SIF Round 3 Project Registration

Date of Submission

May 2024

Project Reference Number

10061352

Initial Project Details

Project Title

HeatNet

Project Contact

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Challenge Area

Whole system network planning and utilisation to facilitate faster and cheaper network transformation and asset rollout

Strategy Theme

Optimised assets and practices

Lead Sector

Electricity Distribution

Project Start Date

01/03/2024

Project Duration (Months)

3

Lead Funding Licensee

UKPN - South Eastern Power Networks Plc

Funding Licensee(s)

UKPN - South Eastern Power Networks Plc

Funding Mechanism

SIF Discovery - Round 3

Collaborating Networks

UK Power Networks

Technology Areas

Active Network Management

Voltage Control

Project Summary

Heat pumps are key technology for decarbonising the UK's building stock, but widespread deployment will have significant impacts on local electricity networks.

HeatNet aims to demonstrate how the coordination of heat pump operation using advanced optimisation algorithms can help address network operators' challenges. Our aim is to develop an independent service offering to networks to accelerate the electrification of heat through new strategies that improve voltage quality and network reliability.

The project will develop novel machine learning tools to manage power loads from heat pumps and help regulate voltage-drops at the grid-edge while making sure our customers can keep warm.

Add Third Party Collaborator(s)

Passiv UK

Imperial Consultants

Project Budget

£164,387.00

SIF Funding

£145,516.00

Project Approaches and Desired Outcomes

Problem statement

According to the 2023 Future Energy Scenarios, there will be at least 900,000 domestic heat-pump installations per year by 2028. To ensure a faster, cost-effective network transformation, new digital tools and commercial arrangements will be required to manage the increased demands from these devices and optimise existing network capacity.

Accurately predicting electrical load growth from heat-pumps is complex. Residential demand characteristics from heat-pumps can vary significantly over a year, due to weather, archetype and consumer segment. For DNOs there are critical uncertainties over where and when heat-pumps will emerge across the network and how to best plan for and manage these new loads.

Maintaining appropriate voltage levels is critical for network stability and DNOs must ensure homes remain within statutory limits (216V to 253V). When demand rises during peak heating times, the increase in current flow can result in higher voltage drops, impacting the quality of the electricity supply. When the voltage drops below the statutory limits, it can reduce performance and nuisance trips of devices, causing issues for customers.

When heat-pump demand on a feeder is closer to a distribution substation it presents less of a challenge, however, demand clustered at the end of the feeder results in greater levels of voltage drop and triggers earlier reinforcement than planned. DNOs already use smart services to actively manage their networks. However, coordinating home heating systems to support the network presents a step change in complexity.

While it is already feasible to incentivise households to switch off electric heating or even remotely manage smart systems during times of network stress, these actions can have negative consumer outcomes. Households could be left cold and uncomfortable, and vulnerable consumers and those in fuel poverty may be exposed to health risks.

There is an urgent need for co-ordinated smart home heating solutions that can address localised LV-network voltage management challenges without sacrificing thermal comfort. DNOs do not intend to directly control these assets, now or in the future but rather procure this as a service.

HeatNet aligns to Challenge 1 and will build on over a decade of R&D in smart heat-pump control optimisation by Passiv UK, to leverage data and digital tools and maximise existing capacity. This includes:

- NEDO Smart Communities (2016) – Heat pump DSR
- FREEDOM (2018) – Aggregated heat pump DSR and demand forecasting
- Bridgend LEM (2020) – Proof-of-concept, optimised heat pump coordination
- EQUINOX (Present) - Testing commercial methods for heat pump control.

Video Description

https://www.youtube.com/watch?v=o3UNHR7YnS0

Innovation justification

HeatNet will explore the opportunity to regulate voltage drops and limit the need for LV-network reinforcement by managing multiple heat-pumps connected at a substation level using advanced optimisation algorithms.

The project aims to develop a novel, independent service procured by DNOs to improve network operations and planning, increase efficiency and reduce cost, whilst helping to accelerate decarbonisation of residential heating systems. The service would ensure thermal comfort is maintained across all homes.

Smart control systems are already being used by suppliers and aggregators to manage distributed energy resources to provide flexibility services, reduce network stress and maintain grid stability. However, this level of modelling and understanding of voltage dependency has not yet been undertaken in the UK. Managing domestic thermal systems presents very different challenges to managing electrical loads such as EV charge-points or batteries. To be acceptable, smart thermal control systems must minimise consumer inconvenience and establish service contracting that sustains comfortable internal temperatures.

HeatNet builds directly Passiv UK's experience in heat-pump smart control who have developed unique predictive heat-pump optimisation algorithms and home-heating/energy modelling capabilities that enable quantitative evaluation of highly complex dynamic scenarios.

Early proof of concept suggests that Passiv's smart-control algorithms can calculate the optimal residential demand shift required to reduce both peak demand and voltage drop across a network to maintain statutory limits. This optimisation would be designed to maintain in-home temperatures (defined by SLA or similar) whilst also minimising network stress.

HeatNet's approach to optimising domestic heat-pumps and local network stability is highly innovative and could not have been funded elsewhere within the price control or as part of business-as-usual activities. Given the phased nature of the SIF, HeatNet is well-suited as it will undertake a feasibility study ahead of further trial or deployment. Similarly, the scale is limited to technical feasibility as appropriate for SIF Discovery. Once established, future phases will engage consumers and relevant stakeholders, (e.g. heat-pump manufacturers, developers) to assess appetite.

Readiness Levels have been summarised as follows:

· Technology readiness: Discovery will enable progression from initial proof of concept (TRL3) to validation (TRL4)

· Integration readiness: Initial levels are low (0), but with scope to modify and transpose existing specifications (e.g. PAS1879 (4)) during future phases.

Commercial readiness: Discovery will develop an initial understanding of the commercial opportunity (1).

Impacts and benefits selection (not scored)

Financial - future reductions in the cost of operating the network

Financial - cost savings per annum on energy bills for consumers

Environmental - carbon reduction – indirect CO2 savings per annum

New to market – processes

Impacts and benefits description

The pre-innovation baseline is that heat-pumps are installed by customers and the DNO has little visibility of their voltage impact on neighbouring customers. It is expected that customer benefits will be realised using HeatNet's optimised load shifting algorithms between localised clusters of heat-pumps on an LV network using smart controls to help reduce seasonal network stress and voltage drop challenges. The benefits identified so far can be tracked using the following metrics:

Financial - Future reduction in the cost of operating the network.

· Average avoided network upgrade costs to the DNO of the HeatNet optimised solution compared to uncoordinated and unmanaged installations

· Better-informed voltage management will lead to reduction in cost from resolving voltage issues, associated site visits, and obtaining a more resilient network

Financial - cost savings per annum on energy bills for consumers

· Long-term savings by reduced distribution use of system (DUoS) costs from reduced socialised costs for network upgrades.

Environmental - carbon reduction -- indirect CO2 savings

· By having a well-managed and prepared network, HeatNet can facilitate faster uptake of heat pump installations ensuring the carbon reductions from these LCTs are delivered sooner.

Metric: Number of HeatNet optimised homes adopted over time (number of households) and CO2 savings from optimised load shifting.

New to market - services

· Although the detail of the commercial mechanisms for HeatNet are out of scope for the Discovery Phase, the project intends to define and monitor the roles and benefits for service providers (suppliers, aggregators) and users (DNO/DSO) in subsequent phases.

· Number of homes benefiting from the HeatNet service, and overall consumer satisfaction with HeatNet optimised connections compared to current unmanaged approach

The Discovery Phase will validate high-level assumptions and identify additional opportunities for benefits beyond those described. The details of potential cost savings to the network, consumer savings, environmental benefits, and opportunities for a HeatNet service will be explored further and quantified during the Alpha and Beta Phases. All benefits are linked to the deployment of the HeatNet solution as a commercial proposition following Beta Phase, although some may be realised during the course of the Project.

Teams and resources

The HeatNet Discovery Phase project team will be comprised of UKPN, ICON and Passiv. It is built on working relationships that have been established through several previous innovation pilots, including FREEDOM (field trial demonstrating multi-home heat pump DSR and demand forecasting) and the ongoing Heatropolis SIF Alpha. All organisations have established strong track records in delivering high-quality applied research and demonstration projects and have well-proven project management capabilities.

UKPN is responsible for providing sufficient network capacity to connect residential heat pumps onto their network. Part of their commitment is to be an enabler of the decarbonisation of heat and not be a blocker to Net Zero. UKPN's Innovation Team has led multiple large-scale network innovation projects focused on the decarbonisation of heat. Work on the HeatNet project will be supported by our DSO and Connections teams who design, undertake, and monitor new and managed electricity supply connections.

Role: UKPN will identify several representative LV networks for the baseline modelling, consisting of a substation with 1-3 feeders. The heat-pump demands will be added until constraints are reached then model the impact of the HeatNet service. This will be used to calculate voltage drop matrix between properties in collaboration with partners.

Passiv has established advanced domestic energy modelling and smart heat-pump control capabilities, evidenced in projects such as SMETER (thermal modelling of homes), 4D Heat (modelling flexibility in residential heat to reduce wind curtailment), Bridgend LEM (modelling the coordination of heat pump demands across 200 homes for a local energy market) and EQUINOX (field trial simulating and testing commercial methods for smart heat-pump control).

Passiv's sophisticated "digital twin" simulation methodology will be used to accurately predict the thermal performance and half hourly annual energy demands of domestic properties, which is particularly important when modelling and controlling non-linear heating systems such as heat-pumps that are slow to respond and have complex interdependencies with external climatic conditions.

Role: Using Passiv's predictive thermal modelling and control capabilities, the team aim to validate HeatNet feasibility to limit voltage drops, by using optimisation algorithms to coordinate and control demands from localised groups of heat pumps.

ICON is at the forefront of analysing technical and economic performance of future low carbon energy systems and regularly provides insight to DNZES, CCC, Ofgem and energy utilities.

Role: Insight into the commercial potential and overall energy system benefits using proprietary tools that could be realised by HetNet service proposition.

Project Plans and Milestones

Project management and delivery

The aim of the Discovery Phase will be to validate the underlying control methodology for the HeatNet service and explore the potential value to the DNO and customers, by modelling heat pump interdependencies and potential dynamic coordination.

The project team has a strong track record delivering innovation projects and demonstrating success through established practices.

The work packages proposed are:

WP1: Project Management (Passiv)

· Aims: Project mobilisation, tracking and reporting.

· Success criteria: Project delivered on time, in budget and to quality standards

WP2: LV network interdependence (UKPN):

· Aims: Identify and use suitable sub-section of UKPN LV network as a baseline network model to identify and define voltage drop interdependence between properties.

· Success criteria: Voltage drop interdependence is defined

WP3: Household energy demand forecasting (Passiv),

· Aims: Create models to understand electricity demand from heat pumps and thermal comfort levels in multiple housing architypes

· Success criteria: Representative architypes defined

WP4: Scenarios for HeatNet (Passiv):

· Aims: Model heat pump installation uptake and explore opportunities for voltage drop limitation through dynamic coordination.

· Success criteria: Identify additional heat pumps installed against counterfactual.

WP5: Cost benefit analysis (ICON):

· Aims: Generate cost-benefit analysis for the HeatNet service by comparing outputs from the baseline and the combined optimisation of a) heat pump load reduction and b) voltage drop optimisation modelling

· Success criteria: System capacity implications and whole-system benefits of HeatNet are identified

Our key risks in the Discovery Phase and mitigation strategies are detailed in the accompanying risk register. Example risks include:

· Proposed solution is more complex than initially perceived

· Outputs from modelling scenarios are not reliable

Project management will be led by Passiv through the implementation of best-practice project planning, governance, regular review meetings and effective reporting.

Passiv will deliver the project using an in-house PMO and in accordance with tried-and-tested methodologies developed over multiple innovation projects. The project will follow clearly defined task-based responsibilities and outputs tracked to dependent task inputs to provide clear oversight to support programme adherence, and mitigation of delays.

We do not anticipate policy and regulatory challenges and there will be no supply interruptions or engagement with energy consumers during Discovery. However we will engage with heat pump owners and manufacturers to assess appetite in future phases, once the technical feasibility has been determined.

There may be need to modify connection requirements prior to adoption as BAU.

Key outputs and dissemination

Learning and knowledge dissemination will be key success criterion for HeatNet. The project will help inform and demonstrate how coordination of residential heat pumps could limit voltage drop and network stress. It will also identify the opportunities and challenges are for the adoption at scale across the UK. The project will also help to validate how flexibility from residential heat can be grown to inform future policy and regulatory decisions. Our dissemination activities will provide clear and consistent messaging and will use a range of communication channels to maximise effectiveness.

The key outputs for each Work Package in the Discovery phase include:

· WP1 - Project Management: End of phase reports (Passiv)

· WP2 - LV network interdependence: Documented and tested voltage drop interdependence matrix between properties. (UKPN)

· WP3 Household energy demand forecasting: Report chapter on representative housing archetypes to be used in optimisation scenarios. (Passiv)

· WP4 Optimisation Scenarios: Report chapter presenting outputs from the application of Passiv's optimisation algorithms, identifying how to coordinate demand from multiple homes to limit the impact of voltage drops. (Passiv)

· WP5 Cost benefit analysis: Outline benefits case for HeatNet service proposition for development in Alpha. (Imperial College)

As part of our initial project set-up phase, we will develop a dissemination plan to identify further communication channels for different groups of stakeholders, such as housing developers, registered social landlords, heat pump manufacturers, and the information that will need to be shared with them. This will ensure the most relevant information reaches each target audience to maximise the effectiveness of the dissemination activity. Our key communication channels will include:

· Dissemination Events: delivering show-and-tell sessions and presentations.

· Working Groups: providing information about the project to relevant industry working groups.

· Industry Events: Energy Innovation Summit, Distributed Energy Show

· Press releases: to increase visibility and grow the profile of the project.

Our project outputs will be uploaded to the Smarter Networks Portal and feature on the UKPN website with specific project

learnings being disseminated at the IUK Show & Tell events. UKPN will look to share project successes and learnings via its social media channels, and the project will be presented at other UKPN events should the opportunity arise.

The HeatNet methodology is still at exploratory stage, with ICON identifying the value proposition and relevant market stakeholders within Discovery. This learning will help ensure the solution developed under this project will not undermine the development of competitive markets.

Commercials

Intellectual Property Rights (IPR) (not scored)

All the project partners will comply with the default arrangements for IPR and Chapter 9 SIF Governance Document.

Prior to starting the Discovery Phase, the project partners will make a declaration of background IP for the consortium agreement that will clearly define the background IP they bring to the project. Specific IP issues arising during project delivery will be addressed by the Project Steering Group.

An IP Register will be created at the beginning during the set-up phase and will be developed and maintained throughout the project. Any restrictions on freedom to operate from individual components or know-how used in Discovery Phase will be evaluated as part of the project delivery.

Value for money

The total cost of the Discovery Phase will be £164,387 with a total SIF-funding request of £145,516, after taking project partner contributions. The project partners are contributing 11% of the total project costs which is more than the minimum 10% compulsory contribution. The contribution will be in the form of labour. This demonstrates commitment to the project from partners as well as value for money to customers.

Breakdown:

UKPN:

- Total costs: £35,875
- Total contribution: £3,588 (10%)
- SIF-funding: £32,287

Passiv UK:

- Total costs: £104,192
- Total contribution: £10,419 (10%)
- SIF-funding: £93,773

ICON s

- Total costs: £24,320
- Total contribution: £4,864 (20%)
- SIF-funding: £19,456

Passiv represent the majority of the cost as they have developed the underlying predictive heat pump control algorithms and will be leading the majority of the workstreams and carrying out most of the modelling work. UKPN represent a relatively small share of costs as they will provide project oversight, and support with initial network design and data inputs.

The project delivers good value for money for four key reasons:

1. An established team. The team has the required skills, and capabilities to deliver this project efficiently and of high-quality. Initial proof-of-concept modelling by Passiv identified a technical capability for coordinating multiple heat pumps to deliver network benefits without compromising residential comfort. UKPN as a DNO will provide key input on network design and considerations and then operational requirements needed to realise the benefits of this new capability. ICON will establish the commercial potential and overall energy system benefits.

2. Building on previous innovation. Previous public and network innovation funded projects have tested smart control of heat pump control capabilities. HeatNet builds directly on these trials and aims to balance the needs of consumers to maintain thermal comfort levels in their homes while limiting voltage drops and reducing demand on the low-voltage network.

3. Proving the value proposition. HeatNet is targeted at unlocking benefits from optimised heat pump coordination to reduce voltage drop and localised stress at the grid edge. The benefits section outlines the opportunities for value creation and metrics for tracking this in more detail. Without this first Discovery phase, the value proposition of HeatNet service will remain unproven.

4. Bespoke modelling: ICON are offering their bespoke models, and tools at no charge to deliver assessments around economic value, network readiness, and business case evaluations.

Supporting documents

File Upload

HeatNet SIF Discovery Rd3 - End of phase summary.pdf - 1.3 MB
SIF Round 3 Project Registration 2024-07-08 10_26 - 65.1 KB
SIF Round 3 Project Registration 2024-05-13 10_37 - 65.0 KB

Documents uploaded where applicable?

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