nationalgrid

St Fergus MCPD Emissions

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HOLDS

Hold	Date	Description

HYDROGEN / CARBON DIOXIDE REPURPOSING STATEMENT

As part of the St Fergus Gas Terminal Final Options Selection Report, National Grid Gas Transmission (NGGT) were requested[1] by Ofgem to provide a view on the implications of repurposing the terminal for Hydrogen (H2) and Carbon Dioxide (CO2), including upper concentration limits and cost implications.

The requirements are shown in Table 1 but providing detail in response is not possible at this stage of the UK's Hydrogen transportation and Carbon Capture Storage development endeavours. It is possible to lay out the maturity levels of NGGT's own activities in relation to Hydrogen transport and its effects on the National Transmission System (NTS) and this is presented in the narrative following Table 1. The relevant high-level response to each of the specific requirements is shown in the table with reference to the Project Union, FutureGrid Network Innovation Competition (NIC) and Network Innovation Allowance (NIA) / Strategic Innovation Fund (SIF) Innovation programme schemes NGGT currently has in progress.

	Ofgem requirements	NGGT Response
Hydrogen Related Activities	A review of the potential upper concentration limits for Hydrogen in Methane if no changes to metallurgy or equipment are made and the terminal is specified for Methane only service.	The below is dependent on an in-depth review of asset state and capability of each facility. The current understanding is that most NTS assets can accept up to 20% Hydrogen. The work to date is predominately desktop-based including benchmarking of global activities. Physical testing of NTS assets and materials is underway through the FutureGrid NIC project and several NIA and SIF innovation projects. The Atmospheres Explosibles Directive (ATEX) requirements of Hydrogen blends below 28% can utilise the rules associated with natural gas however as blends exceed this all equipment would need to be transferred to meet Hydrogen ATEX requirements. Discussions with metering system Original Equipment Manufacturer (OEM)s has led to the understanding that the current ultrasonic metering equipment can perform at blends up to 20% (turbine and orifice plate may need seal upgrades and recalibration) but to reach blends up to 30% would require a transformer upgrade. Gas analysers would need to be upgraded to analyse Hydrogen, they do not currently measure Hydrogen and utilise Hydrogen as the carrier gas. Gas analysers are currently in cycle for refresh through the RIIO-2/RIIO-3 Cyber programme, St Fergus is in the plan for RIIO-3. The new systems could more easily be upgraded to accept Hydrogen using an argon carrier gas. Hydrogen in any gaseous blend concentration can permeate both polymeric and metallic materials. The impact of this depends on the asset type, fatigue load and function, however, generally the affect is to reduce the asset lifetime. Increased inspection of assets is identified as a requirement in the transition to ensure the safe operation of the network.

[1] Refer Special Condition 3.11 Compressor emissions Re-opener and Price Control Deliverable (CEPt), Specifically, St Fergus requirements about the possible future repurposing of some NTS assets for use in Hydrogen and Carbon Capture and Storage systems.

		In the case of no change to existing assets, we believe we could manage up to 10% Hydrogen but would not be able to undertake gas analysis.
	The potential cost implications to increase the Hydrogen in methane concentration from what could be achieved by a standard methane service design to higher purity levels. This should be completed in a stepwise manner selecting sensible break points based on equipment tolerance.	**NGGT are unable to define the potential cost implications based on our current understanding. An appreciation of the costs associated with moving to a Hydrogen fuel source will only start to be understood as an output from the current development activities such as FutureGrid and Project Union. Once it is understood what must change on the NTS then the costing process will commence.** The current understanding is that most NTS assets can accept up to 20% Hydrogen. Each asset class has varying parameters of hydrogen acceptance. These are summarised below: **<10% H2 Gas Analysis Upgrade** To measure Hydrogen blends an upgrade to the analysers is required for all blends of Hydrogen. **<20% H2 Metering Upgrade** It is believed that blends of 20% could be achieved with small upgrades to metering equipment. Although the meters could manage 30% Hydrogen, ATEX changes occur at ~28%, which would incur further upgrades. >**25% H2 Compression upgrades** The compression equipment past 25% will require upgrade; in most instances the gas turbines can be repurposed with a change of the combustion can system and fuel system; the compressor will require replacement at a point between 25-50% Hydrogen that is to be determined through testing in the coming years. **25% H2 ATEX Upgrades** Once past 25% Hydrogen blends we must consider the uprating of all equipment to meet Hydrogen ATEX requirements. Other considerations should be made to the functionality of key elements such as gas detectors, these may be specifically calibrated or run with reduced capability when blends are utilised. **>30% HYDROGEN** Blends greater than 30% Hydrogen have not been accommodated by the metering OEMs currently utilised. However, solutions for 100% Hydrogen have been developed, work is ongoing to resolve this and find solutions to blends between 30-100% Hydrogen. The system design and equipment use evidence is still in development, we are working closely with the HSE to ensure we can repurpose the network as required as we move to net zero. **100% HYDROGEN** Specific equipment for Hydrogen metering, gas analysis and compression can be deployed to enable 100% Hydrogen. **Variability**

		Variability in the blend can provide a challenge to the network equipment and is under further investigation to understand what is achievable.
	The issues that would arise if the terminal is designed for methane service only and subsequently re-purposed to transport CO2.	A project has commenced to develop an understanding of the opportunity of transporting CO2 in the network. NIA_NGGT0202 Technical and Commercial Impact of High-Pressure Carbon Transportation is due to complete in April 2023. Although a network operability study and high-level engineering feasibility report is being progressed, a detailed assessment of repurposing the St Fergus terminal for CO2 is not in scope of this work. Subject to a decision point in March/April 2023, the next stage of the project will include a FEED study. This will include a more detailed assessment of how CO2 will reach the offshore infrastructure. One option may be to repurpose assets at the terminal, but the approach needs further development.
	A summary of any other potential options identified to allow the equipment onsite to be repurposed post Cessation of Production (COP)	Repurposing of our assets to manage net zero gases is a key focus for our programmes of work including HyNTS. Each network asset is being reviewed to find the lowest cost option for enabling the use of the system in a Net Zero future.

Table 1

Currently NGGT has two focal schemes looking specifically at the potential use of Hydrogen and of converting the existing infrastructure to transport it: ‘FutureGrid’ and ‘Project Union’. There is also an associated suite of NIA and SIF projects that build our knowledge and evidence base for the Networks’ use with Hydrogen and carbon dioxide. It is noted that at this time NGGT are starting to look at the transportation of Carbon Dioxide at a high level, particularly in the Scottish Cluster, however this is very early stages and is not considered here further.

Project Union is a pioneering project led by NGGT to create a UK Hydrogen backbone, transporting 100% Hydrogen, while connecting Hydrogen production and storage with end users. Through the phased repurposing of existing gas transmission network infrastructure, the backbone will comprise 1,500 to 2,000km of repurposed assets, representing up to 25% of the UK’s current methane transmission network, with minimal new infrastructure by the early 2030s. During the transition of the NTS to carry 100% Hydrogen, security of supply on the remaining methane network will need to be retained.

Project Union is currently in the Feasibility Phase which aims to develop the evidence and strategy for a credible and deliverable transition of the NTS away from transporting methane to transporting 100% Hydrogen. The approach will consider Government policy, stakeholder insights, critical analysis and the evidence provided by wider internal and external innovation projects.

The Feasibility phase will deliver the following outputs over a 12-month period to the end of 2023.

- A Phasing Strategy, including prioritisation and timing for delivery of each section of the Hydrogen backbone while ensuring security of supply on the remaining methane network. It will also deliver a staged approach to project delivery and funding
- Front End Engineering and Design (pre-FEED) activities for a full Hydrogen backbone, delivering an appraised set of routing options, a constructability assessment and a planning and consenting strategy based on enhanced cost estimates and asset data. A full engineering policy review will also be undertaken
- Hydrogen market enabling activities including development of options for the design of regulatory and commercial frameworks for Hydrogen infrastructure and ongoing customer and stakeholder engagement

The outputs will be used to gather the evidence required to deliver a cost-effective and minimally disruptive transition of the UK’s gas transmission infrastructure to carry 100% Hydrogen.

Project Union has identified St Fergus as a potential key strategic production site, and we anticipate the admission and transportation of Hydrogen at St Fergus may be significant, with the reuse of existing assets and infrastructure to be a potential requirement to meet the above project aim.

Hydrogen compatibility at St Fergus will continue to be reviewed in line with Future Grid and innovation outputs and Project Union requirements as we progress through the next investment stage. This includes ensuring new assets are Hydrogen compatible where possible and economically viable. Compression assets specifically have been shown by OEMs to have a high tolerance for Hydrogen blending for little change in upfront cost.

Figure 1 shows an illustrative route map of an Hydrogen backbone as developed through Project Union:

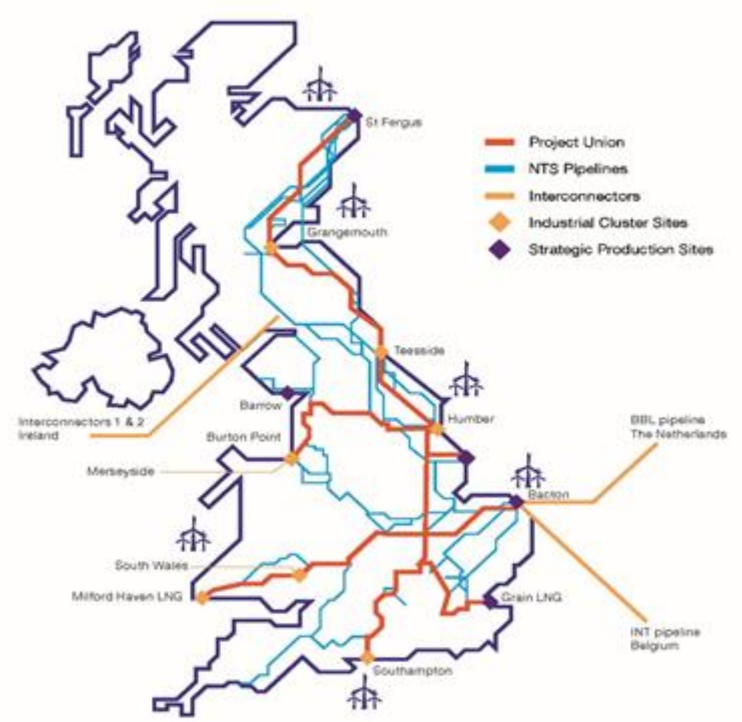

Figure 1 - Project Union Map – routing of Hydrogen backbone is illustrative

Alongside this initiative, FutureGrid has developed an Hydrogen test facility using real-world decommissioned transmission assets, which will demonstrate in real time the ability of our NTS to transport Hydrogen safely and reliably. This test facility is representative of the current network and will be used to test a range of different Hydrogen concentrations (including 2, 5, 20 and 100%). Located in Cumbria, the project started in April 2021 with funding from Ofgem's Network Innovation Competition (NIC) and is expected to be complete by the end of 2023. Project partners are DNV GL, the Health and Safety Executive, Northern Gas Networks (NGN), Fluxys (the equivalent Gas Transmission Operator in Belgium), Durham University and Edinburgh University.

In parallel to the main test facility, there are several standalone Hydrogen test modules operating alongside the to provide key data including:

- Material Permeation Testing
- Pipe Coating and Cathodic Protection Testing
- Fatigue Testing
- Flange Leak Testing
- Asset Leak Testing
- Rupture Testing.

The current indicative timescales for testing of the various Hydrogen Blends can be seen in table 2.

FutureGrid Hydrogen Blends Gas Transmission and Metering

0%	**Hydrogen – 100% Natural Gas** In the Flow Facility, decommissioned NTS assets will be tested initially with 100% natural gas to attain a baseline case for assessment.	March 2023
2%	**Hydrogen – 98% Natural Gas** 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, therefore, creating demand for hydrogen produced and enabling changes to GSMR to be made which allows blending on the NTS.	April – May 2023
5%	**Hydrogen – 95% Natural Gas** A 5% hydrogen blend with 95% natural gas is a recent addition to the test programme and was not in the original scope. The EU have released a Decarbonised Gas Package where it has been proposed all TSO's must be able to accommodate up to a 5% blend – it is in our ambition to keep aligned since we are interconnected with Europe. The potential for variable hydrogen blends in the early stages of blending requires a safety margin, 2% blend would likely be the first, so 5% blend would provide a safety margin.	May – June 2023
10%	**Hydrogen – 90% Natural Gas** The accuracy of meters at 10% hydrogen is 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.	June – July 2023
20%	**Hydrogen – 80% Natural Gas** The last blend is 20% hydrogen with 80% natural gas. The blend limit has been set to 20% because this is the level which has been researched to show gas customers supply and usage will not be impact by this change in gas composition. This may dictate the maximum blend compatible with the NTS without modification.	July – August 2023
100%	**Hydrogen – 0% Natural Gas** The final test will be flows with 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, which will enable the development of appropriate processes, procedures and safety standards which are required to operate our network safely.	August – September 2023

Table 2

The output of the FutureGrid test programme will feed into our Hydrogen analysis to determine which of the existing assets and infrastructure at St Fergus will be suitable for the transportation of Hydrogen, including the cost to upgrade where required. These results will be fed into the next stage of design where applicable.

The NIA and SIF projects in development can be found on the smarter network portal where the project scopes, progress and closure reports are stored alongside the technical overviews. A snapshot of our current asset evidence status can be seen in Figure 2:

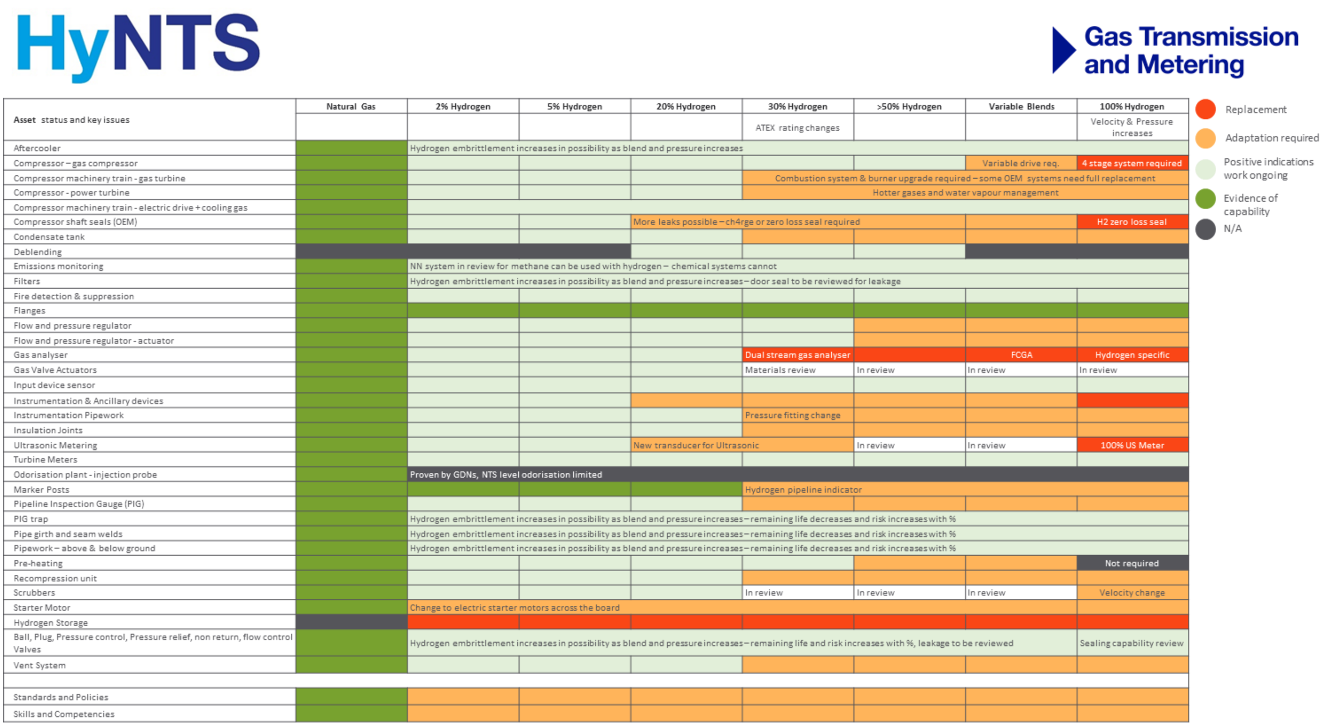

Figure 2