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

Mar 2024

Project Reference Number

NIA_NGT0231

Project Registration

Project Title

Purging approach for the NTS

Project Reference Number

NIA_NGT0231

Project Licensee(s)

National Gas Transmission PLC

Project Start

April 2024

Project Duration

1 year and 0 months

Nominated Project Contact(s)

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

Project Budget

£239,692.00

Summary

The transition from methane to hydrogen in the NTS presents several challenges and considerations. Hydrogen's lower ignition energy, wider flammability range, and lower density compared to methane necessitate a careful reassessment of current purge practices. Implementing an optimal purging method becomes crucial to economically remove methane from the network during the transition. Defining acceptance criteria and determining the endpoints purge for hydrogen are essential steps to ensure safety and efficiency. Additionally, addressing the skills gap and training requirements is imperative for personnel involved in handling hydrogen, emphasising the need for specialised training programs to facilitate a smooth and secure transition.

Third Party Collaborators

DNV

Nominated Contact Email Address(es)

Box.GT.Innovation@nationalgrid.com

Problem Being Solved

The transition from methane to hydrogen in the NTS presents several challenges and considerations. Hydrogen's lower ignition energy, wider flammability range, and lower density compared to methane necessitate a careful reassessment of current purge practices. Implementing an optimal purging method becomes crucial to economically remove methane from the network during the transition. Defining acceptance criteria and determining the endpoints purge for hydrogen are essential steps to ensure safety and efficiency. Additionally, addressing the skills gap and training requirements is imperative for personnel involved in handling hydrogen, emphasising the need for specialised training programs to facilitate a smooth and secure transition.

Method(s)

This project will carry out an initial investigation into the impact of hydrogen and hydrogen blends on NTS purging practices, continuing from work undertaken in distribution led projects. The project looks to provide guidance on the required changes to standards and procedures in place for natural gas and undertake a technology review of potential innovative methods/tools that can be used for safe hydrogen purging (transmission). This project will also investigate methane removal methods from the NTS and identify optimal solutions.

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 purging technologies and tools. Additionally, CFD simulation will be used to inform the necessity of further analysis.

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:

WP1: Initial assessment on the impact of hydrogen on NTS purging process/operation

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

1. Data gathering:

Review current NGT natural gas purging processes and methods used for newly commissioned or existing pipelines (procedures, technical requirements and limits such as rider and vent sizes, key parameters such as gas velocity, equipment and tooling used).

Propose to hold a workshop or one-to-one interviews with National Gas Transmission personnel familiar with the current procedures to confirm the details (procedures/guidelines) describe work 'as done' (if required).

Purging research will be reviewed. Research on hydrogen distribution pipeline purging to be reviewed including HyDelta in the Netherlands, and HyPurge, which was commissioned by SGN as part of H100, as well as work by DNV for H21. Other standards to be considered include the European Industrial Gas Association (EIGA) Doc 121/14, and ASME B31.12 code on Hydrogen Piping and Pipelines.

Review the results from the work completed by Wood as part of NIA_NGGT0205 ‘Safe Venting & Recompression of Hydrogen’ project. We understand this project has considered venting, flaring and recompression of gas to avoid emissions. The equipment requirements, procedures and costs will be used in this project.

2. Impact assessment:

Assess the impact of introducing hydrogen on the current purging method used by National Gas Transmission. This will consider aspects such as the ignition likelihood since hydrogen has a lower minimum ignition energy (0.01 mJ) compared to methane (0.26 mJ), changes to the explosive volume as a percentage of the pipe volume that occur with hydrogen, and the potentially higher overpressures developing inside the pipeline should ignition occur. The potential consequences of ignition will be assessed, including possible projectile damage.

Current key purging parameters such as gas velocity will need to be updated to include 100% hydrogen or hydrogen blends. Identify potential risks associated with hydrogen purging, including equipment compatibility, safety concerns such as electrostatic ignition, flame propagation into the pipe from an ignited airborne cloud, and run-up from deflagration to detonation.

Assess the opportunity of repurposing current purging equipment and tools for hydrogen use and identify the environmental (emissions/energy), safety and economic impacts of purging.

3. Technical review:

Propose mitigation strategies for the identified risks and challenges and an effective approach to ensure gas quality compliance. This review will encompass the energy requirements, emissions data, and economic analysis from task 2.

4. An interim report will be prepared. This will detail the evidence collected, the impact assessment made and the mitigation strategies that could be employed for any identified challenges.

WP2: Purging technology review for hydrogen/hydrogen blends

This work package will deliver a technical report reviewing purging technologies. The report will identify technologies and approaches suitable for the NTS with a focus on hydrogen and hydrogen/methane blends. It will identify and assess technologies and approaches suitable for review suitable for use in the NTS with a focus on hydrogen and hydrogen/methane blends.

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

1. Benchmarking:

Carry out a technology review to establish existing hydrogen purging technologies and methods used in gas transmission systems and across industry. The review will concentrate on hydrogen conversion envisaged in Project Union and blending scenarios (i.e. 2%, 5%, 20%, 100% hydrogen in natural gas) but will not exclude suitable methods used for other gas mixtures. The review will include:

a. Methods currently used in gas transmission and distribution systems in the UK, Europe and the USA;

b. Methods used in industry (e.g. refineries); and

c. Technologies and methods used at gas distribution level and from other projects (e.g. H100).

2. Technology assessment:

Undertake a technology assessment of the methods and technologies identified in the Benchmarking task. The commercial, safety, and technical aspects of each identified technology or method will be assessed and ranked. The assessment will consider the full range of hydrogen blends (i.e. 2%, 5%, 20%, 100% hydrogen in natural gas). The technical parameters will include but not be limited to:

a. Scalability to NTS.

b. Efficiency in terms of gas usage.

c. Ability to remove contaminants.

d. Challenges in development deployment, or use, development.

e. The technology readiness level (TRL) identified using the UKRI definitions (or others as agreed);

f. Cost effectiveness considering factors such as gas use, equipment required, duration, footprint, mass and working area/access requirements.

g. Impact on pipe integrity (e.g. the use of extreme pressures, temperatures, or non-standard gas mixtures and chemicals);

h. Overall viability.

A further environmental and safety assessment will be made of all the technologies considered viable. This will consider the level of emissions to the atmosphere, the energy requirements, and the potential risk and impacts of accidents.

3. An interim report will be prepared. This will detail both the technical assessment and environmental and safety assessment. It will identify the most viable methods and technologies and the range of conditions and gas blends for which they are best suited. It will also identify the work or developments needed to improve promising technologies for future use.

WP3: Policies, standards, and procedures for purging hydrogen/ hydrogen blends

This work package will review and adapt existing policies, safety processes, standards, and procedures to accommodate the introduction of hydrogen and hydrogen/methane blends in the NTS purging operations.

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

1. Review current standards, policies, and procedures for natural gas:

Conduct a review of existing NTS policies and procedures for purging building from WP1.

Identify safety and quality parameters for key operational and maintenance procedures as outlined in WP1 and changes to be implemented to ensure requirements for hydrogen purging.

2. The results of the works undertaken in WP1 and WP2 will be assessed to determine what parameters may need to be further assessed that may have an impact on the procedures, such as purge velocity.

Review current regulations and standards related to hydrogen purging relevant to the NTS listed above in order to identify the impact on purging operations within the NTS.

Propose modifications or additions to current procedures and policies to ensure compliance and alignment with the requirements of hydrogen purging.

3. Carry out computational fluid dynamics (CFD) modelling to assess the flow conditions (e.g. gas mixing behaviour, gas distribution and possible stratification, and extent of the possible flammable region) inside the pipeline at various timesteps. This will enable an understanding of mixing behaviour in the pipeline during purging operations. A straight pipeline geometry with an appropriate length will be considered in the study. The results will be used to inform the necessity of further analysis with other pipeline geometries (at a later stage, not part of this scope).

4. Presentation to the relevant policy managers at National Gas Transmission. This will enable their feedback to be obtained but it will be envisaged that only minimal changes will be required to the interim report. It will act as a stage gate meeting prior to starting WP4.

An interim report will be prepared. This will describe the review of the policies and procedures and other work done but will primarily be focused on the results of the CFD analysis.

WP4: Propose an optimal hydrogen purging plan to achieve transition/ post-transition

This work package will develop a purging process tailored to the introduction of 100% hydrogen into the NTS. The scope of work proposed for this work package is as follows:

1. Demonstration plan for hydrogen purging:

Building from WP1, WP2, and WP3, the feasibility of implementing solutions identified in WP1 and WP2 will be assessed.

Create a purging protocol / plan, outlining the steps involved in hydrogen purging. This will cover but not be limited to:

a. Pipelines, branched pipework, stub/dead end pipework, Above Ground Installations.

b. Isolation requirements; and

c. Optimal pipeline pressures, minimum velocity and other technical parameters required to achieve a successful hydrogen purging operation.

Contingency measures for unexpected events during purging will be considered and included.

Review purging demonstration opportunities at FutureGrid.

2. Acceptance criteria:

Where the research supports a scientific basis for purging operations DNV will define clear acceptance criteria required to achieve a successful hydrogen purging and will establish gas quality end-points and a monitoring approach for the purging operation.

3. Cost benefit analysis:

Undertake a economic analysis to determine the most economically feasible route to purging residual methane from the network. The analysis will assist in answering the question of how various purging scenario configurations can be realised in the most cost-efficient way, while meeting safety, purity and quality requirements. It will value the asset/infrastructure configuration(s) developed in the technical part of this work package. These valuations will be used to determine which design option(s) deliver the:

i) Most positive net economic impact (or efficient cost) across the scenarios developed.

ii) Infrastructure requirements at scale; and

iii) Infrastructure requirements at speed.

Develop an estimate of the capital and operating costs for the assets that constitute the infrastructure developed in the technical part of this work package. DNV will draw on publicly available information from government and regulators (policy/planning) documentation, marketplaces, as well as DNV's in house cost databases from previous advisory work.

· For each scenario, the most important costs and benefit effects will be identified. The effects of these will be discussed quantitatively and where necessary qualitatively.

· Costs: the size and timing of the costs to deliver each scenario will be important. Both, direct and indirect costs will be considered, opportunity costs and intangible costs. Examples of such costs are negative externalities such as environmental impacts and any social disruption as well as investment costs such as capex spend on new assets and repurposing of existing assets, network costs associated with switching from natural gas to hydrogen, any relevant costs associated with decommissioning sections of the network that would no longer be in use.

· Benefits: Consider benefits that span the range of direct, indirect, intangible and competitive etc. These benefits could include CO_2 emissions savings from more optimal purging solutions.

4. An interim report will be prepared. Thus, will outline the test plan, the acceptance criteria and the CBA.

WP5: Identify skills gaps: training programme / skills requirements

This work package will identify specific skill gaps related to hydrogen purging, propose detailed updates and recommendations to the current National Gas Transmission training program in order to refine the present skill set.

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

1. Training needs analysis:

Assess the current skill set of personnel involved in the purging process. This will include a review of the current training programme materials and a discussion with training providers and skilled operatives as required. This will identify gaps in knowledge and skills related to hydrogen purging by analysing the training provided and the differences in procedures etc from previous work packages.

2. Training programme development:

Outline the key changes that are required to the training programme to accommodate hydrogen/ hydrogen blends purging. This will focus on upgrading skills using procedures analogous to those currently employed. Where novel technologies have been identified, training needs will be identified at a suitable level (e.g. OEM recommendations). We will identify long term training options within the FutureGrid flow facility, but also another designated facilities where applicable.

3. An interim report will be prepared. This will describe the training needs and analysis and the options for training development.

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)

- Develop a purging plan for hydrogen blends to be used during maintenance and outage events in early transition.
- Identify the optimal purging method required to remove methane from the NTS and achieve transition to 100% hydrogen.
- Perform cost benefit analysis of methane removal
- Establish a purging plan to be used during maintenance and outage events for 100% hydrogen post-transition
- Define safety and quality acceptance criteria for hydrogen and hydrogen blends purge
- Purging plan to be developed considering Project Union strategy

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.

- Provide a hydrogen/hydrogen-blends purging plan aligned with quality, purity, and safety standards. This plan should facilitate the transition from natural gas to hydrogen and address considerations for both the transition period and post-transition.

- Identify of new technologies and procedures to support the transition from natural gas to hydrogen and hydrogen blends.
- Project findings inform the HyNTS safety case to provide evidence to HSE.

Project Partners and External Funding

Lead Network: National Gas Transmission plc

Supplier: DNV

External costs: £ 179,770

Internal Costs: £ 59,923.33

Total: £ 239,693.33

Potential for New Learning

The project will be the initial step in understanding the impact of hydrogen on NTS purging practices and exploring how these practices can be adapted for hydrogen. Insights into the most effective methods for eliminating methane and introducing hydrogen will be gained, and necessary changes to meet safety and quality standards will be identified.

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 is a desktop study which will provide insight into the impact of hydrogen on NTS purging practices, and procedures. 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

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

United Kingdom, Warwick.

Revenue Allowed for the RIIO Settlement

None – hydrogen focused innovation project.

Indicative Total NIA Project Expenditure

External costs: £ 179,770

Internal Costs: £ 59,923.33

Total: £ 239,693.33

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:

National Gas Transmission (NGT) are 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. Successfully transitioning from methane to a hydrogen network involves implementing a robust purging process. This is crucial due to the expected challenges which can be posed by the intricate gas mixtures and blends during purge, requiring the purging method to meet quality and safety standards requirements while remaining cost-effective.

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	TRL2-3	Concept stage for purging procedures for transitioning from methane to hydrogen
Opportunity	100% or multiple asset class	The project can be applied to • Pipeline

		• Branched pipework • Stub/dead end pipework. • Above Ground Installations AGIs
Deployment costs	-	Deployment costs are not known at the start of the project but will be defined throughout the project.
Innovation cost	£ 239,693.33	The cost includes desktop-based work and site visits.
Financial Savings	-	Any financial savings are not known at the start of the project. Methane removal will be economically assessed as a part of CBA
Safety	-	Understand the impact of hydrogen on NTS purging practices E.g. flammability mixtures in the pipeline NTS safety case evidence to HSE.
Environment	-	Environmental impact assessment of methane removal
Compliance	Support compliance	Review guidelines, procedures
Skills & Competencies	Individuals	Skills gap analysis / training requirements
Future proof	Supports business strategy	The project will help enable hydrogen 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 hydrogen purging methods, practices, tools/technologies applicable to the NTS; 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 throughout the project

lifecycle. The cost-benefit analysis in this project mainly aims to identify the optimal purging method for removing methane and introducing hydrogen

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 purging for operational purposes and during asset maintenance. 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 hydrogen purging practices for the NTS. 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

Work has not yet been undertaken to understand the impact of hydrogen on NTS purging practices and how this method can be optimised and used to economically remove methane from the transmission network and introduce hydrogen. This project will be the first step in understanding the impact and identifying potential solutions to any challenges.

This work is a counterfactual to certain previous and ongoing projects undertaken by GDNs, which have primarily examined hydrogen purging for small pipeline diameters with a greater emphasis on emissions impact. In addition to examining emissions, this project will also investigate purging practices within the transmission network, exploring potential updates to existing purging practices to accommodate hydrogen and hydrogen blends. The focus includes identifying quality and safety criteria and evaluating new technologies.

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

This investigation into NTS hydrogen purging practices, 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