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

Oct 2020

Project Reference Number

NIA_SGN0165

Project Registration

Project Title

HyTechnical – Literature, science review and subsequent revision technical standards for hydrogen pipelines

Project Reference Number

NIA_SGN0165

Project Licensee(s)

SGN

Project Start

June 2020

Project Duration

0 years and 10 months

Nominated Project Contact(s)

Nancy Thomson

Project Budget

£826,929.00

Summary

move to decarbonisation in the UK has generated major interest in initiatives into the use of existing natural gas networks (pipelines and installations) for the transportation and distribution of hydrogen (H2) and natural gas/H2 mixtures. The SGN Future of the LTS Phase 1 project identified the potential to repurpose the LTS network. In February 2020 SGN held an industry workshop with attendees from the GDNs, NGGT, HSE, BEIS and industry experts. The aim of the workshop was to share and disseminate the knowledge from the first phase of the project, identify gaps and develop a roadmap for the future. The main outcome from the workshop was to develop a common framework of needs to allow the projects to be developed to complete the gaps. Following the workshop, we established IGEM LTS Futures group. This group will ensure the research undertaken underpins the national standards and supports hydrogen implementation. All the GDNs and NGGT are members of IGEM LTS Futures, which SGN chairs, and the work will be done collaboratively.

Following on from the Future of the LTS Phase 1 project, there is a requirement to undertake; material testing and analysis, desktop exercises to understand the impact hydrogen has on, (i) inspection, maintenance and repair (IMR) and (ii) repurposing pressure reduction installations (PRI) and closing gaps in the Quantified Risk Assessment (QRA). The desktop exercise to understand the impact hydrogen has on IMR, PRI and QRA will be done in parallel of writing the standards to provide input to the standards and further guidance to the GDNs and NGGT.

The development of approved industry standards to formalise requirements and secure safe best practise is needed to ensure consistency in repurposing existing natural gas networks, construction of new assets, and to ensure compliance with legislation. The GB gas industry are driving forward towards live consumer trials in the medium terms. As such it is imperative that the GB industry have a suit of supportive standards that deliver consistency and confidence in the engineering practise deployed for such trial activity and future expansion of hydrogen for heat. This is therefore a high priority. Current projects which will benefit from the availability of approved standards include, the SGN ‘Future of the LTS’ and H100 projects, the Cadent HyNet project which includes development in the WWU network, H21 and the National Grid HyNTS.

The standards which apply to the existing natural gas networks have been developed over many decades and are widely regarded

having overseen significant improvements in asset delivery and management resulting in exemplary level of safety and reliability. These standards are published and managed by the Institution of Gas Engineers and Managers (IGEM). Following on from the Future of the LTS Phase 1 project, there is a requirement to undertake an urgent literature-based research for the development of new supplements/documents to these IGEM current natural gas standards which will enable the repurposing of the existing assets and the design and construction of new assets for H2 and Natural Gas/H2 mixtures. The research and the creation of new supplements/documents can be prepared, approved and published more quickly than developing new standards and can be incorporated into the existing standards when they are next reviewed.
This NIA is directly focused on the future low carbon solutions for the gas industry which will support the government's target of Net Zero by 2050 by creating technical standards which allow real engineering to be developed. This work is essential to provide, secure and sustainable long term customer benefits.

Nominated Contact Email Address(es)

sgn.innovation@sgn.co.uk

Problem Being Solved

The move to decarbonisation in the UK has generated major interest in initiatives into the use of existing natural gas networks (pipelines and installations) for the transportation and distribution of hydrogen (H2) and natural gas/H2 mixtures. The SGN Future of the LTS Phase 1 project identified the potential to repurpose the LTS network. In February 2020 SGN held an industry workshop with attendees from the GDNs, NGGT, HSE, BEIS and industry experts. The aim of the workshop was to share and disseminate the knowledge from the first phase of the project, identify gaps and develop a roadmap for the future. The main outcome from the workshop was to develop a common framework of needs to allow the projects to be developed to complete the gaps. Following the workshop, we established IGEM LTS Futures group. This group will ensure the research undertaken underpins the national standards and supports hydrogen implementation. All the GDNs and NGGT are members of IGEM LTS Futures, which SGN chairs, and the work will be done collaboratively.

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Method(s)

There are 3 parallel workstreams to complete the work; the desktop exercises for the research work packages, the repurposing standards, hazardous area classification.

Workstream 1 Desktop Exercises
PRI Work Package

The scope of work for the investigation of, and justification for, additional work required to develop the procedures and specifications which will be required by GDNs and NGGT for the repurposing of the LTS/NTS and its future operation for H2 service required will involve:

Literature Review and Industry Visits:

- Review current code requirements specified in pressure reduction and installation PRI standards compliance with PSR and PSSR to repurpose existing PRI.

- Literature review to identify the key requirements for the operations inspection, maintenance identified in existing published and authoritative research to determine approach applied to existing H2 installations can be applied to existing installations.
- Contact equipment manufacturers to understand their experience in designing and manufacturing hydrogen pressure reduction equipment to support the design of new installations and repurposing of existing PRIs
- Arrange research visits to existing hydrogen facilities in UK and Europe to identify learning which can be applied to design and repurposing of network PRIs.

Venting/Hazardous Areas:
Review Energy Institute EI Model code of safe practice Part 15: Area classification for installations handling flammable fluids Annex B to determine if additional experimental studies are required to evaluate the venting / hazardous areas. Pressure ranges from 2 to 50 bar relief sizes 10mm, 15mm 32mm, 50mm, 100mm. Gas composition 100% H2 and mixtures of H2/Natural Gas with 20% to 50% H2.

IMR Work Package
The scope of work for the investigation of, and justification for, additional work required to develop the procedures and specifications which will be required by GDNs and NGGT for the repurposing of the LTS and its future operation for H2 service required will involve:

Review current code requirements specified in pipeline standards and required for compliance with PSR and PSSR. To include routine and non routine IMR activities. Brief literature review to identify the key requirements for inspection, maintenance and repair identified in existing published and authoritative research i) carried out for the networks, ii) published and iii) included in standards for pipelines transporting H2 and NG/H2 mixtures.

Identify the procedure and specification requirements to address the key damage mechanisms and parameters affecting the requirements for damage identification, sizing and assessment for the operation of H2 and H2/NG mixture pipelines, including reduction of ductility and toughness (embrittlement), fatigue crack growth, denting/gouging and metal loss

Using P11 as a roadmap to assess if there are any major changes in inspecting / repairing H2 and NG/H2 pipelines.

Output will be documented as P11 impact assessment which will detail for each document subsection: no change / editorial / minor technical / major technical.

(a) Review current / emerging in line inspection capabilities for H2 and NG/H2 pipelines to cover:

- Current tool accuracy, repeatability, POD and feature detectability limitations.
- Ability of existing technologies to be extended for H2 and NG/H2 pipelines and any limitations (flow / diameter / feature type (especially crack detection in gas pipelines etc.)
- Emerging technologies that are under development and their suitability for H2 and NG/H2 pipelines – tool (material) compatibility, flowrate

(b) ILI interval assessment – assess the methodology required for assessing time dependent failure mechanisms for H2 and NG/H2 pipelines, e.g. corrosion + crack growth, etc.

Review and assess the currently available repair methods for application to H2 and NG/ H2 pipelines, including epoxy shells, composite repairs and Plidco clamps. Include assessment of hot work on pipeline steels exposed to hydrogen, and review current capability for carrying out hot tap, stopple and bypass operations on hydrogen pipelines.

Consider the expected performance of pipeline girth welds which to not meet current girth weld quality standards (i.e. girth welds on P18 pipelines)

QRA Work Package

Further work is required on understand building proximity distance (BPD) and the minimum separation distance between parallel pipeline (hydrogen vs hydrogen and hydrogen vs natural gas). This first phase is a desktop exercise.

Impact assessment of hydrogen transmission on TD/1 BPDs

1. Gather background information on the basis of the existing TD/1 BPDs
2. Perform an assessment of the individual elements of the calculations (gas outflow, fire size and radiative properties, thermal effects) to propose how to adapt them using existing knowledge to estimate new BPDs for hydrogen transmission pipelines, based on fire effects.
3. Calculate new BPDs for hydrogen pipelines for fire effects, following the same principles and assumptions as the existing relationships for natural gas.
4. Perform scoping calculations for delayed ignition, using the estimated inventory of hydrogen within the (unconfined) flammable cloud resulting from a hydrogen release and predicting the possible overpressures that could result. Use existing data for delayed ignition of large scale jet releases as a sense check on the predictions.
5. Compare results of overpressure estimates with predicted BPDs to identify whether overpressures from delayed ignition could extend the hazard ranges beyond the predicted BPDs for fires.

6. Report on impact assessment on BPDs with discussion of significance of overpressure effects for hydrogen and recommendations for further development required for hydrogen pipeline risk assessments.

N.B. The scope of work does not include (at this stage) the calculation of risk, which would require inputs on failure frequencies and assumptions of ignition probabilities and ignition timing (especially if overpressure effects are significant). The methodology can be extended to include that in due course as the work on failure frequencies progresses. Ignition will remain an area of uncertainty and hydrogen risk predictions will be cautious until there is more operational experience.

Impact assessment on TD/1 parallel pipeline separation distances

To assess the impact of hydrogen transmission on the recommended separation distances, the possibility of one pipeline transporting natural gas and the other transporting hydrogen may need to be considered, as well as both pipelines transporting hydrogen.

The following steps are envisaged, to assess the impact of hydrogen transmission on parallel pipeline separation distances, drawing on existing knowledge only:

1. Estimate the ground pressure loading predicted from a hydrogen pipeline rupture.
2. Consider the ground pressure effect on a parallel natural gas or hydrogen pipeline.
3. Evaluate available ground crater formation models and assess if existing natural gas model is cautious for hydrogen.
4. Consider effects of thermal loading due to hydrogen fires where recommended natural gas separation distances are not met.
5. Check whether puncture releases can be neglected when considering separation distances for hydrogen pipelines (as for natural gas).
6. Report on impact assessment of the use of existing recommended minimum separations for hydrogen transmission pipelines with discussion of the implications where recommended distances cannot be met. To include recommendations for any further work to provide evidence as required.

Workstream 2 Transmission and Distribution

IGEM will appoint specialist Engineering Contractors to undertake research required to create the new requirements for IGEM standards;

The project will start with TD/1 and TD/13 (above 7 bar) first, followed by TD/3, TD/4 and TD/13 (below 7 bar).

The methodology for the development of the new requirement of the IGEM standards TD/1, TD/3, TD/4 and TD/13 is detailed below and identifies key steps that will be undertaken during development, which would be challenged and reviewed in parallel to the supplementary documents being produced.

1) Risk Register
a. Creation of a risk register identifying additions / updated risks associated with transporting a new fluid (including different pressure tiers, operating conditions and materials)

2) Research Review
a. Review relevant research reports and publications to identify how the influence of the change in product can be assessed in terms of:

- Impact on material properties, applied loading (static / dynamic) and damage / deterioration mechanisms and the consequential change in safety factor and failure frequency
- Behaviour of the product in planned and unplanned releases
- Changes to operations, inspection and maintenance requirements.
- identify any gaps and their impact [priority] in current knowledge that need to be addressed through research and engineering trials

3) Review of current standards
a. Review TD/1, TD/3, TD/4 and TD/13 to identify the safety, integrity, operational, inspection, maintenance and repair requirements to be revised to address the change in product and operational conditions associated with change in use, and the design and construction of new pipelines

b. Identify additional IGEM standards that would need updating to allow for Hydrogen

4) Challenge and Review (based on outputs of 1, 2 and 3)
a. Challenge and review workshop

- Risk Register – is anything missing or unnecessary
- Research – are risks being addressed and if not, where further work is required (outside the scope of this project, this research would need to be funded and procured with the outputs fed in to the document development process, subject to timescales)
- Standards – what has been missed

5) Draft Supplementary Documents for TD/1 and TD/13 > 7 bar

a. Produce draft standards based on the outputs of 4

6) Challenge and Review Workshop
a. Technical workshop to review and challenge draft documents

7) Production of Final Supplementary Documents for TD/1 and TD/13 > 7 bar
a. Incorporate findings of challenge and review seminar
b. Incorporate outputs of research to date

8) Roll-out and Implementation
a. Develop roll-out programme

9) Draft Supplementary Documents for TD/3, TD/4 and TD/13 ≤ 7 bar
a. Produce draft standards based on the outputs of 4

10) Challenge and Review Workshop
a. Technical workshop to review and challenge draft documents

11) Production of Final Supplementary Documents for TD/3, TD/4 and TD/13 ≤ 7 bar
a. Incorporate findings of challenge and review seminar
b Incorporate outputs of research to date

12) Roll-out and Implementation
a. Develop roll-out programme

Workstream 3 Hazardous Area Classification

IGEM will appoint subject matter expert scientists from DVGL and HSE Science Division to assess, research and provide new rules for Hazardous Area Classification for Assets used in the Transmission and Distribution of Hydrogen/ Hydrogen NG Blends. This will be in two phases;

Phase 1

The aim of this work is to review the assumptions in, and therefore the applicability of, IGEM/SR/25 to hydrogen. The review will consider whether the different elements of the standard should potentially be:
a) used as they are,
b) modified but using the same general approach as currently
c) further developed using different assumptions to devise a new HAC methodology.

The two main areas that will be considered are:
a) the 'adequacy of ventilation' rate calculations, and
b) hazardous area distances (including both indoors, outdoors and vents)

Phase 2

Undertake the required modelling and methodology development as defined in Phase 1
Write the technical supplement.
Input to and support to an IGEM Industry Workshop and seminar to present the work for peer review. Update the supplement where necessary.
Development of the standard itself and incorporation of the new data that creates a revised SR25 for Hydrogen. The changes and outputs will be communicated back out to industry through workshops, webinars, conferences, training events and engineering updates through the IGEM journal

Scope

The scope of the project is to complete desktop exercise research and produce supplements/documents related to the safe transmission and distribution of Hydrogen. This will be undertaken by subject matter experts who will research the requirements of the IGEM standards TD/1, TD/3, TD/4, TD/13 and SR/25 to enable the repurposing of existing natural gas networks and the design and construction of new assets for the transportation of H2 and Natural Gas/H2 mixtures.

It is essential that the supplements are developed as follows:

- are available for the application to the repurposing required for planned trials and demonstration activities, repurposing projects and the design and construction of new build projects
- with input and support from users / stakeholders and formal approval by IGEM
- to a short timescale circa 12 months, requiring a fast track methodology using a flexible development programme
- using the research that has been undertaken to support the change from natural gas to H2 and Natural Gas/H2

Objective(s)

The objective of this project is focused directly at the enabling of a low / zero carbon gas network of the future and enabling the safe transportation of hydrogen. It is essential the work is developed to provide, secure and sustainable long-term customer benefits.

It is critical that these standards are developed using the desktop exercises research undertaken and planned in the near term (eg. H21 Phase2) to support the change from natural gas to H2 and Natural Gas/H2 mixtures. Standards will need to be available for the application to the repurposing required for repurposing projects (e.g. SGN The Future of LTS).

They are also required to provide the requirements for the design, construction, testing, operation and maintenance of pipelines for the transmission and distribution of hydrogen and natural gas/hydrogen mixtures (Cadent HyNet & SGN H100). FEED studies for Cadent HyNet.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

The success criteria are as follows:
· Technical report detailing the literature review of PRI using hydrogen
· Technical report detailing the impact of hydrogen on IMR activities
· Technical report detailing the building proximity distance and minimum separation distance between parallel pipelines.
· The development of expert reviewed supplements/documents to the existing standards
  o IGEM/TD/1 – Steel pipelines and associated installations for high pressure gas transmission
  o IGEM/TD/3 – Steel and PE pipelines for gas distribution
  o IGEM/TD/4 – Edition 4 Polyethylene (PE) and steel gas services and service pipework
  o IGEM/TD/13 – Pressure regulating installations for Natural Gas, Liquified Petroleum Gas and Liquified Petroleum Gas/Air
  o IGEM/SR/25 – Hazardous Area Clarification
    § Create New Supplement/Document
    § Produce data for venting distances
    § Produce data for zoning distances - outdoors / 'more than adequately' ventilated
    § Produce data for zoning distances - indoors / 'adequately' ventilated
    § Revise 'adequacy of ventilation' calculations to account for hydrogen
    § Assessment of hazard distances
· All documents/additions are peer reviewed through industry workshops
· Development of the new supplements/standards through IGEM governance
· IGEM Committees Approval
· For each document a series of webinars / communication events will be undertaken to share findings with GB industry.

Project Partners and External Funding

The project will be led by IGEM working in collaboration with Pipeline Integrity Engineers (PIE), Health and Safety Executive Science Division and DNVGL.
IGEM are initiating the work with a £100k contribution towards the total funded cost.

Potential for New Learning

The project is expected to develop the following new learning for Network Licensees:

- Developing the infrastructure for reaching net-zero emissions will require development or enhancement of shared infrastructure such as electricity networks, hydrogen production and distribution
- Strengthening policy-making for the net-zero challenge which must be embedded and integrated across all departments, at all levels of Government and in all major decisions that impact on emissions
- Heating in buildings and supports the infrastructure required that would facilitate for almost all replacement heating systems for existing homes to be ready for hydrogen
- Exposure of new learning to the wider gas industry community to promote debate and knowledge uptake.

Scale of Project

The outcome of the project will be relevant to all of the GB gas networks. The project itself will be a mix of research and desk based literature reviews. It will involve representatives from all areas of the UK gas industry to be a part of the expert review panels.

Technology Readiness at Start

TRL5 Pilot Scale

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

This project will be a mix of research and desk based literature study but the output of Standard Supplements/documents which will be produced will be used by all the GB Network Licensees

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

The total project expenditure (external) is £645,333 external cost

£100,000 IGEM contribution

£181,596 Internal cost (based on the GDN contribution of £545,333)

Total project cost: £826,292 (including IGEM £100,000 contribution)

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)

This project will allow hydrogen pipelines to be repurposed from natural gas (as they are today) to hydrogen. It will also provide the requirements for new pipelines to be designed and built using appropriate technical standards.
This project is a major enabler for the emerging hydrogen economy and it is vital that the correct technical standards are developed which can then be rolled out across the whole of the GB gas network. The recent Go Green Gas initiative states that hydrogen will provide significant savings to the consumer in comparison to alternative decarbonisation technologies.

Please provide a calculation of the expected benefits the Solution

N/A – research project

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

The potential outcomes of this project are applicable across GB gas infrastructure and internationally. All the Network Licensees are aiming to reduce carbon emissions by optimising hydrogen distribution and/or transmission. Whether this is by repurposing the existing gas network to hold hydrogen or building new hydrogen distribution pipelines in the near future. This work has relevance to all GB network operators.

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

N/A – the costs relating to NIA develop the hydrogen based standards which are then available for use across GB industry.

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 and output on developing these new technical standards will be used by all the GB Network Licensees. All the GB networks are driving their vision for a low carbon gas network towards the conveyance of 100% and blended hydrogen in-order to meet the UK's climate change objectives of net-zero by 2050.

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

Decarbonisation, transition to hydrogen and continuing to provide energy services to customer but in a low carbon manner

☑ 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.

These are new technical standards that to date have not been created so they are not duplicating any work that already exists under NIA today.

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 need for standards for hydrogen networks has arrived. Significant infrastructure projects are being developed by all the Network Licensees so the correct standards to build or repurpose these gas grids is now essential. The development of hydrogen standards is not considered business as usual and is firmly within the scope of energy futures to drive research and development necessary that in future years will enable a smooth and lowest cost transition to a low / zero carbon GB gas infrastructure.

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

Hydrogen, to date, is not business as usual although preparation for it is happening across all the networks. These new standards relate to repurposing the existing gas network to hydrogen and building an entirely new hydrogen network so should not be viewed as BAU activities.

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 fully assesses the risks associated with hydrogen and looks to draw on innovative examples from throughout the world. This is not updating existing standards on natural gas but creating new standards for hydrogen which has a fundamentally different technical and risk level being a different family of gas which is currently restricted within the GB network to levels of equal to or less than 0.1%mol.

This project has been approved by a senior member of staff

☑ Yes