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 2023

Project Reference Number

NIA_CAD0097

Project Registration

Project Title

Dispersion of Helium Releases in Domestic Properties

Project Reference Number

NIA_CAD0097

Project Licensee(s)

Cadent

Project Start

September 2023

Project Duration

0 years and 11 months

Nominated Project Contact(s)

Brad Bannerman

Project Budget

£665,166.67

Summary

The project involves the release, and real time measurement, of helium in twelve real, lived-in domestic properties that will be selected to be closely representative of UK housing stock. The experimental data gathered will help the gas industry better understand the movement of a buoyant gas within a variety of domestic scenarios, as well as validating existing mathematical models and industry recommendations being made by current research. The recommendations that the project aims to validate focus on the safe location of meters and appliances under hydrogen operation, and how different safety measures can be most effectively utilised to support these positions in early hydrogen demonstrations.

Preceding Projects

NIA_WWU_2_12 - EUSE - Ventilation Within Buildings

Third Party Collaborators

DNV

Kiwa

Nominated Contact Email Address(es)

Innovation@cadentgas.com

Problem Being Solved

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. It specifically mentioned that a Hydrogen Village Trial should be underway no later than 2025 to enable an important policy decision to be made in 2026 on the options for heating homes in a net zero future.

The End User Safety Evidence group (EUSE) is a group within the End User sub programme of the DESNZ Hydrogen Grid R&D Programme. EUSE will facilitate the gathering of safety evidence downstream of the emergency control valve (ECV) to support delivery of the Village Trial and potential wider rollout of hydrogen in the UK.

Further understanding of the ventilation patterns of domestic properties has emerged as a key factor in being able to demonstrate to the HSE that hydrogen can be safely introduced into UK households for heating and cooking. Various projects have recently been delivered on the back of Hy4Heat to better understand the part that ventilation has to play in the safety case for domestic properties in early hydrogen demonstrations. Ultimately, the recommendations made by these projects are based largely on mathematical models, and there is very little real-world data available on the air tightness of varying property types and ages, and the effect that these characteristics have on hydrogen concentrations and patterns of dispersion should an unexpected escape occur.

The problems being addressed by the project are three-fold:

i) Develop a more substantial qualitative understanding of how well ventilated spaces are where a buoyant gas can leak in a variety of real, lived in, domestic properties.

ii) Provide further quantitative data on the dispersion of buoyant gas within actual domestic properties to enable further validation of the mathematical models developed across the industry.

iii) Combine the improved qualitative and quantitative data to validate the recommendations made by current research with regards to the potential use of ventilation, gas detection, and appliance/meter location in early hydrogen demonstrations.

This project is one of the GDNs collaborative projects, led by Cadent, undertaken as part of the End User Safety Evidence working group.

Method(s)

This project is a technical research and development project designed to gather real data on the dispersion patterns of a buoyant gas within a variety of domestic properties. The data is required to further develop the gas industry's current, and largely theoretical, understanding of the effects of building ventilation on gas dispersion in domestic properties after an unexpected escape.

The methods that will be used to provide a solution to the problems outlined above can be grouped into 4 key areas:

i) Development of the test programme: This will include definition of the size/location of leaks to be undertaken in each property and a robust safety procedure to protect householders and those carrying out the tests from the potential asphyxiant effects of helium.

ii) Execution of the test programme: A range of helium releases will be executed in 12 real properties. This will include installation, testing, and decommissioning of all the necessary equipment within each home, as well as measurement of environmental conditions such as temperature and wind speed. Helium measurement equipment will be installed in up to 5 rooms in each property to understand the movement of helium throughout the whole building.

iii) Analysis of the test data: Comparisons between a range of parameters, for example, the rate of increase in helium concentration in different spaces, for each helium release will be made to better inform the existing mathematical models and industry position on hydrogen detectors/any additional ventilation requirements within a property running on hydrogen.

iv) Reporting and dissemination: All of the above will be captured and reported to the HSE and other key stakeholders at various points throughout the delivery phase of the project.

Project delivery will be supported by hiring professional organisations to support Cadent and the other GDNs on the project. Much of the work will involve physical testing in real domestic properties, so it is important that any organisation involved has experience in executing technical test programmes involving the release and measurement of buoyant gas in buildings.

Measurement Quality Statement

The project will utilise top of the range helium sensing equipment to measure the various gas releases in the different properties. This equipment will be tested and validated in laboratory conditions before any helium is released into any of the properties. The sensors will also be calibrated in situ once installed in each property to enable the highest possible measurement quality.

Data Quality Statement

The project will ensure that all necessary data is of sufficient quality and readily available to meet the objectives of the project. Duplicate sensors will be installed throughout the properties, environmental conditions will be monitored, and real-time logging of the

data will ensure any errors in sensing and logging equipment can be quickly corrected.

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. The external project cost is <£500k and is being delivered by a single external supplier. In terms of the data, general assumptions are already known, however, the selection of the properties for testing and the subsequent test plan will be defined within the project and so a slightly higher risk score is attributed to this area.

The assessed risk score is 5 (Low) which allows the project to be governed by an internal assurance approach as set out in NIA Governance and ENIP.

Scope

This project is undertaken in 7 discrete work packages, with an optional eighth work package, which are:

WP1 – Development of the detailed experimental procedure

The experimental procedure will involve releases of helium at different locations in each house. These aim to be as representative as possible in terms of potential leak locations. The locations suggested are:

1. Under the stairs (a common place for siting gas meters).

2. In the lounge (gas fires are often installed and previous work has shown that lounges are commonly more airtight that other rooms).

3. In the kitchen (a common place for gas boilers and cookers to be sited).

Helium will be released at different rates:

- 1.6 m3/h (equivalent to the 'adverse' leak rate from IGEM/SR/25).

- 6 m3/h (equivalent to the suggested set point for an Excess Flow Valve (EFV) on a spur within a property).

- 20 m3/h (the maximum possible leak rate into the property as the meter EFV will stop any gas flow greater than this rate).

Measurements of helium concentration will be made in the room where the gas is released and in several adjacent rooms (up to 5 rooms). The measurements will be carried out at three different heights in the rooms (300 mm from the floor, mid-height, and ceiling height). Helium sensors will be installed at 5 heights in the room of release so that more granular data can be collected, and assessment can be made of the gas interface height.

The measurements will be made using passive sensors which will respond quickly to the changes in helium concentration. This method is preferred as it does not require samples to be extracted from the rooms and is therefore less intrusive than methods used in previous work. To reduce the uncertainty in the measurements, duplicate sensors will be installed at each sampling point. The results of the two measurements will be compared and the uncertainty in the measurements will be estimated. Careful consideration will be given to sourcing these sensors from competitive manufacturers.

The impact of the internal doors being open or closed will also be investigated with the aim to reach equilibrium concentrations of gas in air throughout the house. However, this may not be possible, particularly at the low release rates and this may be adjusted to reaching equilibrium only in the room of release. The decision regarding this will become apparent during the initial testing and the test programme will be limited to two days per house.

A detailed test matrix will be drawn up in collaboration with relevant stakeholders, so that data collection can be maximised with minimum disruption to the householder. The disruption will also be reduced by deploying a large team of engineers and technicians to carry out the experiments.

The detailed test procedure will be informed by some initial householder engagement to assess what will be acceptable in a house. A detailed health and safety plan will be drawn up in conjunction with the test procedure. The health and safety plan will be based on a Risk Assessment (RA) with mitigations identified to reduce risks and consequences. A Method Statement (MS) will then be written

which will detail the procedures to be followed during preparation, experimental measurement, and decommissioning.

An important part of the project development and planning phase will be the specification and procurement of the equipment. This will include the selection of appropriate helium sensors and the development of a custom data logging and processing system.

Before the system is deployed to the test houses the gas delivery and data collection equipment will be trialled in a controlled environment in a laboratory.

WP2 – Selection of houses for study

Twelve houses from the initial twenty-four that have been air permeability tested under a previous research project will be selected for further study. The aim will be to have a spread of property ages, sizes, and air permeabilities.

The householders will be offered a financial incentive to take part, as the work will be quite disruptive to their usual routine. For example, as large quantities of helium will be released into the properties, people (and pets) will not be allowed in the property during the experimental programme. This will be part of the extensive safety plan for the work developed in WP1.

WP3 – Carry out experimental releases

The experimental releases will be carried out following the procedures developed in WP1. It is important that the RAMS procedures are followed completely for installation, testing, and decommissioning. This will ensure consistency of data collection and safety in the operation of the test programme.

Environmental conditions such as temperature and wind speed will also be collected from the properties.

WP4 – Data evaluation

The data collected will be analysed and collated into consistent data files. For each helium release, comparisons will be made using parameters such as:

- Rate of increase in helium concentration
- Equilibrium helium concentration
- Dispersion from room to room
- Effect of internal doors being open/closed
- Impact of different ventilation rates

WP5 – Validating mathematical models

Different mathematical models have been developed which can be used to predict the dispersion of gases within a building. The theory and equations that define the models are complex and are reported on within existing projects.

The results from the helium releases will be used to validate the models. Each house will be modelled, and the predicted helium dispersion will be compared to the measured dispersion. If necessary, model parameters may be adjusted to give a better fit to the data.

WP6 – Reporting and dissemination

The results of the work will be of relevance to a range of stakeholders. As the results of the work will be used to guide policy and technical decisions, it is important that the stakeholders have sufficient time to consider the results and conclusions to enable a robust comment process. Therefore, a relatively long period of time will be allowed for the reporting and dissemination phase.

WP7 – Project Management

A detailed project plan will be developed showing dependencies of tasks, the critical path, and project milestones. The plan will include the resources needed to deliver the project (manpower, expenses, purchases etc.).

Progress will be measured against the project plan in terms of timings and costs. Regular progress meetings will be held (every 2 weeks) and short progress reports will be prepared for each meeting.

A Technical Advisory Committee (TAC) will be established. The TAC will meet at regular intervals (every 6 weeks). The purpose of the TAC will be to:

1) Discuss technical aspects of the work.

2) Assess experimental results.

3) Guide any changes to the experimental work programme.

(Optional) WP8 – Air tightness testing of 9 properties at NGN's Futures Close

It is suggested that a useful extension to the project would be to undertake similar air tightness testing in the nine properties recently built by NGN at Futures Close in Low Thornley. These properties are designed to represent different eras of typical UK housing stock and so extending the work programme to include this testing will enable a better understanding of how the properties compare to the building regulations of their time, whilst also equipping them with baseline air permeability data which can be used to support any further helium, or hydrogen, release testing on the back of this project.

Objective(s)

The objectives of the work are as follows:

- Measure the dispersion of a lighter than air gas following a range of release rates in domestic properties.

- Understand qualitatively and semi-quantitatively how a very light gas moves in complex occupied properties.

- Enable this semi-quantitative understanding to identify the precise location and number of hydrogen alarms that are required within any property to ensure that flammable concentrations do not occur before the alarm can reasonably be heard anywhere in the property.

- Use these measurements to validate a mathematical model which predicts equilibrium concentrations of the released gas in the room of release and in other rooms in simpler property.

- Use the model to predict the concentrations of flammable gas in air to improve the accuracy of ignition consequences modelling from different leaks into properties with different air permeabilities.

- Examine the effects of ventilation on the equilibrium concentrations and the differences between hydrogen and natural gas leaks.

- Draw qualitative and semi-quantitative conclusions on the implications of this for the village trials of hydrogen conversion and for the wider roll-out of hydrogen for domestic heating and cooking.

Provide further data/inputs into ongoing QRA work.

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. This is because it is a research project, and although it does involve the release of helium in the homes of consumers, a robust safety procedure will be put in place. The consumer will also have to agree to having the testing undertaken in their homes and will be paid a financial incentive to take part.

Success Criteria

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. This is because it is a research project, and although it does involve the release of helium in the homes of consumers, a robust safety procedure will be put in place. The consumer will also have to agree to having the testing undertaken in their homes and will be paid a financial incentive to take part.

Project Partners and External Funding

The project partners are:

Cadent Gas Ltd

SGN

Northern Gas Networks

Wales & West Utilities

Potential for New Learning

Ventilation is a key area where better understanding is required to demonstrate to the HSE that hydrogen can be safely introduced into UK households for heating and cooking. Whilst there is a good level of understanding currently, this is largely based on theoretical findings and the release of hydrogen in controlled, laboratory-type environments. This project is a first of a kind opportunity to understand the real dispersion patterns of a buoyant gas in real, as lived-in domestic properties, enabling the consolidation and/or further development of industry's current understanding of the impact of building ventilation on the dispersion of a buoyant gas after an unexpected escape.

Learning will be disseminated to GDNs, HSE and key stakeholders through an interim test data report, and a series of informal discussions/presentations as required, culminating in a final report summarising all learning at the end of the project.

Scale of Project

A thorough understanding of the ventilation patterns of a range of domestic properties is critical to enabling the Hydrogen Village Trial. The scale of investment is justified by the HSE's position on the criticality of the evidence that the project will generate – a smaller scale project (i.e., less houses selected for the helium releases to take place in) would compromise the depth of the data captured and therefore the ability to make well informed conclusions and recommendations in the final reporting phase.

The project is required to cover key evidence gaps ahead of any potential Hydrogen Village Trial. The Village Trial itself is required to inform a UK government policy decision on hydrogen for home heating, and the work done in this project will not only be relevant to a village-sized trial, but to future larger trials and potential national roll out of hydrogen for home heating.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL5 Pilot Scale

Geographical Area

The helium tests will take place in a selection of UK properties. These have already been tested for air permeability under a current project and this work represents a useful extension to the initial testing that has been undertaken

Revenue Allowed for the RIIO Settlement

Not applicable to this R&D project

Indicative Total NIA Project Expenditure

The project is broken down into an agreed fixed cost. The agreed fixed cost for the project is £499,175. The optional work pack 8 will be sanctioned by a contract variation at the time and all Funding Licensees have budgeted for this in their initial NIA sanctioning requests. This gives a Total NIA Expenditure to reclaim of £499,175 broken down into external and internal costs for each funding licensee as follows: External Cost: Total cost £ 499,175.00 (=£469,175 (split) + £30,000 (Cadent only)) % Split Cadent £264,587.50 50.0% NGN £ 58,646.88 12.5% WWU £ 58,646.88 12.5% SGN £117,293.75 25.0% An extra contingency has been sanctioned on the above external costs by each of the networks to protect against any volatility in the cost of helium and the associated measurement equipment. This PEA document will be updated to reflect these new costs in the unexpected event that the contingency funding is required. Internal Cost: Cadent – £66,146.88 NGN – £14,661.72 WWU – £19,549 SGN – £29,323.44

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 is a vital enabler to the Hydrogen Village, which has a considerable benefit in facilitating the energy system transition in addition to contributing to the evidence base for hydrogen for heat policy decision – expected to be made by government in 2026.

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)

Not applicable

Please provide a calculation of the expected benefits the Solution

Not applicable (this is a research project)

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

The intention is for this project to be relevant and therefore replicable to hydrogen trials, usage, and deployment within domestic properties of any size.

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

Not applicable

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 can be used by any network that intends to do a hydrogen village trial or built upon by any network that intends to do any subsequent trials. Additionally, the evidence generated will be able to be utilised by industries exploring the general use of hydrogen in buildings due to the better understanding developed regarding the dispersion of a buoyant gas by this research.

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

Not applicable

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.

Not applicable

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

Not applicable

Additional Governance And Document Upload

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

This project is a vital enabler for the Hydrogen Village trials which is a highly innovative programme that has not been replicated anywhere else in the world, at the planned scale, to date. This project has been initiated as part of the collaborative projects agreed by DESNZ and HSE ahead of the trial commencing.

Relevant Foreground IPR

All relevant foreground IP created as part of the project will follow NIA governance – the data will be available for any technical body to utilise and will not be owned by the technical organisation carrying out the experimental programme in this project.

Data Access Details

All data used in this project will be sourced from published documentation, the test data will be available upon request.

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 select a project and click ‘Contact Lead Network’. Cadent already publishes much of the data arising from our innovation projects here so you may wish to check this website before making an application.

· Via our Innovation website at https://cadentgas.com/future-of-gas

· Via our 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 hydrogen village projects and any of the associated enabling projects, cannot be considered as BAU due to their first of a kind nature and risks which go beyond BAU.

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 has inherent risks due to its first of a kind nature so it is right that it should be supported using NIA funding.

This project looks to uncover technical, operational, and regulatory considerations when determining the suitability of domestic premises across the UK to be repurposed for heating (and cooking) with hydrogen.

This project has been approved by a senior member of staff

☑ Yes