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## NIA Project Registration and PEA Document

### Date of Submission

Sep 2019

### Project Reference Number

NIA\_CAD0046

## Project Registration

### Project Title

Optimising Distribution of Hydrogen

### Project Reference Number

NIA\_CAD0046

### Project Licensee(s)

Cadent

### Project Start

September 2019

### Project Duration

1 year and 1 month

### Nominated Project Contact(s)

Cadent Innovation Team

### Project Budget

£382,556.63

## Summary

The methodology is to call on experienced subcontractors and combine this with design experience of a Hynet multi-consumer hydrogen network. The work will focus on the issues associated with operating such multi-consumer hydrogen networks.

### Nominated Contact Email Address(es)

Innovation@cadentgas.com

## Problem Being Solved

The UK relies predominantly on three energy vectors; electricity, gas and oil, for the decarbonisation of the power, heat and transport sectors. Progress is being made in reducing the carbon intensity of power generation but, as stressed by the Committee for Climate Change (CCC) in its 2018 review of the Government's Clean Growth Strategy, very little progress has been made in reducing the carbon intensity of heat or transport. Very deep emissions cuts are required across sectors with the urgency for progress made more acute by the decision to change the emissions reduction target from 80% to Net Zero by 2050 and for legislation has been passed in July 2019.

The body of work on the use of hydrogen for combustion and other applications is growing. It is clear that low carbon hydrogen may be able to substitute cost effectively for natural gas in several markets, including contributing to the provision of flexible power, high and low grade industrial heat, transport fuels and the reduction in emissions from consumers connected to the gas distribution network. Technical feasibility has been demonstrated in each of these markets

Beyond a small number of hydrogen pipeline systems connecting commercial users there is little experience of designing, creating, operating and then expanding a multi-user hydrogen distribution system. Such networks will initially be constructed at a relatively modest scale and will subsequently expand in terms of geography and in terms of consumer types. For example, the HyNet NW project plans to have a relatively contained network initially connecting a small number of industrial (and possibly small-scale power) users together with hydrogen injection into the LTS at a small number of points. The initial network will be extended in geographical extent and expanded incrementally to include further users with varying demand profiles, with hydrogen storage and other demand management approaches added to the system.

As anticipated by CCC, hydrogen networks will ultimately be created in several locations across the country and in different Network

Operator regions, emanating from areas where low cost access to Carbon Capture Utilisation and Storage (CCuS) infrastructure is available. Creation of such networks is unique and there is very limited, if any, experience of the system design and issues involved in designing a multi-user hydrogen network for expansion or in operating the growing network.

## Method(s)

The methodology is to call on experienced subcontractors and combine this with design experience of a Hynet multi-consumer hydrogen network. The work will focus on the issues associated with operating such multi-consumer hydrogen networks.

**Work package 1 will review experience of operating hydrogen networks against the requirement to define operating philosophies for new hydrogen networks in the UK.** The work will consider the system operational strategies adopted to meet user requirements including consumer demand profiles and hydrogen specification, and any experience of linking or upscaling networks. A skilled gas network design company will be contracted.

**Work package 2 will define the functional design requirements for a hydrogen network** building on available information from HyNet and other current hydrogen initiatives and will include design features which would form part of mature multiuser networks. In particular hydrogen storage will be included together with hydrogen consumer groups including industrial, power generation, domestic and hydrogen transport refuelling stations. The functional design will represent the discrete steps as the network expands. The functional designs produced will be used to inform the work system design and operation philosophy.

**Work Package 3 will seek to establish a preferred network operation and control approach.** The work will consider control of the network, nominations by users, the role of storage and demand management and the impact of physical design options such as different operating pressures in different parts of the system. The aim will be to seek to retain the same basic operational philosophy as the network expands. The output of the work will be a preferred control and operating strategy and an understanding of the constraints on design and operation of the physical system to inform the design of a realistic network.

**Work package 4 will produce and cost a practical network design including pipeline routing and environment and practical constraints.** Existing data and the emerging conclusions from on system design and operation will be combined to produce a practical physical design routed in sufficient detail to allow construction cost estimates (+/- 30%) to be made together with an estimate of the timeline for detailed engineering and construction. Environmental scoping will include constraint mapping, mitigation options and scoping of key consenting and permitting issues relating to network construction and operation. The associated costs and timeline will be estimated.

**Work Package 5 will provide overall coordination and reporting of the work including interactions with key stakeholders.** Strong interactions with Cadent are expected throughout to inform the technical direction of the work. Key stakeholders consulted will include industrial consumers, local planning authorities and the Planning Inspectorate and the Environment Agency

The Programme is scheduled to be completed in 12 months

## Scope

The primary focus of the project will be to develop an operational and control philosophy for a new hydrogen pipeline network. The results are intended to apply all hydrogen networks adopted by (all) the UK gas distribution networks, with a secondary focus on network design and how this is to be integrated by the network Licensees moving forward.

The analysis will concentrate on the operation of a new hydrogen network. The impact on the design of a new hydrogen distribution network (which will transport 100% hydrogen), and supply hydrogen:

- Injected as a blend (with natural gas) into the existing gas distribution network;
- Supplied to industry following conversion from fossil fuels to hydrogen;
- Supplied to major power generation sites for flexible power generation (to balance intermittent generation from renewables);
- Supplied for use by vehicles, to displace demand for petrol and diesel;
- Stored in underground engineered geological structures to enable supply during peak periods of demand;

The work will focus upon network operation and will include analysis of associated infrastructure, including gas compression and blending. The work will complement and draw upon analysis from wider work currently being undertaken by Cadent.

Whilst predominantly desk-based, the work will include a range of site visits and meetings to determine the system design. It will also require local stakeholder engagement, as described above.

The work will be led by Progressive Energy on behalf of Cadent, with the use of sub-contractors, WSP, Saith, and RSK.

The nature of the work and methods applied when looking at the operation and control of a hydrogen pipeline can be applied across all GDN areas. All GDNs are considering the deployment of low carbon hydrogen to reduce emissions from gas use. New hydrogen distribution systems will be need to be designed and operated and this work will inform the planning of strategies by GDNs in relation to the distribution of hydrogen for heat, power and mobility within their networks.

## Objective(s)

The overarching objective of this work is to develop operational and system control philosophies for hydrogen networks, testing practicality against possible early designs for a multi-user network. To support this objective, there are a range of task-oriented sub-objectives, which can be summarised as follows:

- To achieve this requires consideration of the range of possible operating strategies to control a system involving users with a variety of demand profiles, and the impact of expanding the system,
- The selection and development of appropriate system design and operational control philosophies for the network;
- Understanding the practical implications, impact on network design and associated costs, including on pipeline routing, with the associated environmental issues, linking multiple network users

## Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

### Success Criteria

The success criteria for the project can be summarised as follows:

- Definition of a deliverable operational control philosophy for a new hydrogen distribution network;
- Delivery of a design and routing for distribution networks and quantification of costs (capital and operating).
- Identification of key permitting and consenting issues associated with the proposed network;
- Production of a programme for the development and deployment of the distribution network;
- Information of value in guiding GD2 business plans; and
- Successful management of local and national stakeholders in respect of the proposed network.

### Project Partners and External Funding

This project will be funded via NIA

### Potential for New Learning

This project will address the design and operational control issues for a new multiuser hydrogen networks, providing a suitable operational control philosophy that will enable GDNs to subsequently develop and deploy new hydrogen distribution networks and expand these as the consumer base expands.

The work will provide important data on the costs and timelines associated with hydrogen network infrastructure deployment, including hydrogen storage. This will inform business planning and business case development for such networks. It will also provide a cost base to assist government in developing policy for hydrogen deployment.

### Scale of Project

The project will be a desktop study with modelling undertaken related to hydrogen network control and operating philosophies and in respect of pipeline routing and network cost development.

### Technology Readiness at Start

TRL2 Invention and Research

### Technology Readiness at End

TRL4 Bench Scale Research

### Geographical Area

This study is focused on hydrogen pipeline infrastructure that can be replicated throughout the UK by all the Gas Distribution Networks

### Revenue Allowed for the RIIO Settlement

Not Applicable

### Indicative Total NIA Project Expenditure

£382,556.63

## 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:

n/a

#### 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)

The HyDeploy project suggests that if a 20% H2 blend is rolled out throughout the UK this will enable 29TWh of low carbon heat to be injected onto the GB network and this has the potential to save the consumer £8Bn compared to other methods/routes to decarbonisation such as heat pumps. On a wider scale, the 2050 energy scenario report by KPMG, produced on behalf of the Network Licensees as part of (NIA\_SGN\_00064) Energy Map and Plan (2016) suggest the conversion of the gas network to hydrogen compared to electrification could save the consumer £7,000 to £9,500 each or £152bn to £214bn for GB.

The work will also guide the GD2 business plans for Cadent and other network licensees. This will reduce costs for all customers during GD2.

We would also expect the potential CO2 and air quality benefits from solving the problem to be significant. Such environmental and health benefits can be converted to financial benefits (using 'damage' costs).

#### Please provide a calculation of the expected benefits the Solution

N/A – this is a research project that will define a suitable approach to network operation and control, which can be replicated by other network licensees.

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

The method can be replicated at any locations in which low carbon hydrogen is available in bulk. In most cases, this will require access to carbon capture and storage (CCS) infrastructure (to capture and store the CO2 from hydrogen production from natural gas) and therefore the most appropriate areas are Teesside, Humberside South Wales and Eastern Scotland. Hydrogen clusters potentially similar to that proposed by Cadent in the form of HyNet are being developed in these areas. In such areas the method will guide GD2 business planning.

In the shorter-term, the method can also be applied as part of smaller demonstration projects.

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

The cost of rollout will be clearer once the research project concludes. This will also enable the decision to be made as to whether to pursue initial demonstration projects or not.

### 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

This project will consider how gas distribution networks can be best designed and controlled by Network Licensees to supply hydrogen to a range of users. It will also provide information on the development challenges, costs and timelines associated with network deployment which are relevant to all Network Licensees.

It is envisaged that the above information can be used by relevant Network Licensees to determine the attractiveness of new hydrogen network deployment. It can also subsequently be used to guide development and roll-out of new networks around the wider UK. In addition, it will help Network Licensees to quantify and to then realise the potential benefits of the network supply of hydrogen.

The above will also guide GD2 business plans for Cadent and other network licensees

### 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

- Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

### 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 is a FOAK project in respect of Network Licensees' consideration of operational control philosophies for hydrogen network distribution networks.

Cadent has discussed the project with other Network Licensees and can confirm that there is no duplication with either other historic projects or those currently being considered.

### 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**

The project will represent the first attempt by a network licensee to develop an operational control philosophy for a hydrogen distribution network involving a range of diverse consumers. This project has not been done to date as the Distribution Network Operator's hydrogen projects are still in their feasibility stages. However, due to recent developments in all the hydrogen projects this NIA has now come into focus.

### **Relevant Foreground IPR**

n/a

### **Data Access Details**

n/a

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

This project will provide an operational control philosophy and detailed design to enable the deployment of a new distribution network transporting a new low carbon gas, hydrogen. If achieved this will provide a quantum leap for the UK gas industry and thus cannot be regarded as business as usual.

### **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**

The project conforms to NIA requirements. Commercial risks to be overcome, which require NIA support include the current absence of a relevant support mechanism for CCS and hydrogen as a fuel. Mechanism is currently under consideration by Government, but in the meantime, any network licensee would struggle to justify investment of this nature. However, support in the short-term for this project under the NIA, will allow all licensees to manage commercial risk and then move quickly at the relevant time to deliver maximum benefits to customers in the form of lower costs of network deployment.

### **This project has been approved by a senior member of staff**

Yes