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 2021

Project Reference Number

NIA_SGN0166

Project Registration

Project Title

The Future of LTS: Evaluation of Vintage Pipeline Materials in Hydrogen Environments

Project Reference Number

NIA_SGN0166

Project Licensee(s)

SGN

Project Start

September 2020

Project Duration

1 year and 1 month

Nominated Project Contact(s)

Nancy Thomson

Project Budget

£427,137.00

Summary

The hydrogen economy can be expected to play a significant role in delivering net zero emissions in the UK by 2050. This will require the production of large volumes of hydrogen[AC1] and the rapid development of a safe and cost-effective H2 pipeline transmission network. In this context, SGN have been investigating the repurposing of the Local Transmission System (LTS) for hydrogen, hydrogen blends and carbon dioxide (CO2). The first phase of this project, “The Future of the LTS”, was a desktop study to understand the feasibility of repurposing the LTS. The study included a case study for repurposing the decommissioned SGN Granton to Grangemouth pipeline.

In February 2020, SGN held a workshop in Edinburgh to present the findings, identify gaps and develop a roadmap from the first phase. Strathclyde University (Dr Julia Race) and Pipeline Integrity Engineers (PIE) (Dr Jane Haswell and Dr Andrew Cosham[AC2]) attended this workshop. One of the topics of discussion during the workshop was the known negative effect that hydrogen can have on the ductility and toughness of line pipe steel, (termed “H2 embrittlement”), which can lead to cracking of the steel. Therefore, in order to make a safety justification for the design of new pipelines and/or the reuse of existing pipelines, guidelines are required to close the gaps in knowledge regarding the effects of hydrogen on pipeline materials.

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Problem Being Solved

The hydrogen economy can be expected to play a significant role in delivering net zero emissions in the UK by 2050. This will require the production of large volumes of hydrogen[AC1] and the rapid development of a safe and cost-effective H2 pipeline transmission network. In this context, SGN have been investigating the repurposing of the Local Transmission System (LTS) for hydrogen, hydrogen blends and carbon dioxide (CO2). The first phase of this project, “The Future of the LTS”, was a desktop study to understand the feasibility of repurposing the LTS. The study included a case study for repurposing the decommissioned SGN Granton to Grangemouth pipeline.

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Method(s)

The following work will be carried out in 2 work packages:

Work Package 1: Material testing and analysis (University of Strathclyde)

The proposed test programme, using similar material to the Granton to Grangemouth pipeline, has been designed to address the gaps identified during the Phase 1 LTS study and further understand the effects of hydrogen on vintage line pipe steels. As the test specimens chosen are of the same vintage as the Granton to Grangemouth pipeline, with the exception of the wall thickness, the test results will allow SGN to make a preliminary assessment of the suitability of the pipe material in the LTS for hydrogen service.

Work Package 2: Technical support for Material Testing and Analysis (PIE)

Direct technical support and desktop studies will be provided, as detailed below, in collaboration with Strathclyde University for Material Testing and Analysis. The work package addresses the effect of hydrogen on line pipe steel and how that might affect the failure frequency of pipelines transporting hydrogen and hydrogen blends at pressures above 7 barg. Material testing is to be conducted by the Strathclyde University.

Scope

Work Package 1: Material Testing and Analysis (University of Strathclyde)

Phase 1: Material Characteristics

Prior to the commencement of the testing programme, the pipe material of both sections on each side of the weld and the weld will be characterised in terms of the chemical composition and microstructure. These tests will ensure that the material is “as expected” and compliant with the standards at the time of manufacture of the pipeline. The information will also allow comparison of the test results with literature regarding the expected material response to hydrogen.

Phase 2: Assessment of Material Properties

The tests proposed in this work package are intended to answer the research question - what will the effect on the tensile and fracture properties be when the material is exposed to a hydrogen environment? To answer this question, tensile tests and fracture toughness tests will be conducted for each material before and after exposure to hydrogen. This data will provide information regarding whether the exposed pipe material is acceptable in terms of ductility and/or fracture toughness.

Work Package 2: Technical support for Material Testing and Analysis (PIE)

Phase 1: The effect of H2 on fracture propagation control:

- establish bounds on the decompression behaviour of H2 and blends, through decompression calculations using REFPROP (GERG-2008), GASDECOM or similar (noting that H2 is expected to exhibit less severe decompression behaviour, as implied by Aihara et al., 2008, 2010, Botros & Kondo, 2016);
- determine whether or not the Charpy V-notch impact energies specified in LX/1, etc. (the contemporaneous British Gas specifications) are sufficient for H2 and blends, subject to the assumption that H2 does not affect the fracture propagation transition temperature or the upper shelf Charpy V-notch impact energy.

The effect of H2 on fatigue crack growth:

- establish the effect of H2 on the remaining fatigue life of pipelines and associated assets due to pressure cycling, based on the literature on its effect on the rate of and the threshold for fatigue crack growth (noting that Equation (1) in ASME B31.12 is only applicable to $R < 0.5$, whereas the default assumption for welded joints is $R \geq 0.5$), and using historical pressure cycling data, as available;
- establish the effect of H2 on the significance of other sources of fatigue loading in pipelines and associated assets

The effect of H2 on flawacceptance criteria (corrosion, mechanical, damage, welding defects, etc.):

- establish, based on prior work, what additional failure modes need to be considered, e.g. hydrogen cracking or HIC;
- establish, based on prior work, what time-dependent degradation (growth) mechanisms need to be considered, e.g. fatigue;
- establish, based on prior work and the mechanical testing, the effect of the changes in the toughness of the steel on the acceptance criteria for corrosion, gouges, etc. (blunt and sharp defects);
- define revised acceptance criteria;
- contribute to the updates to P/11, PV/11 and P/18

Objective(s)

The objectives of this work are to evaluate the effects of hydrogen on vintage line pipe steels based on prior work and material testing completed on a line pipe steel similar to the Granton to Grangemouth pipeline.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

This project will provide an understanding of how vintage line pipe steels behave in hydrogen environments. This will provide a clear indication as to whether what further is testing is required for these materials.

Project Partners and External Funding

Project Partner: University of Strathclyde
Project Partner: Pipeline Integrity Engineers (PIE)
External Funding NIA

Potential for New Learning

This project will expand the understanding of the capabilities of repurposing LTS pipelines for the storage and transport of hydrogen. A review has been done of all GB LTS pipelines and the material chosen for testing is a good representative of the GB network and it is similar to the Granton to Grangemouth pipeline which SGN has earmarked to be the blueprint for repurposing an LTS pipeline for hydrogen.

Scale of Project

This project will be a combination of desktop study and laboratory material testing.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The project will test LTS material from the Scotland and Southern license area but the results can be applied more broadly to GB LTS.

The material chosen for testing is a good representative of the GB network and it is similar to the Granton to Grangemouth pipeline which SGN has earmarked to be the blueprint for repurposing an LTS pipeline for hydrogen.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

£427,137

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)

As part of the Paris Agreement and in order to meet its climate targets the UK intends to achieve Net Zero by 2050. To achieve this effectively and economically all options for decarbonisation should be evaluated in order to find the most cost effective solutions for the UK consumers.
There are reports that suggest that electricity alone would be more expensive than repurposing the gas network and the Committee on Climate Change have published a recent report highlighting that hydrogen is a credible option for the future.

Please provide a calculation of the expected benefits the Solution

Indeterminate at this stage, research project (see commentary above)

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

A review has been done of all GB LTS pipelines and the material chosen for testing is a good representative of the GB network and it is similar to Granton to Grangemouth pipeline which SGN has earmarked to be the blueprint for repurposing an LTS pipeline for hydrogen. The test programme will inform the development of a material qualification strategy for GB LTS.

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

The use of the LTS for storage and distribution of hydrogen, both within the UK and at local level, would be highly advantageous for the supply and delivery of low-carbon energy to consumers.

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

A review has been done of all GB LTS pipelines and the material chosen for testing is a good representative of the GB network and it is similar to Granton to Grangemouth pipeline which SGN has earmarked to be the blueprint for repurposing an LTS pipeline for hydrogen. The learnings from the project will be fed into the IGEM LTS Futures Group and LTS Futures programme which are investigating repurposing the GB LTS network. The findings will be disseminated to all licenses and outcomes will be valuable for the National Grid's Future Grid project.

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

SGN are investigating the repurposing of the LTS for hydrogen.
This project will investigate the effect of hydrogen on the ductility and toughness of carbon line pipe steel, which can lead to cracking of the steel. In order to make a safety justification for the design of new pipelines and/or the reuse of existing pipelines, guidelines are required to close the gaps in knowledge regarding the effects of hydrogen on pipeline materials.

☑ 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.

Project scope was reviewed against all existing projects and no areas of duplication where identified. All GDNs and NGGT are members of the IGEM LTS Futures group where the scope has been shared and no duplication was mentioned.

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 is the second phase of The Future of LTS. It is the offsite material testing and analysis detailed in the first phase of the

Future of LTS PEA registration document. This project aims to fill in some of the gaps from the first phase with regards to pipeline material.

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

The pathway to decarbonisation of the LTS requires material testing to ensure that the effects of hydrogen on vintage steels are known. As such it is not part of the usual activities of the business.

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 NIA framework offers a robust, open framework to support this work and ensure the results are shared with all stakeholders. The repurposing of the GB LTS involves potentially significant technical risks. The Project addresses the question of the suitability of vintage line pipe steels under hydrogen service.

This project has been approved by a senior member of staff

☑ Yes