SIF Project Registration

Date of Submission

Mar 2022

Project Reference Number

10023632

Project Registration

Project Title

HyNTS Compression

Project Reference Number

10023632

Project Licensee(s)

National Gas Transmission PLC

Project Start

March 2022

Project Duration

2 Months

Nominated Project Contact(s)

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Project Budget

£146,659.00

Project Summary

The use of hydrogen as an alternative to natural gas is key to ensuring that energy demands of the future are met for heat, power and transport whilst achieving net zero. In order to transport hydrogen throughout the UK, compression will be required. The project will evaluate the costs and opportunities to repurpose the existing compression equipment to keep costs to a minimum for gas consumers.

A technical demonstration will be conducted, at FutureGrid and will provide a facility for any future work as an outcome of this project, whilst enabling the facility to demonstrate further capability such as PIGing and alternative metering systems. The facility will demonstrate a whole systems approach; using an electrolyser to produce hydrogen which will be stored on site and used to power the compression systems during the demonstration. The compression loop will compress and transport hydrogen gas, to demonstrate the compatibility of typical National Transmission System (NTS) components. The system will be connected to NGN's H21 project, demonstrating the use of hydrogen in a distribution system including domestic use.

NGN and SGN will support the project by contributing to meetings and evidence gathering, as compression may be required on the distribution networks in the future.

Siemens Energy have knowledge and experience of the compressors, gas turbines and associated equipment currently used on the NTS as they have supplied several compressor systems which are currently installed on the NTS. They are therefore best placed to investigate the capabilities of the systems currently installed and the potential modifications required to enable them to compress hydrogen.

DNV will be key to demonstration of the compression system, which will take place at DNV's test facility at Spadeadam. DNV have extensive experience of gas pipelines, large scale testing and of the current compression systems installed on the NTS, and are therefore an ideal partner to develop the testing requirements for the system.

ITM Power have the largest electrolyser manufacturing facility in the world and are ideally placed to supply the electrolyser for

production of hydrogen at Spadeadam, which will be used to power the compressor during demonstration.

As the gas industry moves towards the use of hydrogen, there will likely be a requirement for hydrogen production facilities throughout the UK. This may mean that compression will be required on the local transmission systems, not just the NTS, to move the hydrogen through the pipelines after production.

VIDEO - https://www.youtube.com/watch?v=htMK6obOWRo&list=PLrMOhOrmeR6ktSag0RbT7zPNVn0p1P2f6&index=22

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Problem Being Solved

The hydrogen strategy released by the UK government in August 2021 stated that in order to support the net zero targets of 2050, by 2030 there is an ambition to produce 5GWs of low carbon hydrogen. This ambition to provide low carbon hydrogen as a part of a suite of net zero energy sources provides clear guidance to the UK gas networks to progress our hydrogen transportation capability. The national transmission system (NTS) provides a supply of gas to 40 power stations, large industrial users and gas distribution networks from natural gas terminals situated on the coast. The NTS provides a resilient supply of natural gas today and aims to provide the same capability for hydrogen, especially in light of the variability in green hydrogen production.

In order to move the gas through the NTS a compression system is required. Hydrogen has different properties to natural gas and in order to compress the equivalent gas the power input will need to increase, approximately by a factor of 10.

The first step is to understand the capability of the turbine to utilise hydrogen as a fuel gas, reducing emissions and eliminating the need to store natural gas as a fuel on site. We have begun work on this through NIA and will leverage the output of this project to provide insight into this feasibility study. The next step is to consider the compression opportunity with various hydrogen blends in order to provide the most cost-effective solution which is the focus of this work.

The production of hydrogen and injection into the NTS is likely to be inconsistent due to weather fluctuations and varying demand, therefore we will need to understand how the system can manage variable blends of hydrogen and methane. This is likely to increase the cost of the system as variable compressors may be required.

Each compressor on the network would cost at least £40m to replace. Across 24 compressor stations, there are currently 70 compressors. The project will consider the opportunity to repurpose the current compression assets for use with hydrogen and the system modifications which would be required. Determining the most cost effective and efficient route to compress hydrogen is vital to keep costs at a minimum for the NTS transition, and therefore energy customers, through to 2050.

Project Approaches And Desired Outcomes

The Big Idea

The use of hydrogen as an alternative to natural gas is essential for decarbonisation of the UKs energy network. The national transmission system (NTS) will ensure hydrogen can be supplied to consumers reliably from producers such as ITM Power. Compression is required to move gas from the producer to the consumer, build the linepack to store gas and direct flows within the network. Compression is required at multiple locations around the NTS network and at entry points where the gas produced is at a lower pressure such as electrolysers (approx. 30bar). The NTS currently pressurises gas up to 70-90 bar but it is thought this may need to increase with hydrogen due to the lower energy content. It is thought that repurposing the current system will provide the most cost-effective solution to hydrogen compression. This feasibility study will review existing and developing technologies to determine the optimum solution for NTS compression. The technical and commercial feasibility will be assessed, a technical demonstration carried out and strategy created for UK NTS Compression Systems. Although compression is not widely used on the distribution network, some hydrogen systems may require compression such as local transmission system (LTS) assets.

Turbine OEMs have tested turbine capability with hydrogen at varying percentages of hydrogen gas; however, these are limited to fairly new turbines that do not represent NTS systems. In order to accept a high percentage of hydrogen the turbine will need to provide up to ten times more power to the compressor in order to compress the hydrogen required.

The compressor development within this project will have the greatest impact on our future strategy due to current systems being set for a particular gas composition. In the future we may have an increasing % blend of hydrogen in the network over time which could lead to several system retrofits or a variable blend as green hydrogen production can be variable.

Although work is ongoing on the development of gas turbines and compressors for hydrogen, this does not include repurposing current assets. The project will evaluate the costs and opportunity for repurposing as well as potential alternative solutions to ensure value to the consumer. The project will look at the whole system approach of compression from the producer through to the distribution network determining the optimum solution for each use case. The project will also determine the operational parameters to take forward to future phases.

Innovation Justification

Turbine OEMs have tested turbine capability with hydrogen at varying percentages of hydrogen gas; however, these are limited to fairly new turbines.

Research has been carried out on the requirements to compress hydrogen and in order to accept a high percentage of hydrogen the system will need to provide up to 10 times more power to the compressor in order to compress the gas as required. The power from existing turbines will be limited to the turbine capability, gearing between the turbine and the compressor could help up rate the turbine output and enable a level of variability in the compressor but comes at an additional cost.

The current compressors installed on the National Transmission System (NTS) are centrifugal compressors which have been designed for specific flow rates, pressures and gas composition. Hydrogen studies made by OEM's have shown that both centrifugal and reciprocating compressors are likely to require more compression stages to achieve the same pressure ratio that is currently achieved with natural gas. An increase in the pressure ratio can be achieved by centrifugal compression by increasing the tip speed. This may be achieved increasing the speed of rotation and modifying the impeller diameter.

A variable blend of gases through the NTS is likely, which will impact the operational envelopes of compressors and whether they can operate efficiently. Variable compressor systems have been reviewed in the RIIO-1 period and could provide a solution to a small level of variability.

In Europe, compression testing has been undertaken at a blend of 10% hydrogen, however this has not looked at the possibility of repurposing existing equipment. Our challenge looks at both existing equipment and blends \>10%.

In the transition to hydrogen innovative steps will be required to maintain the safety of the site infrastructure around the compression system. This includes the starter, cab and control systems. In a likely future of more variable gas flows the control systems and management through the GNCC/GSO will require development. We will consider novel sensing systems and required data sets on our compressor systems that allow us to meet energy demand.

A high-level comparison of compression types has been carried out, which will be updated throughout the project as we learn more. As well as reviewing current NTS compression systems, potential alternative compression solutions will be identified and evaluated to

ensure that the most suitable solution for the NTS is selected. See attachment.

Project Plans And Milestones

Project Plan And Milestones

The project is split into seven work packages:

1. Project management will be the responsibility of National Grid and includes project management and development of the requirements for future phases of the project.
2. Business case and requirements will be the responsibility of National Grid and will include modelling, cost benefit analysis and determining the functional requirements of the project. A review of work on hydrogen compression worldwide will be undertaken as well as engagement with relevant projects in the UK.
3. Gas turbines and alternative drive systems will be the responsibility of Siemens with input from National Grid. This work package will investigate the use of hydrogen as a fuel gas for gas turbines, the capabilities of gas turbines currently installed on the NTS and potential impacts of hydrogen and hydrogen blends have to be investigated. This phase will also look at potential alternatives and gas turbine testing requirements.
4. Compressor equipment will be the responsibility of Siemens with input from National Grid. This work package will review the current compression systems installed on the NTS and investigate their capability to compress hydrogen. The impact of varying blends will be considered. The modifications required to the compression system will be designed and a test plan developed for use with hydrogen. If it is concluded that existing compression systems cannot be repurposed, alternative systems will be identified.
5. Site infrastructure and development will be the responsibility of DNV and National Grid, and will focus on the design of the test facility and required compression system ancillary equipment.
6. The build, commissioning and testing of the FutureGrid compression facility will be the responsibility of National Grid and DNV. This work package focusses on the concept design and feasibility in the SIF Discovery phase.
7. The final work package focuses on implementation and roll-out of the technology. Developing the strategy and requirements for deploying the results on completion of the demonstration work in the Beta phase.

Potential risks identified for the discovery phase of the project include a delay in signing contracts and suitable resources being unavailable for the project. We will mitigate these risks by preparing contracts for the discovery phase in November to ensure contracts are in place for project kick-off. We will ensure that suitable resources are available by sharing project knowledge across the team and detailed project documentation is kept to enable the project to continue in the case that a resource becomes unavailable.

Route To Market

The long-term strategy formed from the project will represent the most cost-efficient solution for hydrogen compression. This will be implemented across the UK at compressor stations on the National Transmission System (NTS) and will provide guidance to hydrogen production facilities and distribution networks, providing a whole system approach for compression. The learning gained during the project will allow existing compression systems to be upgraded to manage hydrogen and develop the most cost effective solution for replacement when necessary throughout the UK. The learning could also support the development of hydrogen ready transmission compression assets across the globe and could be exploited as such. The project will include regular stakeholder updates throughout, to ensure key UK projects are engaged and learning is shared. This will enable other gas networks, hydrogen production facilities and industrial consumers to implement compression of hydrogen in localised areas, if required.

The whole systems approach of the demonstration at FutureGrid will include hydrogen production, via electrolysis, which will be stored on site and used to power the compression systems during the demonstration. The compression loop will compress and transport hydrogen gas, to demonstrate the compatibility of typical NTS components. The project will include suppliers and experts in compression drive systems, compression, electrolysis, compression cabs and ancillary equipment and hydrogen gas seals. Many of these project partners are international companies operating worldwide. The knowledge gained by suppliers will enable them to provide hydrogen ready compression systems and associated equipment, and where possible, help to modify existing assets for use with hydrogen in the UK and internationally.

On completion of the project the results of this project will feed into Project Union; the ambitious national grid gas led project to provide a high pressure hydrogen backbone in the UK linked to Europe and the industrial clusters; with repurposing of assets due to begin 2025. The transition to hydrogen is planned, in the UK, to begin in the areas of Teeside, Humberside and Merseyside through the industrial cluster activities East Coast Hydrogen and HyNET. It is vital that the learning from the compression project is utilised to provide links between these areas to ensure that hydrogen can be transported to and from each industrial cluster. If successful, the evidence built throughout the project, and in subsequent projects, will allow hydrogen compression systems to be implemented internationally on existing assets.

Costs

Total Project Costs

155333

SIF Funding

146659

This project has been approved by a senior member of staff

☑ Yes