

NIA Project Registration and PEA Document

Date of Submission

Jun 2022

Project Reference Number

NIA_NGGT0194

Project Registration

Project Title

Impact of Hydrogen on NTS Polymer / Elastomer Materials – Phase 1

Project Reference Number

NIA_NGGT0194

Project Licensee(s)

National Gas Transmission PLC

Project Start

June 2022

Project Duration

0 years and 9 months

Nominated Project Contact(s)

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Project Budget

£61,866.00

Summary

Within the overall objective of re-purposing the NTS for hydrogen, there is current uncertainty as to the risk posed by degradation of polymeric (including elastomeric) materials when exposed to high-pressure hydrogen environments.

To investigate this risk, it is proposed to conduct a project to compile a full list of all polymeric materials on the NTS alongside the expected hydrogen operating conditions for these components. The functional and material property requirements of the polymers can then be determined. In parallel, a review of the susceptibility of such polymeric materials to hydrogen damage will be undertaken. This work will inform the definition of a test programme to validate the performance of the polymeric materials in a hydrogen transmission system, where appropriate.

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Problem Being Solved

Polymer and elastomer materials are used across the National Grid Gas network in a variety of assets, including, but is not limited to, isolation valves, valve stem seals, pig traps, filters, actuators, and gaskets. Due to the complexity of the NTS, and varying standards of record keeping a complete documentation dataset of what polymer/elastomers on the NTS is not available.

Polymers are widely used for hydrogen distribution and storage systems because they are chemically inert towards hydrogen. However, when exposed to high-pressure hydrogen environments, there is a risk of hydrogen permeation into polymeric materials, which can lead to loss of function via swelling or other degradation mechanisms. Furthermore, in applications where the polymeric material is subject to rapid gas depressurisation, there is a risk of failure of the component via blistering or cracking.

Gas Transmission believes that hydrogen, under high pressure, could damage the polymers/elastomers in the NTS; thus, there is a

case to understand the extent of this potential damage/degradation, and provide mitigation if required.

Method(s)

This project will comprise multiple work packages proposed to understand the polymeric materials on the NTS and define appropriate test programme to validate performance for hydrogen transmission:

1. Map out all polymeric/elastomeric materials that would be exposed to hydrogen throughout entire NTS
2. Review available literature surrounding impact of high-pressure hydrogen on polymeric/elastomeric materials on the NTS
3. Confirm expected service conditions (pressure, temperature, gas composition) in a hydrogen grid for each material in NTS
4. Determine functional, material property and maintenance requirements for all materials, based on expected service conditions
5. Generate proposed test programme to validate polymeric/elastomeric materials in 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. In this instance the project will be limited to a desktop study and analysis from TRL2 to TRL3 to inform the current state of polymer materials on the NTS as well as detail future robust testing approaches.

Data Quality Statement

The project will ensure that data used is of sufficient quality to deliver project objectives through the development of a robust testing plan considering key variables which will be managed in the Phase 2 testing programme if required. The relevant data and background information will be stored for future access within the National Grid Innovation SharePoint site.

Scope

The project will be split into 6 work packages:

- 1) Work Package 1 – Determination of Materials in the NTS (Duration – 3 months)

Lead – DNV

Establish and compile a register of engineered polymer components / coating systems etc (asset / location, component type, generic polymer type, manufacturer, relevant standard, history / age, failure records), present within the NTS and associated equipment. Material will be classified as gas facing or non-gas facing.

DNV shall review industry standards, equipment lists, manufacturers/suppliers data sheets, maintenance records and maintenance management system databases, procurement records, stores and spare parts inventories, and conduct interviews with relevant site personnel.

A gap analysis shall be performed to identify uncertainty and required actions to mitigate.

- 2) Work Package 2 – Impact of hydrogen on polymeric NTS materials (Duration – 3 months) Lead – DNV

This WP will review the available literature surrounding impact of high-pressure hydrogen on polymeric/elastomeric materials on the NTS.

To assess the risks of high-pressure gaseous hydrogen on the application of polymeric materials a failure modes, effect and criticality analysis (FMECA) shall be performed. This shall draw on DNV's polymer global expertise working on both offshore and onshore oil and gas applications, inclusive of recent Joint Industry Projects activity looking at compatibility of polymerics for hydrogen applications. Identified risks and failure modes will be divided into categories on their nature and application and the criticality determined.

The FEMCA will be supported by a comprehensive literature review of prior art knowledge in the public domain taken from academic

research, industry programmes and standards in other sectors.

The FMECA outputs shall identify actions to manage and mitigate identified failure modes which shall form the basis of a qualification plan. DNV will assess and compare industry qualification plan methodology, standards and codes (national, global) to manage identified failure modes to evidence fitness for purpose for high pressure gaseous hydrogen applications.

3) Work Package 3 – Establish expected service conditions (Duration – 3 months)

Lead – DNV

Based on the outputs of Phase 1, WP2 and using legacy gas transmission historical experience the in-service conditions for identified polymeric engineered components within the NTS and associated equipment on conversion to hydrogen or hydrogen/natural gas blends will be established and compiled.

4) Work Package 4 – Establish functional, material property and maintenance requirements (Duration – 1 month)

Lead – DNV

Based on outputs of Phase 1, WP1, WP2 and WP3 the design basis and functionality of polymer components will be determined. The purpose of the design basis is to provide a common set of requirements against which all qualification activities and decisions can be assessed.

A threat assessment will be undertaken using a knowledge of material property relationships and failure modes; potential threats will be mapped against functionality of the component and known in-service conditions to determine short-term and long-term failure risks that must be managed.

From Phase 1, WP1 and WP2 the incumbent asset management repair and maintenance plans, schedules and activities for polymer systems will be assessed. Their suitability for gaseous hydrogen will be evaluated and risks identified. Actions to manage identified risks (if necessary) and cost implications will be determined.

5) Work Package 5 – Test and Validation Plan Proposal (Duration – 2 months)

Lead – DNV

The NTS and associated equipment will utilise different generic polymer types for various applications ranging from seals to coatings. These polymer systems should have been subjected to qualification testing regimes to evidence fitness for purpose for their intended function and service life.

Using outputs of WP1-4 the gaps in qualification for transportation of high-pressure hydrogen within the NTS and associated equipment will be elicited.

DNV propose that relevant technology stakeholders are engaged to determine what testing evidence is available / planned (if any) to demonstrate that gaps can be closed out. In the event, that gaps remain DNV will discuss with industry partners how these can be closed out.

In parallel DNV will develop a screening programme with the aim of evaluating the effect of high-pressure gaseous hydrogen on polymers identified in the NTS to tease out material failure modes and red flag any obvious compatibility issues. Testing will be conducted on base polymer properties to assess for deterioration in bulk material properties, change in dimension with time, wear performance and rapid gas decompressions resistance etc.

This methodology will not validate polymer components for hydrogen use since qualification of a technology will be dependent on design, material properties, and effective industrialisation typically conducted by the technology developer. However, the qualification data shall provide supporting evidence that hydrogen does not pose immediate risk to polymers.

In subsequent work packages outside this scope of works further component testing will be required to qualify the technology for gaseous hydrogen.

6) Work Package 6 – Standards & Reporting (Duration – 1 month)

Lead – DNV

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

1. Draft Technical report, subject to Gas Transmission review before final submission.
2. Draft Technical summary, subject to Gas Transmission review before final submission.
3. ENA closure report if required.

Objective(s)

The objectives for this project are to:

- Establish what polymeric/elastomeric materials are on the NTS and associated metadata
 - o Material grades – including coatings and/or surface treatments
 - o Manufacturer
 - o Location – which assets, geographic location in NTS
 - o Age
 - o Condition (level of existing damage)
- Determine expected hydrogen environment for materials
 - o Pressures including variation
 - o Temperatures including variation
 - o External environment (soil/air/water etc.)
 - o Gas composition (% H₂)
- Define polymeric/elastomeric material functional and material property requirements
 - o Function: E.g. Prevent gas escape (leak); Electrical isolation
 - o Material Property: E.g. Elasticity; Hardness; Compression set; Stress relaxation; Permeation
- Capture details of polymeric/elastomeric material maintenance requirements
 - o Is it a consumable? How often replaced? Cost of replacement?
 - o Is it maintained? How? Cost of maintenance?
 - o Is it "fit & forget" (i.e. no regular maintenance)? Cost or replacement?
- Propose test programme to validate polymeric/elastomeric materials for hydrogen supply.

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:

- Study objectives met to time and cost.
- All current polymer materials in the NTS known.
- Robust lab testing plan for validation of polymer materials created.

Project Partners and External Funding

Gas Network – National Grid Gas PLC

Technical & Industrial Lead – DNV

Potential for New Learning

The project will capture information on potential susceptibility of polymeric materials on NTS to hydrogen transmission conditions. Where appropriate test programmes will be determined to validate performance of these polymers in conditions representative of hydrogen transmission. These results might be informative to other transmission networks globally as well as domestic and international GDNs.

Scale of Project

This project is a desktop-based study that will provide insight into whether there is an opportunity to repurpose existing assets which contain polymer/elastomer materials. The scale of the quantity of polymeric material on the network is unknown and this needs to be understood to safely transition to Net Zero and hydrogen. This is the first phase of multiple phases of work, designed to refine the project scopes of each following phase so not to deliver unnecessary research/learnings.

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 network focused project

Indicative Total NIA Project Expenditure

£61866

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, the NTS will need to ensure hydrogen can be supplied to consumers reliably. Polymeric materials are prevalent through the NTS, in valves, regulators, door seals, etc. It is essential to understand the current materials in the presence of high-pressure hydrogen as well as understand improved, safer materials to enable the smooth transition to net zero.

This project will investigate bridge the knowledge gap and set out the testing regime needed to further understand the safety impacts of polymeric materials and hydrogen.

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)

RIIO-1 Question N/A

Please provide a calculation of the expected benefits the Solution

The project will capture information on potential susceptibility of polymeric materials on NTS to hydrogen transmission conditions. Where appropriate test programmes will be determined to validate performance of these polymers in conditions representative of hydrogen transmission. In doing so, the project solution will contribute to enabling the repurposing of existing asset plus construction of new pipeline for hydrogen transmission. 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 solution to the end-user.

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

The project will assess the polymeric materials on the NTS, however, much of these materials will also be present on other industry networks. The knowledge gained will be applicable across the gas industry and the testing design can be mimicked by other networks.

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

The cost of rolling out the robust testing regime is minimal. However, the cost for either repurposing or replacing the polymeric

materials in the NTS is unknown until further research, including this project's work is undertaken.

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 learning will be collated into a technical report and shared via the ENA portal. The GIGG group, as well as the NSI Board, will also be made aware of this technology and provided the option to contribute.

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

RIIO-1 Question 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 hydrogen impacts on polymeric materials, however, none of this research has been executed on the NTS and the materials in the NTS. The focus existing research does not incorporate the option of repurposing existing assets to ensure the energy transition can be undertaken at as low a cost as possible to the consumer.

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

There is currently no systematic record of the performance of polymeric materials in the National Transmission System in high pressure hydrogen environment. This project will be the first to determine the susceptibility of the materials in the National Transmission System to hydrogen damage and, if required, propose a suitable test programme for validation of existing and new polymeric materials. This is novel as this work has not previously been undertaken.

Relevant Foreground IPR

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).

The results of the tests will create knowledge around the capability of potential metering systems to support the NTS but will not create any new systems.

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 Grid 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@nationalgrid.com. Further data can be shared upon request through the innovation mailbox. Each request will be assessed by the GT Innovation Team for its merits and viability.

Please identify why the Network Licensees will not fund the project as part of its business and usual activities

Hydrogen-ready polymer products have not yet been fully developed nor tested to satisfaction on simulated operational network environments, therefore is a low TRL system with high levels of risk associated. 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