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.
Network Licensees must publish the required Project Progress information on the Smarter Networks Portal by 31st July 2014 and each year thereafter. The Network Licensee(s) must publish Project Progress information for each NIA Project that has developed new learning in the preceding relevant year.

NIA Project Annual Progress Report Document

Date of Submission

Jun 2025

Project Reference Number

NIA2_NGESO066

Project Progress

Project Title

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

Project Reference Number

NIA2_NGESO066

Project Start Date

June 2024

Project Duration

1 year and 7 months

Nominated Project Contact(s)

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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.

Objectives

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.

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.

Performance Compared to the Original Project Aims, Objectives and Success Criteria

National Energy System Operator (“NESO”) has endeavoured to prepare the published report (“Report”) in respect of Electrification of the residential heat sector: Spatial and temporal analysis of electricity demand and flexibility, NIA2_NESO096 (“Project”) in a manner which is, as far as possible, objective, using information collected and compiled by NESO and its Project partners (“Publishers”). Any intellectual property rights developed in the course of the Project and used in the Report shall be owned by the Publishers (as agreed between NESO and the Project partners).

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Much of the project period thus far has been focussed on scoping, literature review and comparison of planned modelling methods with external data. The remaining 7 months of the project will be more focused on delivering data and quantitative analyses.
Thus far, the project has delivered expected work packages to schedule. These include:
Work Package 1 - Literature review and specifications of the project’s output
Three sections of Work Package 2:
2.1 - scenario narratives and identification of assumptions for the model
2.2 - summary of data collection, cleaning and initial analysis prior to modelling
2.3 - validation of the model developed for estimating half-hourly electricity consumption of heat pumps. These work packages have been delivered as outlined in the original project aims.

Work Package 1 involved a literature review of existing models relating to heat pump operation and estimating heat demand in general. This also included a review of available datasets relating to heat demand modelling. This was to identify best practice for estimating heat demand regionally and temporally and any caveats of this analysis.

Work Package 2.1 involved identifying which assumptions should be used by the model to define long term scenarios and sensitivity analyses. The data used to align with the spatially resolved model input data in terms of technology uptakes, was the FES 22 scenario data. This was used because it was the most recent publicly available data. The assumptions were split into two groups, one to define long term scenarios and another for exploring sensitivity analysis, and data were sources identified.

For Work Package 2.2, the approach was to investigate different methods for estimating annual heat demand on a bottom-up basis in terms of working from LSOA level. The GB aggregate of these two methods was compared against the ECUK data for verification.

For Work Package 2.3, the approach was to consider different operational profiles for heat pumps and apply a range of weightings of these profiles among the total heat pump stock. This enabled investigation into the effect of different combinations of profiles on total annual and peak demand and to consider which profiles would be most appropriate to represent real world consumer operation of heat pumps.

More detail on the outcomes is described in the Lessons Learnt and Outcomes of the Project sections below

Required Modifications to the Planned Approach During the Course of the Project

No modifications to the planned deliverables, timelines, or cost are planned or required at this stage of the project.

Lessons Learnt for Future Projects

From the literature review and initial analysis of estimating annual demands it was shown that there exists a relatively large amount of uncertainty in estimating annual heating demand. This was deemed to be due to factors such as limited data on housing stock, heat pump performance and occupant behaviour. Factors such as the recent cost of energy crisis and increased working from home since COVID-19 have also added to this uncertainty.

Assumptions were identified for the model to define long term scenarios and sensitivity analyses. These include housing data, EPC data (including data on potential energy efficiency), indoor heating temperatures, efficiency of heat pumps, weather data and heating demand profile patterns.

Two methods for estimating annual heat demand were performed and compared against government ECUK data. Both methods, one using heat demand directly from EPC data, and one using the project's lumped parameter RC model for half hourly consumption, tended to overestimate heating demand compared to the ECUK data. For validation, there will be a focus on comparing the model outputs to external sources.

Different scenarios for heat demand profiles were explored by distributing the aggregated demand among pre-defined heat pump operation profiles, and the effect of different profiles on output demands was analysed. The pre-defined profiles were based on real world heat pump monitored data. The pre-defined operation profiles included were bimodal (similar to a gas boiler profile), daytime and continuous. The scenarios which assumed bimodal and daytime operation profiles for heat pumps resulted in the highest peaks, with the bimodal pattern giving the highest. The continuous profile gave a lower peak and lower total consumption.

More analysis will be done on the sensitivity of these profiles to the assumptions identified above and the effect of flexibility and to determine what profile distribution most heat pump operations fall into. More detailed analysis will also be performed to determine the impact of this geospatially and considering flexibility through pre-heating.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

At this stage of the project, we have gained early insights into the effects of heat pump profile operation on peak demands, whereby continuous profiles can deliver significant reduction in peaks. However, it is too early in the delivery to be able to incorporate this into our modelling quantitatively, as this will require the model outputs, which have not been fully developed yet. This will be further developed as part of work packages 3 and 4.

Data Access

Details on how network or consumption data arising in the course of NIA funded projects can be requested by interested parties, and the terms on which such data will be made available by NESO can be found in our publicly available "Data sharing policy related to NIA projects (and formerly NIC)" and Innovation | National Energy System Operator.

National Energy System Operator already publishes much of the data arising from our NIA projects at www.smarternetworks.org. You may wish to check this website before making an application under this policy, in case the data which you are seeking has already been published.

Foreground IPR

Reports for each of the following work packages:

- WP1 – Literature review and specifications of the project's outputs
- WP2 – Electricity demand profiles for heat pumps (three of four sections)