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

Apr 2022

### Project Reference Number

NIA_NGN_301

## Project Registration

### Project Title

Failure Modes and Permeation Testing of PE

### Project Reference Number

NIA_NGN_301

### Project Licensee(s)

Northern Gas Networks

### Project Start

May 2022

### Project Duration

1 year and 11 months

### Nominated Project Contact(s)

Chris Bates cbates@northerngas.co.uk

### Project Budget

£435,226.00

### Summary

This project is to determine the suitability of the existing PE network for 100% hydrogen conversion, addressing the knowledge gap of existing operational assets. While testing has concluded current specification PE pipework is suitable for 100% hydrogen conversion, no research has been conducted on PE subjected to prolonged exposure to natural gas under pressure, adversely effecting material properties over time, in some instances up to 50 years.

This project will expand the evidence generation programme of PE assessment to include permeation testing, slit defect leakage rate, stress cracking susceptibility, fracture toughness and leak tightness of house fittings for pre-1976 specification PE.

### Third Party Collaborators

Radius Systems

### Nominated Contact Email Address(es)

innovation@northerngas.co.uk

### Problem Being Solved

The UK was legally bound to make ambitious carbon reductions under the terms of the Climate Change Act (2008). However, the UK government signed legislation on 27th June 2019 committing the UK to a legally binding target of Net Zero emissions by 2050. This means the UK must tackle decarbonisation at pace and change the way energy is produced, transported and consumed to meet this new target.

All networks have committed to work with stakeholders and the government to work towards a strategy to convert the gas distribution networks to hydrogen, including the H21 100% hydrogen project.
In order to utilise the existing distribution gas network to transport hydrogen, the effects of the changes in characteristics of hydrogen

from natural gas need to be reviewed and the resultant effect on the network assessed. This is particularly of importance for the upcoming H21 Phase 3 Occupied Trials project and future conversion projects.

To date assessment of the conversion suitability of the existing polyethylene (PE) distribution network has been limited to current specification PE, with no further consideration of materials that have been in service for 50+ years and will have undergone property changes / degradation. This project will expand the evidence generation programme of PE assessment to include permeation testing, slit defect leakage rate, stress cracking susceptibility, fracture toughness and leak tightness of house fittings for pre-1976 specification PE.

This project aims to fulfil two objectives. It aims to address gaps in the work performed jointly with HSL in the two referenced studies which are appropriate to aged materials. The second and most important objective, is to ensure direct evidence is available for the oldest materials in the network to permit risk assessors building safety cases to provide appropriate evidence.

## Method(s)

Project partners, Radius Systems, through contribution to the H100 project developed a PE testing facility for use in assuring safe conversion for PE networks. The hydrogen test facility is a unique piece of equipment designed with the specific purpose of accelerating the lifetime of polyethylene pipe and fitting systems of the type used by GDNs in their networks. It means pipe systems can be tested, in contact with hydrogen, until failures occur, the failure condition being managed to a safe state. Testing will be conducted across the follow criteria:

- Permeation testing
- Slit defect leakage rate
- Stress crack – plain pipe baseline effects
- Stress crack – combined stresses / pre-existing damage
- Stress crack – Repairs / alterations / diversions
- Fracture toughness – fast fracture resistance
- Leak tightness of house entry fittings

Output of each testing criteria will be included in production of final reports with dissemination to relevant stakeholders, such as; IGEM, BEIS and HSE

## Scope

This project will review the following:

Permeation is the one factor with a known negative impact on conversion to hydrogen. It has been well researched with modern materials to establish diffusion coefficients but no study has been performed on materials that are 50 years old, of the type used in the United Kingdom, to assess the influence of time dependent property changes. A safety case requirement exists to determine whether permeability through the material is affected by previous use with methane, and by time dependent stress response of the material.

The wear out mode for polyethylene pipe, like fittings, will involve some form of slow crack growth mechanism and this results in brittle like cracks. To assist with a reasonable assessment of risk for actual representative defect sizes, it is proposed to age pipe in a way that induces cracking and assess the size of the resulting defect. This provides evidence to marry to third party work conducted by NGN on the effect of various defect sizes giving rise to risk from the network .In studies to date, there has been no evaluation of the effect on time to failure for polyethylene pipes in contact with hydrogen for slow crack growth. It is not known whether the reliable lifetime is shortened, or extended, versus known references (such as lifetime evaluated in contact with water which forms the baseline).

Fracture toughness continues to hold significant question marks as to whether hydrogen affects the fracture toughness of polyethylene materials, the theory indicates that for the pressure ranges used in practice it should not have an effect but previous tests have been inconclusive. This is though, a key attribute that is required to have confidence that the asset will be no more susceptible to damage, for example from a third party strike. Confidence in this attribute also informs the outcome that risk of such fractures propagating will also reduce.

Leak tightness of house entry fittings is a small item within the overall scheme of works but a key learning from the H100 project was that some creep relaxation of polymer materials supporting other plastic components and elastomeric seals is to be expected in practice. To assist in providing some evidence in relation to hot iron fittings it is proposed to conduct two forms of leak tightness testing to assist with a quantified risk assessment in this area.

The project will undertake initial modelling/calculations/measurements for the items above that will provide an indication of whether the items above are suitable for hydrogen transportation instead of natural gas and make recommendations for further research/testing that may be required. The delivery of the scope above will assist in highlighting potential issues that need to be researched further and will provide input into confirming the compatibility of the existing gas distribution networks to transport hydrogen.

The repurposing the UK gas networks with hydrogen to support the challenge of the climate change act has the potential to save £46 billion with minimal gas customer disruption verses alternative decarbonisation solutions.

## Objective(s)

This proposal aims to fulfil two objectives.

- It aims to address gaps in the work performed jointly with HSL in the two referenced studies (H100 and HyDeploy) which are appropriate to aged materials.
- To ensure direct evidence is available for the oldest materials in the network to permit risk assessors building safety cases to provide appropriate evidence

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

An assessment of distributional impacts (technical, financial and wellbeing related) for this project has been carried out using a bespoke assessment tool, which assesses the project as having a positive, negative or neutral effect on consumers in vulnerable situations. To help inform the assessment, this tool considers the categories of consumers identified in the Priority Services Register.

This project has been assessed as having a **neutral impact** on customers in vulnerable situations.

## Success Criteria

The project will be measured as successful if technical notes have been produced providing the results and highlighting any potential areas of concern that maybe effected by the characteristics of hydrogen and make recommendations for further testing/research to further understand the issue and determine suitability of existing PE distribution network for conversion.

## Project Partners and External Funding

NGN will lead the project, with all gas networks supporting, as part of the H21 NIA bid consortium with support from the wider H21 NIA project partners. As part of delivering this project NGN have invited the Radius Systems to provide their expertise in developing the scope and conducting material assessment in their specialised PE testing facility.

## Potential for New Learning

Output of this project will impact wider learning through the H21 suite of projects and wider hydrogen conversion works in the form of technical assessment to suitability of conversion for existing assets. Learning gained from this project will form technical guidance towards the suite of hydrogen conversion evidence and the safety case for hydrogen networks. In additional to guidance notes, stakeholder engagement sessions and output dissemination groups will be conducted throughout, and on completion of, the project.

## Scale of Project

The project will undertake assessment to determine the viability and safety implications of conversion of the existing distribution networks and all PE assets not captured within the H100 review of current materials. The scale of the project is necessary to provide an accurate and representative sample of material to give a high degree of confidence in the results.

## Technology Readiness at Start

TRL3 Proof of Concept

## Technology Readiness at End

TRL4 Bench Scale Research

## Geographical Area

The project will take place at Radius Systems PE testing facility in Derbyshire, on behalf of Northern Gas Networks.

## Revenue Allowed for the RIIO Settlement

NA

## Indicative Total NIA Project Expenditure

Northern Gas Networks
External Costs - £35,944.47
Internal Costs - £65,800
NGN Total NIA Costs - £101,744.47

SGN
External costs - £71,888.94
Internal costs - £23,963
SGN Total NIA costs - £95,851.94

Cadent
External costs - £143,777.88
Internal costs - £47,92638,700
Cadent Total NIA costs - £191,703.88

WWU
External costs - £35,944.47
Internal Costs - £11,981
WWU Total NIA costs - £45,925.47

# 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 project will help determine the suitability of the existing PE distribution network for the conversion to 100% hydrogen. Large section so the network have been in operation for significant periods of time at resent there is little understanding on the impact of time / pressure based degradation and its impact on transition to a hydrogen network, this project will address that knowledge gap.

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

This is not applicable to this project.

## 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 is not applicable to this project.

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

This is not applicable to this project but repurposing the UK gas networks with hydrogen to support the challenge of the climate change act has the potential to save £46 billion with minimal gas customer disruption verses alternative decarbonisation solutions.

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

The research and learning undertaken as part of this project is applicable to all GDNs within the UK as the networks have the same construct and design parameter and potential operational issues and so will assist with future Hydrogen conversion projects

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

This project will not deliver anything that will rolled out to the networks, it is a research project that feeds into a wider suite of projects to decarbonise the gas network.

## 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 research and learning undertaken as part of this project is applicable to all GDNs within the UK as the networks have the same construct and design parameter and potential operational issues and so will assist with future Hydrogen conversion projects.

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

This is not applicable to this project.

### 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.

Other projects are researching 100% hydrogen in a network but only for new networks rather than existing networks. This project will provide initial research/modelling to assess if the following failure modes of pre-1977 PE will be affected by the conversion to 100% hydrogen:

- Permeation
- Slit defect leakage rate
- Stress crack – plain pipe baseline effects
- Stress crack – combined stresses / pre-existing damage
- Stress crack – Repairs / alterations / diversions
- Fracture toughness – fast fracture resistance
- Leak tightness of house entry fittings

### If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

This is not applicable to this project.

## Additional Governance And Document Upload

### Please identify why the project is innovative and has not been tried before

No other project is investigating the suitability of PE assets that have been in operation for prolonged periods of time, and no

assessment has been completed on the degradation of these assets from time in service, pressure cycling and natural gas permeation.

## Relevant Foreground IPR

This project and the resultant outcomes / deliverables will conform to the default treatment of IPR as set out under the agreed NIA Governance, where the default requirements address two types of IPR: Background IPR and Foreground IPR.

## Data Access Details

For all data access requests, please follow the guidance set out in Northern Gas Networks Innovation Data Sharing Policy. https://www.northerngasnetworks.co.uk/ngn-you/the-future/our-funding/

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

There is no allowance in BAU business plans for this type of work and the commercial benefits and technical/operational risks associated with these type of 100% hydrogen projects are outside the traditional environment of any gas distribution network or its shareholders.

## 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 would only be undertaken with support from NIA funding, it is in the interests of gas customers, the regulator and the UK government and realisation of any benefits are outside the control of the gas networks. There is no allowance in BAU business plans for this type of work and the commercial benefits and technical/operational risks associated with 100% hydrogen projects are outside the traditional environment of any gas distribution network or its shareholders.

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

☑ Yes