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

Sep 2024

Project Reference Number

NIA_NGT0249

Project Registration

Project Title

Impact of Hydrogen on NTS Polymer/ Elastomer Materials – Phase 2

Project Reference Number

NIA_NGT0249

Project Licensee(s)

National Gas Transmission PLC

Project Start

October 2024

Project Duration

1 year and 0 months

Nominated Project Contact(s)

Kousseyla Hamadi, box.GT.innovation@nationalgas.com

Project Budget

£694,224.00

Summary

This project is a follow-up to the study on the impact of hydrogen on NTS polymers (Phase 1). The aim of this phase is to address the knowledge gaps identified in Phase 1 and then conduct physical testing to inform policy and procedural updates, as well as identifying in-service requirements to ensure the safe utilisation of NTS polymers in a hydrogen-pressurised environment. Unlike Phase 1, Phase 2 will also involve examining the impact of CO2 on NTS polymers by replicating the activities to include CO2

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

Within the overall objective of re-purposing the NTS (National Transmission Network) for hydrogen and carbon dioxide (CO2), there is current uncertainty as to the risk posed by degradation of polymers when exposed to pressurised hydrogen and CO2 environments. Based on previous studies, it was found that hydrogen gas can interact with polymeric materials, altering crystallinity. Additionally, it is suspect that hydrogen molecules act as plasticizers in the amorphous phase, thereby degrading material properties.

Previous studies have also shown that CO2 may cause more damage to polymers compared to hydrogen due to its high solubility and lower diffusivity, resulting in increased damage when subject to, for example, Rapid Gas Decompression (RGD)

Method(s)

In Phase 2, the project will proceed with additional required activities to ensure the safe utilisation of NTS polymers in a hydrogen pressurised environment. These activities include laboratory testing for screening purposes, followed by identification of opportunities

for asset-level testing to assess polymers degradation in real life conditions. Subsequently, requirements for in-service monitoring will be identified, and policy update recommendations will be provided.

In contrast to Phase 1, Phase 2 will involve examining the impact of CO2 on NTS polymers by replicating activities to include CO2.

Workshops involving NGT SMEs, and meetings will be used to collect information and assess project advancement. Desktop research and engagement with OEMs will be employed to review polymers usage in CO2 and hydrogen.

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 six work packages detailed below:

4.1. Work Package 1 – Data Capture

The goal of this step is to close knowledge gaps from the previous Phase 1 project regarding hydrogen and include the impact of CO2 on polymers. The results will be kept separate for H2 and CO2, so the resulting reports can be used separately for follow-up.

Deliverables:

WP1.1 Review gaps analysis and close knowledge gap:

The compiled register of polymers in the NTS grid during phase 1 is described as "a snapshot of the NTS assets and polymers present". Prioritised gas-facing assets, that may pose a risk, must be added to update the register. Furthermore, the register must be expanded by adding information on the usage of polymers in assets throughout the years (now called aged assets).

WP1.2 Review polymers usage in H2 / CO2 environments:

Review of main material interaction and degradation principles to form the basis for WP2 test program; feed in of previous knowledge on material compatibility with H2 and CO2; review of current maintenance practices of the investigated asset to be used in WP4.

WP1.3 CO2 pipeline operation conditions:

Provide an overview of CO2 pipeline operating conditions as industry practice as input for WP4.

WP1.4 CO2 impact review:

Expand the register (WP1.1) to include CO_2 and identify the impact on polymers (WP1.2), making use of previous knowledge on polymeric materials-CO_2 interaction including the ongoing work by DNV on the impact of CO_2.

Work Package 2 – Laboratory testing: Experimental test programme

The goal of WP2 is to gain insight in the impact of H_2 and CO_2 on NTS polymers, by conducting practical laboratory research. WP2 is considered at the heart of this research: it translates theory from WP1 and Phase 1 into practice trough intensive testing and forms input for full-scale testing (WP3) and maintenance and policy update recommendations (WP4 and 5).

Deliverables:

WP2.1 Sourcing of polymers for testing must be carefully done to create a balanced, complete, and large enough sample size: both used and new materials are considered.

WP2.2 NTS polymers identification and classification must be done due to the vastness of the register resulting from WP1. Identification allows for grouping to allow for correct prioritisation in test programs.

WP2.3 Conduct screening Lab-level testing must be done based on the categorisation in this WP combined with supplier knowledge on material interactions.

WP2.4 Based on the screening testing program of materials, a list of “suspicious materials” needs more elaborate next level testing at specific operating conditions to gain insight into specific material interaction with hydrogen, possible hydrogen blends and or CO_2.

Work Package 3 – Identification of asset level testing opportunities

This work package aims to identify facilities that can facilitate mid- or full-scale testing of selected assets to assess degradation under real-life operating conditions. Although work package 2 will test under similar examples, the polymers will be used using samples and not in full operation. Whereas similar outcomes regarding degradation are to be expected, mid- or full-scale testing of the complete asset (e.g., valve) factors in other factors like asset age and maintenance intervals, validates laboratory data and further provides support for the HSE safety case. No practical testing is to be done in this work package. Again, the results for H_2 and CO_2 will be kept separate.

Deliverables:

WP3.1 Identify critical assets for testing: Critical gas facing assets must be identified with input from Phase1 project and previous work packages.

WP3.2 Possible physical testing locations will be selected throughout Europe, with an emphasis on UK and The Netherlands, that can facilitate mid- or full-scale testing programs under real life operating conditions. Also, collaboration opportunities with similar projects should be identified, to prevent time-consuming and cost-intensive double work.

WP3.3 Acceptance criteria and qualification: A first test program must be identified for the selected assets when exposed to hydrogen or CO_2, including acceptance criteria on the suitability of polymers included.

WP3.4 Results extrapolation: Results of lab-level sample testing will be extrapolated to populations of NGT assets where possible, and recommendations are needed on follow-up testing to allow for further extrapolation.

WP3.5 Recommendations: A list of recommended assets for safe transport of H_2 and CO_2 must be compiled, where results are inconclusive concrete follow up research should be recommended.

Work Package 4 – In-service assessment

WP4 aims to propose assessment plans for polymers in use and procurement requirements based on the results of previous work packages.

Deliverables:

WP4.1 Defining requirements for in-service assessment of polymers:

Assessments plans for in-service polymers taking into account current maintenance scheduling should be made; implications of the materials research (Phase 1, WP1 and 2) on stock levels and number of suppliers should be made clear, current procurement lists need updating and a future process for verification of suitability of polymers should be proposed

Work Package 5 – Policy updates

The goal of this work package is to present a clear overview of the current procedures suitable for H2 and CO2 and which procedures require adaptation.

Deliverables:

WP5.1 Review current standards, policies & procedures: a clear and comprehensible overview (spreadsheet) in which all relevant documents are listed and their suitability for hydrogen (blends) and CO2 is noted.

WP5.2 Procedures and guidelines update (if required): if it is identified that the procedure or guideline needs adaptation, a clear and detailed update recommendation will be given in order to give the update process an auspicious start. At this point, we are assuming approximately 20 documents to be reviewed, these are mainly maintenance procedures.

WP6: Reporting

This work package will provide the technical, progress and closure reports required for the NIA funding.

The scope of work proposed for this work package is as follows:

1. Production of a final report (which will include an Executive Summary).

a. It is envisaged that this will be made up of sections of the interim reports from the previous work packages and will be subject to final review by National Gas Transmission.

b. It is understood that the project outcome will be used to develop the safety case approach for the NTS and as such all information must be auditable.

2. Populating technical parts of the ENA Project Closure Form.

Objective(s)

Data and Evidence Gathering

o Review Phase 1 gap analysis and close knowledge gaps

o Including any required reviews of other industry practice

• Test Programme

o Conduct laboratory-scale screening testing across range of polymers

o Follow up with more detailed and specific next level testing for selected polymers to confirm application-specific performance

• Identify Asset-level Testing Opportunities

o Identify opportunities for testing of polymer degradation in mid- or full-scale assets under representative operating conditions

• Implementation

o Investigate applicability of current NGT polymers maintenance practices for hydrogen and carbon dioxide operation

o Provide recommendations to update NGT procedures and guidelines for hydrogen and carbon dioxide

o Create a procurement list of approved polymers for hydrogen and carbon dioxide

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

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.

- Address the knowledge gaps identified in Phase 1 and conduct physical testing to inform policy and procedural updates, as well as identifying in-service requirements to ensure the safe utilisation of NTS polymers in a hydrogen-and CO2 pressurised environment

- Project findings inform the HyNTS safety case to provide evidence to HSE.

Project Partners and External Funding

Lead Network: National Gas Transmission plc

Supplier: KIWA

External costs: € 616,910

Internal Costs: € 205,636.67

Total: € 822,546.67

Potential for New Learning

Gain an understanding of the impact of hydrogen and CO2 on NTS polymers which will inform policies and procedural update. In-service requirements will also be identified to ensure the safe use of NTS polymers in hydrogen and CO2 pressurised environments

The findings from the project will be uploaded to the ENA Smarter Networks portal and will be shared via National Gas innovation social media.

Scale of Project

The project includes desktop and Lab testing activities which will provide insight into the impact of hydrogen and CO2 on NTS polymers. This learning will help to inform the hydrogen strategy and develop required learning for the energy transition and towards the operation of hydrogen networks.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

United Kingdom, Warwick.

Revenue Allowed for the RIIO Settlement

None – hydrogen focused innovation project.

Indicative Total NIA Project Expenditure

External costs: € 616,910

Internal Costs: € 205,636.67

Total: € 822,546.67

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:

National Gas Transmission (NGT) is committed to reducing emissions from the operation of the National Transmission System (NTS) and eliminating emissions by 2050. A key route to achieving this involves transitioning the network from natural gas to hydrogen and carbon (CCUS). Successfully transitioning from methane to a hydrogen or carbon network requires a safe use of polymeric materials. This is crucial due to the expected challenges posed by the interaction of gases (H**I**/CO**I**) with polymeric materials, which are part of multiple assets in the network.

Understanding gases interaction with polymeric materials through different mechanisms such us solubility, diffusivity, permeation is key to achieve material compatibility selection in line with quality and safety standards.

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

Value tracking

	Data Point	Data Point Definition
Maturity	TRL3-	Concept stage for compatible polymeric materials selection
Opportunity	100% or multiple asset class	The project can be applied to all assets where gas facing polymers

		Are identified
Deployment costs	-	Deployment costs are not known at the start of the project but will be defined throughout the project.
Innovation cost	€ 822,546.67	The cost includes desktop and testing activities.
Financial Savings	-	No direct deployment costs as this is a research project. However, costs might need to be incurred to ensure hydrogen readiness of assets with respect polymeric/elastomeric component performance..
Safety	-	No direct safety improvement as this is a research project. However, confirmation of polymer/elastomer performance might inform decisions on asset condition monitoring in hydrogen. NTS safety case evidence to HSE.
Environment	-	No direct environmental benefits as this is a research project. However, confirmation of polymer/elastomer performance might enable life extension or avoidance of replacement of assets with associated avoidance of environmental harm.
Compliance	Support compliance	Review guidelines, procedures
Skills & Competencies	Individuals	The project will inform individuals who are directly involved

Future proof	Supports business strategy	The project will help enable hydrogen/CO2 in the NTS and support the energy transition.

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

The project is focussed on safe utilisation of NTS polymers in a hydrogen and CO2 pressurised environment; however, the research undertaken and learning from the project could assist with future hydrogen conversion projects for onshore gas infrastructure and industry.

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

The project does not intend to roll out any tools or technologies, but rather to gather knowledge and information on the safe usage of polymeric materials throughout the project lifecycle.

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

Gas networks utilise multiple assets that contain polymeric materials. Some of these networks are exploring a transition from natural gas to hydrogen. Although this project focuses on the transmission network, the learnings gained can be relevant to all gas networks.

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.

This project will address safe usage of NTS polymeric materials. 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.

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

More work still needs to be done to understand the impact of H2/CO2 on NTS polymeric materials. This project will provide insights on the impact and inform materials compatibility selection as well as in-service assessment requirements.

This work is a counterfactual to certain previous and ongoing projects undertaken by GDNs, which have primarily examined hydrogen impact on polymeric materials with a greater emphasis on polymeric pipelines. In addition to examining the impact and materials compatibility, the project will also investigate potential updates to existing maintenance practices to accommodate hydrogen and CO2. The focus includes identifying quality and safety criteria and evaluating new technologies/materials.

Relevant Foreground IPR

This project will not result in any new Foreground IPR.

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 not currently present in the NTS. 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

Hydrogen and CO2 impact on NTS polymeric materials, technologies and procedures is early-stage research and therefore carries additional exposure to risk. The NIA funding reduces exposure to risk and enables feasibility assessment of hydrogen transmission technologies.

This project has been approved by a senior member of staff

☑ Yes