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 2022

Project Reference Number

NIA_CAD0084

Project Registration

Project Title

Implications of Hydrogen Purity

Project Reference Number

NIA_CAD0084

Project Licensee(s)

Cadent

Project Start

September 2022

Project Duration

2 years and 1 month

Nominated Project Contact(s)

David Jones

Project Budget

£475,000.00

Summary

Testing thus far has assumed 100% pure hydrogen will be delivered when in reality it will pick up contaminants through the network. This project proposes to assess the nature of contamination that may be present in any existing pipework that may be repurposed from carrying natural gas to 100% hydrogen. The contaminants may have an effect on material degradation and combustion safety associated with the end user, and information is required to evaluate the potential effects and determine if there is any impact on overall safety.

Third Party Collaborators

GL Industrial Services Ltd

DNV

Nominated Contact Email Address(es)

Innovation@cadentgas.com

Problem Being Solved

The Prime Minister's Ten Point Plan for a Green Industrial Revolution set out the government's intent to explore the option of hydrogen to be used within the current gas network infrastructure. It specifically mentioned that a Hydrogen Village trial should be underway no later than 2025 to enable an important policy decision to be made in 2026 on the options for heating homes in a net zero future.

End User Safety Evidence group (EUSE) is a group within the End User sub programme of the BEIS Hydrogen Grid R&D Programme. EUSE will facilitate the gathering of safety evidence downstream of the emergency control valve (ECV) to support

delivery of the Village Trial.

Any Hydrogen Village Trial will rely in part on the current natural gas network being repurposed for hydrogen service. It is therefore important to assess the nature of contamination that may be present in any existing pipework that may be repurposed from carrying natural gas to 100% hydrogen. The contaminants may have an effect on material degradation and combustion safety for the end user, and information is required to evaluate the potential effects and determine if there is any impact on overall safety.

Existing knowledge of contamination of the pipeline networks will be used to underpin the understanding of the contaminants that may need to be considered. It is the presence of these contaminants and the potential impact on overall hydrogen purity that is the focus of this Project.

It is possible that with prolonged hydrogen transportation these contaminants may be purged from the network, but timescales and the rate of purging is not known at present. In the interim, understanding the impact as hydrogen is distributed through repurposed networks and the potential impact of contaminants is an important aspect to address to ensure customer safety.

This project is one of the GDNs collaborative projects, led by Cadent, undertaken as part of the End User Safety Evidence working group.

Method(s)

This project will rely on different methods to identify and test the likely contaminants that will be found in a hydrogen gas network

The project will use the following methods:

Literature Review: The initial phase will involve a review and assessment of contaminants in the network and characterisation of these into types that may impact on the end use of hydrogen from a repurposed natural gas network. This characterisation phase will identify components that will need to be investigated both from a materials impact and from a combustion viewpoint.

Experimental Testing: This will form the heart of the project and will build on the initial characterisation phase. Two separate structured experimental test programmes will be carried out looking at the effect of contaminants on materials and combustion characteristics of hydrogen and whether this has an effect on appliance operation/safety. The testing phases will operate in parallel and use bespoke cylinders containing hydrogen and individual contaminants.

Stakeholder Engagement: Stakeholder engagement will happen throughout the project to ensure that all the facts are considered, and any key information is included within the analysis. Stakeholders engaged will be from both from the public and the private sector. This will be supported by the ENA through their existing gas stakeholder groups.

Quantitative Risk Assessment (QRA): The outcomes of the experimental testing will inform the development of the Hydrogen Village Trial QRA and support the inclusion of any factors that relate to hydrogen purity/contaminants.

Technical Report Writing: A report combining contributions from the methods outlined above will be produced. It is anticipated that the results from this work could inform and support the development of hydrogen purity standards and specifications.

Measurement Quality and Data Quality will be supported by hiring professional organisations in to support the Cadent on the project.

Scope

This project is undertaken in 5 work packages, which are:

Work Package 1: This involves a literature review and collection of background information/data on likely contaminants that may be found in a hydrogen gas network. Existing data and information will be assessed to identify the key contaminant types and potential amount fraction within the pipeline network. Prior to the experimental activities, it is critical to define a suitable and realistic list of contaminants that are susceptible to be present in the gas network. It is important to shortlist the contaminants that are most relevant

for the studies into materials and combustion; the range of contaminants includes those from hydrogen production, those picked up from existing pipelines and those that may be formed as a result of chemical reactions in salt cavern storage where chloride and sulphur chemistry may extend the range and characteristics of contaminants.

Further research will also be carried out into materials likely to be present in installations to support the testing carried out in subsequent work packages.

An interim report will be produced on completion of this work package based on the literature review, contaminant data assessment and materials to indicate the expected scale of the issue. This will be shared with GDNs, ENA and key stakeholder groups.

Work Package 2: This work package is a structured experimental test programme looking at the effect of contaminants on materials that may be present in end-user systems downstream of the meter. The work package will be split into two parts:

2a – tests carried out in air to form the baseline comparison.

2b – tests carried out using hydrogen and contaminants.

Testing will include slow strain rate testing and fatigue testing of typical materials in air and hydrogen to give a measure of the material's resistance to environment assisted cracking.

As in Work Package 1, an interim report will be produced to share findings with GDNs, ENA and key stakeholder groups.

Work Package 3: This is another structured experimental regime this time looking at the effect of contaminants on the combustion characteristics of hydrogen and whether this has an effect on appliance operation/safety. Results to be recorded will include thermal imaging/video footage for flame behaviour, photographic images of the flame, flame temperature measurements, and emission measurements e.g., NOx.

To ensure the impact of contaminants in hydrogen on the combustion process is judged consistently, the gas mixtures produced in Work Package 2 will be used. This work package will provide an overall understanding of the impact of the contaminants in hydrogen along the network and the combustion and will allow a better understanding of the emission and combustion impact.

Factors that could influence the overall "transience" of contamination will also be reviewed, as it is expected to decrease over time as the hydrogen may purge through the contaminants. Quantification of the transient effects is difficult as it will depend on flow, pressure, adsorption and desorption rates, and contaminant concentration, however this work will provide an indication of the timescales for any purging benefits.

An interim report based on the results from the combustion studies will be produced and shared with GDNs, ENA and key stakeholder groups.

Work Package 4: Work Package 4 is designed to provide feedback of results and lessons learned to the team developing the Hydrogen Village Trial QRA. The project team will liaise with the QRA team to ensure that any factors impacting on safety and risks that may result from the impact of hydrogen purity and the presence of contaminants are raised and included in their studies. The work undertaken here will include:

- Effects of how the composition of contaminants over time will impact on safety.

- Identification of key factors from the presence of contaminants that may be required in the QRA models and support the quantification of the effects on the risk ratings.

- Support for the QRA team to investigate and develop mitigation methods for any issues identified by this current research.

There is no formal deliverable but the overall report in Work Package 5 will contain the information from the interaction with the QRA team.

Work Package 5: This work package will provide a milestone report at the end of March 2023, to provide an update on the current testing and provisional data assessment before producing a synthesis report based on the outcomes and results of Work Packages 1-4.

The final report will include recommendations on whether any materials are unsuitable for hydrogen service or if additional appliance development should be considered.

The final report will be shared with GDNs and ENA, with results presented and explained to key stakeholders like BEIS and HSE.

Objective(s)

The objectives of the project are as follows:

- To provide greater understanding of the impacts of contaminants in domestic applications focusing on both the internal pipework material and the utilisation in combustion equipment.

- Provide information for the QRA tasks to identify if there are any factors that could impact on the potential use of hydrogen in domestic applications.

- Support developments of hydrogen gas quality standards and specifications (not a direct deliverable but a potential added benefit).

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

This project will consider the wider impact of hydrogen purity on all consumers and so specific impacts on consumers in vulnerable situations are not expected to emerge. Should any negative impact be identified then further work must be initiated.

Success Criteria

The success criteria for the project is the delivery of the following;

- A detailed technical report highlighting the results from the literature survey and data assessment review on contaminant types and concentrations.

- An interim report based on the results from the materials and combustion studies. This will be delivered in March 2023 to provide an overview of progress and an early indication of impacts found to date.

A synthesis report drawing conclusions from all individual work packages to identify recommendations for the village trials. To be delivered on completion of the project.

Project Partners and External Funding

NGN,SGN,WWU,Cadent.

Potential for New Learning

A lot of work is currently being carried out on hydrogen gas quality for transport applications. This project will support detailed technical studies on the impact of contaminants on materials and end use that will support the development of the Hydrogen Village Trials.

The work will extend the existing technical knowledge on hydrogen for end use by addressing the potential impact of contaminants in the supply. The contaminants may be from the hydrogen source but in addition they could be entrained in the hydrogen flow from existing contamination of the natural gas pipeline if the pipeline is repurposed to transport hydrogen. This project will research and review information on contaminants to better understand the nature and concentration of the contaminant chemical species, and then use this information to assess the impact on infrastructure materials and on combustion through a parallel experimental test programme.

The learnings from this work will inform the Hydrogen Village QRA and test results will enable the evaluation of the magnitude of any impact, together with options for mitigation. Learnings will be disseminated through a series of interim reports, culminating in a final synthesis report on completion of the project.

Scale of Project

The implications of hydrogen purity on materials and combustion for the end user will be considered as part of the safety evidence base to enable the Hydrogen Village Trials potentially located in the North West and North East of England. The outcomes of the Project will also feed into future hydrogen gas quality standards and specifications, therefore contributing to the knowledge base that will inform a government policy decision in 2026 on hydrogen for home heating.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

Desktop and laboratory-based project carried out in the facilities of selected technical delivery partners.

Revenue Allowed for the RIIO Settlement

Not applicable to this R&D project.

Indicative Total NIA Project Expenditure

The project is broken down into an agreed fixed cost, with contributions from multiple delivery partners. The agreed fixed cost for the project is £365,000.

This gives a Total NIA Expenditure to reclaim of £365,000.

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:

This project is a vital enabler to the Hydrogen Village, which has a considerable benefit in facilitating the energy system transition.

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

Not applicable.

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)

Not applicable.

Please provide a calculation of the expected benefits the Solution

Not applicable (this is a research project).

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

The intention is for this project to be relevant and therefore replicable to all hydrogen village trials and any further rollout of hydrogen for home heating across GB

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

Not applicable.

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 can be used by any network that intends to do a hydrogen village trial or built upon by any network that intends to do any subsequent trials.

The learning will also be applicable to any national rollout of hydrogen for home heating.

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

Not applicable.

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 is no previous work being undertaken in this particular area due to the novel nature of the Hydrogen Village.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

Not applicable.

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

This project is a vital enabler for the Hydrogen Village trials which is a highly innovative programme that has not been replicated anywhere else in the world to date. This project has been initiated as part of the collaborative safety evidence projects agreed by BEIS and HSE ahead of the project commencing.

Relevant Foreground IPR

All relevant foreground IP created as part of the project will follow NIA governance.

Data Access Details

Current expectation is that all data used in this project will be sourced from published documentation – test cases will be available upon request.

Data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found or requested in a number of ways:

· A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact select a project and click 'Contact Lead Network'. Cadent already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.

· Via our Innovation website at https://cadentgas.com/future-of-gas

· Via our managed mailbox futureofgas@cadent.com

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

The hydrogen village projects and any of the associated enabling projects, cannot be considered as BAU due to their first of a kind nature and risks which go beyond BAU.

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 project has inherent risks due to its first of a kind nature so it is right it should be supported using NIA funding.

This project looks to uncover the presence of contaminants in any future hydrogen network, and the potential safety impact these may have on the end user as a result of changes to overall hydrogen purity.

This project has been approved by a senior member of staff

☑ Yes