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

Jul 2024

Project Reference Number

NIA_CAD0108

Project Registration

Project Title

Air (Oxygen) Ingress in Isolated Installations

Project Reference Number

NIA_CAD0108

Project Licensee(s)

Cadent

Project Start

June 2024

Project Duration

0 years and 7 months

Nominated Project Contact(s)

Michael Sinclair

Project Budget

£389,550.00

Summary

This project will help to inform the GDNs, and wider industry on the mechanism for potential air ingress into gas-conveying downstream pipework, particularly during periods of isolation (e.g., if a consumer manually shuts their ECV before then going on holiday for a number of weeks). The work will investigate the phenomena/behaviour for pure natural gas, hydrogen blends (20%), and pure hydrogen - to inform a holistic view for all gas scenarios.
The findings will help enable any proactive mitigation measures to be considered and/or implemented in future, to help maximise the safety of consumers in any future scenario and engineer-out any possible risks.

The work is supported by all 4 GDNs, and will collaborate with, and leverage, a preliminary project led by SGN.

Third Party Collaborators

Enertek International Ltd

Steer Energy

Nominated Contact Email Address(es)

Innovation@cadentgas.com

Problem Being Solved

The UK has mandated that it shall reach Net Zero emissions no later than 2050. The UK was the first major world economy to set this target and it shows the UK's commitment to tackling climate change for future generations. This mandate has put the UK on an accelerated programme to reduce emissions across our entire society whether this is industry, transport, agriculture, or the way we create our power and heat our homes.

The UK Government's Ten Point Plan for a Green Industrial Revolution set out the government's intent to explore the option of hydrogen to be used within the current gas network infrastructure – with a commitment to making strategic decisions on the role of hydrogen in heating in 2026.

In the meantime, industry must demonstrate to policymakers that the use of hydrogen in domestic and non-domestic buildings can be made-safe, via the various evidence projects delivered via the End User Safety Evidence (EUSE) group.
Ultimately, this evidence will inform the HSE's CFA (Comprehensive Formal Assessment) on safety in late 2024. All evidence must be submitted to the HSE by September 2024 in order to be considered in this CFA review.
This particular project will help to inform the GDNs, and wider industry, on the potential mechanism for air ingress into downstream gas-conveying pipework, particularly during periods of isolation (e.g., if a consumer manually shuts their ECV [Emergency Control Valve] before going on holiday for a number of weeks).
Initial investigations have shown that shut-in gas installations can experience loss of fuel and corresponding air ingress, forming a flammable mixture inside the installation. Anecdotally, the effect has been observed in Natural Gas pre-payment meter installations - where central heating boilers can experience 'rough starts' after extended periods of isolation from the gas supply.
Evidence is therefore needed to properly understand this phenomenon of air ingress, the mechanism(s) which allow it to happen, how the mechanism may be influenced differently by natural gas, blends, and hydrogen - and how it can be designed-out ahead of any future conversion scenario.
The findings will help identify if any proactive mitigation measures are required, and if so, enable options to be considered and/or implemented in future, to help maximise the safety of consumers in any future conversion scenario.
The phenomenon appears to happen when the gas is 'turned off' - as would be the case in an installation when the emergency control valve is isolated. The phenomenon also appears to require at least a small level of system leakage; however, the effect has also been observed in gas installations that have passed tightness tests. There could also be a link between depressurisation of the system and the ingress of air. These are all elements that need to be better understood. A full understanding of the causes and behaviour of this phenomena with natural gas, hydrogen blends, and 100% hydrogen is required - to fully assure end-user safety in any future scenario.
It is intended that this project broadly provides further evidence to support 8 of the HSE's 'Safety Demonstrations', around:
i. Continuity of supply
ii. Materials
iii. Appliance design (particularly valves within appliances and sequence control of ignition)
iv. Gas tightness (both of the installation pipework and components within appliances)
v. Hazards
vi. Understanding of ignition sources and probability
vii.Gas appliance design standards
viii.Purging of any gas/air mixtures from pipework

Method(s)

This activity/service involves live/physical testing in laboratory environments, in addition to some desk-studies (literature reviews) and reporting to communicate findings and conclusions.
The initial aim of this work is to explore and quantify the phenomenon of air ingress in installations and identify the likely impact on hydrogen appliances and components (in the case of a 100% hydrogen scenario). Mitigation measures/design options are to be investigated and proposed for this phenomenon.
The investigation will cover two aspects of the challenge:

i. air ingress into a gas installation

ii. investigation into the potential of light-back from an appliance fed by a flammable mixture.
Multiple small-scale test cells will be used to identify the challenge; prior tests have shown that test times can be reduced from weeks to days by using small test cells to investigate and quantify the phenomenon. It will answer the questions of:

"What is the minimum pressure required for this to occur?"
and

• "What are the overarching conditions required for the effect to occur?".

Components of each proposed test cell could include:
• Small volume test cell with a VQ546MR 100% vol. gas detector

• Differential pressure measurement, internal and external, to capture pressure fluctuations
• Internal and external temperature measurement to capture potential drivers of pressure fluctuations

• Optional fittings can be added to explore components that are vulnerable to this phenomenon, including isolation valves

Tests will explore how external environmental factors influence the rate of the effect. They will confirm if the system must be at ambient pressure or if the effect is also seen with the system under pressure. Different gases will be included in the study for comparison, providing relative rates for hydrogen, methane, blends, (and other gases if desired).

Key questions to be answered by the air ingress studies are:

• What effects dominate this phenomenon?
•Can it happen under pressure?
•How long does the effect take, and what are the influencing factors?

Learnings from this could then be applied to domestic applications (extending to non-domestic and distribution network if appropriate in future phases/projects) to understand if processes, procedures, appliance design etc. need to be changed. These changes could be an adaptation of how tightness tests are carried out, a change to the maximum permitted leak rates, or an automated purge process following a system's isolation.

Measurement Quality Statement

The project will utilise appropriately selected sensors of required range and precision for, pressure, temperature, flow, and gas concentration measurements. Other parameters will be measured as required with appropriately sourced equipment. Many of the sensors will be digital sensors which are internally compensated by design. This equipment will be tested and validated in laboratory conditions to a range of externally calibrated pressure gauges and flow controllers. The gas sensors, like many gas detectors, have a tendency to drift, hence the need for regular calibration and bump testing. Steer will span the detectors to 100% fuel gas and 0% regularly – normally at the start and end of each test, to ensure accurate gas concentration readings. This will enable the highest possible measurement quality within the budget for the project.

Data Quality Statement

The project will ensure that all necessary data is of sufficient quality and readily available to meet the objectives. Duplicate sensors will be installed where appropriate, and regular cross calibration will be used throughout. Environmental conditions will be monitored, and real-time indication of logged data will ensure any errors in sensing and logging equipment can be quickly corrected. Once recorded, the data is logged and stored by Steer in the form of raw and calibrated data. This enables traceability from raw data measurements to calibrate individual logs including management of multiple data streams on individual data loggers.
Risk Assessment Scoring

The project does not involve the development of a specific product and so there is no TRL change associated with the project (Score 1). The external project cost is <£500k (Score 1) and is being delivered by only two external suppliers (Score 1).

In terms of the data, some general assumptions are already known, however, some need to be explored and validated within the project. Therefore, a higher risk score is attributed to this area (Score 3) given the scope and nature of the project.

The assessed risk score is therefore 6 (Low) which allows the project to be governed by an internal assurance approach as set out in NIA Governance and ENIP.

Scope

The scope of works is aimed to investigate all potential factors (including temperature, pressure, time, pipework integrity, connected appliances etc.) – for each fuel type of natural gas, 100% hydrogen, and also blends.

The initial phase will focus on domestic installations. However, depending on the findings of this initial phase, the project/scope can be extended to investigate non-domestic and/or network considerations.

The proposed tests will be in controlled laboratory environments, however, will be representative of a typical downstream gas installation in a domestic property.

A scoping document was prepared and circulated by Steer Energy to the gas network operators. This was collated into a programme work pack and circulated by Cadent.

The phenomenon of air ingress, or oxygen entrainment, has also been independently noted, and elements of this are being investigated in a separate/preliminary scope of work by Kiwa Energy for SGN, ahead of the H100 project.

The scope of work for this project (primarily with Steer but supported by Enertek) aims to understand what causes air ingress in domestic installations and to understand the likelihood of ignition in domestic installations after ingress has happened. This is to inform the HSE's upcoming CFA review. A full scope of this Phase 1 work is provided below.

Phase 1 of the Steer work has been split into 6 work packages, as follows:

1.Literature review and anecdotal evidence
2.Small scale experimental tests
3.Installation, appliances and ECV tests
4.Ignition consequences
5.Potential of appliance ignition

6.Project management, reporting, and dissemination
Enertek will also be providing additional support via the use of:

•Hydrogen appliances
•A climatic chamber (to facilitate temperature effects)
•CFD modelling (to support/corroborate with real experimental results)

Objective(s)

The ultimate objectives of this project are to establish a sound understanding of the air ingress mechanism and recommend some appropriate mitigation measures (if required) – supported by robust evidence generated via the experimental testing programme. This is to be done in the quickest time possible (within reason), with the context of the HSE's CFA timelines.

It is acknowledged that any preliminary findings in the early tests may inform or influence the direction or importance of future tests. This flexibility has been agreed with the technical suppliers and accepted by all parties as a pragmatic approach, given the context and nature of the investigative project.

The key deliverables of this work are an interim (pre-CFA) and final (mid-CFA) report covering Phase 1 of the project which provide documented evidence of the causes and effects of air ingress into isolated domestic gas systems.

The interim report will include:

• Literature reviews on the phenomenon, including anecdotal evidence from a range of sources such as appliance manufacturers, gas network operators and installers.

• Details of testing carried out to demonstrate the phenomenon of air ingress and parameters influencing the effect. Identification of whether de-blending is occurring during this process.

• A summary of domestic fixtures, fittings and appliances that may contribute to air ingress in domestic systems.

• Details of overpressures generated in domestic pipework containing air/fuel mixtures for hydrogen, methane and blends.

• A summary of any appliances seen to cause light-back when operated with air/fuel mixtures.

The final report will also include:

• Full details of domestic fixtures, fittings and appliances that may contribute to air ingress in domestic systems.

• Full details of the appliance light-back tests, giving devices susceptible and conditions where this could happen.

• Relevant standards will be reviewed, and mitigation measures will be proposed to prevent air ingress and subsequent light-back in domestic systems.

Fortnightly update meetings will be held with the project review panel. Regular liaison is also expected with the hydrogen QRA team.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The project findings will likely be relevant to any consumers on pre-payment meters – which can halt/isolate the supply of gas to properties today. However, this topic is one of the original reasons/drivers for the preliminary work conducted by SGN – which this project will tie in with accordingly (and as explained throughout).

The role of pre-payment meters in any future hydrogen rollout scenario is to be determined by other projects and regulatory positions.

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 positive impact on customers in vulnerable situations. While the project is focussing only on research in the immediate term, and hence will not deliver any immediate impacts on customers or the existing natural gas network – it may help to inform best practice or procedures beyond any future conversion scenario in the long term. The assessment has identified that this project will look to reduce the amount of supply interruptions to consumers in the home in the long term. Other considerations including the projects impact on supply and immediate health and safety in the home have been made in carrying out this assessment.

Success Criteria

Success will be establishing a sound understanding and explanation of the air ingress mechanism (for each fuel type – natural gas, blends, and 100% hydrogen) – with some appropriate mitigation

Success will also be the timely delivery of both the:
•Interim report (pre-CFA) before the end of August
•Final report (mid-CFA) before the end of October

Project Partners and External Funding

This project will be collaboratively funded by all 4 GDNs, under the standard 4:2:1:1 model.
Cadent will act as the appointed lead party on behalf of all GDNs, and have appointed two project managers (primary and secondary/delegate) to oversee the project and manage the suppliers:

•Steer Energy Solutions Limited (Steer) will act as the primary external supplier – for total external costs of up to ~£253k.

Within these costs, Steer will also sub-contract with Kiwa Energy for specialised technical support and to ensure that knowledge is shared both ways with the preliminary work conducted by Kiwa (on behalf of SGN).

•Enertek International Limited (Enertek) will act as the secondary external supplier for total external costs of up to ~£27k. Enertek will provide specialised support to the project (via access to appliances, a climatic chamber, and CFD modelling) and will work collaboratively with Steer via the agreed multi-party agreement.

All GDNs will also provide internal 'contributions in kind' via labour time (for circa ~25% equivalent value of respective external funding). This will include time for attending project meetings, and conducting technical reviews of project outputs and reports.

Potential for New Learning

The purpose of this project is naturally to generate 'new learning' by better understanding the mechanisms of how and when air ingress occurs in isolated downstream pipework, and also to propose some ideas of how to mitigate against this (if required).

Therefore this project is very relevant to all UK GDNs – and hence it is positive that all 4 GDNs are collaborating as partners on this. As a result, all learning will be shared by default with each GDN – who will have full access to project outputs and discussions.

As the project is being delivered within the EUSE working group's framework – the findings are also required to be formally submitted to the HSE ERG (Evidence Review Group). It will also be shared with the end-user stakeholders at DESNZ, in addition to British Gas (as appropriate) as key stakeholders in the downstream/in-home space and a key member of the EUSE working group.

As the phenomena (and potential mitigation measures) may also have an impact on future QRA models – it is likely that there would be benefit in sharing the relevant results / data with the team at DNV conducting the latest revisions of the GB QRA work, so that this model may be as up to date and as informed as possible. The sharing of any learning will be managed on a case-by-case basis.

Sharing of project outputs with any additional parties outside of those listed above will be subject to agreement between the project partners, and managed on a case by case basis as appropriate.

Scale of Project

The project is a relatively moderate, with ~5-6 months of work across June-November, with a moderate external budget of £280k.
A large proportion of the costs can be associated with the materials and labour time required to set up the test rig (including measurement instrumentation, and various fuel types – methane and hydrogen). The project also includes the use of hydrogen appliances, climatic test chambers, and CFD modelling software.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL2 Invention and Research

Geographical Area

The bulk of the work will be completed by Steer as the primary external suppliers, and hence will be based at their facilities near Stroud (South-West England).
Some work will also be undertaken by Enertek as secondary external suppliers, and hence will be based at their facilities in Hull (East England).
Cadent will also likely host some project update or closure meetings in a central location to all parties - at Cadent HQ in Ansty, Coventry.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

An indication of the Total NIA Expenditure that the Funding Licensee expects to reclaim for the whole of the Project (RIIO2). •External Costs: ~£253k (Steer) ~£43.05k (Enertek) Split as follows between the GDN parties under the standard 4:2:1:1 model: ▪ Cadent (50%) - £148.125k ▪ SGN (25%) - £74.0125k ▪ WWU (12.5%) - £37.00625k ▪ NGN (12.5%) - £37.00625k • Internal Costs: all GDNs will also provide internal contributions via labour time (for circa ~33% equivalent value of respective external funding). This will include time for attending project meetings and conducting technical reviews of project outputs and reports. Therefore, an estimate of these respective internal costs is as follows: ▪ Cadent: ~£46.7k ▪ SGN: ~£23.3k ▪ WWU: ~£11.7k ▪ NGN: ~£11.7k

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:

As downstream pipework (i.e. gas installations beyond the ECV) are an essential component of any domestic (or non-domestic gas supply) – this matter applies to any and all use-cases of gas (methane, blends, or hydrogen) for heat.

It is therefore important that the phenomena is well understood today (with natural gas) and that the effects associated with any step-change (to either blending or 100% hydrogen) are also understood for any future scenario. Ultimately this will help ensure that any future gas scenario is able to be made as safe as possible for consumers (via appropriate mitigation measures, if required).

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

The project findings will likely be relevant to any consumers on pre-payment meters – which can halt/isolate the supply of gas to properties today. However, this topic is one of the original reasons/drivers for the preliminary work conducted by SGN – which this project will tie in with accordingly (and as explained throughout).

The role of pre-payment meters in any future hydrogen rollout scenario is to be determined by other projects and regulatory positions.

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)

N/A

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

N/A – dependent on the future project findings, and recommended mitigation measures (if any).

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

N/A – dependent on recommended mitigation measures (if any).

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

As explained throughout – the learnings of this research project cannot be pre-empted, but depending on the findings (which all UK GDNs will have full access to as project partners) – it may be the case that certain mitigation measures are agreed upon by the networks to ensure that the risks associated with pipework depressurisation/air ingress is adequately removed or reduced.

It could also be the case that the potential for the phenomena to occur is able to be 'designed-out' (or 'engineered-out'), which naturally is the preferable option for both the networks and consumers for any case, if required.

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

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

The use of 100% hydrogen (for heat) has not yet been publicly deployed in the UK at any scale. The UK GDNs are committed to continuing to provide the highest levels of safety of customers for any future gas scenario – including the potential use of 100% hydrogen. However, while so far many questions on the use of hydrogen have been addressed, and many evidence gaps have been

closed, naturally some new items arise through the completion of these projects.
One of the gaps remaining to be addresses is related to this depressurisation of isolated downstream pipework and potential entrainment of oxygen into the pipework. A full understanding of the causes and behaviour of this phenomena with natural gas, hydrogen blends, and 100% hydrogen is required - to fully assure end-user safety in any future scenario.
Therefore, the investigation into this previously unexplored phenomenon is innovative by default.

Relevant Foreground IPR

All matters of Intellectual Property are addressed and governed via Section 6 of the agreed GIGG contract terms.

Data Access Details

All matters of Data Protection are addressed and governed via Section 9 of the agreed GIGG contract terms, with additional details on Good Data Management Practices provided in Schedule 6. No personal data is being captured or used by or during this project.
Other data for this project and all other projects funded under the Network Innovation Allowance (NIA), Network Innovation Competition (NIC) or the new Strategic Innovation Fund (SIF) can be found, or requested, in a number of ways:

• A request for information via the Smarter Networks Portal at https://smarter.energynetworks.org, to contact a project click 'Contact Lead Network'. Cadent already publishes much of the data arising from innovation projects here – so visitors may wish to check this website before making an application.

•Via Cadent's Innovation website at https://cadentgas.com/future-of-gas
•Via Cadent's managed mailbox futureofgas@cadent.com

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

The links with the parallel project, and how this will be managed, are detailed above.
Meetings have been held between the relevant parties, including between:

Cadent and SGN (as leads/owners)

In addition to wider technical calls also including the suppliers (Kiwa, Steer and Enertek)
To ensure that both projects maintain alignment and that knowledge sharing is facilitated for mutual benefit, and optimal delivery.

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 links with the parallel project, and how this will be managed, are detailed above.
Meetings have been held between the relevant parties, including between:
• Cadent and SGN (as leads/owners)
•In addition to wider technical calls also including the suppliers (Kiwa, Steer and Enertek)
To ensure that both projects maintain alignment and that knowledge sharing is facilitated for mutual benefit, and optimal delivery.

This project has been approved by a senior member of staff

☑ Yes