see below the exisitng HyStreet and H21 Distribution Micro Grid, alongside the outline for FutureGrid Phase 1, and the potential future phases (as detailed on page 40 and 41).



Business case update

At the time of writing, there have been no changes to the anticipated benefits to be gained by the project.

The key financial benefits of the FutureGrid programme of works are:

- **Method 1 – Creation of a 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 would need to be carried out. This could either all be completed separately or combined at 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, the plans of which 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 by avoiding a proportion of valve replacement at a cost of 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 CO_2 emissions per energy demand of 0.0549 kg/ft3 by converting the NTS to 100% hydrogen by 2050, we will reduce carbon emissions by 81 million tonnes CO_2e.

- **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 CO_2e being saved, based on an initial part of the NTS transitioning to hydrogen.

Project deliverables

The project deliverables and evidence agreed at the time of the project direction have been stated below. We have also added check points on the key deliverables. The purpose of the check points is to ensure that all the results have been achieved for that specific hydrogen blend test, before we proceed to the next blend. This is because returning back to previous hydrogen blend tests after a check point 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 involved important activities which were being carried out over a longer period. They were split further in order to align to the checkpoints required in the project. This does not have an impact on the overall deliverable timeline.

Ofgem deliverable ref 1.0: Groundworks and construction – November 2022
(original bid date: November 2021)

Evidence for deliverable:
Construction of the FutureGrid test facility at DNV's Spadeadam site with the production of the following as evidence:

- As built drawings will be completed during the next reporting period.
- A written scheme of examination is currently being developed and will be completed during the next reporting period.
- A DNV report of build activity and lessons learnt will be completed.

Reason for revised date:
The construction programme has been revised to maximise the opportunity to conduct standalone test modules in parallel, whilst avoiding unfavourable weather conditions. This has delivered a more efficient programme and also provides the opportunity for any early contingency plans if required.

The programme was revised to allow further asset remediation activities to be conducted or for alternatives to be sourced. The decommissioning plan had several options of assets, some which had to be modified to suit the build of the facility. These modifications ensure the most efficient testing conditions, but require additional time to complete as part of the build. In addition to this, the re-compressor is a critical path item and the delays experienced due to ongoing constraints on supply chains has also affected the deliverable date.

Ofgem deliverable ref 2.0: Testing and commissioning – December 2022
(original bid date: Jan 2022)

Evidence for deliverable:
- Successful completion of testing and commissioning processes with supporting documentation:
  - Some standalone test plans have been developed and approved.
  - Some tests have been completed and the data is currently being analysed. The offline testing will be completed in the next reporting period and the design and test reports will be made available.
- Dissemination of the facility design and layout to allow detailed development of Phase 2 and 3 interactions. The design will not be finalised until the build of Phase 1 has been completed.

Reason for revised date:
The standalone tests were initially planned to be conducted after completion of the ground works and construction deliverable. Upon detailed review, the project programme was revised so the standalone tests are being conducted in parallel with ground works and construction. This is to allow the learning from this stage to be implemented in building and testing the facility. It also provides the opportunity for any early contingency plans which are required as a result of the learning obtained from the stand-alone tests.

GO/NO GO checkpoint – natural gas tests complete, no additional natural gas tests required

Ofgem deliverable ref 3.1: Testing 2% hydrogen – April 2022
(original bid date: October 2022)

Evidence for deliverable:
- Completion of 2% Hydrogen tests identified by the master testing plan, including launch and close out events - online testing will commence after the facility rig has been built and commissioned, which will be the end of the 2022 reporting period. Findings will be made available during the 2023 reporting period.
- Identification of future test requirements as a result of the findings - this will be completed in the 2023 reporting period with the future test requirements being detailed within the test report.
- Results collated, documented and validated for impact on next phases of hydrogen development activities - this will be completed in the 2023 reporting period with the future test requirements being detailed within the test report.

Reason for revised date:
The testing deliverables follow the groundworks and construction deliverable. As such, the revised timeline for construction has an impact on the testing deliverables.

GO/NO GO checkpoint – 2% hydrogen tests complete, no additional tests required

Ofgem deliverable ref 3.2: Testing 20% hydrogen – May 2023
(original bid date: October 2022)

Evidence for deliverable:
- Completion of 20% Hydrogen tests identified by the master testing plan including launch and close out events - online testing will commence after the facility rig has been built and commissioned, which will be the end of the 2022 reporting period. Findings will be made available during the 2023 reporting period.
- Identification of future test requirements as a result of the findings - this will be completed in the 2023 reporting period with the future test requirements being detailed within the test report.
- Results collated, documented and validated for impact on next phases of hydrogen development activities - this will be completed in the 2023 reporting period with the future test requirements being detailed within the test report.

Reason for revised date:
This deliverable follows deliverable 3.1 and any delays also have an impact on this deliverable.

GO/NO GO checkpoint – 20% hydrogen tests complete, no additional tests required

Ofgem deliverable ref 4.1: Testing 100% hydrogen – July 2023
(original bid date: February 2023)

Evidence for deliverable:
- Completion of 100% Hydrogen tests identified by the master testing plan including launch and close out events - online testing will commence after the facility rig has been built and commissioned, which will be the end of the 2022 reporting period.
- Identification of future test requirements as a result of the findings - this will be completed in the 2023 reporting period with the future test requirements being detailed within the test report.
- Results collated, documented and validated for impact on next phases of hydrogen development activities - this will be completed in the 2023 reporting period with the future test requirements being detailed within the test report.

Reason for revised date:
This deliverable follows deliverable 4.1 and any delays also have an impact on this deliverable.

GO/NO GO checkpoint – 100% hydrogen tests complete, no additional tests required

Ofgem deliverable ref 4.2: 100% hydrogen fatigue testing – August 2023
(original bid date: April 2023)

Evidence for deliverable:
1. 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.
2. 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.
3. Completion of the required number of pressure cycles and completion of the test.
4. Results collated, documented and validated for impact on next phases of hydrogen development activities - this will be completed in the 2023 reporting period with the future test requirements being detailed within the test report.
5. Identification of future test requirements as a result of the findings - this will be completed in the 2023 reporting period with the future test requirements being detailed within the test report.

Reason for revised date:
Due to Covid-19 there are ongoing constraints on supply chains. This means that the pumps are being delivered later than initially scheduled. The fatigue rig will be constructed over 15 months as it was the ideal timescale to replicate. We believe it is not suitable to decrease the timescale for this rig as there may be some loss of learning. This means that although most of the other activities in the project will be completed earlier, the fatigue rig will be completed later than initially anticipated.

Ofgem deliverable ref 5.0: QRA and safety case – August 2023
(original bid date: March 2023)

Evidence for deliverable:
- Overpressure testing on secondary off-line NTS test facility – literature review and test plan development are currently ongoing with the resulting report being made available in the next reporting period.
- Validation of results into existing QRA model and any mitigations reviewed (updated QRA and mitigation log) - the review and evaluation of the QRA and methodology will commence and be completed in the next reporting period, with the mitigation options made available within the 2023 reporting period.
- High-level review of NGGT's documented procedures and standards is currently ongoing with the resulting report being made available in the next reporting period.
- Prepare a commented version of the safety case - information gathering will commence in the next reporting period with the draft template being developed and completed in the same reporting period.
- Updated asset assessment and hydrogen risk review – an impact assessment has commenced on the above ground installation (AGI) against a 20% hydrogen bend. The AGI and compressor reviews are to be completed during the next reporting period.

Reason for revised date:
As the fatigue rig testing will be completed later on in the project than anticipated, the results from it will directly feed into the QRA. This means the final steps of the QRA will also be completed at a later date.

Ofgem deliverable ref 6.0: Knowledge dissemination – August 2023
(original bid date: April 2023)

Evidence for deliverable:
As per 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.
- Over this reporting period, we have shared relevant information and the project team attended the Energy Networks Innovation Conference to exhibit the project and provide a keynote presentation.
- Dissemination of facility design and layout to allow detailed development of Phase 2 and 3 interactions will be available and completed in the next reporting period.

Reason for revised date:
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.

Ofgem deliverable ref 7.0: Comply with knowledge transfer of the governance document – August 2023
(original bid date: April 2023)

Evidence for deliverable:
- The Annual progress report has been completed and complies with the requirements of the governance document.
- Evidence of attendance and participation in the Annual Conference as described in the governance document. We have attended various conferences, including the Energy Networks Innovation Conference, sharing knowledge related to the innovation projects that have the potential to deliver low carbon and/or environmental benefits to customers.
- The closedown report will be completed as per the governance document at the end of the project in 2023.

Reason for revised date:
This deliverable is associated with the activities which will be conducted as part of the governance. This has been extended in line with the other key project deliverables.

Progress against plan

As part of the FutureGrid programme of work, we completed the Roadmap to FutureGrid NIA project. This project was key to developing the principles and specification of the proposed offline test facility, including the development of a robust testing plan to provide an updated safety case for the NTS.

This FutureGrid NIA project built upon the learning across our portfolio of projects including the 'Feasibility of Hydrogen in the NTS' and 'Hydrogen Injection in the NTS' projects, as well as key learning outputs from projects carried out by the GDNs to help develop a robust programme of work.

During this phase, a series of design workshops were facilitated between DNV and NGGT's project teams to ensure all disciplines are covered by the final design. A significant challenge was faced during the initial stages of the design discussion, due to the Covid-19 restriction as the workshops were conducted virtually.

When Covid-19 restrictions were relaxed, we were able to hold face-to-face workshops which were more interactive and productive. To supplement the workshop and assist with developing a robust design, DNV visited various NGGT sites to confirm existing NTS assets that could be used for hydrogen and any mitigations required. These workshops, site visits and coordination resulted in the NIA project delivering three key outputs:

- **Design of the test facility** – conceptual design of the hydrogen test facility including the pipe layout, the assets to be tested, injection and mixing points, storage capabilities and flows.
- **Development of the master testing plan** – detailed testing plan to validate NTS assets and flow parameters such as gas velocities, pressures, energy delivery and other operating parameters for hydrogen blends of 2, 20 & 100%.
- **Asset integrity testing and interpretation** – design and development of a number of desktop and small-scale asset integrity tests, with analysis and interpretation of the results to feed into the full design and testing programme.

These three outputs enabled the commencement of the build of the NTS facility for testing entry and exit points, filters, safety critical components such as valves, meters and other equipment with hydrogen/natural gas blends (2%,10%, and 20% hydrogen) and 100% hydrogen.

For this reporting period, the following key Phase 1 activities have been the focus of our work:

Ofgem deliverable 1.0:

Groundworks and construction

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

Preparatory phase
To enable FutureGrid to commence, key planning activities have been carried out to ensure the build/testing phases 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 were able to identify the standards and policies to be used throughout FutureGrid to ensure it was delivered efficiently without impacting upon the testing parameters.
- **Design:** The FutureGrid design has undergone further development. Progress has been made against the following disciplines:
  - Civils
  - Mechanical/gas engineering
  - Electrical
  - Control and instrumentation
- **Asset inspections:** Detailed inspections have been carried out on all assets to be incorporated into FutureGrid. This consists of visual inspections, magnetic particle inspections (MPI) followed by more thorough Ultrasonic testing (UT) to confirm mechanical soundness and identify any defects. This has identified assets which cannot be incorporated into the facility in their current condition. This ranges from assets which simply require cleaning, through to assets which no 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:** Basic maintenance will be carried out on some assets to ensure that they can safely operate within the FutureGrid test facility without compromising the project ethos of representing the NTS. Typical examples include replacing the sealant in a ball valve and replacing worn gaskets/o-rings.
- **Asset replacement:** Where assets have been identified as not having the required integrity or functionality, remediation is not an option. The FutureGrid team have invoked the contingency plan in such instances. A clear benefit of having another gas network as a project partner was realised when NGN donated 18" pipe to the project.
- **Procurement:** The recompression unit has been ordered and the design is being refined to ensure it is compliant with hydrogen design codes. There are still ongoing risks related to the recompression unit, due to the impact Covid-19 is having upon supply chains. This risk has been escalated and a mitigation plan has been deployed by the project team.
- **Review of metering:** The NTS flow computers have been transported to DNV's laboratories where the software configurations are being examined to determine if modification is 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. Both parties have held discussions to identify alternative meters which would provide the data required.

Build phase

DNV have completed an extensive ground condition survey which allowed for the commencement of the groundworks. During this reporting period, the groundworks completed include the levelling and stoning of the test pad area. This is a major milestone as it will allow other construction activities to proceed without being hindered by poor weather conditions associated with winter.

Some progress has also been made in the installation of drainage and ducting to ensure the supporting infrastructure required for the facility can proceed to plan.

Planned works

The construction of the FutureGrid facility will continue to accelerate following the completion of groundworks. In order to ensure the build and commissioning phases are complete in the next 12 months the following will be completed:

- Completion of asset inspections and carrying out relevant maintenance tasks.
- Welding of pipe sections/assets to join them together.
- NDT of all welds to ensure they are of a suitable quality for the installation.
- Casting of concrete plinths for assets, including the recompression unit.
- Fabrication and installation of stands/supports for assets.
- Completion of manufacturing, testing and delivery of recompression unit.
- Installation of control cabin.
- Installation of electrical, control and instrumentation cables and apparatus.
- Testing of metering and gas quality assets.
- Hydrostatic testing of relevant assets and compilation of commissioning documents.
- Commissioning of FutureGrid flow facility.

Ofgem deliverable 2.0:

Testing and commissioning

The master test plan defines the different tests which are to be conducted throughout the project, to ensure as much relevant information as possible is extracted to confirm asset suitability with hydrogen. The master test plan covers tests on 11 asset types and will be capturing data across 853 data measurement points over the duration of the project. The data gathered will be analysed in detail and used to evidence the changes in operation for gas transmission assets in hydrogen service.

As part of our engagement activities we have shared the master test plan with other organisations for review and feedback. This includes European transmission operators as well as operators in the US and Australia. After discussions with Future Fuels Cooperative Research Centre (FFCRC), an Australian research centre, we identified an opportunity to improve the methodology of the permeation testing and so updated the master test plan to reflect this.

We have also gone through the process of assessing the welds which are to be used in the fatigue rig; this includes identifying weld procedures and reviewing these with subject matter experts in NGGT and DNV. This resulted in some small changes to the test plan for the fatigue rig to ensure it is an accurate reflection of NTS pipelines.

During this reporting period, the leak testing has commenced with the orifice plate metering skid and the filter skid. The flange leak test has also been completed. These tests have been completed using water, 100% natural gas and 100% hydrogen to ensure a comparison is available.

The testing sequence has been reprogrammed to ensure the results are received in a timely manner to support the main test facility. A collaborative approach recommended the refurbishment of some assets to ensure the tests would be representative of the NTS.

Standalone Hydrogen test module progress:

Standalone hydrogen test module	Description	Start date	End date	Progress
Material permeation testing	This test will determine the rate at which hydrogen permeates through the pipe wall in a pressurised hydrogen environment. This will inform the soak time required for full saturation on other tests.	Oct 2021	Mar 2022	• Sample of pipes and valves selected for testing • Sample cut and delivered to the laboratory • Laboratory set-up of testing has commenced
Pipe coating and CP testing	These tests will assess the impact of hydrogen on external pipe coatings as well as the cathodic protection system to identify any issues.	Mar 2022	Jun 2022	• Planned to be conducted after the permeation testing as the results can be used for planning the test parameters for the coating tests
Fatigue testing	To demonstrate the NTS can endure tens of thousands of pressure cycles in hydrogen service.	July 2021	Aug 2023	• Asset identified • Material certificate identified • Welding procedures identified • Procurement of long lead items (pumps and dome ends) completed
Flange testing	To assess the effect of hydrogen on RF (raised face) and RTJ (ring type joint) flanged joints.	July 2021	Dec 2021	• Asset identified • Material certificate identified • Test completed
Asset leak testing	To compare the leak rate of hydrogen with natural gas when testing existing assets at their operating pressure. Assets include the orifice plate meter skid, the regulator skid a filter and a 36” ball valve. Hydrogen is more prone to leaking than natural gas. We need to understand the extent of this to determine if additional mitigations are required.	Sep 2021	Jan 2022	• Assets identified • Orifice plate meter skid leak test complete • Regulator skid leak test complete • Filter leak test complete • Valve leak test in preparation • Results and data from tests being compiled and sent to NGGT for review.
Rupture testing (only the build of the test rig – testing falls under Ofgem Deliverable 4.2)	Investigate overpressures caused by delayed ignition of ruptures on a buried line containing 100% hydrogen. 36” NB gas storage array to provide the necessary gas flow.	Sep 2021	Sep 2022	• Commencement of preliminary investigation to failure mechanism

The methodology for the permeation testing on pipe coupons has been revised to a more robust method which allows for direct high pressure permeation measurements. The inner surface of the sample of pipe is exposed to high pressure hydrogen and the outer surface has a hydrogen detector attached. The hydrogen flux (permeation) is then directly measured across the test sample. Samples of the decommissioned assets have been taken and delivered to the laboratory for the permeation testing.

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.

Hydrogen testing

The hydrogen blends will be tested for the following durations:

Hydrogen blend	Duration
2%	4 weeks
10%	2 weeks
20%	4 weeks
100%	4 weeks

This deliverable has not commenced and is not expected to commence by the next reporting period.

In order to operate the flow facility at a representative NTS pressure of 70 barg, additional materials testing is required on the line pipe proposed to be used to construct the facility. The materials testing is being completed by DNV in their Columbus testing laboratory in the US. Following the completion of the materials testing DNV will be able to confirm the design factor that will be used in line with ASME B31.12. This work is being covered by a separate NIA project.

FutureGrid is one of the first large scale projects to demonstrate hydrogen at transmission pressures. As the project progresses we are collaborating across both the UK and international gas industries to share the knowledge and outputs we gain. This approach helps to accelerate the hydrogen transition, overcoming technical challenges to making this a reality.

The FutureGrid project and LTS Futures projects are working closely and sharing learnings and test results during the testing phase. LTS Futures are specifically interested in the permeation testing and the pipe coating testing, along with the fracture toughness and fatigue crack growth testing for the pipe. There is strong synergy between the two projects in terms of the assets and operating conditions used. FutureGrid will be using X52 pipe, which is the main component of the LTS, in its construction and laboratory testing and so will be of particular use for the project. Likewise, LTS Futures is assessing risks from venting and hot working which are essential to the operation of the NTS.

Ofgem deliverable 3.1:

Testing 2% hydrogen

The facility will be tested with a blend of hydrogen and natural gas. The first blend to be tested will consist of 2% hydrogen combined with natural gas. The blend of hydrogen will then be increased during the subsequent testing stages to 10% and then 20% hydrogen. Tests with low concentration blends of hydrogen are being conducted to reflect the assumption that blends will be required to facilitate hydrogen production and the NTS will not transition instantly to 100% hydrogen. The results from these tests will be collated and documented for analysis. No significant changes to operation are expected with a 2% hydrogen blend. The 2% testing phase has a go/no-go stage gate.

Ofgem deliverable 3.2:

Testing 20% hydrogen

Once the 2% hydrogen testing has been completed and confirmed safe some of the volume of the system will be vented and additional hydrogen will be added to the high pressure reservoir to increase the blend to 10% hydrogen. The 10% stage is an additional part of the deliverable and is being conducted to check the compatibility of the meters and flow computers with low concentrations of hydrogen.

A shorter duration test will then be conducted to calibrate and assess the meters and flow computers before then increasing the blend to 20% hydrogen. The 20% test is expected to show changes to the thermal and flow characteristics of the gas, however these changes are expected to be relatively small and won't change the overall operation of the system.

Ofgem deliverable 4.1:

Testing 100% hydrogen – main flow facility

Once the 20% hydrogen testing is complete and the approval is given to go ahead with the 100% hydrogen testing, the system will be vented and additional hydrogen will be added. It is envisaged that there will be some modifications required to the facility as we transition to 100% hydrogen.

Ofgem deliverable 4.2:

Testing 100% hydrogen – fatigue test module

Preparation for the fabrication of the fatigue test module has commenced. Suitable line pipe has been sourced from which to fabricate the test module. This pipe has seen natural gas service, having been removed from the NTS as part of a diversion project. Weld procedures have been identified from existing NG pipelines and modifications, which represent the differing techniques used across the lifetime of the NTS.

The team have worked closely with welding engineers to locate and identify weld procedures from NG's library and by carrying out extensive searches through the NTS archives. The pumps required to pressurise the test module have been ordered. The lead time for the pumps has increased from the originally quoted 12 weeks to 18 weeks. This will cause a delay to the completion of the project by six weeks. The lead time increase is associated with the Covid-19 pandemic and global material shortage.

Ofgem deliverable 5.0:

QRA and safety case

This workstream has been developed and there are six areas that will be updated following the results of the testing:

1. **Procedures review:** categorisation of NGGT procedures as high, medium, low impact with a report detailing the methodology findings and next steps for each.

2. **Hazardous assessment of transmission system (HATS):** assess impact of hydrogen on MAPD. Provide an updated 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 site and a typical AGI (above ground installation) site at 20% & 100% hydrogen and compared to existing natural gas drawings.

5. **Overpressure risk:** 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. **NGGT safety case:** assess and update the NGGT safety case (policies, procedures and work instructions) considering on the impact of hydrogen. The review will involve NGGT subject matter experts.

During this reporting period, we have started the hazardous area review and also a review of the impact hydrogen will have upon key NTS procedures. This will inform whether a change of gas within the NTS is acceptable from a societal risk perspective, or if additional mitigations or control measures will need to be identified and implemented to allow conversion. This activity is currently on schedule for this reporting period.

Progress during next reporting period

The next reporting period aims for the completion of the hazardous area impact assessment, completion of NGGT procedure review and commencement of the safety case review (knowledge gap analysis).

Ofgem deliverable 6.0:

Knowledge dissemination

We have adopted a ‘digital first’ approach to engagement and dissemination, to be as open and inclusive as possible for stakeholders across the UK, and to open the collaborative opportunities internationally. In addition, given recent significant adaptations to ways of working due to Covid-19, a ‘digital first’ approach ensures a resilience to engagement, knowledge dissemination and collaboration through virtual means, rather than physically face-to-face. It does not remove the opportunity for face-to-face engagement, but it does mean that where physical events are planned they will be supported digitally, such as with live stream technology, so stakeholders can participate and engage with us in ways that suit their personal circumstances, through presentations, panel discussions and learning sessions.

Over the past year we’ve established our engagement strategy, setting up a strong foundation for engaging with our stakeholders and disseminating information about the project. Across the industry we continue to engage in forums such as Gas Goes Green and the Hydrogen Research and Development Group, and working with the gas networks, BEIS, Ofgem and other key industry bodies. In addition, we’ve established the quarterly network steering groups bringing 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 in exploring opportunities for Phase 2.

As part of our wider engagement ambitions, we’ve remained focused on the use of a variety of media, allowing stakeholders on both a UK and global scale to engage and interact with the project. We’ve established three key pillars of engagement for FutureGrid outlined at right:

FutureGrid
Explore

FutureGrid Explore are 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. To date, these events have been very successful and we’ve received a lot of positive feedback. Highlights include:

Constructing the test facility – October 2021
Watch here

To date our events have been virtual but we have several physical events planned for 2022.

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 is happening. To date we’ve released two blogs with more planned in the coming months as construction progresses.

Reaching our hydrogen future – August 2021
Read here

Construction has started – October 2021
Read 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. To date there are two podcasts we’ve created, with more planned in 2022:

Our offline hydrogen test facility – May 2021
Watch here

The decommissioned assets – November 2021
Watch here

In addition to this, we continue to engage both within the UK and globally across a wide range of forums and events. We are a founding member of the Hydrogen Gas Asset Readiness (H2 GAR) group with several of the European Transmission System Operators (TSOs), 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:

- UK International Conference on Gas Decarbonisation – March 2021
- The Energy Networks Innovation Conference (ENIC) 2021– October 2021
- Pipeline Maintenance and Integrity Management Conference – October 2021

Ofgem deliverable 7.0:

Comply with knowledge transfer of the governance document

The project remains in compliance with the knowledge transfer activities associated in V.3.1 of the Gas Network Innovation Competition 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, as and 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.

Progress against budget

As referenced throughout the report, the project spend has been reallocated to suit the revised project programme. Although the project end date has extended, there have been no changes in the overall revised costs from the original NIC budget.

The equipment costs have increased, but this increase has been offset by driving down the spend on labour and reallocating some of the contingency to cover the additional costs. As a result, the revised budget for equipment has increased and the revised budget for labour and contingency has decreased compared to the original NIC budget.

The table below provides an overview of the original NIC budget, revised budget, project forecast and actual spend up to November 2021. 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	Expected Spend by Nov 2021	Actual Spend by Nov 2021	Variance	% Variance
Labour	£5,303,769	£5,201,157	£1,100,041	£1,119,795	-£19,754	1.80%
Equipment	£4,229,006	£4,443,221	£1,051,739	£906,286	£145,453	-13.83%
Contractors	£65,020	£65,020	£0	£0	£0	0.00%
IT	£10,000	£10,000	£2,000	£0	£2,000	-100.00%
Travel and expenses	£50,400	£50,400	£15,312	£0	£15,312	-100.00%
Contingency	£420,159	£308,556	£7,292	£7,292	£0	0.00%
Other (Comms)	£160,000	£160,000	£9,000	£8,500	£500	-5.56%
Totals	**£10,238,354**	**£10,238,354**	**£2,185,384**	**£2,041,873**	**£143,511**	**-6.57%**

Commentary on budget line items:

- **Labour** – The actual spend is 1.8% more than the expected spend due to DNV bringing forward some of the labour-intensive tasks which are weather dependent, to minimise the risk of weather delays. This increase is offset by an underspend to date for NGGT labour costs due to a lag in the system for timesheets costs to land against the project budget on SAP.
- **Equipment –** The actual spend for equipment is 13.83% less than expected. This is due to delays in delivery of some materials procured by DNV (due to Covid-19 supply chain issues) and also due to deferral of some non-time critical equipment purchases for site infrastructure into the new year.
- **Contractors –** No contractor spend is expected up to this point, therefore there is no spend or variance to report to date.
- **IT –** The forecast spend on IT costs has been delayed as we finalise the scope for equipment required to support the project delivery and dissemination activities.
- **Travel & Expenses –** The travel & expenses costs are recorded on our internal SAP system centrally and are to be reallocated to the project. Due to some delays and system issues the transfer of expenses has not yet been made directly to the project. Costs which have been incurred to date are within budget and will be allocated directly to the project accounts and recorded as spend in the next reporting period.
- **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 5.56% less than expected. This is due to a lag in invoicing for communications activities including production of this report.

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 NGGT 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

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 NGGT 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)

The bank account also contains 8 of the 12 monthly payments as part of the Ofgem Funding Award for FutureGrid, with payments received totalling **£6,126,76.49** to date

The mirroring process is ongoing due to unexpected internal transfer issues. Deductions totalling **£1,230,950.38** will be made from the bank account as part of the bank account mirroring process to cover costs incurred up to October 2021 on the FutureGrid project including:

- DNV Costs
- NGGT Internal Costs
- Additional Contractor Costs
- HSE payment costs

As of the end of November 2021 the bank account balance after the mirroring process is fully completed: **£6,925,029.21**

Interest rates

The interest payments expected to be achieved when the project direction was given will not be achieved. This is due to the low interest rates set up by Bank of England in this reporting period. There is expected to be a shortfall in funding awarded as a result.

Learning outcomes

Lessons learnt are a vital element of project management as a mechanism to record knowledge gained from conducting the project. They provide an overview of elements which went well in the project and where improvements could have been made. This knowledge gained is powerful and can be implemented for future projects of a similar nature to deliver them more efficiently and effectively.

A lessons learnt workshop is planned quarterly between NGGT and DNV to discuss the lessons learnt in the project. These lessons learnt are tracked throughout the project and are mentioned where relevant on the monthly governance meetings. The aim of this lessons learnt process is to benefit future phases of the project and other similar projects. These lessons are shared internally within NGGT and with DNV. We are also disseminating our learning through our detailed engagement programme (under Ofgem Deliverable 6 & 7).

The key lessons learnt in this reporting period are the following:

- **NIC bid interview process:** In the interview process for the NIC bid submission OFGEM only asked one round of supplementary questions and were pleased with the NIC submission. This is because the content was clear and detailed. In addition to this, we were also well prepared for the interview process. This is a positive lesson learnt and will be implemented in future submissions.

- **Assets received required remediation work:** Some of the decommissioned assets received required more maintenance than originally envisaged. This is because the de-commissioning projects from where the assets have been sourced were completed in advance of the FutureGrid project commencing. This has resulted in remediation/replacement work to be completed, for example, carrying out maintenance activities on the assets and sourcing spare parts. This could be mitigated by conducting early asset assessments and more detailed surveys prior to the design stage of the project. In addition to this, contingency plans need to be in place to allow for unsuitable assets being rejected and replacement assets to be sourced.

- **Decommissioned projects being brought forward:** Once the assets required were identified plans were made to package and transport them to Spadeadam. There were some de-commissioning projects which were being conducted later in the year. We conducted early liaison with the relevant project teams to find any opportunities of commencing those projects earlier. As a result of early liaison these projects were conducted earlier than anticipated. This is a positive lesson learnt and will be implemented in future where possible.

- **Additional material testing:** Additional material testing has had to be carried out to obtain the necessary information required for the construction of the facility, with associated additional costs. A key lesson learnt for the future will be to conduct a thorough desktop review of available records for specific assets and include it as a key consideration for deciding which assets are to be included.

- **Good engagement with project partners:** The communication plan created at the start of the project had activities in which the project partners are engaged regularly. This plan has been effective as key issues are discussed and a collaborative solution is formed. E.g. pipe required to connect the facility obtained from a decommissioning project was unsuitable to be used. FutureGrid project team were able to source an alternative pipe from NGN swiftly.

- **Covid-19:** Due to lockdown restrictions in the early stages, key project meetings had to occur virtually which were not as effective as in person meetings. There were travel restrictions which meant key initial site surveys of assets were not conducted and as a result the delayed surveys of assets meant issues were highlighted at a later stage. In addition to this, there is a shortage of several materials. This has impacted the project as there have been delays to delivery of key materials and manufacturers are uncertain of delivery dates. Mitigation measures such as contacting suppliers well in advance and anticipating longer lead times for materials and services are in place. The project has adapted in case there is another lockdown.

Moving forward

We plan to continue to conduct regular lessons learnt workshops throughout the project. We will also continue sharing these lessons throughout the project with our engagement sessions with the gas networks and wider industry. In addition to this, we will also note any lessons of similar projects which are shared with us to develop our knowledge and understanding.

Section 12

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 for 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 their in-kind contribution to FutureGrid.

Section 13

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 an NIC or NIA funded project can be requested by interested parties, and the terms on which such data will be made available by NGGT can be found in our publicly available "Data sharing policy relating to NIC/NIA projects" at www.nationalgrid.com/gasinnovation

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

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

NGGT has 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.

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 through 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, further action.

The risk register has been attached to Appendix 1.

The top five risks in this reporting period are the following:

- **Delays on delivery of re-compressor unit:** The re-compressor unit is a critical path item and the programme is constantly monitored. The manufacturer has described experiencing global material shortages due to Covid-19. This has the potential to delay the overall project timeline as it is a critical path item. We are mitigating this risk by constantly engaging with the manufacturer and working collaboratively to explore any opportunities to be on schedule.

- **Assets fail during the master test plan:** In this reporting period some standalone tests have been conducted on the assets. We have found that there have been unexpected leaks on the assets which should not occur on general gas transmission operations. It is our understanding that these leaks are due to the ageing conditions of the assets and they were decommissioned a few years before the project started, with no regular maintenance occurring. This means some key components of assets need to be replaced, which add costs and time to the project. In addition to this, although pre-assessment checks are carried out on assets as they have been received by DNV, there is still a risk present, due to the age of the assets, that they may fail during the testing phase of the facility. To mitigate this, we have developed a robust test plan to implement safety controls in liaison with SMEs and NG Operations to plan for a worst-case scenario.

- **Covid-19 and Brexit causing volatility to the construction industry**: suppliers have described experiencing global material shortages due to Covid-19 and the increased customs requirements. This has the potential to lead to delays and increases in goods prices. Currently, the pump lead time was extended by six weeks as a result of these issues. Additionally, there is an uncertainty about the timely delivery of the compressor, which could delay the overall programme. However, tight mitigation measures such as contacting suppliers well in advance and anticipating longer lead times for materials and services are in place to manage the risk.

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

- **The assets may not have the required condition to support build the test rig:** In this reporting period most assets have been delivered to DNV Spadeadam. DNV is conducting asset pre-assessment. As part of this activity, there were a few assets that required replacement and there were others that need to be refurbished. The asset replacement and refurbishment is a high risk on the project – if the assets are not in the minimum-required condition this may cause additional time scales and add costs to the project. The pre-assessment process moved forward to allow NGGT to source replacements or alternatives if assets fail checks.

- **Welding procedures not provided to DNV in a timely manner causing delay to fabrication of the fatigue test module:** The NGGT project team has been working with its subject matter experts to provide DNV with a selection of possible welding procedure specifications (WPSs) that can be used to fabricate the fatigue test module. This allows a selection of different weld types to be tested. The risk is that there is a delay in sourcing the information and providing it to DNV, causing a delay to the fabrication, and ultimately a delay to the start of the testing. To date, some procedures have been provided and DNV is assessing the availability of weld consumables and welding equipment with which to carry out some of the more complex weld types.

FutureGrid

Phase 2 and 3 development

Once FutureGrid Phase 1 has been built and tested, there are further phases planned in order to adapt the FutureGrid facility to allow for the technical demonstration of more complex equipment. These demonstrations are essential to understanding how a hydrogen NTS would operate.

The following applications have been submitted as part of FutureGrid Phase 2:

- **SIF HyNTS compression** - This project investigates the key challenges associated with compression of hydrogen using existing national transmission system (NTS) assets. This project will also provide the capability for critical operations such as In-Line Inspection (ILI) to be tested at FutureGrid.
- **SIF HyNTS deblending and purification** - 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.

In addition, Phase 3 opens up the FutureGrid facility for third parties to trial and test technologies. Currently there are number of additional SIF applications that seek to utilise the facility including:

- **Fuel Cell Gas Analyser & Data Analytics**
  This project aims to demonstrate a fuel cell gas analyser for blends of hydrogen and natural gas up to 100% hydrogen in the NTS.
- **EcoNET Telemetry**
  The EcoNet programme sets out to create a pathway to modernise future telemetry solutions. The project develops on the NG Cyber RIIO-1 NIAs to deploy a robust future proofed telemetry system.
- **Hydrogen Metering**
  This project will investigate how gas metering will change as the network is transitioned to hydrogen. There will be scope for demonstration of new technology potentially at FutureGrid.
- **HyNTS Pipeline Data Set**
  This project will address several challenges within the Inline Inspection industry as the pipelines are transitioned to hydrogen. Different inspection tools, techniques and criteria.
- **Hydrogen barrier coatings for Gas Network assets**
  This project looks into the potential for deployment of hydrogen barrier coatings via electrodeposition onto the internal surface of a pipelines and other assets.

Further projects outside of SIF are also underway that are considering use of the FutureGrid facility.

Section 15

Accuracy assurance statement

This report has been prepared in accordance with the Network Innovation Competition governance document (v3.1) published by Ofgem. In preparing this report we have ensured accuracy of the information by validating against monthly progress reports, project updates and through a challenge and review process with NG and DNV colleagues. Where financial figures have been used, these have been validated against our SAP system and the bank account statements. As Project Sponsor for DNV, Gary Tomlin has also reviewed and signed off this report.

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: 14 December 2021

Section 16

Material change information

Based upon the criteria set out in the Network Innovation Competition Governance document (v3.1) published by Ofgem there are currently no material changes with regards to the FutureGrid project. There are a number of deliverables which are at risk of being material changes which will be continually reviewed and mitigated by the FutureGrid team to minimise the likelihood and associated consequences of them occurring.

Section 17

FutureGrid
Get involved

NGGT FutureGrid team

The FutureGrid team is made up of six team members, in addition to the project sponsor:

Antony Green
Hydrogen Director & FutureGrid Project Sponsor

Tom Neal
FutureGrid Programme Manager

Shaun Bosomworth
Senior Delivery Engineer

Haroon Khan
Project Manager

Lloyd Mitchel
Hydrogen Engineer Materials

Dan Harrison
Hydrogen Engineer – Asset Integrity

Dan Knowles
Hydrogen Engineer – Electrical & Instrumentation

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 at www.nationalgrid.com/FutureGrid

Follow us on the 'Innovation at National Grid'page on Linked In click here

You can also find us on:

Follow us on Twitter @NationalGridUK click here

Follow us our Instagram page @NationalGrid click here

Like us on Facebook click here

Watch our latest videos on YouTube click here

FutureGrid

Appendix 1
Risk register

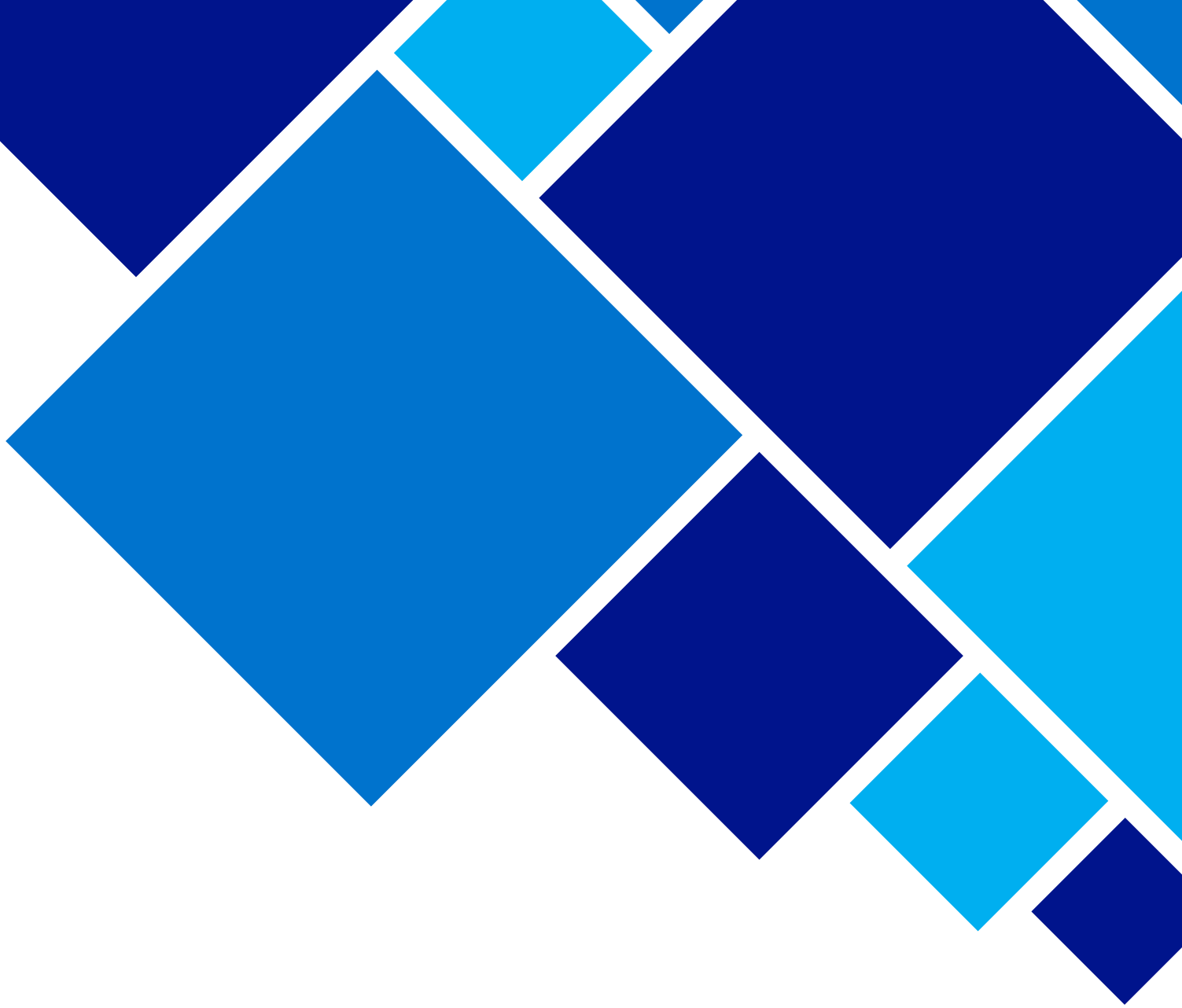
FutureGrid Programme Tracker

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-21 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 NGGT sites d) Potential to use Local Transmission Assets which have been decommissioned. e) Update the decommissioned assets tracker	2	4	8	5
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	3	6	20
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 b) Detail master test plan c) Use DNV technical authorities	1	2	2	6
5	Open	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	2	2	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 3rd parties for installation b) Follow agreed specifications and procedures for installation	1	2	2	10
7	Open	Build	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 NGGT and DNV b) Clear, well planned and thought through commissioning plan	2	3	6	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-21 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	3	3	
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 NGGT 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 its 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	4	8	20
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	3	6	8
13	Open	Project Management	All	A lack of support from the gas distribution networks	Poor communication from NGGT	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	2	2	3
14	Open	Project Management	All	A critical NG 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	3	2	6	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, this 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-21 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	2	2	
17	Open	Build & 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 with 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	2	2	15
18	Open	Assets	All	Asbestos may be present in some assets	Older assets	Delays and costs to project	3	5	15	a) NGGT 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	5
19	Closed	Build	All	Delay in Contracts	Delay in start date	Delay in Programme			0				0	
20	Open	Build	All	NORM may be present	Naturally occurring radioactive material can be entrained in flows gas wells	Exposure to NORM radiation when breaking containment	3	3	9	a) Conduct NORM checks when de-commissioning assets	2	3	6	3
21	Open	Build	1a	Weld Procedure are not provided to DNV in time	Lack of access to legacy weld procedures	Delay in procurement of welding consumables	3	4	12	a) Constant liaison with Subject Matter Experts (SMEs)	3	4	12	8
22	Closed	Build	All	Land may not be available	Approvals from RAF	Delays to the overall project construction	2	5	10	a) DNV to liaise with 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 liason with Leigh Palmer	2	5	10	5
24	Open	Assets	All	USM 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) NGGT-DNV to contact OEM to confirm suitability	2	5	10	5
25	Closed	QRA	All	Procedural documents may not be suitable or available for DNV	Availability and suitability	Delays in QRA	4	5	20	a) NGGT in liaison with SMA	2	5	10	5
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) NGGT SME verifying data. DNV in liaison also	2	5	10	
27	Open	Build	All	Re-compressor rig delays	Delay in delivery date	Delays in rig	5	5	25	a) DNV in constant liaison with time	4	5	20	25
28	Open	Build	All	Delay Lab permeation testing	Delays in transport of material	Delay commissioning of the fatigue test module	2	3	6	a) Early shipment of materials	1	3	3	3
29	Open	Build	All	Supply chain issues	Covid-19 and Brexit	Delays in essential materials being delivered	4	5	20	a) Early contact with vendors and purchase orders raised earlier than normally required	3	5	15	15



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