Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

NIA Project Registration and PEA Document

Date of Submission

Jun 2021

Project Reference Number

NIA_NGGT0176

Project Registration

Project Title

HyNTS - Hydrogen Fuel Gas for NTS Compressors

Project Reference Number

NIA_NGGT0176

Project Licensee(s)

National Gas Transmission PLC

Project Start

September 2021

Project Duration

0 years and 11 months

Nominated Project Contact(s)

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Project Budget

£783,874.67

Summary

The project will undertake a feasibility study on an example NTS compressor station to examine safety, environmental, technical, operational and economic issues in blending hydrogen/methane for combustion in a gas turbine (GT) driving NTS compression. The project also determines how to establish an innovative green hydrogen production, storage and supply facility to fuel GTs on varying hydrogen/methane blends.

This strategic study is preparatory work ahead of demonstration in an NTS compressor station, which precedes hydrogen blending in NTS compressors as 'business as usual'. Higher hydrogen concentrations may be achieved in the GTs in advance of similar blends within the transmission pipes. As such, this strategic and innovative project could de-risk the hydrogen transition of GT compression operations and bring forward CO2 and NOx reductions.

Nominated Contact Email Address(es)

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Problem Being Solved

The use of hydrogen as a fuel gas for compressors to reduce carbon emissions at compressor stations has been considered with paper-based studies being undertaken. This activity further develops these feasibility studies with a real-life proposal that will investigate: hardware and control systems compatibility; safety systems (including DSEAR); utilization and storage to manage or ensure consistent blends, and procedures for maintenance and assessment.

The transition to hydrogen blends within the NTS could require SGT-A20 Gas Turbines (GTs) powering compression to run on varying fuel blends of hydrogen and methane. Delaying testing the GTs at varying input fuel blends until the blends are within the NTS exposes operational risks and license non-compliance arising from GT operational or maintenance failures. If varying blends of gas are not

feasible in compressor engines further work will be required to understand the requirement for storage of hydrogen against predicted utilization maps. Alternative technologies are looking to reduce emissions with methane powered compression (such as software mitigation and hardware updates), the introduction of hydrogen will further improve these reductions and support our transition to Net Zero by 2050.

Method(s)

The project will undertake a feasibility study on an example NTS compressor Station that will examine the safety, environmental, technical, operational and economic issues in blending hydrogen/methane for combustion in a gas turbine (GT) driving NTS compression. The project also determines how to establish an innovative green hydrogen production, storage and supply facility to fuel the SGT-A20 GTs on varying blends of hydrogen.

This strategic study is preparatory work ahead of a demonstration of local hydrogen supply and use in a real-life example NTS Compressor station. This in turn would precede the adoption of hydrogen blending in compressors as 'business as usual' within the NTS. Higher hydrogen concentrations may be achieved in the GTs in advance of similar blends being attained within the transmission pipes themselves. As such, the project is by its nature strategic and innovative having the potential to de-risk the hydrogen transition of GT compression operations and bring forward CO2 and NOx reductions.

The focus of the study will be on the SGT-A20 GTs, (of which there are 29 across the current compressor stations), a robust and simple Gas Turbine. Prior work indicates they can run material blends of hydrogen and methane with limited adaptation. The SGT-A20 GTs present a lower operational and financial risk for a demonstrator than would be the case if trials were conducted on more modern GTs, having low capital value in NGGTs books versus say one of its modern Siemens SGT range which and more complex and higher value. The consequences of unreliability are therefore less with the SGT-A20 compared to more modern GTs.

The deliverables from this study will take the form of a report which, if the concept proves feasible, will support future project stages through to implementation. The report will include a set of recommendations for next steps in the development process.

Aspects considered are:

- Outline 'reference' design
- Business case and commercial arrangements
- Replication and learning sharing opportunities
- Recommendations including road map

Measurement Quality Statement

The measurement approach used to meet Data Quality objectives will be through the identification of high calibre project partners whom are experts in their given field and the use of real data from National Grid sites. In this instance the project will be limited to a desktop study and therefore will combine separate partner historic data sources to inform new insights into the use of Hydrogen. The resulting insights will be assessed by the academic partners to correlate with other research and alternative opportunities in the field of compression.

Data Quality Statement

The project will ensure that data used is of sufficient quality to deliver project objectives by the independent peer review of key activities by the academic partners in the project. The relevant data and background information will be stored for future access within the National Grid Innovation Sharepoint site.

Scope

The feasibility study will comprise five work packages.

Work package 1 – Turbine Capability

Work Package Lead – Siemens with Peer Review by Cardiff University

This work package looks to develop an understanding of the capability of the SGT-A20 gas turbines and all equipment that support operation (including: package enclosure, fuel metering and DCS) with varying blends of hydrogen. The work package will focus initially on 25% and 100% blends as 29% is seen as the threshold of hydrogen capability without the need for large investment. It will include:

site survey; compressor usage assessment; blending and variability study; scenario development and their implication on equipment modifications and emissions; opportunities for replication and learning sharing across UK wide compression fleet; benchmarking; defining physical test programme; consideration of alternative technologies.

Work package 2 - Operational Considerations

Work Package Lead – Mott MacDonald with Peer Review by Cardiff University and Imperial College on respective specialist areas

This work package looks at the operational considerations on our compressor sites. The work package will consider: safety; HMI; environmental and cost implications of using hydrogen as a fuel gas. It will include: technical concept development of both GT equipment/controls and hydrogen production, storage and supply; site environmental considerations including HAZID; utility capacity; site regulations and safety systems; impact on procedures and standards.

Work package 3 – Electrolyser capability.

Work Package Lead – SBLC Ltd supported by Mott MacDonald and Siemens with Peer Review by Imperial College

This work package looks at the electrolyser capability and inputs key technical limitations in relation to the production of hydrogen including the reliability of the renewable energy sources, water and costs associated. It will include: electrolyser tech watch; location and production feasibility; commercial review and supply chain assessment.

Work package 4 – Business Case

Work Package Lead – SBLC Ltd supported by Mott MacDonald and Siemens with Peer Review by Imperial College

This work package brings information from work packages 1-3 together to build the business case and provide guidance on the future work required to use hydrogen as a fuel gas for compressor turbines. It will include: economic modelling; value and risk assessment; funding opportunity analysis; understand the impact of hydrogen legislation and policy; consider whole energy system interactions and define opportunities for replication and sharing learning.

Work Package 5 – Project Management, Standards & Reporting

Work Package Lead – SBLC Ltd

This package will include the project management, project and technical reporting and risk identification. As per NIA governance all activity through the project needs to be logged and reported to allow dissemination to the energy industry.

This project will have limited financial benefits at this stage as it is a desktop study. Optimised business cases will be able to be developed to enable improved pricing in future price control periods.

Objective(s)

1. Determine the viability of running SGT-A20 GTs on blends of hydrogen and methane up to 100% hydrogen.

2. Determine the viability of supplying green hydrogen to the SGT-A20 GTs at an example Compressor Station.

3. Identify relevant safety, environmental, technical, operational and economic issues.

4. Generate an innovative outline reference design of the hydrogen system linking locally produced green electricity to hydrogen consumed by the SGT-A20 GTs.

5. Generate a business case showing the economic and environmental benefits to consumers, local and regional people and economies.

6. Develop a roadmap from the outcome of the study, through practical trials, prototyping to full roll-out with significant hydrogen blending.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The National Transmission System (NTS) is a key UK infrastructure for the transport of Gas to consumers, including those considered vulnerable. In a scenario where hydrogen replaces methane as a household heat source, it is essential the vulnerable are not excluded by virtue of fuel inaccessibility. In cases where vulnerable consumers already utilise gas it is likely that in a net zero future the optimum option is to provide a consistent energy solution. The transition to hydrogen within the NTS provides continuity of access to the vulnerable of hydrogen as a replacement to methane, with ongoing benefits of efficiency and economy of scale within a closely regulated environment. This project supports the transition of the NTS to hydrogen which in turn supports the availability of gas to the vulnerable.

Success Criteria

The Following key criteria need to be met for the project to be considered successful:

· Study objectives met to time and cost.

· The Business case developed provides guidance on the optimal manner to enable the energy transition for the NTS, in particular for the compression and compressor site safety when considering hydrogen.

· Peer review ensures the insights drawn from the project are traceable, reliable and comparable.

Project Partners and External Funding

Project Partners –

· Gas Network - National Grid Gas PLC

· Project Lead & Electrolysis Technical Lead - SBLC Ltd

· Turbine and Compressor Technical Lead – Siemens

· Infrastructure and Safety Lead - Mott MacDonald

· Business Case Peer Reviewer - Imperial College

· Technical Peer Reviewer - Cardiff University.

Potential for New Learning

1. Operational learning from running SGT-A20 GTs on varying blends of hydrogen/methane ahead of blends in NTS.
2. Understanding of the effect of Hydrogen on our NTS compression assets (including a study on their current state)
3. Scale of CO2 and NOx savings realizable.
4. Commercial arrangements required to support green hydrogen production and storage facility development.
5. Interactions between the vectors of green electricity and gas.
6. Analysis of upgrades required to balance of plant at NTS compressor sites to allow hydrogen to be used as a fuel gas
7. Potential for model replication at other compressor sites.

Scale of Project

This will primarily be a desktop study which will examine how hydrogen can be produced locally, be supplied to power the GTs at an example Compressor Station and the part that innovative new technologies, processes and commercial arrangements could play in facilitating this. The learning from this study will apply to other compressor sites.

Technology Readiness at Start

Technology Readiness at End

TRL2 Invention and Research

TRL5 Pilot Scale

Geographical Area

NTS Compressor Stations in the UK utilising SGT-A20 GT engines

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£783,874.67

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

The transition to hydrogen blends within the NTS could require SGT-A20 GTs powering compression to run on varying fuel blends of hydrogen and methane. Delaying testing the GTs at varying input fuel blends until the blends are within the NTS exposes operational risks and license non-compliance arising from GT operational or maintenance failures. If varying blends of gas are not feasible in compressor engines further work will be required to understand the requirement for storage of hydrogen against predicted utilization maps. This strategic study is preparatory work ahead of demonstration in an NTS compressor station, which precedes hydrogen blending in NTS compressors as 'business as usual'. Higher hydrogen concentrations may be achieved in the GTs in advance of similar blends within the transmission pipes. As such, this strategic and innovative project could de-risk the hydrogen transition of GT compression operations and bring forward CO2 and NOx reductions.

How the Project has potential to benefit consumer in vulnerable situations:

Although this project does not directly affect vulnerable consumers the energy transition may and as such, we must consider the effect of the work we are doing through the NIA funding. The National Transmission System (NTS) is a key UK infrastructure for the transport of Gas to consumers, including those considered vulnerable. In a scenario where hydrogen replaces methane as a household heat source, it is essential the vulnerable are not excluded by virtue of fuel inaccessibility. In cases where vulnerable consumers already utilise gas it is likely that in a net zero future the optimum option is to provide a consistent energy solution. The transition to hydrogen within the NTS provides continuity of access to the vulnerable of hydrogen as a replacement to methane, with ongoing benefits of efficiency and economy of scale within a closely regulated environment. This project supports the transition of the NTS to hydrogen which in turn supports the availability of gas to the vulnerable.

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)

N/A

Please provide a calculation of the expected benefits the Solution

This is a research project to enable development and demonstration of hydrogen rotating machinery packaged solution. The exact benefits will be examined during the feasibility study, but a typical methane based rotating machinery package replacement is in the order of £17m and could be substantially more for a Hydrogen ready equivalent system. In demonstrating that current gas turbines with minimal change can utilise Hydrogen, we could dramatically reduce the cost of the transition to Hydrogen. This project will also look at the optimum solutions for surrounding sites infrastructure, so the successful solutions could be materially more cost effective than the base cost. This project also has environmental benefits in using Hydrogen instead of methane as a fuel gas, to help bring forward CO2 and NOx reductions. The recipients of the benefits will be consumers ultimately as NTS compression fuelled by hydrogen will be materially de-risked as a result of the feasibility study.

Please provide an estimate of how replicable the Method is across GB

The learning from this project has the potential to roll out the solution at some other compression sites with GTs and the learning to all

15 other compressor sites running gas turbines, not just those having the SGT-A20 GTs.

Please provide an outline of the costs of rolling out the Method across GB.

This is a feasibility study and it is not possible to provide indicative implementation costs before this work has concluded.

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 NIA Project must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

☐ A specific piece of new (i.e. unproven in GB, or where a method has been trialled outside GB the Network Licensee must justify repeating it as part of a project) equipment (including control and communications system software).

☐ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☐ A specific novel operational practice directly related to the operation of the Network Licensees system

☐ A specific novel commercial arrangement

RIIO-2 Projects

☑ A specific piece of new equipment (including monitoring, control and communications systems and software)

☑ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☑ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☑ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☑ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☑ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

Only NGGT operate gas turbine powered compression equipment in the UK, although learning from Europe is to be undertaken and included as part of the project.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

N/A

Is the default IPR position being applied?

☑ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

NGGT are the sole operator of gas compression equipment and have not undertaken activities in this area. NGGT are active participants in the H2GAR workstream for compression and benchmarking of other TSO activity will be included in this study. Later in RIIO-2 it is planned that physical test work can be undertaken on an example compression system at the FutureGrid Spadeadam site and this study will drive the business case for the use of hydrogen in current compression systems instead of purchasing new systems.

There are no other live NIA projects looking at this problem.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

N/A

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

Hydrogen gas is now seen as a viable alternative to methane gas. However technical and financial considerations need to be examined before hydrogen gas can be used. This review of new technologies in combination with existing assets is seeking to establish the viability of a sustainable solution for a hydrogen production, supply and use in compression power. In particular, hydrogen blends in live compressor gas turbines have not been studied in any detail within the UK; but will need to be proven to enable the UK's NTS to be used in the proposed decarbonisation strategy. Doing so now gives NGGT early learning ahead of the time when material volumes of blended gases are being transported in the NTS.

Relevant Foreground IPR

There is limited foreground IP being created as part of this project, the project will review several data sets together to provide new insights into the optimal solution for using Hydrogen as a fuel gas for NTS turbine systems. Background IP from past work may be introduced to the project and will be available for the partners to utilise in order to disseminate the foreground IP as per contracting requirements.

Data Access Details

Data from our NTS sites and GSO will be collated to understand the business case and infrastructure requirements through this project. Where data is sensitive this will be de-sensitised as required to enable the use within the project to support the successful outputs and limited to the internal partners. We will document any reasons for de-sensitising data and publish a de-sensitised version incorporating the minimum number of changes. The project will adhere to the data sharing policy as stated in 2.13-2.16 of the RIIO-2 NIA Governance Document - https://www.ofgem.gov.uk/publications-and-updates/riio-2-nia-governance-document.

Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

The benefits of the project to the Network Licensee are uncertain and would not accrue within the current price control, therefore this activity would not be undertaken as BAU.

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project

NIA funding is in place to allow networks to undertake higher risk innovation activities that are not associated to their current business plans. In this instance, we are looking at Hydrogen as a fuel gas, which is a strategic energy option for Net Zero targets. Using BAU funds will not be possible for this package of work. However, this work is to de-risk future Net Zero investments and hopefully, reduce the overall implementation costs to the consumer.

Commercial, technical, operational or regulatory risks will also be explored and captured throughout the feasibility study.

This project has been approved by a senior member of staff

☑ Yes