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

Jan 2019

Project Reference Number

NIA_NGN_237

Project Registration

Project Title

Integrated Graphene Based Pre-heating System phase 2

Project Reference Number

NIA_NGN_237

Project Licensee(s)

Northern Gas Networks

Project Start

January 2019

Project Duration

0 years and 11 months

Nominated Project Contact(s)

Gareth Paayne-Integrity Engineer

Project Budget

£63,000.00

Summary

NGN must pre heat gas at critical stages whilst distributing to overcome the Joules-Thompson effect, where by the gas temperature drops approximately 0.5°C for each Bar pressure drop.

There have been two new pre-heating technologies recently introduced onto NGNs network through NIC funding:
• Proheat unit
• HotCat Unit
These technologies are still being assessed for efficiency in comparison to existing technologies (Water Bath Heaters & Modular Boilers). At this stage, evidence that the additional requirements both in associated systems, electrical energy use and increased maintenance costs suggests that further solutions should be explored.

Third Party Collaborators

Energy Innovation Centre

Haydale Composite Solutions

Nominated Contact Email Address(es)

innovation@northerngas.co.uk

Problem Being Solved

NGN must pre heat gas at critical stages whilst distributing to overcome the Joules-Thompson effect, where by the gas temperature drops approximately 0.5°C for each Bar pressure drop.

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Method(s)

Several projects have investigated more efficient methods of gas preheating, which has brought a lot of learning and data into a process in need of innovation. However, the long term ideal situation is to install a fit and forget heat exchanger within the pipeline, which has no internal moving parts and heats the gas without the need for a sub-process.

When gas is reduced in pressure the Joules-Thompson effect causes a temperature drop of 0.5°C for each 1 bar drop. When the gas temperature and thus that of the conveying pipework and equipment falls below 0°C problems arise. The temperature below ground is very constant at about 5°C, thus pressure drops of greater than 10 Bar result in the gas temperature dropping below zero.

This degree of pressure reduction and subsequent temperature loss requires the GDNs to heat the gas prior to the pressure reduction process, known as Pre-Heating.

The challenge is to develop a modern, innovative, fully compliant graphene-based pre-heat solution for use on gas operational sites that is more efficient and reliable than existing systems and has in-built flexibility to either retrofit onto existing pipes or to be built into new heat exchangers.

While developments are taking place in this area, Northern Gas Networks (NGN) has identified problems with new & existing technologies used for Natural Gas pre-heating. Traditional steam and water bath systems are inefficient and present a high carbon footprint. Newer electric heating systems are more efficient, but require backup generators to operate during power outages, since they require a 230V ac supply and cannot operate from the 24V dc Very Low Voltage (VLV) power supplies which are available.

NGN would like to continue developments in the area of preheating, utilising new materials, remove the need for subsystem processes, install a fit and forget long term solution. This would be a large project with several key review stages. Each key stage review will be used to assess the progress and determine if funds should be released for the next phase.

Scope

The development of fully compliant in-line graphene based preheating system would be a multi-staged complex project with several collaborating partners, specialists in their field, possibly over a number of years. Prior to commencing such a complex arrangement, the project partners believe this stage one theoretical assessment would provide a sound basis for future stages in NGN's long term objective.

This project aims to complete a detailed theoretical assessment that will cover three main tasks and a number of sub-tasks:

• Structural design requirements, energy requirements and thermal modelling.
o Preliminary heat flow calculations to determine the size and power requirements of a graphene-based heater system based on the user needs (size, voltage etc).
o Further testing of Haydale materials to supply data for modelling.
• Computer modelling to support design calculations will be conducted and will be in two parts:
o Structural and stress modelling of the new pipe / heat exchanger with an integrated graphene-based heater – this will be conducted by Haydale with input from NGN.
o Electrical and thermal modelling will be conducted to determine the power requirements and thermal losses/heat transfer in the pipe – this will be conducted by a third party.
• Final Review Stage
o The production of a detailed final project report that summarises the findings from the project and makes comparisons with the current preheating technologies used by NGN

The modelling will both demonstrate the feasibility of the proposed development and also define the requirements from the composite pipe with an integrated graphene-based heater.

Objective(s)

Stage 1 Objectives – Preliminary Heat Calculations
Preliminary heat flow calculations to determine the most efficient size and power requirements of a graphene-based heater system

based on the user needs - NGN will provide Flow, Pressure (MOP), and temperature increase requirements.

Stage 2 Objectives – Test data
Testing of Haydale materials to supply the empirical data required for the modelling. The test materials will be constructed sufficiently to demonstrate feasibility, i.e. number of layers and coupon dimensions. Measurements will be voltage, current, power of basic systems to feed into model.

Stage 3 Objectives – Electrothermal Modelling
Electrical and thermal modelling will be conducted to determine the power requirements and thermal losses/heat transfer in the pipe. Model will show the effect of input variables on the system and aim to optimise an efficient solution.

Stage 4 Objectives – Product Design

Structural and stress modelling of the new pipe / heat exchanger with an integrated graphene-based heater using analytical and finite element modelling. Outputs to show where any modifications may be required.

Stage 5 Objectives – Final Review

The production of a detailed final project report that summarises the findings from the project and makes comparisons with the current preheating technologies used by NGN

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The initial modelling stage demonstrates feasibility of a (possibly composite) gas pipe or heat exchanger with an integrated graphene-based heater to deliver the specific technical requirements set by NGN and a significant improvement over current technology.

- Preliminary Design Report
- Electrical and Thermal test data
- Structural Model
- Electro-thermal Model

Comparison to current technologies

Project Partners and External Funding

Haydale Ltd

EIC

Potential for New Learning

The main learning from this project will be:

- Whether it is theoretically feasible to use a graphene based heater in a gas pipe or heat exchanger as an alternative pre-heat solution for use on the gas distribution network.
- The limitations of such a graphene based system

The potential for new learning will be:
- Design and manufacture of new composite integrated heat exchangers
- Methods for application of retrofit systems to existing pipes
- Design of nano heaters / systems
- Control algorithms and functions for low voltage heaters

Scale of Project

The project will consist of desktop modelling and lab testing to determine the viability of upscaling graphene to be used for pre-heating.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

Project meetings will take place at NGN and Haydale offices.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

Total project costs - £63k

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:

n/a

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

n/a

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)

This project is an early stage feasibility project, which aims to prove the transferability of this technology to an operational environment.

Please provide a calculation of the expected benefits the Solution

n/a

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

n/a

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

n/a

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

The project will develop learning in the form of understanding if graphene can be scaled up and used vs existing preheat technology.

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

If the project is successful the learning developed will contribute to the environment and low carbon and reliability and maintenance themes of the gas network innovation strategy.

☑ Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

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.

n/a

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

Graphene is a relatively new material and the full capability of its uses have not been explored fully in this field. Graphene has never been used for undertaking pre-heating on gas sites.

Relevant Foreground IPR

n/a

Data Access Details

n/a

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

There will be significant developments required for this to be progressed to a business as usual solution that can be used alongside existing pre-heat technology. Due to the degree of uncertainty with regards to the outputs of this project it makes it justifies the need for this project to be funded under NIA.

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

Due to technical & commercial challenges of this project it makes sense for the project to be undertaken using the NIA funding.

This project has been approved by a senior member of staff

☑ Yes