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

May 2022

Project Reference Number

NIA_CAD0079

Project Registration

Project Title

FI-0011 - Functional Specification: Hydrogen Blending Infrastructure

Project Reference Number

NIA_CAD0079

Project Licensee(s)

Cadent

Project Start

May 2022

Project Duration

0 years and 11 months

Nominated Project Contact(s)

James Whitmore

Project Budget

£160,366.00

Summary

Hydrogen is a key energy source for the Net Zero transition and is being considered as an alternative to natural gas. Over the next 5 years there is an ambitious work plan within the UK's gas transmission and distribution industry to prove the viability of blending hydrogen into the UK's existing gas networks.

This project seeks to develop a functional specification for the infrastructure required to blend hydroge from industrial clusters.

Separate projects will explore the adaptations necessary to commercial frameworks and in other blending scenarios

Nominated Contact Email Address(es)

Innovation@cadentgas.com

Problem Being Solved

The UKs objectives to meet net-zero by 2050 require urgent solutions to decarbonise heat. 85% of homes are heated by natural gas, therefore an approach that includes repurposing all or part of the existing gas network for hydrogen service is likely to provide an effective solution. Furthermore, blending up to 20% hydrogen with natural gas could provide quick and meaningful carbon reductions, with little-to-no disruption for consumers. Blending hydrogen into the gas grid provides a reliable demand to enable the development of hydrogen production models and the wider supply chains. The government have recognised the important role of hydrogen blending by including the ability to blend hydrogen into the gas grids by 2023 as a policy objective within its 10-point plan.

Hydrogen bending in the UK has been undertaken in trials, but wider deployment of blending into GBs natural gas grid is novel and will be subject to further considerations. At this stage it is unknown what infrastructure will be required at a blending facility and the surrounding network to successfully deploy hydrogen blending, while maintaining compliance with the relevant codes and regulations.

Method(s)

Work Pack 1 – Functional specification

A generic functional specification will be developed that will set out the functionality requirements for the hydrogen-to-grid blending facility. Appendix A provides an indicative structure for the functional specification. The structure is based on the Functional Specification produced for biomethane-to-grid facilities by Dave Lander Consulting Limited on behalf of the Review Group on Energy Market Issues for Biomethane Projects (EMIB). The two facilities (biomethane-to-grid and hydrogen-to-grid) will share many common features. However, it is likely that some of the unique features of hydrogen will necessitate amendment as evidence gathering and assessment progresses.

In order to develop these functionality requirements several key principles will need to be established. These principles will dictate the direction of travel in establishment of the functional specification and are discussed in the following sections.

Key Principle 1 – The legislative and regulatory framework

The most relevant items of legislation with respect to blending of hydrogen into the natural gas network are the Gas Safety (Management) Regulations (GSMR) and the Gas (Calculation of Thermal Energy) Regulations (GCOTER).

Schedule 3 of the GSMR requires gas transporters to not convey gas that contains more than 0.1% hydrogen, so in order to blend hydrogen in significant quantities a future amendment to the GSMR is required. The Network Innovation Competition project HyDeploy aims to demonstrate the safe conveyance and utilisation of a blend of up to 20% hydrogen in natural gas and is likely to provide the principal evidence base for such an amendment. HyDeploy is currently conducting a field trial of blending in a small part of Northern Gas Network's medium pressure system in Winlaton near Newcastle, having previously successfully conducted a field trial in a private network at Keele University. The two field trials are being conducted under formal exemptions from the GSMR's hydrogen requirements and a third phase of HyDeploy is addressing demonstration of safety of the wider roll-out within GB of hydrogen blending.

The GCOTER specify the basis by which consumers are billed for gas they consume and place certain limits on the calorific value (CV) employed to derive gas users' energy bills. The principal driver is that the daily billing CV for a charging area cannot be more than 1 MJ/m3 greater than the CV of the lowest source of supply into that charging area. Compared to natural gas, hydrogen has a low calorific value and hence blends of hydrogen with natural gas could become the lowest source and trigger a cap in the billing CV.

The triggering of caps in billing CV can have significant financial consequences in terms of unbilled energy. However, the Hydrogen Blending Feasibility Study set out conditions by which hydrogen could be blended without triggering a cap in billing CV and indicates the key operational features in terms of the percentage hydrogen added to natural gas and the proportion of total energy delivered each day into a charging area as blend.

Task 1: We propose to build on the conclusions of the Hydrogen Blending Feasibility Study by further discussion with Gas Transporters and Regulators on the constraints, and agreement of the functionality that will deliver the means to control hydrogen percentage in natural gas both locally and in co-ordination across multiple sites to ensure the risk of billing CV capping is mitigated. The regulatory basis by which hydrogen can be permitted will be set out in the functional specification.

End user requirements

Based on the lessons of HyDeploy to date, we expect that most consumers' appliances, such as domestic and commercial users, will be largely unaffected by the conveyance of hydrogen blend. However, we recognise that some users – particularly process users of gas – may experience some sensitivity to hydrogen, and in particular, rapidly-changing gas properties as a result of variation in hydrogen. Some industries are sensitive specifically to hydrogen – gas engines are sensitive to engine "knocking" and are particularly sensitive to hydrogen – whereas others are not sensitive to hydrogen per se, but to properties that change when hydrogen is added – the Wobbe index of the blend, for instance.

HyDeploy is consulting with commercial and industrial users on this issue, and we expect that valuable insight will be available from HyDeploy into end-user sensitivities so that properties of blend leaving the blending facility are controlled in a manner that is appropriate to the needs of those sensitive users. We do point out that gas quality variation – and in particular rate of change of gas quality – will also occur at the interface between blend and natural gas within the gas network. As supply and demand patterns change the "zone of influence" of a hydrogen blend supply will enlarge and contract and it is likely that some users may experience rapid transitions between blend and natural gas. Mitigation of transitions in gas quality is not simply a case of ensuring good control of hydrogen concentration at the blending facility. Other mitigation strategies will need to be pursued, such as identification of sensitive users within the likely zone of influence and assessment of local mitigation measures.

Task 2: We propose to establish the most effective blending control strategy by consultation via a one-day workshop with key parties, including end-users and HyDeploy project staff to establish the likely limitations in gas quality for sensitive users, the most appropriate gas quality strategy at the blending facility, and identification of the most sensitive users for whom local mitigation measures may be required.

Hydrogen Supply profiles

Currently there is a limited hydrogen production and supply infrastructure in GB and extended roll-out of hydrogen blending in gas networks will require a co-ordinated approach with other projects to ensure that as production capability becomes available, stakeholders can be confident that hydrogen blending into the gas network is both a feasible and cost-effective use of hydrogen. The operational constraints to control capping of billing CV will drive towards balancing availability of hydrogen with the necessary proportion of hydrogen in blend and the necessary proportion of charging area energy supplied as blend.

Task 3: We propose to illustrate to stakeholders how growth in hydrogen injection will be dependent on the number and size of hydrogen blending facilities and their location. A number of differing growth scenarios will be presented that will establish hydrogen requirements that can be matched to likely future hydrogen production capability.

Operational requirements

The Hydrogen Blending Feasibility Study has already indicated that successful management of capping of billing CV under the present legislative framework is possible, but that an increased level of management of energy flows across the charging area will be required. We expect that improved network control tools will be essential to within-day management of billing CV capping and in turn such tools will need key information provided “live” from blending facilities.

Currently blending and enrichment of biomethane is managed on a local level by assignment of a target CV to the biomethane delivery facility operator. For hydrogen blending a similar approach is envisaged, but the setting of targets may need to be more co-ordinated across the whole of the charging area. A key finding of the Hydrogen Blending Feasibility Study was that conveyance of a blend containing a hydrogen concentration of around 4.7% is unlikely to trigger a cap in billing CV. However, uncoordinated blending of hydrogen at multiple sites on the same pipeline could result in “double-blending” and lead to billing CV capping.

Task 4: We propose to illustrate to stakeholders the key site information that will need to be transmitted to and from hydrogen blending facilities to mitigate risk of billing CV capping.

Hydrogen storage

The instantaneous hydrogen flowrate required at the blending facility will be dictated by the operating mode appropriate after considering the blending constraints set out in Section 3.1.1 and the end-user constraints set out in Section 3.1.2.

Task 5: We propose construction of a model of hydrogen supply and hydrogen demand at the blending facility that will estimate the appropriate hydrogen storage requirement. We anticipate that two hydrogen storage options will need to be assessed: on-site storage vessels and linepack in the hydrogen supply pipeline. Advantages and disadvantages of both options will be assessed and a recommendation on situations where one or a combination of both elements might be considered.

Other Gas Quality requirements

Hydrogen content and calorific value are not the sole gas quality parameters that will need to be controlled at the blending facility. Schedule 3 of the GSMR sets out additional requirements, such as:

- Hydrocarbon and water dew temperature
- Carbon dioxide content
- Wobbe index and the interchangeability parameters Incomplete Combustion Factor and Sooting Index
- Odour Intensity and odour character

In general, the blending of hydrogen will reduce the risk of impact of most of these parameters except for Wobbe index and odorisation. However, monitoring for low Wobbe index will be required. Adding unodorised hydrogen will lower the odour intensity of the blend and the strategy for dealing with this will depend on the location of the blending facility. In essence, independent blending facilities will need an independent odorant injection facility, whereas blending facilities located at NTS offtakes, for instance, can utilise existing odorisation injection equipment provided the control strategy is adapted. The lower flammability limit of blend is slightly different from natural gases. This will require a slightly different odorant injection rate from natural gases, but this is very small, and the functional correction will set out the appropriate correction to apply for blends.

Task 6: We propose to set out and evidence in the functional specification other gas quality parameters that will need to be monitored and/or controlled.

Other Key Functionality requirements
Hydrogen blending will require utilisation of technology not commonly applied at natural gas AGIs and we propose to include an assessment of two key technologies:

- Hydrogen sensing and measurement. Hydrogen sensing and measurement will be required for blend control as well as for determination of CV and other gas properties.

- Gas mixing. Demonstration of optimum mixing of hydrogen with the blending natural gas is important for billing purposes that CV determined at the mixing point is representative of the blend. In addition, space may be at a premium at some AGIs so selection of the most efficient and compact mixing equipment will be crucial. Good mixing has been demonstrated in the HyDeploy field trial at Winlaton, but for confident extension to the high pressures of mixing at LTS pressures, we propose that demonstration of mixer performance using computational fluid dynamics of the preferred option be carried out in the Case Study.

The functional specification will set out functional safety requirements.

The functional specification will assess the accuracy requirements demanded for CV and volume determination for billing CV purposes and also monitoring arrangements for compliance with the requirements of the GSMR.

Task 7: We propose to set out and evidence in the functional specification the remaining key functionality requirements that will need to be incorporated in the design of the hydrogen blending facility.

Work Pack 2 – CASE Study
The feasibility of the functional specification from Work Package 1 will be tested by development of a high-level design and cost estimate for a hydrogen-to-grid blending facility. The selection of the Case Study will be carried out after detailed discussion with stakeholders after consideration of what might constitute a representative site, availability of information on the site (including site layout and design drawings) and accessibility for site visit(s) to establish any relevant geographical or operational features.

Case Study Selection and Site Assessment
The functional specification will be tested by its application to an appropriate example that is as realistic and appropriate as feasible. The findings of the Hydrogen Blending Feasibility Study indicate that location at the highest-pressure tier (e.g., injection into a Local Transmission System), where demand is relatively high, will allow greatest scope for growth of hydrogen as and when initial supplies of hydrogen emerge. Initial hydrogen content in early blending operations is likely to be relatively low (ca. 3.7%), but the high-level design will need to demonstrate that the functional specification is appropriate for higher hydrogen concentrations and flows. Other factors that will impact on site selection include:

- Proximity to potential hydrogen supplies, such as those planned within the HyNet project

- Existing or greenfield site. If the example blending facility is based on an existing site, such as an NTS offtake, the geography and site size and layout will be known and existing drawings showing existing equipment can be utilised.

Task 1: We propose to select the most appropriate example site by consultation via a one-day workshop with Gas Distribution Networks.

High Level Design
Testing the output of Work Pack 1 will be essential to ensure that the theoretical can be practically delivered using current technology. We propose to deliver two high level designs that can be reviewed by the stakeholders early in the design phase, selecting one that can be developed fully in line with the project requirements to produce a solution that will meet the legal, regulatory and network requirements employing BATNEEC.

Following selection of the most appropriate design solution to develop, we will devise a basis of design which details the user requirements for both the inlet and outlet conditions as well as the design constraints.

The concept design solution will be tailored to the proposed site to verify that the design fulfils the requirements for blending and operation, this will validate how viable the proposition is terms of manufacture and installation but also considering ongoing activities to support the integrity of the system.

Within the design phase we will produce a cause-and-effect diagram which will form part of the design pack submitted.

Scope

The core aim of this project is to develop a functional specification for the network infrastructure required to successfully deliver hydrogen blending from Industrial Clusters. This will not include hydrogen production or transportation of hydrogen to the blending facility but will consider any need for upstream hydrogen storage.

This project is not seeking to produce core technical evidence on the safety of Hydrogen blending, as this is being delivered by projects such as Hydeploy and Future Grid.

This project will not explore the commercial frameworks to enable hydrogen blending but will interact with sister project "Functional Specification: Hydrogen Blending Commercial Frameworks".

A case study will be developed in Work Pack 2 to act as a test case of the functional specification and to produce a high-level design, which can be used to derive a high-level cost estimate.

The benefits of this project will provide a better understanding of what is physically needed to deploy hydrogen blending into the gas networks, supporting a value-for-money assessment due to be undertaken by BEIS in Q3 2022, and a policy decision in 2023.

Objective(s)

The objectives of this project are as follows:

1. Determine the functional requirements of a blending facility

2. Understand the infrastructure and equipment needed

3. Assessment of technology and equipment to achieve the functional requirements

4. Assessment of reflective site/s to understand space considerations

5. Understanding of indicative costs to design and build a hydrogen blending facility

6. Highlight any limitations or considerations

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

We conclude that this project will have a low impact on consumers in vulnerable situations. This is because the project methodology and the solution will not deliver outputs that will impact the financial or well-being of any consumers. It is envisaged that this project will enable a future low carbon safe, secure, and reliable energy supply.

Success Criteria

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

1. A functional specification for hydrogen blending infrastructure

2. A case study encompassing a high-level design and cost estimate of a blending facility based on the functional specification.

Project Partners and External Funding

The GB Gas Networks (Cadent, SGN, NGGT, NGN, WWU) are the licensees to fund through the NIA process on a 4,2,1,1,1 split of costs.

Delivery partners are Dave Lander Consulting & Thyson Technology

Potential for New Learning

The new learning that will be generated form this project will be how a hydrogen blend can be physically delivered into the gas network, the infrastructure required and functional requirements to ensure compliance with regulations and that producer and consumer needs are met.

The project will publish relevant reports onto the ENA portal and share key learning with BEIS to help inform decisions on hydrogen blending.

Scale of Project

This is a desktop exercise with some stakeholder engagement with the Networks, Hydrogen Clusters and GGG Advisory Group. Geographically, the footprint of the whole UK gas network is considered.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL3 Proof of Concept

Geographical Area

The results from this project will be applicable across the gas networks throughout the UK.

Revenue Allowed for the RIIO Settlement

Not applicable to this R&D project

Indicative Total NIA Project Expenditure

- External cost: £120274.00
- Internal cost: £ 40092.00
- Total: £160366.00

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 research project will define the UK Gas Networks first considered view of the necessary infrastructure to enable hydrogen blending from industrial clusters.

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

N/A

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

This is a research project so there is no calculation of the expected benefits.

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

The findings from this project will be applicable to all instances of hydrogen blending from industrial clusters in the initial "Prepare" phase of hydrogen blending roll out.

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

This is a research study and it is not possible to provide indicative implementation costs before this work has concluded.

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 from this project will be applicable to all instances of hydrogen blending from clusters in all UK 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.

There is no previous work that is duplicated by this project. It builds from learnings in technical research programs and will be the first view of the network infrastructure required to blend hydrogen from industrial clusters.

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

Hydrogen blending is new in the UK and there is currently no knowledge or guidance for adapting current arrangements to accept a hydrogen blend from an industrial cluster.

Relevant Foreground IPR

The foreground IP created in this project are determining the required adaptations to the current commercial and regulatory frameworks to enable hydrogen blending into the UK gas networks from industrial clusters.

Data Access Details

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 current work in this area is sufficient for conveying natural gas in the gas networks, but to understand the necessary arrangements for a hydrogen blend is not a BAU activity and is currently wholly funded via innovation mechanisms.

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 research project will explore and recommend novel arrangements to enable hydrogen blends into the UK gas networks. This is not a BAU activity for the networks, therefore no allowable funding is in place.

Should the networks not be able to demonstrate a means to bring a hydrogen blend into the gas networks from industrial clusters there is a risk that government policy may not support the further development of hydrogen as a replacement fuel for natural gas.

This project has been approved by a senior member of staff

☑ Yes