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 2019

Project Reference Number

NIA_SPEN_0045

Project Registration

Project Title

SAFE-HD (Spatial Analysis of Future Electric Heat Demand)

Project Reference Number

NIA_SPEN_0045

Project Licensee(s)

SP Energy Networks Distribution

Project Start

August 2019

Project Duration

2 years and 5 months

Nominated Project Contact(s)

Gavin Montgomery

Project Budget

£200,000.00

Summary

Electrifying a large amount of heat demand is expected to impact future network infrastructure due to the scale and seasonal nature of heat demand. This project aims to develop and apply methods to explore optimal decarbonisation pathways to determine likely future heating technology mixes against a backdrop of policy, cost and demand uncertainties.

Third Party Collaborators

University of Glasgow

Nominated Contact Email Address(es)

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Problem Being Solved

The Committee for Climate Change (CCC), an independent, statutory body established under the Climate Change Act 2008 has, in its 2018 review of UK progress towards meeting 2030 and 2050 carbon targets, continued to highlight the ongoing difficulties and lack of progress in decarbonising the heat sector.

Deep decarbonisation of residential heating, and thus a considerable shift away from natural gas use by 2050, represents a major challenge. This challenge is made more significant when aiming for a net-zero emissions target which the CCC has recently recommended that the UK Government should legislate. The CCC suggests that for a net-zero target, low carbon heating will need to increase from 4.5% today to 90% in 2050, and unlike the current 80% target where there is flexibility not to pursue some emissions reductions options, a net-zero target requires that low carbon opportunities must be used if available. For this, they continue to strongly promote the uptake of heat pumps as a major part of the solution, whether as a stand-alone system or as an element in a hybrid

system. They recommend that by 2035 almost all replacement heating systems for existing homes must be low-carbon or ready for hydrogen, and from 2025 new homes should not be connected to the gas network. This policy advice is likely to be mandated by the UK Government in the Future Homes Standard.

Heat pumps represent a key technology towards decarbonising the heat sector in the UK, but projected cost savings and system suitability may differ depending on factors relating to dwelling characteristics and occupants. Electrifying large amounts of heat demand through heat pump uptake will also likely impact future electricity network infrastructure requirements due to the scale and seasonal nature of heat demand. In turn, a wide selection of alternatives will also likely play key roles. Therefore, there are many uncertainties with regards to the uptake of alternative heating options making it a challenge for network licensees to predict where and when electricity demand will grow due to heating purposes. For these reasons, this project aims to develop and apply methods to explore decarbonisation pathways for residential heating against a background of policy, cost and consumer uncertainties in order to better inform load related planning studies.

Method(s)

It is proposed that this project will consist of two packages. Package 1 is the core SAFE HD analysis which will be carried out using the following methods outlined below.

Phase 1 - Geospatial Analysis:

This analysis is undertaken to examine the diversity of UK residential heat demand, dwelling characteristics and social demographics, representable for the different nature of distribution networks. Building on this, households will be characterised by their behaviour and attitudes towards alternative heating technology uptake. Critical literature review and stakeholder engagement are important to avoid potential duplication of innovation, this should cover other sectors such as Gas/Heat.

Phase 2 - SAFE-HD Model:

The SAFE-HD model is proposed to be a spatially explicit agent based model (ABM) that will be developed and used to explore the spatial distributions of future electric heat demand under uncertainty. The SAFE-HD model will be ‘soft-linked’ with the whole energy systems model called UK-TIMES (UKTM) in order to account for wider energy system interactions under different decarbonisation pathways for residential heating. The UKTM model, is a long-run single region whole energy systems least cost optimisation model for the UK, that was notably used by the UK Government to inform the ‘Clean Growth Strategy’. Examples of the type of ‘soft-links’ proposed between the SAFE-HD model and UKTM are heat demands, technology characteristics and modelling constraints.

Phase 3 - Network Impact Assessments:

Based on the learning from Phase 1 and the outputs from Phase 2 in the form of spatially disaggregated data, spatial investigations will be conducted to assess how the findings relate to existing network infrastructure. The network planning process is an ongoing process, therefore efforts will be made to permit the tracking of heat demand and technology uptake over time so that triggers for necessary network planning actions such as least regret network reinforcements can be identified.

Package 2 involves analysis of data obtained from early adopters which will complement the work carried out through the SAFE HD analysis. In this package we undertake an analysis of data obtained through a number of existing projects relating to the decarbonisation of heat currently being undertaken in the SPEN network region. This includes a monitoring of heat pumps being installed within new housing developments and 3 phase instantaneous water heaters being installed at a development within Chester city centre. Within this package an attempt to extrapolate the impact of individual LCTs on the overall ADMD will be undertaken.

Scope

This project will have full GB coverage for the residential sector. Based on initial research activities, the spatial resolution could be as high as postcode level for the whole of Great Britain (GB).

Objective(s)

Package 1:

Phase 1 - Geospatial Analysis:
Generate high spatial resolution heat energy demand estimates based on actual energy consumption data and investigate how these heat demands relate to type of heating system, dwelling characteristics and social demographics.
Characterise households by their behaviour and attitudes towards alternative heating technology uptake.

Phase 2 – SAFE-HD Model:

Develop the SAFE-HD agent based model and explore the spatial distributions of future electric heat demand under uncertainty.

Phase 3 – Network Impact Assessments:

Conduct network impact assessments with the aim of identifying least regret network investment options required.
Recommend how the tools and methods developed for the SAFE-HD project can be used by all DNO's.

Package 2:

Extrapolate individual LCTs effect on ADMD.
Assess the impact of heat pumps and electric water heating in off gas grid areas.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

Improve DNO understanding of how to plan for electric heat demand growth under uncertainty which requires whole systems multi-scenario analysis and a deeper understanding of the customer base.

Project Partners and External Funding

Engineering and Physical Sciences Research Council (EPSRC); University of Strathclyde

Potential for New Learning

- Methods for deriving high spatial resolution heat energy demand estimates that relate to actual energy consumption.
- Methods for characterising the customer base in terms of heat demand and behaviour and attitude towards alternative heating technology uptake.
- Methods for undertaking whole energy systems multi-scenario analysis to explore electric heat demand growth under uncertainty. Specific to this, understanding how sector specific models can be 'soft-linked' with whole energy systems models to conduct a more robust analysis.
- This project should lead to recommendations detailing how data analysis methods can be used in order to track heat demand related aspects that may trigger network reinforcements.

Scale of Project

This project is a desktop PC study with the aim of using open-source software freely available for commercial and academic use.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

The SAFE-HD project is aimed at having a geographical coverage of GB. Obtaining high spatial resolution is a priority for this analysis, however, data aggregation may be required in order to deal with very large datasets, or, to align high resolution data with lower spatial resolution data that is at such spatial granularity for anonymity reasons.

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

£180,000

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:

n/a

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)

Estimated cost savings:

Over RIIO-ED2 (5-year period), total estimated distribution network cost savings could range from 1.7 million to 19 million GBP [2012/13 prices].
To the year 2050, total estimated distribution network cost savings could range from 11 million to 180 million GBP [2012/13 prices].

Assumptions made:

- Costs for facilitating extra network capacity: £ / MW 150,000 [2012/13 Prices].
- New HP capacity that has the potential to trigger network reinforcement ranges from 25% to 50%
- The SAFE-HD project can lead to 1 in 20 (5%) of potential network reinforcement schemes being avoided.
- Lower bound estimates for HP peak demand are based on National Grids Future Energy Scenarios results (Figure 2).
- Upper bound estimates for HP peak demand are based on assuming an average HP unit capacity of 6 kW and using FES data for number of HP installations. It is assumed that during an Average Cold Spell (ACS) or a 1 in 20 peak winter day, HPs would be running at or close to maximum rated capacity thus, individual units are assumed to have a peak demand of 6kW.

Please provide a calculation of the expected benefits the Solution

This is a research project.

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

It is proposed that this project will have a geographical coverage of GB which will be carried out using open-source freely available software and datasets. Therefore, all Network Licensees in GB should benefit from the learning from this analysis and will also be able to use the resulting geographical datasets that will be made available. The methods developed and used to carry out this work should also be replicable by all Network Licensees once documented.

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

This research project is aiming to use software that is freely available for both commercial and academic use, therefore, the costs associated to replicate this project will largely be for human resource time required to carry out the work proposed.

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

This research project is concerned with improving load related network planning capabilities by extending the traditionally used approaches to the wider energy system and improving the ability to plan for and adapt to future demand uncertainty. All methods developed and used for this project will be applicable by all other Network Licensees.

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

☑ Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

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 ENA portal has been reviewed and no previous work as outlined in this document has been identified. The proposal for this project has been developed within the Industrial Board for the EPSRC Centre for Doctoral Training in Future Power Networks and Smart Grids, which has several DNO members. The ENA R&D group has also been consulted with.

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 decarbonisation of heat poses a new challenge to network design and operation. The SAFE HD model is a novel approach to assessing the impact of heat demand on the electrical network and will assist the development of cost effective strategies to deal with decarbonisation of heat as it progresses.

Relevant Foreground IPR

n/a

Data Access Details

n/a

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

The development and use of the SAFE HD model is an innovative approach to understanding large scale heat decarbonisation pathways. Such a project does not form part of our business as usual activities due to its innovative nature and lack of in house expertise.

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 outcome and learnings from the project are expected to have significant impact for SPEN and other licensees and will ultimately be expected to deliver benefit for customer. While the foregoing makes the business case strong work of this nature by its nature carries financial risk as the outcome may not be as expected. The fundamental aim of NIA funding makes it possible to carry out such investigative research work. In the event of the project outcome being unsuccessful, the sharing of the learning from the project as required under NIA rules means there will be potential for future cost savings from avoidance of investment into similar investigations.

This project has been approved by a senior member of staff

☑ Yes