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

Jan 2015

Project Reference Number

NIA_NGN_114

Project Registration

Project Title

H21 Leeds Citygate

Project Reference Number

NIA_NGN_114

Project Licensee(s)

Northern Gas Networks

Project Start

January 2015

Project Duration

2 years and 4 months

Nominated Project Contact(s)

Dan Sadler & Richard Pomroy

Project Budget

£266,400.00

Summary

As the UK transitions to a low carbon economy there are numerous scenarios that could play a part in the future UK energy mix. Gas currently contributes over 35% of the UK's energy needs and is seen as an important transitional fuel as the UK moves to a low carbon economy. However, what if it isn't just a transitional fuel but a key principle contributor to the carbon reduction targets.

As a pure element Hydrogen leaves no carbon footprint, the combustion of hydrogen with oxygen results in water and heat. Most people have heard of hydrogen vehicles (fuel cell technology) but what if there was a bigger opportunity in the long term i.e. a hydrogen based distribution system for domestic heating and cooking! This could then be used to connect fuelling station forecourts to have hydrogen 'on tap' for the new generation low carbon vehicles.

As part of the ongoing studies of hydrogen this project will play a pivotal role in the debate. The project will redesign the gas network for Leeds to establish a high pressure (17 bar) outer city ring main transporting methane (CH4) to strategically placed Steam methane reforming (SMR) plants for distribution into the below 7bar network. These will also be supplemented by power to gas technology.

Third Party Collaborators

University of Leeds

ITM Power

Toyota

Kiwa

Cambridge Carbon Capture

Hyundia

Scottish Hydrogen Society

England Hydrogen Society

Institution of Gas Engineers and Managers

Carbon Capture Society

Nominated Contact Email Address(es)

innovation@northerngas.co.uk

Problem Being Solved

Hydrogen could also be an alternative fuel for heating in future, although there are significant uncertainties over its availability and cost. If available at a competitive price, it could be transported through the existing gas distribution networks to provide heat in buildings, but like biomethane there are also competing potential uses in transport and industry. As one of the more innovative potential solutions for the future, hydrogen as an option is generally not well represented in existing analyses and warrants further work. (source Future Heat Series Part 1, Pathways for Heat: Low Carbon Heat for Buildings, Carbon Connect)

There are substantial uncertainties regarding the production, cost and delivery of hydrogen as well as its most economic uses in the energy system in the future. Delivery is a critical issue for its use in buildings, and the representation of hydrogen options suffers from the difficulty of representing the spatial element of networks in energy system models.

One of the options includes converting parts of the existing gas network to a Hydrogen Network. If existing gas networks could be converted for use with hydrogen at reasonable cost, this could avoid some of the issues that building new district heat networks or upgrading the electricity system to carry heat demand could entail. This would have greatest benefits in some of GB's larger urban cities, like Leeds.

Some of the GB network was originally converted from town gas (which is primarily hydrogen), particularly in city center environments, and parts are currently being converted to plastic pipes, which are more suitable for carrying hydrogen. However at present, understanding of the costs of new infrastructure or conversion remains poor, and as a result these options are inconsistently modelled across the pathways.

Without a specific modelled example based on a GB based location these uncertainties will remain.

Method(s)

To undertake a holistic research project to assess the feasibility of converting one of the UK's largest cities to a Hydrogen Network.

- Redesign an existing network, which is highly suitable for a transition to Hydrogen, to take into account all available research and develop effective options.
- Research the viability and requirements to meet future demand of Steam Methane Reforming
- Assess the impact and commercial viability of power to gas technology to support hydrogen supplies
- Undertake a review and assessment on the impact of differing levels of hydrogen on gas appliance within Leeds city
- Work with the road transport industry to assess the benefits of using a converted gas network to deliver hydrogen to road users
- Undertake an impact review on the gas network with conversion costs and customer impact assessment
- Undertake an academic review of the whole conversion and complete a comprehensive report

Scope

As the UK transitions to a low carbon economy there are numerous scenarios that could play a part in the future UK energy mix. Gas currently contributes over 35% of the UK's energy needs and is seen as an important transitional fuel as the UK moves to a low carbon economy. However, what if it isn't just a transitional fuel but a key principle contributor to the carbon reduction targets.

As a pure element Hydrogen leaves no carbon footprint, the combustion of hydrogen with oxygen results in water and heat. Most people have heard of hydrogen vehicles (fuel cell technology) but what if there was a bigger opportunity in the long term i.e. a hydrogen based distribution system for domestic heating and cooking! This could then be used to connect fuelling station forecourts to have hydrogen 'on tap' for the new generation low carbon vehicles.

As part of the ongoing studies of hydrogen this project will play a pivotal role in the debate. The project will redesign the gas network for Leeds to establish a high pressure (17 bar) outer city ring main transporting methane (CH_4) to strategically placed Steam methane

reforming (SMR) plants for distribution into the below 7bar network. These will also be supplemented by power to gas technology.

Objective(s)

To produce a report capped at 100 pages covering the challenges, benefits, risks and opportunities of converting a major UK to city, Leeds, to a hydrogen network using the existing gas network.

Produce a design scenario for Leeds city gas network converted to a Hydrogen Network.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

- Complete a research review and study in Steam Methane Reforming, including international learning
- Complete a review into Power to Gas Technology and its impact on Leeds City
- Complete an impact assessment of the gas appliance population within Leeds based on a hydrogen network
- Complete an impact assessment on the existing gas network within Leeds of the introduction of hydrogen, based on international trials and best practice
- Undertake an assessment on the potential use of a hydrogen delivered via a network on road vehicles
- Re-model the Leeds Gas Network based on hydrogen conversion including costs and customer impact
- Based on the learning from all stages undertake a holistic review of the conversion process with detailed conversion strategy, costs, timescales, benefits and challenges
- Produce a detailed planning report on the project for dissemination to the energy sector

Project Partners and External Funding

n/a

Potential for New Learning

n/a

Scale of Project

Area One: Evidence and Data Collation

Review and study into SMR plants including:

1. Capacity and associated size of plant
2. Carbon Footprint
3. Commerciality (upfront costs Vs ongoing cost of operation)
4. Existing worldwide examples

Partner: TBC

Review and study into Power to gas technology including:

1. Capacity and associated size of plant Vs size of available electrical load
2. Impact on constrained costs in the leeds and Yorkshire area.
3. Carbon footprint
4. Commerciality (upfront costs Vs ongoing cost of operation)
5. Existing worldwide examples

Partner: ITM Power / NPG

Gas quality parameters relative to existing boiler and heating appliance stock in leeds to include:

1. Impact of differing levels of hydrogen / methane mix on the appliance population – i.e modification required to standards and specific modifications to burners with associated costs (for leeds)
2. Impact of pure hydrogen on appliance population (i.e. modification required to standards and specific modifications to burners with associated costs (for leeds)
3. Changes to GSMR required for the above
4. Timeline estimates for conversion appliances

Partner: KIWA

Collation of latest hydrogen trial data to support hydrogen as a fuel (e.g. Denmark trials, transportation evidence e.g. chemical industry, material evidence (what hydrogen can be transported through – soft steel, PE etc) appliance conversion, hyhouse etc, areas where hydrogen methane mix is significant e.g. town gas china).

Partner: KIWA (with international energy association)

Carbon capture and storage – pre and post burn technology

1. Identification of existing pre and post burn technologies and their respective TRL.
2. Identification of work required to further develop the technology with costs.
3. Integration with Yorkshire carbon capture pipeline (due to be built 2016)
4. Examples of worldwide application of technologies

Partner: Cambridge Carbon Capture

Hydrogen vehicle technology

1. Fuelling station parameters including costs per station
2. Hydrogen technical parameters for vehicles (e.g purity) and challenges with gas network fuelling (e.g. odorant)
3. Vehicle details – capital cost vs payback (increased efficiency for the consumer) against traditional vehicles for both commercial and private vehicles
4. Vehicle take up projections – evidence how quickly could a city (leeds) then wider expect to see hydrogen vehicle take up based on fuelling station development,

Partner: Hyundia / Toyota

Area Two (run concurrently with stage one) – Leeds network Modelling

Re model leeds removing the internal 17 bar feeds mains and redeveloping a 17 bar ring main (Methane) including indicative cost estimates

Delivery: NGN Staff

Model requirements for hydrogen conversion from 17 bar to low-pressure (below 7 bar) inside the ring main hydrogen network including:

1. Estimates on any associated reinforcement
2. Cost of full conversion below seven bar to PE including timescales for completion based on realistic city disruption appetite.
3. Timescales for completion of external ring main modifications

Delivery: NGN Staff

Area Three: Academic / expert opinion review and consideration.

Run in conjunction with stage four these academics establishments will review the work and add comment throughout then process.

Partner: Leeds university, UCL (P Dodds), Scottish Hydrogen society, England hydrogen Society, IGEM, Carbon capture society. GDN's/IDN's

Area Four: H21 City gate template

Merger of alternative technologies and modelling of the Leeds network (post 17 bar ring main development) to understand the scale and number of SMR/ P2G facilities required to provide fuel requirements for leeds. To include:

1. Sizing of plants (SMR/P2G) and approximate locations when modelled by NGN to provide pure hydrogen fuel for Leeds.
2. Consideration of season variance in fuel demand for plant sizing when also considering the uptake in hydrogen vehicles. This would consider summer Vs winter fuel demand and how the plants would accommodate this coupled with consideration against an increase vehicle take up and hydrogen vehicle fuel demand
3. Consideration of nearby PowerStatio conversion.
4. Costs for the agreed solution and timescales for realistic build.
5. Consideration for a conversion strategy form methane to hydrogen for the city i.e. appliance modification
6. Cost and locations for fuel courts with associated technical parameters

7. Integration of carbon capture technology at SMR plants with associated costs and payback options for pre and post burn carbon capture at the SMR facilities.

Partner: All consortium

Stage 4: gap analysis and final report

1. Final report capped at 100 pages on the above
2. Gap analysis of clear areas for further works.

Partner: All Consortium

Area Five: Knowledge Dissemination

At all stages of the project progress will be disseminated through the NGN website, attendance at conferences etc.

Delivery: Head of Energy Futures, NGN

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

Based on the Leeds 17bar Network and it supply system

Use international learning to best inform research results

Conclude impact of this review on the future of GB networks

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

External: £200,000 Internal £66,400 Due to the nature and complexities of this project at this stage these are purely indicative costs based on NIA requirements. NGN will look to gain additional external funding and partner contribution to assisting in funding. Once full commitment to this project has been achieved this proposal will be updated to reflect these changes.

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)

If successful this project would result in avoiding significant costs of building new district heat networks or upgrading the electricity system to carry heat cooking demand. It will also address some of the issues around the delivery of hydrogen for transportation purposes without the need for additional transportation costs.

Please provide a calculation of the expected benefits the Solution

As this is a research project detailed costs will be provided as part of the success criteria

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

Research project

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

The result of modelling and undertaking an impact assessment on the Leeds City Network can be adopted for similarly designed and sized networks within GB.

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

If available at a competitive price, hydrogen transported through an existing gas distribution networks could provide heat in buildings, support road transportation and deliver additional benefits to industry. If an existing gas networks could be converted for use with hydrogen at reasonable cost it would avoid some of the issues that building new district heat networks or upgrading the electricity system to carry heat demand could entail.

The learning shared across the UK Energy sector from this project could have a significant impact on this countries energy policy over the next 50 years.

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

- Redesign an existing network, which is highly suitable for a transition to Hydrogen, to take into account all available research and develop effective options.

- Research the viability and requirements to meet future demand of Steam Methane Reforming

- Assess the impact and commercial viability of power to gas technology to support hydrogen supplies

- What are the significant issues around the impact of differing levels of hydrogen on gas appliance within Leeds city

- What would be the isks and benefits to the road transport industry of a converted gas network to deliver hydrogen to road users

- What are the technical, commercial and regulatory issues on the gas network regarding conversion costs and customer impact assessment

☑ 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.

n/a

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

n/a

Relevant Foreground IPR

n/a

Data Access Details

n/a

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

n/a

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

n/a

This project has been approved by a senior member of staff

☑ Yes