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NIA Project Registration and PEA Document

Date of Submission

Sep 2022

Project Reference Number

NIA2_SGN0030

Project Registration

Project Title

HyCompact Laboratory Testing

Project Reference Number

NIA2_SGN0030

Project Licensee(s)

SGN

Project Start

September 2022

Project Duration

1 year and 0 months

Nominated Project Contact(s)

Alexander Webb

Project Budget

£133,333.00

Summary

This project will carry out laboratory-based testing of a novel hybrid boiler/heat pump system, combined with a smart control system to provide a view of potential network impacts of large scale roll out of the technology.

An understanding of the network impacts and value to the decarbonisation pathway will be essential to both inform policy decisions on support of smart hybrid technology and ensuring the network is able to efficiently accept the technology roll out if this is to occur.

Nominated Contact Email Address(es)

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Problem Being Solved

The key to the success of hybrid technologies is system control. Controls play a key part in determining the performance achieved by products in realistic operating scenarios (as opposed to standardised type testing conditions where many controls are disabled).

The effects of optimum start/stop, automatic weather compensation and the like are difficult to characterise. This is particularly the case if learning algorithms are embedded in the product. Measuring the effects on the performance of products of such controls would require multiple sequential tests.

The control philosophy has the potential to have a large effect on the system efficiency and could be set (for example) to optimise for:

- Most economic – selects the lowest cost option of the available heat sources
- Lowest carbon – prioritises the lowest carbon emitter of the available heat sources

This means that the choice of test cycle to be used to determine performance is complex and depends on the objectives for the user (who is likely to require the lowest cost approach) or policy maker (who might e.g. require control algorithms to prioritise technologies in a specific hierarchy).

This is further complicated by the heat pump generally being of low heat output and thus suited to continuous heating of the property and the boiler being much larger and suitable for bimodal (morning & evening) heating. Bimodal heating results in lower mean internal temperatures resulting in lower energy demand (but comfort levels may not be met at all times). This can significantly reduce the energy savings apparently delivered by more efficient but continuously firing devices.

There is also the issue of the level of comfort experienced by the user. It has been shown in a number of previous studies that the savings achieved have been lower than anticipated. This has often been attributed to the end user preferring to take the savings as an increased level of comfort rather than reducing costs.

In this study we will be comparing 2 control systems on the same product. In order to show improvements, it will be necessary to ensure that comfort levels are consistent between tests.

Method(s)

This project will use Kiwa's Dynamic Heat Loss Test Rig (DHLTR) facility. The DHLTR has been designed to enable performance of wet heating appliances to be measured under dynamic demand conditions. This enables the performance of appliances to be evaluated under conditions typical of the way in which they are operated in normal use.

Testing will be carried in 3 phases:

1. Characterisation of hybrid operation
2. Testing of hybrid with default control system
3. Testing of hybrid with PassivSystems control system

Characterisation of hybrid operation

- Characterise heat pump performance (COP) with no boiler operation, at a variety of operating conditions (external temperatures and flow temperatures)
- Characterise heat pump performance (COP) in the presence of boiler operation, under the same set of operating conditions (and perhaps also different levels of boiler operation), to understand how boiler operation improves heat pump performance (i.e. efficacy of heat recovery)
- Optionally (if gas metering available), also characterise gas boiler performance (efficiency) at a variety of operating conditions
- The hybrid will be operated at a range of external conditions varying load and distribution of heat provider. This data will be used to optimise the PassivSystems control system; the key characteristic is how boiler operation improves heat pump efficiency. This is a very important number to understand, but something that is not covered by the product datasheets and is very difficult to infer from deployments in real houses.

Instrumentation will be required to be placed within the appliance to monitor temperatures, and heat metering will also be necessary.

Testing of hybrid with default control system

The hybrid system will be tested at a range of external temperatures and for 2 different property types, these being an average sized house and a smaller property.

The test conditions will seek to represent the heating load during average spring, average autumn, average winter and more extreme winter conditions. When using conventional boiler systems, the user would normally set heating to bimodal operation during the spring/autumn periods and unimodal operation during the winter and continuously on during an extreme winter period. However, with more advanced controls systems, especially those using predictive control and weather information, these periods will become somewhat blurred.

Testing of hybrid with PassivSystems control system

This part of the test programme would mirror the hybrid testing with the default control system. However, since the PassivSystems controller learns from the behaviour of the property it is necessary to do a number of pretest learning days of operation.

Data Quality Statement

Input data for this project will adhere to data quality dimensions as set out by the Government Data Quality Hub:

- Accuracy: Data reflects reality. High data accuracy allows us to produce reliable analysis.

- **Completeness:** All the data required for a particular use is present and available to be used
- **Uniqueness:** A measure of the number of duplicates. Unique records build trust in the data
- **Consistency:** Data values do not conflict with other values within a record or across different data set. Consistent data improves the ability to link data from multiple sources. This, in turn, supplements your data set and increases the utility of the data.
- **Timeliness:** Whether the data is available when expected and needed.
- **Validity:** the extent to which the data conforms to the expected format

Key input data for this research will be the simulated climatic conditions and building characteristics e.g. size, heat loss coefficient, radiator system.

Recorded data will include gas consumption, electricity consumption, water flows and temperatures in the circuits, the temperatures of the environmentally controlled enclosures, thermostat activity and many ancillary measurements.

The final data will be collated and reviewed in a final report to be made available on completion of the test work.

Measurement quality statement

Each test will be carried out over 1 day and to ensure thermal stability conditions at start and end of test will be matched as closely as possible. Data will be logged every 10 seconds during the test period.

Each test will start (and finish) at a consistent simulated time to provide a consistent start point, but this may have to be altered to match control systems taking weather data from the internet or using a real date/time to anticipate likely weather conditions.

Given the low technology readiness scale of this project additional peer review is required for this project.

Scope

The project will use a dynamic heat load test rig to investigate the use of different control systems on a novel hybrid boiler/heat pump system. This will allow networks to develop an understanding of how the smart control system may impact on consumer demand before applying new demand profiles to network models. This scenario modelling will give an insight into impacts on the network including; asset sizing, operating pressures etc.

An understanding of the network impacts and value to the decarbonisation pathway will be essential to both inform policy decisions on support of smart hybrid technology and ensuring the network is able to efficiently accept the technology roll out if this is to occur.

Objective(s)

The objectives of this project are set out below:

Characterisation of hybrid operation

- The hybrid will be operated at a range of external conditions varying load and distribution of heat provider:
- Characterise heat pump performance (COP) with no boiler operation, at a variety of operating conditions (external temperatures and flow temperatures)
- Characterise heat pump performance (COP) in the presence of boiler operation, under the same set of operating conditions (and perhaps also different levels of boiler operation), to understand how boiler operation improves heat pump performance (i.e. efficacy of heat recovery)
- Optionally (if gas metering available), also characterise gas boiler performance (efficiency) at a variety of operating conditions

Testing of hybrid with default control system

Testing of the hybrid system at a range of external temperatures for 2 different property types, these being an average sized house and a smaller property. The test conditions will seek to represent the heating load during average spring, average autumn, average winter and more extreme winter conditions.

Testing of hybrid with PassivSystems control system

This part of the test programme would mirror the hybrid testing with the default control system. This will require a number of pre-test learning days of operation.

Comparison of the different control systems

A technical report and presentation will be produced, summarising the findings and implications of the testing programme.

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 success criteria for this project are:

- A technical report and presentation summarising the findings and implications of the testing programme

Project Partners and External Funding

KIWA are project partner and will subcontract PassivSystems to supply and assist with testing of the Hybrid Heat Pump/Boiler.

Potential for New Learning

This project will carry out laboratory-based testing of a novel hybrid boiler/heat pump system, combined with a smart control system to provide a view of potential network impacts of large scale roll out of the technology.

The data will be collated and reviewed in a final report to be made available on completion of the test work.

Scale of Project

This project will carry out laboratory-based testing of a novel hybrid boiler/heat pump system, combined with a smart control system to provide a view of potential network impacts of large scale roll out of the technology.

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The project outcomes are not constrained to a specific area. The learnings can be applied to the modelling of any given GB area or energy network configuration.

This project is being carried out in collaboration with funding partners, Wales and West Utilities.

Revenue Allowed for the RIIO Settlement

Not applicable

Indicative Total NIA Project Expenditure

External Cost: £100,000

Internal Cost: £33,333

Total Cost: £133,333

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 carry out laboratory-based testing of a novel hybrid boiler/heat pump system, combined with a smart control system to provide a view of potential network impacts of large scale roll out of the technology.

The flexibility offered by this system can deliver environmental and economic benefits for consumers by optimising the use of fuel to avoid high prices and/or grid electricity with a high CO2 intensity.

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

Flexible hybrid systems can deliver environmental and economic benefits for consumers in vulnerable situations by optimising the use of different fuels to avoid high prices.

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

This is a research project at TRL level 3/4.

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

The project outcomes are not constrained to a specific area. The learnings can be applied to the modelling of any given GB area or energy network configuration.

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

This project will not roll out a specific piece of technology, however the learning will be shared with all networks.

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

Hybrid boiler control systems are capable of responding dynamically to price and carbon signals as well as network constraints. The development of these heating systems can also mitigate the need for expensive network capacity upgrades and/or additional generation.

This project will help networks to understand the potential network impacts of a large scale roll out of the technology.

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.

The scope has been reviewed against all existing projects and no areas of duplications have been identified. All networks were notified of the project, with no objections.

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 builds on that work, focusing on the changes to demand we may see from the use of a hybrid heating system. Work of this type has never been completed and is truly innovative

Relevant Foreground IPR

A report will be produced as part of the project, this will form the foreground IP.

Data Access Details

The data will be collated and reviewed in a final report to be made available on completion of the test work. Further details/data can be accessed upon request via the smarter networks portal

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

The project is carrying out laboratory-based research on an emerging technology. This technology is at a low technology readiness level and as such it is not part of the usual activities of the business.

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project

The NIA framework offers a robust, open framework to support this work and ensures the results are disseminated to all licenses.

This project will carry out laboratory-based testing of a novel hybrid boiler/heat pump system, combined with a smart control system to provide a view of potential network impacts of large scale roll out of the technology

This project has been approved by a senior member of staff

Yes