SP Energy Networks

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

Apr 2025

Project Reference Number

NIA_SPEN_0104

Project Registration

Project Title

LCT Determinator

Project Reference Number

NIA_SPEN_0104

Project Licensee(s)

SP Energy Networks Distribution

Project Start

April 2025

Project Duration

2 years and 3 months

Nominated Project Contact(s)

Andrew Moon

Project Budget

£800,000.00

Summary

The objective of the project is to develop a solution that can identify the number of LCTs (initially HPs and EV chargers) using data gathered from a Low Voltage (LV) feeders.

It is planned that the solution would deliver an output from at least two existing power quality monitor devices, and ideally any power quality monitor available on the market

The HP & EV determinator will enable Network Operators to validate the LCT uptake modelling and thus improve the accuracy of intervention plans. Collecting data allows assessment of when and where to reinforce the network. This data and validated models will help inform networks what demand will look like in the future, and outline what actions are necessary in order to maintain system operation.

Ultimately, the HP & EV determinator will benefit customers by ensuring DNO interventions are prioritised and delivered in timescales which avoid network barriers barriers to the electrification of domestic heat and transport.

Nominated Contact Email Address(es)

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Problem Being Solved

In the UK, there has been and will continue to be a rise in LCT (Low Carbon Technologies) installations, such as heat pumps (HPs) and electric vehicles (EVs). This increased uptake will result in additional strain on an already pressured HV and LV network.

There are currently modelling tools used which aim to predict growth and potential uptake of HPs and EVs such as EV-Up and Heat-

Up, but they are currently unverified with in-situ LCT adoption data. There is a need for the networks to verify these predictions to guarantee the reliability of these modelling tools which will help network planners to optimally allocate investment plans across the network which will reduce over and under investment for the business.

Method(s)

The project employs a multi-stage approach to develop the software solution. The first stage focuses on defining the current and harmonic signatures for heat pumps and electric vehicle chargers. This involves using a power quality monitor to gather data from a low voltage feeder with a known number of homes equipped with HPs and EV chargers. The collected data is then analysed to establish the unique electrical signatures of these devices, which are crucial for their identification in the network.

In the second stage, the project moves on to algorithm development. This stage involves creating a detailed model of the test network and validating it with the data collected in the first stage. The algorithm is iteratively refined using data from the network model, which is varied to generate different datasets for the algorithm to learn from. This process ensures that the algorithm can accurately identify HPs and EV chargers across a range of network conditions. The development of this algorithm is critical as it forms the core of the software solution, enabling it to detect the presence of HPs and EV chargers in real-world scenarios.

The third stage involves extensive field testing to assess and further refine the algorithm. This stage includes deploying the algorithm on multiple LV feeders across different distribution substations. Each test site is carefully selected, and the algorithm's performance is evaluated using data from various power quality monitors. The field tests are designed to identify any accuracy issues and to ensure that the algorithm can reliably detect HPs and EV chargers under diverse conditions. The feedback from these tests is used to make necessary adjustments to the algorithm, enhancing its robustness and reliability.

Throughout the project, a combination of data analysis, modelling, and real-world testing is employed to develop a solution that is both accurate and practical for network operators. The methods used ensure that the solution can provide reliable data on the number of HPs and EV chargers connected to an LV feeder, thereby supporting better network planning and management. This comprehensive approach not only validates the existing prediction models but also helps in optimizing network interventions, ultimately contributing to a more efficient and sustainable electrical grid.

Scope

The scope of the project is clearly defined to ensure focused and efficient development. It includes several key stages aimed at developing a robust software solution to identify the number of heat pumps (HPs) and electric vehicle (EV) chargers connected to a low voltage (LV) feeder. The project begins with the definition of current and harmonic signatures for HPs and EV chargers. This involves deploying power quality monitors on a test LV network to gather data and establish the electrical profiles of these devices. This stage is crucial for creating a baseline understanding of the unique signatures of HPs and EV chargers. Following the initial data collection, the project moves into the algorithm development phase. Here, a detailed model of the test network is created and validated using the collected data. The algorithm is iteratively refined through simulations that vary network parameters, ensuring it can accurately identify HPs and EV chargers under different conditions. This stage is essential for developing a reliable detection mechanism that can be applied to real-world networks. The final stage involves extensive field testing across multiple LV feeders at different distribution substations. These tests are designed to validate the algorithm's accuracy and robustness in diverse conditions. Feedback from these tests is used to make necessary adjustments, ensuring the solution is practical and effective for network operators. The project concludes with the delivery of a comprehensive report detailing the methodology, findings, and a user guide for the software solution. Overall, the project aims to provide network operators with a tool that enhances their ability to plan and manage the electrical network efficiently. By accurately identifying the number of HPs and EV chargers, the solution supports better network reinforcement planning, reduces the risk of overloads, and facilitates the integration of low carbon technologies, ultimately contributing to a more sustainable energy system.

However, the project scope excludes certain elements to maintain focus. It does not include the analysis of LV networks with a high portion of commercial loads, such as industrial estates, nor does it cover the integration or analysis of battery energy storage systems (BESS). Additionally, the development of the software interface for the algorithm, including input screens and results display, is not part of the current project scope and would be considered in a further phase of development. Extensive compatibility testing with all available power quality monitors is also not included; while the project will ensure compatibility with at least two types of monitors, further tests may be required to ensure wide compatibility. By clearly defining what is included and excluded, the project aims to stay focused on its primary objectives, ensuring efficient use of resources and timely delivery of the HP and EV Determinator solution.

Objective(s)

The project has several key objectives aimed at developing a software solution to identify the number of heat pumps and electric vehicle chargers connected to a low voltage (LV) feeder. Here are the main objectives summarized:

1. Establishing Signatures for HPs and EV Chargers: The project aims to define the current and harmonic signatures for a range of HPs and EV chargers. This involves deploying power quality monitors on a test LV network to gather data and establish the electrical profiles of these devices. This stage is crucial for creating a baseline understanding of the unique signatures of HPs and EV chargers.

2. Algorithm Development: The project will develop a detailed model of the test network and validate it using the collected data. The algorithm will be iteratively refined through simulations that vary network parameters, ensuring it can accurately identify HPs and EV chargers under different conditions. This stage is essential for developing a reliable detection mechanism that can be applied to real-world networks.

3. Field Testing: Extensive field testing will be conducted across multiple LV feeders at different distribution substations to assess and refine the algorithm. These tests are designed to validate the algorithm's accuracy and robustness in diverse conditions. Feedback from these tests will be used to make necessary adjustments, ensuring the solution is practical and effective for network operators.

4. Delivering a Comprehensive Report: The project will conclude with the delivery of a comprehensive report detailing the methodology, findings, and a user guide for the software solution. This report will support network operators in using the HP and EV Determinator to enhance their ability to plan and manage the electrical network efficiently.

Overall, the project aims to provide network operators with a tool that supports better network reinforcement planning, reduces the risk of overloads, and facilitates the integration of low carbon technologies, ultimately contributing to a more sustainable energy system.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

The project does not increase vulnerability of customers.

Success Criteria

Must Criteria

These are the essential requirements that the project must meet to be considered successful:

1. Operational Determination: The project must accurately determine when heat pumps and electric vehicle chargers are operational on a low voltage (LV) feeder.

2. Measurement Accuracy: It must measure the number of HPs and EV chargers on an LV feeder with sufficient accuracy as agreed upon by the project team.

3. Phase Connection Identification: The project must determine which phases the HPs and EV chargers are connected to.

4. Load Contribution: It must measure the percentage of total load on an LV feeder due to HPs and EV chargers.

5. Time of Measurement: The project must confirm that the measurement of LV feeder data is required during the heating season.

Desirable Criteria

These are additional requirements that could be considered if there is time and budget remaining:

1. Individual Size Determination: The project could determine the individual size (kW) of HPs and EV chargers connected to an LV feeder.

2. Phase and Location Identification: It could determine the phase and location of the connected HPs and EV chargers.

3. Data Sampling Rate: The project could qualify the minimum data sampling rate required by a power quality monitor to enable the identification of HPs and EVs.

4. Capacity Calculation: It could determine the method of calculating the capacity (power) of an identified HP.

5. Diversification of Coefficient of Performance (COP): The project could determine the likely diversification of COP for HP installations.

6. Measurement Duration Sensitivity: It could determine the sensitivity of the measurement accuracy to the measurement duration.

7. Smart Meter Data: The project could test the feasibility of using Smart Meter data to improve the accuracy of the results.

These criteria collectively ensure that the project delivers a robust and reliable solution for identifying and measuring the impact of HPs and EV chargers on LV networks, thereby aiding network operators in planning and managing their infrastructure more effectively.

Project Partners and External Funding

There are not exernal project partners.

Potential for New Learning

The project has significant potential for new learning, particularly in the context of managing and optimizing low voltage networks with the increasing adoption of low carbon technologies (LCTs) such as heat pumps (HPs) and electric vehicles (EVs). Here are some key areas where new learning can be expected:

1. Usage Patterns of LCTs: The project will provide valuable insights into the usage patterns of HPs and EV chargers. Understanding when and how these devices are used can help network operators better predict demand and manage load on the LV network.

2. Network Utilization and Capacity: By identifying the number of HPs and EV chargers connected to an LV feeder, the project will improve understanding of network utilization. This knowledge is crucial for determining the headroom available on the network and planning for future capacity needs.

3. Impact on Power Quality: The project will explore the aggregating impact of multiple inverter-driven equipment (such as HPs and EV chargers) on power quality levels. This includes understanding harmonic levels and how they compare to G5 planning limits, which is essential for maintaining network stability and performance.

4. Algorithm Development and Data Analysis: Developing and refining the algorithm to identify HPs and EV chargers based on power quality data will generate new learning in the field of data analysis and machine learning. This includes understanding the key variables that impact the visibility of these devices and improving the accuracy of the identification process.

5. Customer and Community Impact: The project will also shed light on the customer and community impact of increased LCT adoption. This includes understanding how network interventions can be prioritized to avoid barriers to LCT uptake and ensuring that network upgrades are targeted to areas with the greatest need.

6. Environmental and Financial Benefits: By improving the accuracy of LCT uptake models and network planning, the project can contribute to more efficient use of resources, reducing the need for emergency repairs and minimizing environmental impact. Additionally, it can help justify financial investments in network reinforcement and other measures.

Overall, the project has the potential to significantly enhance the knowledge base of network operators, enabling them to better manage the transition to a low-carbon future and support the widespread adoption of LCTs.

Scale of Project

The project aims to develop a software solution that identifies the number of heat pumps (HPs) and electric vehicle (EV) chargers connected to a low voltage (LV) feeder. This solution will use data from power quality monitors installed at distribution substations to determine the operational status and load contribution of these devices. The project is divided into three stages:

1. Signature Definition: Establishing current and harmonic signatures for various HPs and EV chargers using existing data.

2. Algorithm Development: Creating and refining an algorithm to identify HPs and EVs based on the collected data.

3. Field Tests: Conducting field tests to validate the algorithm's accuracy and further refine it using data from different power quality monitors.

The project will enhance network operators' ability to manage and plan for the increasing adoption of low carbon technologies, ensuring efficient network reinforcement and improved customer service. The expected outcome is a reliable tool that helps validate and update prediction models for LCT uptake, ultimately supporting the transition to a low-carbon future.

Technology Readiness at Start

TRL2 Invention and Research

Technology Readiness at End

TRL7 Inactive Commissioning

Geographical Area

This project will cover the SPD or SPM Licence areas but can be replicated elsewhere with radial LV network configurations. The project will also study whether the solution would be suitable for interconnected LV networks like the SPM region.

Revenue Allowed for the RIIO Settlement

£11.1 M for between 2023 - 2026

Indicative Total NIA Project Expenditure

£800,000

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:

This project Facilitates the energy system transition by providing a new method for detecting heat pumps and EVs that have gone unregistered. It can also determine the EV and Heat Pump ADMD and usage patterns, to verify the SP Energy Networks Heat-Up Tool. With regular processing of LV monitoring data, targeted proactive network reinforcement can be deployed to reduce the dangers of LCT cluster on looped services and mains cables. This proactive investment will enable LCT deployment across SP Energy Networks and other Network areas.

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

This is not applicable.

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

Cost-Benefit Analysis have been carried out to estimate the project's benefits for the SPD network license area.. In order to avoid overlapping benefits already accounted for in the LV monitoring CBA it was assumed that the solution only provides benefits in the reinforcement of LV cables by providing detailed information on where the new loads are located across the network. As opposed to the detection of secondary transformer and feeder overloading which indicates the load on the feeder and the transformer.

Two separate approaches have considered. The first one, the worst case, where it was assumed that new power quality monitors need to be purchased which then need the moved from substation to substation on a weekly basis. The second one, where the currently installed LV monitors are used for the monitoring so no additional hardware needs to be purchased and where the operation cost is also lower.

	Option 1	Option 2
10 year NPV	£10,168,676	£11,236,425
Whole life NPV	£122,953,038	£125,598,982

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

The solution can be deployed on any network where LV monitoring is present on the transformer secondary feeder cables. The first version of the approach may only be applicable to radial networks, but meshed networks will also be attempted.

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

The rollout is estimated cost between £5.86m and £2.02m for the SPD, if the solution can only use used for radial networks the GB wide rollout would be between £13.94m and £40.43m. In case the solution can be used on interconnected part of the country these figures would increase to £30.3m and £87.9m.

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

Our initial scoping revealed that other network areas also face similar challenges related to unverified LCT installations. The modular nature of this project allows it to be applied without need for a network wide rollout at any radial Network License areas. Each license area can implement the project at the required scale, eliminating the need for a network-wide rollout to realize most of the project's benefits. If deemed useful, the project can be easily scaled up to the necessary size.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

The supplier has the background IP on the LCT signatures. The network models and methodology will be shared with all DNO stakeholder upon request and in a closedown report. This will allow for a Fast Follow by network operators.

Is the default IPR position being applied?

☐ Yes

Please demonstrate how the learning from the project can be successfully disseminated to Network Licensees and other interested parties.

A supplier has the background IP on the LCT signatures. The network models and methodology will be shared with all DNO stakholder upon request and in a closedown report.

Please describe how many potential constraints or costs caused, or resulting from the imposed IPR arrangements.<

None for stage 1.

Please justify why the proposed IPR arrangements provide value for money for customers.

The solution is replicable following stage of the 2-stage post project, either under licence or in house versions, using project foreground IP. The "value for money" is demonstrated through the benefits calculation.

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 project development team have carried out a detail literature review and stake holder consultation. The closest techniques to the project analyse smart meter voltage data to detect LCTs. This approach has some uses cases, but requires enhancements brought about by this project, because the LCT determinator analysis uses the additional hi granularity data from the substation combined with AI models and data training. The Project cannot be regarded as duplication due to these differences.

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

The project development team have carried out a detail literature review and stake holder consultation. The closest techniques to the project analyse smart meter voltage data to detect LCTs. This approach has some uses cases, but requires enhancements brought about by this project, because the LCT determinator analysis uses the additional hi granularity data from the substation combined with AI models and data training. The AI models are train on a real test network, with known LCT and a digital twin. No other project has tried this method before.

Relevant Foreground IPR

1. Customer demand usage profiles i.e. smart meter data, individual customer data.
2. Information on LCT devices connected at customer properties.
3. LV network information (test networks).
4. Usage patterns for HPs and EV Chargers.
5. Refined profiles for HPs and EV.
6. Methodology to develop algorithm to identify HPs and EVs in power monitored data.
7. Version 1 Algorithm for identification of HPs and EV chargers from LV feeder monitored data.

Data Access Details

Data Sharing Policy - SP Energy Networks

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

The methology is currently at TRL 2.

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 project technique requires deveopment and a trial to demonstrate the BaU buisiness case to warrant rollout investment.

Risks:

1. Not being able to define accurate signatures for HPs/EV chargers.
2. Not gaining access to the Cambridge LV substation.
3. Not identifying all HPs and EV charger in the initial dataset.
4. Complications with algorithm training due to variations in data and anomalies.
5. Survey of number of HPs and EVs on substations for Field test 1, 2 and 3 are

not successful or not effective.

This project has been approved by a senior member of staff

☑ Yes