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 2024

Project Reference Number

NIA2_NGESO066

Project Registration

Project Title

Electrification of the residential heat sector: Spatial and temporal analysis of electricity demand and flexibility

Project Reference Number

NIA2_NGESO066

Project Licensee(s)

National Energy System Operator

Project Start

June 2024

Project Duration

1 year and 7 months

Nominated Project Contact(s)

innovation@nationalgrideso.com

Project Budget

£250,000.00

Summary

The large-scale uptake of heat pumps to decarbonise the GB residential heat sector is expected to significantly impact the magnitude and shape of the electricity demand profiles at different spatial scales. Aggregate electricity demand profiles of heat pumps for regions are different due to varying characteristics of the housing stock that affect number and size of heat pumps that can be installed. This will lead to different level of network reinforcement needs at different Bulk Supply Points (BSPs).
Key objectives of this projects are:

- To estimate half-hourly electricity demand profiles for heat pumps at different spatial scales such as LA and national, for selected future scenarios.
- To quantify technically available flexibility from electrified residential heat

Nominated Contact Email Address(es)

Innovation@neso.energy

Problem Being Solved

- NGESO's current heat pump profiles are derived from gas boiler thermal demand profiles. Due to this, the profiles have been criticised for likely not being representative of heat pumps in reality.
We need better analysis of peak heat demands from electrification. Improved profiles will help this.
- We need more robust flexibility analysis. The current heat model is not able to consider flexibility from the thermal inertia of buildings – only thermal storage.

- There is currently not enough transparency on our regional modelling outputs, due to losing detail within model aggregations and known issues with the heat model regional outputs.
- The current heat model is not able to consider space availability for heat pumps, and only looks at cost comparisons.

Method(s)

To achieve the first objective of the project; which is “to estimate half-hourly electricity demand profiles for heat pumps at different spatial scales such as LA and national, for selected future scenarios”. We will use spatially resolved housing stock data to identify buildings in each region that are suitable for installing heat pumps (e.g. space availability etc. will be considered) – alternatively data on regional heat pumps uptake from Distribution FES will be used. We will enhance an existing model, that for selected heat pump uptake scenarios and a temperature profile, will estimate half-hourly electricity demand profiles for heat pumps aggregated at Local Authorities (LAs) (or BSPs).
To achieve the second objective of the project; to quantify technically available flexibility from electrified residential heat sector. We will use a lumped parameter model to analyse thermal behaviour of buildings, and considering size and operating state of heat pumps, as well as thermal inertia of buildings, we will quantify magnitude (MW) and duration (minutes) of flexibility from electrified residential heat sector.

The project will be delivered in four work packages:

• WP1 – Literature review and specifications of the project’s outputs
• WP2 – Electricity demand profiles for heat pumps
• WP3 – Flexibility from the electrified residential heat sector
• WP4 – Model documentation and handover

Scope

Successful completion of this project will provide a range of short-term and long-term benefits to National Grid ESO, UK PLC and consumers.
Short-term benefits:
The outputs of this project will provide temporally and spatially resolved data for electricity demand needed for heating residential buildings in future years. Such information will inform timely and optimal electricity generation and network reinforcement planning.
A software tool will be built on an existing model to quantify spatial and temporal electricity demand for heat pumps. This software tool with a non-exclusive licence will be provided to National Grid ESO. The software tool can be used in future to update the estimations for electricity demand for heat pumps.
Additionally, flexibility that can be exploited due to thermal inertia of buildings will be quantified. Such data can inform ESO's FES.
Long-term benefits:
Flexibility from residential heat sector will be quantified. It is expected that only using the thermal inertia of buildings could provide up to 40 GW flexibility during typical winter days. Understanding the potential for providing flexibility from electrified residential heat sector will help developing incentives and appropriate business model and flexibility service products.
Exploiting flexibility from the electrified residential heat sector is expected to reduce the need for network reinforcement and peaking generation capacity.

Objective(s)

Key objectives of the project are:

- To estimate half-hourly electricity demand profiles for heat pumps at different spatial scales such as LA and national, for selected future scenarios.
- To quantify technically available flexibility from electrified residential heat sector.

Consumer Vulnerability Impact Assessment

The proposed project will not impact on consumers in vulnerable situations. There are no distributional impacts.

Success Criteria

- Identification of buildings in each Lower Layer Super Output Areas (LSOA) which are suitable for heat pumps.
Estimation of half-hourly electricity consumption of heat pumps at LSOA level and above for buildings within the specified regions.
- Associated estimation of the magnitude and duration of flexibility resulting from electrified heating systems in different temperature scenarios.

- Delivery of the developed modelling tool and source code for calculating the above criteria.
- Delivery of documentation and training so that ESO staff are able to use the model.

Project Partners and External Funding

No external funding is proposed. The studies will be undertaken by Cardiff University.

Potential for New Learning

- New learning on how heat pump operation is likely to affect peak and annual demands, due to the use of real observed heat pump data and the machine learning model.
- New learning on regional distribution of heat pump demand due to latest updated building stock data and heat pump suitability modelling.
- New learning on flexibility which can be unlocked from heat pumps and the thermal mass of homes under different outdoor temperature scenarios.
- A literature review will be conducted in WP1 which will review key methods reported in literature for estimating spatial and temporally resolved heat demand for residential buildings in GB. Furthermore, most up-to-date data that can be used for estimating the heat demand (e.g. housing stock, real operational data for heating technologies, etc) will be identified.
- Documentation and handover of flexibility estimation model. A model documentation will be prepared that describes the model, data and instruction to use the model. Several workshops will be organised at ESO to demonstrate how the model can be used by the staff at ESO.

Scale of Project

The project's scale is directly linked to its scope, which includes developing a modelling tool for calculating the spatial and temporal demand from electrified heating systems and quantify the associated flexibility. The incorporation of new data and methods into this process requires a comprehensive review and associated investment to achieve robust and meaningful outcomes. A smaller project scope would not allow for the depth of development, testing, and validation necessary to address these technical challenges effectively, limiting the potential for impactful insights from the analysis.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The project development will take place at Cardiff University in collaboration with NGESO on-site. The focus of the analysis from the project will be across GB.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£250,000

Project Eligibility Assessment Part 1

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

Outcomes from the project, including improved understanding of the effects of electrification of heat on annual and peak demands, spatially and temporally, will help inform FES analysis and help inform what needs to happen for network planning for the energy system transition. Information from flexibility will also help inform this.

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

Improved outputs on electrification of heat, particularly from the regional demand outputs and heat pump suitability could help provide information on where to target heating technology roll out and where infrastructure may be needed. This could indirectly help vulnerable consumers to decarbonise heating.

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

N/A

Please provide a calculation and/or description of the expected benefits of the solution

N/A

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

The project outputs will cover GB using the housing data and therefore will be applicable across GB/all DNOs areas.

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

The outputs of the project should allow the calculation of the costs of rolling out heat pumps.

Requirement 3 / 1

Involve Research, Development or Demonstration

Projects 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

Involve Research, Development or Demonstration - Please select all that apply

☐ 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 outcomes of this project – improved spatial and temporal analysis of annual and peak demands, and flexibility, due to the electrification of heat – will provide information to Network Licensees which could help them plan for infrastructure and energy security under the FES pathways. The regional aspect of this could be key to Network Licensees, as this could provide more detailed information and/or transparency for their local networks than currently available from the FES modelling.

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. Networks must explicitly mention similar projects that they have considered and how these differ.

Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

Not aware of other work using heat pump trial data and a machine learning model to estimate heat demand regionally. The current ESO Spatial Heat Model does produce bottom-up heat demand from EPC data at Local Authority level. However, its heat profiles are based on gas profiles and its flexibility calculations are only assessed from thermal storage. It also does have known issues with the regional granularity and transparency, such as the loss of granularity in calculation aggregation. The outputs of this project will aim to be integrated alongside the current Spatial Heat Model to prevent duplication.

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 project is innovative due to:

- The incorporation of new data into our modelling which hasnt been used previously, including latest heat pump trial operation data, new EPC and housing related data to most effectively represent heat demands
- New modelling approach and methods using the machine learning model developed

New outcomes including potential flexibility using the thermal mass of buildings (this has not been able to be modelled previously)

Relevant Foreground IPR

- Literature review and specifications of the project's outputs
- Electricity demand profiles for heat pumps
- D2.1 - A report explaining the approach for defining the scenarios and their key characteristics, as well as a dataset that will include

all data representing the scenarios.

- D2.2 - A short report explaining the data collected and the data cleaning process, as well as a dataset that will include data inputs to the model.
- D2.3 - A short report on model validation.
- D2.4 - D2.4: A dataset including the spatially and temporally resolved electricity demand for heat pumps.
- D3.1 – A report describing the method for estimating thermal properties of residential buildings, and a database that will include produced data D3.2 – A report describing the approach for quantifying flexibility from heat pumps and aggregating the flexibility, as well as a dataset that will include the values for upward and downward flexibility
- D4.1 – Model documentation, model (with a non-exclusive licence), a training workshop
- D4.2 – Model documentation, model (with a non-exclusive license), a training workshop

Data Access Details

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'. National Grid ESO 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://www.nationalgrideso.com/future-energy/innovation
Via our managed mailbox innovation@nationalgrideso.com
Details on the terms on which such data will be made available by National Grid ESO can be found in our publicly available "Data sharing policy relating to NIC/NIA projects" at https://www.nationalgrideso.com/document/168191/download.

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

More knowledge is required on heat pump operation and the method of the machine learning model to estimate granular demands which we wouldn't be able to pursue under Business as Usual (BAU). The research developed by the team at Cardiff University and expertise would be valuable to the sector.

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

Successful completion of this project relies on availability of a range of data about housing stock, energy performance of buildings, real-world performance of heat pumps, as well as a team of researchers with multi-disciplinary research expertise in data-driven modelling and machine learning, building physics, and whole-energy system modelling which isn't currently available?? Still not clear why this need NIA support if it's already out there. This relies on support of NIA and would not be covered under BAU.

This project has been approved by a senior member of staff

☑ Yes