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

Apr 2024

Project Reference Number

NIA_NGT0235

Project Registration

Project Title

Pre-heating Requirement for Hydrogen Transportation

Project Reference Number

NIA_NGT0235

Project Licensee(s)

National Gas Transmission PLC

Project Start

May 2024

Project Duration

0 years and 7 months

Nominated Project Contact(s)

Ellie Udomwong, box.GT.innovation@nationalgas.com

Project Budget

£242,200.00

Summary

National Gas Transmission (NGT) own and operate the UK's National Transmission System (NTS), transporting natural gas from terminals to end users. NGT have ambitions to repurpose the existing to transport hydrogen and hydrogen blends. Understanding the impact of hydrogen on our existing assets is a key enabler for this.
This project will determine the impact of hydrogen and blends on our gas pre-heating systems. Gas pre-heating is used in a range of operations, primarily to avoid liquid-drop out due to the Joule-Thomson effect when reducing the pressure of natural gas. The project will involve assessing the current assets and procedures for gas pre-heating with hydrogen and blends, determine any upgrades or modifications required, and review current procedures to assess their applicability to gas-preheating with hydrogen.

Preceding Projects

NIA_NGGT0205 - Safe venting & recompression of hydrogen

Third Party Collaborators

Wood PLC

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

To support the energy transition, National Gas are looking to repurpose the National Transmission System (NTS) to hydrogen. Pre-heating system is one of the components that plays a great role in NTS system by preventing gas quality issues, such as heavy

hydrocarbon drop-out or icing when depressurisation causes gas to cool. This effect is known as the “Joule-Thomson (J-T) Effect” of natural gas, where the temperature of gas decreases when the pressure decrease.
As hydrogen has different properties to natural gas, J-T effect of hydrogen is an “exception” due to the extremely small molecule. The temperature increases when the pressure decreases, and the inversion temperature of hydrogen is much lower than ambient temperature. More importantly, the J-T effects of hydrogen blends and their impacts on pre-heating system are not currently available. The previous study in FutureGrid Phase 1 has indicated the challenges on data availability of JT effects for natural gas/hydrogen mixtures and the testing for hydrogen blends outside the capability of the pre-heating system is required. The FutureGrid physical testing for Industrial Modular pre-heating system type at FutureGrid is also ongoing which could provide additional data to this. Consequently, it is essential to understand the needs and impacts of pre-heating system for hydrogen transportation and fuel gas on gas quality control and any additional system that may be required in order to control their inverse J-T effects. Additionally, hydrogen blends can exert great influences in this system and the impacts of J-T effects in different hydrogen blending ratios. Pressures and temperatures needed to be studied.

Method(s)

The overall aim of this project is to determine the key differences between pre-heating system for natural gas and hydrogen and consider if additional changes are required to the current NTS assets to ensure safety and optimised operation. A phase approach is required to deliver the study in the following phases and timelines:
The project will conduct literature review for Joule-Thompson data available at the specific blends (100% natural gas, 2%, 20%, 50%, 80% and 100% hydrogen) that allow the effects of hydrogen on pre-heating system to be studied. Using the outputs of Phase 1, the desktop studies will build a model of gas pre-heating systems on the NTS to understand the impact of hydrogen and blends on existing assets. Assess the impact of hydrogen and blends on current NTS pre-heating assets and procedures, including any modifications or changes required.
The key deliverables are as follows: (1.) Data collection on current assets and procedures for gas pre-heating on the NTS (2.) Impact assessment of hydrogen and hydrogen blends on existing assets (3.) Modelling study of existing system with hydrogen and blends to understand the need for pre-heating with hydrogen (4.) Comparison between new hydrogen systems with our current systems (5.) Determine risk areas and potential resolutions (6.) Assumptions log for the proposed design and assessment (7.) Report findings
Measurement Quality Statement
The measurement approach used to meet Data Quality objectives will be through the identification of high calibre project partners who are experts in their given field. The methodology used in this project will be subject to our supplier’s own ISO 9001 certified quality assurance regime and the source of data, measurement process and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and made available for review.
Data Quality Statement (DQS)
The project will be delivered under the NIA framework in line with the agreed Energy Networks Innovation Process document and NGT internal policies. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal SharePoint platform ensuring backup and version management. Relevant project documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.

Scope

The project is split into four work packages (WP) as follows:
Phase 1 – Evidence Requirement of the Joule-Thompson effect with hydrogen and blends
This phase will conduct literature review for Joule-Thompson data available at the specific blends (100% natural gas, 2%, 20%, 50%, 80% and 100% hydrogen) that allow the effects of hydrogen on pre-heating system to be studied. This will also include data from FutureGrid physical testing.
Phase 2 – Impact of Hydrogen and Blends on NTS Gas Pre-Heating Systems
This phase will investigate the impact of hydrogen on NTS gas pre-heating assets and operations. A model will be developed representing gas pre-heating assets on the NTS and used to determine the thermodynamic impact of hydrogen. Additionally, the current asset design and materials will be assessed to determine their suitability for hydrogen duty. Finally, current operating procedures will be reviewed and assess for hydrogen suitability.
Phase 3 - Pre-heating system requirement for hydrogen
This phase compares hydrogen operations with the current preheating system, to determine key areas of risk and focus for redesign, replacement or additional assets needed. Hydrogen pre-heating system design will be benchmarked and hydrogen design will be compared with current NTS. This Phase will then have a deeper look in operational envelope and their retrofitting for hydrogen services. With the outputs from the studies previously, optimum design for repurposing ‘typical’ pre-heating system for hydrogen operation will be developed along with cost and risks estimates and NTS pre-heating strategy development. This phase will also identify any physical testing required to update procedures for operating a hydrogen network.

Phase 4 - Report findings
This work package will provide the technical and regulatory reports required to close the project and record the outcome for Ofgem. The deliverables under this WP are listed below:

- Technical Report: Supplier to provide a technical report of all work carried out including a Cost Benefit Analysis
- Technical Summary: Supplier to provide the summary within the above-mentioned technical report.
- Draft Standard update: National Gas to review output of project and identify if any standards need to be updated considering the results.
- Closure Report: Depending on funding mechanism, the supplier may need to populate an ENA closure report document using the information provided in the technical report.

The project scope (in/out) is listed below:
In scope

- Evidence requirements of Joule-Thomson effect for hydrogen blends
- Impact assessment on current assets and procedures related to gas pre-heating with hydrogen and blends considering future hydrogen scenarios
- Determination of required modifications or upgrades to existing pre-heating systems and associated risks and costs.
- Technology review of new hydrogen pre-heating systems
- Determine whether the physical testing is required

Out of Scope

- Physical testing of NTS assets#

The final findings shall be provided to NGT in the following formats.

- Draft Technical report, subject to NGT review before final submission.
- Draft Technical summary, subject to NGT review before final submission.
- ENA closure report if required.

The benefits of this project are in determining the key differences between pre-heating system for natural gas and hydrogen and consider if additional changes are required to the current NTS assets. This is vital information to understand the capabilities of existing assets with hydrogen and any modifications or new equipment required. Hydrogen will provide long term decarbonisation opportunities for the UK and is key to our net zero targets.

Objective(s)

Model the Joule-Thomson Effect for Hydrogen and Hydrogen blends

- Assess the impact of hydrogen and blends on current NTS pre-heating assets and procedures
- Determine whether pre-heating systems are required for hydrogen duty
- Determine the key differences between pre-heating system for natural gas and hydrogen and consider if additional changes are required to the current NTS assets to ensure safety and optimised operation.

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.
An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register. This project has been assessed as having a neutral impact on customers in vulnerable situations. This is because it is a transmission project.

Success Criteria

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

- Objectives met to time and cost
- Project findings inform the difference between natural gas and hydrogen pre-heating system and the requirement for safe operation of NTS network with hydrogen blends and 100% hydrogen

Project Partners and External Funding

Lead Network: National Gas Transmission
Supplier: Wood

Potential for New Learning

The project will provide stakeholders with an understanding of the gaps in evidence and the work required to bridge these gaps in order to update National Gas Transmission policies and procedures for hydrogen. This is a key activity in allowing hydrogen to be transported in the NTS and for Project Union to become operational. The learning will develop an understanding of changes required to gas networks to meet hydrogen safety and optimum operation, with hydrogen and hydrogen blends. The findings from the project will be uploaded to the ENA Smarter Networks portal and will be shared via NGT innovation social media.

Scale of Project

This project is a predominantly a desktop-based study initially with experimental study, that will provide insight into whether there is an opportunity to repurpose existing pre-heating assets. If the initial Work Packages (as defined above) are completed successfully, then this project will move into a full-scale test phase. The extent to which the pre-heating system on the network will be affected by hydrogen is unknown and this needs to be understood to safely transition to net zero and hydrogen.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

United Kingdom

Revenue Allowed for the RIIO Settlement

None – hydrogen-focused innovation project

Indicative Total NIA Project Expenditure

Total funding = £242,200.00

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:

This piece of work will support the energy transition through enabling the long-term transportation of hydrogen through the NTS pipeline network. The process by which the network provides evidence and data associated with its difference to between natural gas and hydrogen system is vital to ensuring a robust and safe outcome. The outputs from this project will help educate, inform and drive the journey towards adopting hydrogen within the UK gas network, which will in turn help contribute towards the UK's target of net-zero emissions by 2050.The outcome of this project will be utilised to drive the transition of the network elements for both 100% hydrogen and blends. In the case this new process is not developed, the robust delivery of evidence and associated data sets for the network transition cannot be assured.

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 natural gas as a household heat source, it is essential the vulnerable are not excluded by virtue of fuel inaccessibility. Ensuring robust NTS assets and consistent hydrogen production options will support 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

Value tracking Data Point Data Point Definition
Maturity TRL 2-4 The maturity of the existing uprating process is advanced, consideration for how hydrogen impacts this new process has not been made and therefore the TRL is low at the start of this project but should rapidly increase.
Opportunity 100% of single asset class The project will cover only pre-heating system. The project is not delivering something that will be deployed on the network.
Deployment costs - The project is not delivering something that will be deployed on the network.
Innovation cost £242,233.33 The cost of the innovation includes a desktop study, site visits (travel), reporting and project management.
Financial Saving - The project may result in financial savings if the findings can be used to avoid costly changes to Pre-heating system and configurations however this will not be realised within this work.

Safety - The project can be taken forward to update policies and procedures for hydrogen, which will enable safe operation and maintenance of the NTS.
Environment - The project will not have any direct CO2 savings but will help enable hydrogen in the NTS.
Compliance Ensures compliance The project will support compliance with relevant safety standards for safe operation of hydrogen network in the future.
Energy Networks Innovation Process NIA Project Registration and PEA Document
8 Energy Networks Association
Skills & Competencies Individuals Individuals directly involved with the project will gain an understanding into the hydrogen networks and current NTS assets designs with hydrogen.
New tool, skills and competencies will need to be developed across the departments.
Future proof Supports business strategy The project will help enable hydrogen in the NTS and support the energy transition.
The project has the potential to influence future decision-making, such as RIIO-3 investment to enable NTS network decisions on future hydrogen transmission infrastructure.

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

National Gas Transmission, as the operator of the UK's gas transmission system, have a number of similar documents (operational procedures) to the Gas Distribution Networks. A number of projects are underway where the TSO and GDNs are collaborating on updating these documents. This project focuses specifically on National Gas assets however there will be similarities and overlaps with GDN documents. Therefore, the findings from this project could inform GDN work into procedure updates. Furthermore, the test designs could also support evidence gathering for GDN documents.

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

The project will not deliver a method that can be rolled out. The solution proposed will be specific for National Gas pre-heating assets and their relevant policies and procedures.

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

National Gas Transmission, as the operator of the UK's gas transmission system, have similar assets to those of the Gas Distribution Networks local transmission system. A number of projects are underway where the TSO and GDNs are collaborating on the development of hydrogen knowledge. This project focuses specifically on National Gas asset design, however there will be similarities and overlaps with GDN assets. Therefore, the findings from this project could inform GDN hydrogen deployment.

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.

There will be no duplication of activities done as part of this program and the learning will be shared with the gas industry and wider energy industry to avoid future duplication. This project will address a gap in National Gas' ongoing innovation work in understanding the technical-focused development of a hydrogen pre-heating system and design to make investment decisions of future transmission infrastructure today.

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

Work has not yet been undertaken to understand the differences of pre-heating system between a natural gas and a hydrogen service and consider if changes are required to the current NTS pre-heating system to ensure safety and optimised operation. This project will be the first step in understanding the impact and potential solutions to any challenges identified.
The project aims to establish pre-heating system design based on existing NTS assets which has not been proven. It will identify challenges and solutions for decision-makers by considering the wider assets and evidence of hydrogen transportation.

Relevant Foreground IPR

The project is a research and development activity, therefore no new Foreground IPR will be generated. However, the project will deliver a clear view of the pre-heating system for hydrogen which will support not only the repurposing of the natural gas assets but also assist in any new build design activities. The learning is relevant for all transmission scale assets in the UK.

Data Access Details

Details on how network or consumption data arising in the course of an NIA funded project can be requested by interested parties, and the terms on which such data will be made available by National Gas can be found in our publicly available "Data sharing policy relating to NIA projects" at www.nationalgas.com/gasinnovation. National Gas data access is managed IAW provisions under 2.15-2.18 for the current NIA Governance Document.
National Gas already publishes much of the data arising from our NIA projects at www.smarternetworks.org. You may wish to check this website before making an application under this policy, in case the data which you are seeking has already been published.
Data Quality Statement (DQS):
The project will be delivered under the NIA framework in line with the agreed Energy Networks Innovation Process document NGT internal policies. Data produced as part of this project will be subject to quality assurance to ensure that the information produced with each deliverable is accurate to the best of our knowledge and sources of information are appropriately documented. All deliverables and project outputs will be stored on our internal SharePoint platform ensuring backup and version management. Relevant project

documentation and reports will also be made available on the ENA Smarter Networks Portal and dissemination material will be shared with the relevant stakeholders.
Measurement Quality Statement (MQS):
The methodology used in this project will be subject to our supplier's own ISO 9001 certified quality assurance regime and the source of data, measurement process and equipment as well as data processing will be clearly documented and verifiable. The measurements, designs and economic assessments will also be clearly documented in the relevant deliverables and final project report and made available for review.

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

Hydrogen is being directed as a future energy solution but RIIO-2 business funding does not allow the development of hydrogen ready solutions and therefore this project cannot be undertaken as part of BAU activities.

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

This investigation into the impact of hydrogen on the differences of pre-heating system between a natural gas and a hydrogen service is early-stage research and therefore carries additional exposure to risk. The NIA funding reduces exposure to risk and enables feasibility assessment of hydrogen assets.
Risks if project is not undertaken with NIA support include:

- Commercial: A lack of timely decisions on investments in hydrogen transmission infrastructure by businesses.
- Technical: The potential for future stranded assets and developments in locations not feasible for hydrogen network.
- Regulatory: Insufficient information for making timely and effective decisions on frameworks for incentive systems to incentivize hydrogen network in transmission scale.

This project has been approved by a senior member of staff

☑ Yes