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

Nov 2024

Project Reference Number

NIA_NGT0251

Project Registration

Project Title

Gas Inhibitors for Hydrogen Pipelines

Project Reference Number

NIA_NGT0251

Project Licensee(s)

National Gas Transmission PLC

Project Start

December 2024

Project Duration

0 years and 7 months

Nominated Project Contact(s)

Robert Best, box.GT.innovation@nationalgas.com

Project Budget

£149,333.00

Summary

The impact of small additions of oxygen into the hydrogen gas mixture on hydrogen embrittlement processes was investigated in a previous NIA project (Inhibition of Hydrogen Embrittlement Effects in Pipeline Steels - NIA NGGT0183). Laboratory results were promising and so this next phase will focus on understanding the requirements for implementation of the technology at a network level.

One of the primary challenges is maintaining oxygen levels at the required and safe thresholds, it is also crucial to understand the deployment requirements, particularly regarding safety, operability, and cost. This project will focus on identifying and addressing critical concerns related to the deployment of gas inhibition in hydrogen pipelines to enable informed decision-making on whether and how to progress this technology further.

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

Scaling up and implementing oxygen inhibition technology will present significant challenges, which must be thoroughly understood. One of the primary challenges is maintaining oxygen levels at the required and safe thresholds, it is also crucial to understand the deployment requirements, particularly regarding safety, operability, and cost. This project will focus on identifying and addressing critical concerns related to the deployment of gas inhibition in hydrogen pipelines to enable informed decision-making on whether and how to progress this technology further.

Method(s)

A stage gated approach to demonstrate feasibility of progressing the oxygen inhibition project will be undertaken in this project:

WP1 Feasibility of maintaining oxygen inhibitor in gas flow analysis

· Using flow assurance software demonstrate the required oxygen concentration can be controlled and maintained in the network within the required/prescribed limits?

o Consider:

§ Straight pipe section with flow and no flow

§ Bend pipe section with flow and no flow

§ Dead leg (no flow)

§ A more complex geometry – i.e. a mini network or part of the NG gas network

§ Does the level of demand/flow impact the concentration required

§ Will oxygen get used up? How long will it last within the pipeline to maintain the minimum requirement?

§ Do the scenarios inc. no flow scenario cause oxygen concentration to exceed the safe upper limit?

§ Based on the analysis where might want to inject and measure oxygen to maintain and manage the concentration

· Certain positions / intervals

· Dependant on pipe condition or other factors?

§ What happens to concentration if oxygen supply / injection is lost for a certain time period (e.g. 1 hour)?

Variables to consider:

· Blends from 2%, 5%, 20% H2/NG to 100% H2

· PPM of oxygen – 250 ppm minimum up to 500 ppm or 1000 ppm max

WP2 Feasibility of technology implementation

· High level review of business case and technical feasibility for oxygen inhibition, scope to cover aspects of the following areas:

o Literature review update to the previous desktop literature review looking at available data regarding the effects of hydrogen and oxygen on fracture toughness and fatigue crack growth.

o Literature review of alternative inhibitors that may provide improved pipeline properties in a hydrogen environment.

o Safety review – does WP1 and other areas of WP2 demonstrate that oxygen can be controlled within safe limits. Is there anything else that needs to be done before the technology could be deployed?

o Based on the findings of the flow analysis feasibility study, where will network injection points be located:

o Can upstream and downstream customers accept oxygen in gas?

- Monitoring and exception planning (e.g. for out of specification gas)
- Network design and operation
- Network integrity management

WP3 Economic Considerations

- Based on the output of WP2 and WP3 consider the cost of injection and monitoring against the operational benefits
- Consider cost to installations.
- On-going oxygen cost.

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 the supplier's own certified quality assurance regime and the source of data.

Data Quality Statement

The project will ensure that data used is of sufficient quality to deliver project objectives. The relevant data and background information will be stored for future access within the National Gas Transmission Innovation SharePoint site.

Scope

The National Transmission System (NTS) in the UK offers a resilience to the UK's varying energy demand and supply. It enables suppliers to input gas at one location in the country and transport it to consumers via the distribution networks whilst simultaneously acting as a storage system to ensure there is energy available even on the coldest winters day. The NTS currently transports natural gas which on combustion produces carbon dioxide plus other greenhouse gases which contribute to climate change. The UK has set an ambitious target of eliminating net carbon emissions by 2050 and a wide range of green technologies are required to reach this goal.

A key technology in this transition is hydrogen as an alternative for carbon fuels in heat, transport, and industrial uses. Transporting hydrogen across the UK and connecting renewable energy producers to customers is an opportunity for the NTS and a potential way to extend the life of assets already paid for by UK consumers. However, the NTS was not designed to transport hydrogen and learning needs to be developed on the capability of these assets in this new use case.

This project will investigate the technical feasibility of using gas inhibitors, such as oxygen, in the hydrogen transmission network.

The project scope is summarised below:

In Scope

- Modelling of gas inhibitors at small and large scales
- Blends of hydrogen and natural gas and 100% high-pressure hydrogen
- Technology scalability and implementation challenges
- Cost-benefit analysis

Out of Scope

- Laboratory or full-scale testing
- Design or implementation of the identified solutions

Objective(s)

This project has the following key objectives:

1. Identify and address critical concerns related to the deployment of gas inhibition in hydrogen pipelines.

- Such critical concerns include impact on safety, upstream and downstream customers, cost-benefit analysis.

2. Investigate feasibility of technology deployment on gas networks

- Covering aspects such as locations of injection points, gas monitoring and exception planning, and integrity management of inhibited pipelines.

3. Recommend next steps for technology, including if appropriate follow-on testing/activities.

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, quality, and cost.
- Deliverables completed to time, quality, and cost.
- Project results inform decision-making on whether and how to progress this technology further.

Project Partners and External Funding

Gas Network – National Gas Transmission PLC

Technical & Industrial Lead – ROSEN Group UK Ltd

Potential for New Learning

The project will investigate the opportunity to deploy gas inhibitors on the National Transmission System. This information will then be used to undertake a cost-benefit analysis of the use of this technology on hydrogen and hydrogen-natural gas blended pipelines with the outcomes fed into Project Evolve and Project Union.

These results might be informative to other transmission networks globally as well as domestic and international gas distribution networks. Where appropriate, results will be disseminated via meetings, committees and conferences.

Scale of Project

This project is a desktop-based study that will focus on the deployability of gas inhibitors on the National Transmission System. The intent of the project scope is to cover all aspects relating the implantation of this proposed technology to ensure a rigorous cost-benefit analysis can be carried out. The outcomes of the cost-benefit analysis will inform whether and how this technology progresses. By undertaking this review future work can be economically justified providing best value for the consumer.

Reducing the scope of this project risks not being able to consider all critical concerns associated with this technology thereby affecting the quality and robustness of the cost-benefit analysis.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

Warwick – United Kingdom

Newcastle – United Kingdom

Revenue Allowed for the RIIO Settlement

None – Hydrogen network focused project

Indicative Total NIA Project Expenditure

External – £ 112,000.00

Admin – £ 32,333.33

Internal – £ 5,000.00

Total – £ 149,333.33

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:

For the transition to hydrogen, National Gas are committed to delivering hydrogen to the consumer in the most efficient and cost-effective manner. Gas inhibitors have the potential to optimise the transmission of hydrogen gas enabling higher pressures than might otherwise be possible, whilst maintaining high levels of safety.

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. 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

The project will investigate the critical concerns related to the deployment of gas inhibition in hydrogen pipelines are identified and addressed, enabling an informed decision on viability of technology for deployment on the National Transmission System.

The overall benefit will be the ability to transport hydrogen in lieu of natural gas thus contributing to greenhouse gas emission reductions. Repurposing existing assets will represent the lowest cost and quickest solution to the end-user.

The project value tracking is listed below:

· Maturity

o TRL 3-5. Desktop study focussed on deployability of technology.

· Innovation Opportunity

o 100% and multiple asset classes. Technology has potential to mitigate hydrogen embrittlement across all metallic gas-facing assets.

· Deployment Costs

o £0.00. Unknown at present. Technology deployment cost-benefit analysis to be conducted during project.

· Innovation Cost

o £ 149,333.33. Cost of innovation project.

· Financial Saving

o £ 0.00. Unknown at present. Technology deployment cost-benefit analysis to be conducted during project. Technology has the potential to enable higher operating pressures with huge financial benefits.

· Safety

o 0%. Unknown at present. Depending on deployment strategy, the technology has the potential to provide additional safety benefits by mitigating hydrogen embrittlement effects.

· Environment

o 0.0 tonnes CO2e. Unknown at present. Technology has the potential to enable higher operating pressures with associated environmental benefits.

· Compliance

o Support compliance. Project supports transition to hydrogen.

· Skills & Competencies

o Individuals. Work will augment knowledge of individuals involved in project.

· Future Proof

o Supports business strategy. Results will support operation of future hydrogen national transmission system.

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

The project will focus on the deployability of gas inhibition technology on the National Transmission System, however the learning will be applicable across the domestic and internal gas industry.

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

A cost-benefit analysis will be undertaken as part of the project which will outline the costs of rolling out the technology across Great Britain.

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

- ☐ 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 research and analysis undertaken in this project will be applicable to pipeline operators and will inform the strategy for pipeline/asset repurposing for the energy transition.

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. There is work undertaken, globally, on gaseous inhibitors in a laboratory environment, however very little has been published on the deployment of this technology on a gas network. A literature review at the beginning of the project aims to capture the latest research on this technology and the work scope will be amended to ensure no unnecessary duplication of work is undertaken if appropriate.

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

Whilst there have been multiple laboratory studies on the impact of gaseous inhibitors as a hydrogen embrittlement mitigation strategy, there is very limited published data on the implementation of this technology at a network level, and nothing specific to the UK National Transmission System.

Relevant Foreground IPR

Foreground IP might be generated associated with network design for gaseous inhibitors. This project and the resultant outcomes/deliverables will conform to the default treatment of IPR as set out under the agreed NIA Governance (where the default requirements address two types of IPR: Background IPR and Foreground IPR).

Data Access Details

Data for this project, and all other projects funded under the Network Innovation Allowance (NIA) funding scheme, can be found, or requested in a number of ways:

· A request for information (RFI) via the Smarter Networks Portal at https://smarter.energynetworks.org. National Gas Transmission regularly publishes much of the data arising from our innovation projects on the ENA portal, before submitting a RFI check this website.

· Via our managed mailbox box.GT.Innovation@nationalgas.com. Further data can be shared upon request through the innovation mailbox. Each request will be assessed by the NGT Innovation Team for its merits and viability.

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

This project is focussed on the impact of high-pressure hydrogen gas on metallic network components, as the existing network does not carry hydrogen gas this work cannot be considered business as usual. It is therefore relevant for NIA funding.

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 approach is unknown and there are many routes that could be taken, there is a risk that without this work the different energy networks would spend time and money on carrying out the research and testing. The NIA funding reduces this risk and enables the feasibility of repurposing existing assets to be assessed.

This project has been approved by a senior member of staff

☑ Yes