WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Date of Submission

25th January 2021

NIA Project Registration and PEA Document

Notes on Completion: Please refer to the **NIA Governance Document** to assist in the completion of this form. Please use the default font (Calibri font size 10) in your submission. Please ensure all content is contained within the boundaries of the text areas. The full-completed submission should not exceed 7 pages in total.

Project Registration

Project Title

Peak Heat

Project Reference

WPD_NIA_XXX

Funding Licensee(s)

Western Power Distribution

Project Start Date

Febuary 2021

Project Duration

Years	Months
1	3

Nominated Project Contact(s)

Ricky Duke – Innovation & Low Carbon Network Engineer

Project Budget

£269,816

Contact Email Address

wpdinnovation@westernpower.co.uk

Lead Sector

Electricity Distribution	☒	**Gas Transmission**	☐
Electricity Transmission	☐	**Gas Distribution**	☐

Other Sectors

Electricity Distribution	☐	**Gas Transmission**	☐
Electricity Transmission	☐	**Gas Distribution**	☐

Research Area

Network improvements and system operability	☐
Transition to low carbon future	☒
New technologies and commercial evolution	☐
Customer and stakeholder focus	☐
Safety, health and environment	☐

Problem(s)

Domestic heat electrification could have a major impact on Low Voltage (LV) and Medium Voltage distribution network peak loads. Further knowledge is required to understand the resultant load profiles of these new electricity loads and technology shifts (e.g. from Economy Seven storage to Heat Pumps), the impact they may have on networks, and the opportunities they present for flexibility. Furthermore, these loads could be either further compounded or dampened by domestic thermal storage. Off-gas grid areas and new builds are of particular interest since they are likely to experience transition to electric heating early on.

Method(s)

Following the project kick off the project will be comprised of the following work packages (WP):

1. **WP1: Archetype creation -** defining the relevant archetypes of interest to establish the physical demand characteristics taking into account housing physical characteristics and customer factors (e.g. occupancy patterns).

2. **WP2: Heat market landscaping –** characterising the range of technologies (e.g. maturity, cost, size etc.) potentially available and mechanisms which could be deployed to help deliver low carbon electric heating, including domestic thermal storage. Technologies covered will include ground source heat pumps, air source heat pumps, hot water tanks and phase change material heat stores.

3. **WP3: Customer modelling -** exploring the range of impacts on load profiles from heating technologies, storage, and flexibility at a single customer level. Scenarios will include modelling the average winter load and the impact of '1 in 20' peak winter condition for each customer archetype. This WP will use building physics modelling to calculate the heat demand of the different archetypes (graph of input power demand on a half hourly basis).

4. **WP4: Area typology modelling -** representative mixes of house archetypes will be modelled for a sample of four representative distribution (LV) network community typologies at the primary substation level. Analysis of all the LV feeders associated with all of the distribution substations connected to a specific primary will be used to create a number of feeder archetypes (e.g. 10 feeder archetypes) for the purposes of modelling the system. We will provide the necessary distribution grid data (including number of customers connected to each LV feeder). This will help assess the impact that heat electrification will have on typical local distribution networks (average winter day, average winter peak and in a '1 in 20' peak winter scenario). This WP will aggregate the demand profiles at the household level to the LV feeder level. This will be based on diversity assumptions as well as the nature of the

distribution network (i.e. number of customers per feeder).

5. **WP5: CBA, Analysis and recommendations -** drawing together all the findings from the research. This will include conducting a high-level cost benefit analysis (CBA) to identify the potential lowest cost options. This will principally entail comparing the long run marginal cost of upgrading the LV network versus the cost of installing different heat flexibility and thermal storage technologies as a way to reduce peak demand (and therefore the required cost to upgrade the LV network). This will be combined with the outputs of the modelling and market study to form a comprehensive set of evidence which we can use to inform its approach to heat electrification, especially as it relates to the implementation of thermal storage.

Scope

This project presents a unique opportunity to learn to what degree heat pumps will impact the LV networks, during the average winter day, the average winter peak as well as in a 1 in 20 winter event. The project will also investigate the market for domestic thermal storage and the ability of thermal storage to help solve constraints on the distribution network. The project will deliver this through five work packages:

1. Customer segmentation and archetype creation - defining the relevant archetypes of interest
2. Heat market landscaping – characterising the range of technologies with a focus on domestic thermal storage
3. Customer modelling - exploring the range of impacts on load profiles from heating technologies including modelling the impact of '1 in 20' peak winter condition, and the flexibility that these may deliver.
4. Area typology modelling - assess the impact that heat electrification will have on four local distribution network typologies.
5. Cost benefit Analysis, analysis and recommendations - drawing together all the findings from the research. This will include conducting a high-level CBA to identify the potential lowest cost options.

Objective(s)

- Look at the latest heat pump loads based on current strategies around heat pump operation (it should be noted that there has been significant development in controls and optimisation strategies for heat pumps in the last few years).
- Investigate the impact of heat pumps based on specific typology areas, considering the effects of clustering on our network.
- Investigate the trade-off between smart shifting of loads and cost to upgrade the network.
- Access the impact of a peak winter (1 in 20) on the network due to both direct (e.g. poorer heat pump performance in cold conditions) and indirect (e.g. customer behaviour during these events) effects.
- Examine the potential market and role for domestic thermal storage.

Success Criteria

This project will be successful if is clearly identifies and characterises the range of flexibility and storage mechanisms which can be used to help reduce the impact of heat pump loads on the distribution network.

This will be broken down into a number of specific success outcomes:

- Creation of demand profiles that can be incorporated into main business planning tools for future network development planning and load growth modelling

- An assessment and understanding of how heat pumps operate in different types of buildings (e.g. construction, size) and regions of our network. Clarity and further understanding of the impact of factors such as building stock and climate on profiles.
- A better understanding, including profiles, of how heat pumps perform in cold weather conditions.
- Assessing the impact that the electrification of heat will have on different LV distribution network typologies
- An understanding of how and when can heat load be shifted to manage network loading whilst maintaining the required customer service.
- An overview of the sources of flexibility and how thermal storage stacks up as an enabler of flexibility. This includes assessing the overall economic case for these sources versus upgrading the network.

Technology Readiness Level at Start	**Technology Readiness Level at Completion**
2	4

Project Partners and External Funding

Delta-EE will monitor and report on the progress of the project and provide technical support. Delta-EE will deliver the main aspects of the project with our support.

Delta-EE is a leading research and consulting company providing insight across the energy transition including heat, distributed energy, energy networks and energy services. Delta-EE provides research to the new energy industry across Europe through research services and bespoke consultancy projects, depending on the individual client's needs. Their sole focus is providing research, analysis and expertise, with a focus from the customer end of the value chain, to help the energy sector best navigate the energy transition.

Potential for New Learning

The learnings from this project could help inform how the smart control of domestic electric heating could be used to alleviate distribution network constrains across the entire GB network. Therefore the project concept has the potential to benefit any network licensee area that will experience network constraints as a result of increased electrification of heat. The project will also provide knowledge on how different type of heat pumps effect the demand on the network and how demand profiles may change with customer types.

Scale of Project

This project will span 15 months with Delta-EE as the main project partner. The project is a desk-based study that relies on a combination of market research, analysis and synthesis of existing resources and new modelling. The modelling in the project will be built on existing work, where proven to be appropriate / robust, to ensure cost effectively delivery. The modelling will cover four main areas:

- Housing stock characterisation and modelling
- Electrical demand modelling based on heat pump performance characteristics
- LV network demand modelling at the LV feeder and distribution substation level
  Cost benefit analysis

Geographical Area

The project will examine and model the temporal and spatial nature of heat pumps in four areas within our licence areas. These will be broadly representative of different regions of our license area based on different climatic conditions and type of settlement. There will be four different regions modelled, including both urban and rural housing, both in the far north and far south of our areas to allow for different climatic conditions which will have an impact on heating usage. The regions will likely be influenced by our Distribution Future Energy Scenarios (DFES). In network terms, each area chosen will mean modelling the homes served by a primary substation. The desk-based nature of this study means that the research and analyses will be conducted at the offices of Delta-EE.

Revenue Allowed for in the RIIO Settlement

N/A.

Indicative Total NIA Project Expenditure

The total cost drawn from NIA funding will be £242,835.12.

Project Eligibility Assessment

Specific Requirements 1

1a. A 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 systems and 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	☐

Specific Requirements 2

2a. Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees ☒

Please answer one of the following:

i) Please explain how the learning that will be generated could be used by relevant Network Licenses.

This type of study is highly replicable across the GB network and the findings are relevant to all DNOs. This project will document the methodology, including data requirements and modelling to enable other DNO's to replicate on their own networks. This type of study can be deployed across all LV feeders and substations across GB. This would help gain a detailed understanding of the impacts of increased electrification of heat at an LV feeder level under a range of scenarios across the GB housing stock. Furthermore, this study also would identify the relevant technologies that may help to mitigate some of the impact of the resulting increased load.

ii) Please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the Project.

N/A.

Is the default IPR position being applied?

Yes	☒
No	☐

If no, please answer i, ii, iii before continuing:

i) Demonstrate how the learning from the Project can be successfully disseminated to Network Licensees and other interested parties

N/A.

ii) Describe how any potential constraints or costs caused, or resulting from, the imposed IPR arrangements

N/A.

iii) Justify why the proposed IPR arrangements provide value for money for customers

N/A.

2b. Has the Potential to Deliver Net Financial Benefits to Customers ☒

Please provide an estimate of the saving if the Problem is solved.

Based on the DFES, there will be an additional 485,000 heat pumps connected to the distribution grid in 2030 than there are today (Two Degree Scenario, heat pumps with electrical back-up). This represents a significant increase in electricity demand across our network due to the electrification of heat alone.

A typical 9kW (Heat capacity) heat pump (capable of meeting the space heating demand of a modern well insulated 4 bedroom house) could have a power draw of up to 3.6kW in cold conditions if trying to meet the peak heat demand of a house where there has been minimal pre-warming.

Assuming an uncoordinated co-incident peak of 3kW per heat pump could result in an additional peak demand of 1.455GW on WPD's network. This represents a significant increase in load above usual peak demand and could lead to major network constraints and failures affecting many customers.

Using a conservative price of £350/kW increased peak demand at LV level as per the 500MW model outputs used to determine network charges as per Common Distribution Charging Methodology (CDCM), this equates to an additional network upgrade cost of £510m. This cost is for just the distribution network upgrades required to accommodate these additional heat pumps alone.

If the co-incident peak demand from the additional heat pumps can be reduced by approximately 1.5kW using a combination of flexibility measures and thermal storage, this halves the required network upgrade costs to £255m, representing a significant investment saving to be passed on to customers. It is therefore not only important to understand the shape of heat pump demand but also the potential flexible technologies, such as thermal storage that could be used to lower this peak demand and therefore save the network multi-million pound upgrades.

Please provide a calculation of the expected financial benefits of a Development or Demonstration Project (not required for Research Projects). (Base Cost – Method Cost, Against Agreed Baseline).

N/A

Please provide an estimate of how replicable the Method is across GB in terms of the number of sites, the sort of site the Method could be applied to, or the percentage of the Network Licensees system where it could be rolled-out.

This type of study is highly replicable across the GB network and the findings are relevant to all Distribution Network Operators (DNO). This project will document the methodology, including data requirements and modelling to enable other DNO's to replicate on their own networks. This type of study can be deployed across all LV feeders and substations across GB.

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

As a desktop research project, many of the findings of this project are directly relevant to other GB DNOs. The costs of replicating this study in other DNO licence areas will heavily depend on the number of representative areas studied for each DNO and the size of these study areas. Assuming the study areas are broadly similar in nature and number to this project, then the cost of replicating the work is approximately £110k per DNO for conducting another 3 study areas for each network.

2c. Does Not Lead to Unnecessary Duplication ☒

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

This project is unique in that it is the first project of its kind to:

- Look at the latest heat pumps loads based on current strategies around heat pump operation (it should be noted that there has been significant development in controls and optimisation strategies for heat pumps in the last few years).

- Investigate the impact of heat pumps based on specific typology areas, considering the effects of clustering on our network.
- Investigate the trade-off between smart shifting of loads and cost to upgrade the network.
- Access the impact of a peak winter (1 in 20) on the network due to both direct (e.g. poorer heat pump performance in cold conditions) and indirect (e.g. customer behaviour during these events) effects.
- Examine the potential market and role for domestic thermal storage.

If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

This project will unlock information about the physical aspect of heat pumps on the network and how flexibility can be used to mitigate this. Current projects within the industry focus on forecasting of installations. The project has already engaged with the UK Power Networks Team on Heat Street to ensure that this project does not overlap on any of the deliverables.

Additional Governance Requirements

Please identify that the project is innovative (i.e. not business as usual) and has an unproven business case where the risk warrants a limited Research, Development or Demonstration Project to demonstrate its effectiveness ☒

i) Please identify why the project is innovative and has not been tried before

This project presents a unique opportunity to learn to what degree heat pumps will impact the LV networks, during the average winter day, the average winter peak as well as in a 1 in 20 winter event. The project will also investigate the market for domestic thermal storage and the ability of thermal storage to help solve constraints on the distribution network.

The learnings from this project could help inform how the combination of smart control of domestic electric heating and domestic storage could be used to alleviate distribution network constrains across the entire GB network. Therefore, the Peak Heat project concept has the potential to benefit all network licensees. The project has already engaged with the UK Power Networks Team on Heat Street to ensure that this project does not overlap on any of the deliverables.

ii) Please identify why the Network Licensee will not fund such a Project as part of its business as usual activities

Low TRL level and a research project.

iii) 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

Low TRL level.

Additional Registration Questions

These are required for summary section of registration; some areas can be copied from sections above.

Technologies (select all that apply)

- ☐ Active Network Management
- ☐ Asset Management
- ☐ Carbon emission Reduction Technologies
- ☐ Commercial
- ☐ Condition Monitoring
- ☐ Community Schemes
- ☐ Comms & IT
- ☐ Conductors
- ☐ Control Systems
- ☐ Cyber Security
- ☐ Demand Response
- ☐ Demand Side Management
- ☐ Distributed Generation
- ☐ Environmental
- ☐ Fault Current
- ☐ Fault Level
- ☐ Fault Management
- ☐ Harmonics
- ☐ Health & Safety
- ☒ Heat Pumps
- ☐ High Voltage Technology
- ☐ HVDC
- ☐ Low Carbon Generation
- ☐ LV & 11Kv Networks
- ☐ Maintenance & Inspection
- ☐ Measurement
- ☐ Network Monitoring
- ☐ Overhead Lines
- ☐ Photovoltaics
- ☐ Protection
- ☐ Resilience
- ☐ Stakeholder Engagement
- ☐ Substation Monitoring
- ☐ Substations
- ☐ System security
- ☐ Transformers
- ☐ Voltage Control
- ☐ Gas Distribution
- ☐ Gas Transmission

☐ Electric Vehicles ☐ Meshed Networks ☒ Electricity Distribution

☐ Energy Storage ☐ Networks Automation ☐ Electricity Transmission

Project Short Name

Peak Heat

Project Introduction

This project presents a unique opportunity to learn to what degree heat pumps will impact the LV networks, during the average winter day, the average winter peak as well as in a 1 in 20 winter event. The project will also investigate the market for domestic thermal storage and the ability of thermal storage to help solve constraints on the distribution network. The project will deliver this through five work packages:

- Customer segmentation and archetype creation - defining the relevant archetypes of interest
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- Customer modelling - exploring the range of impacts on load profiles from heating technologies including modelling the impact of '1 in 20' peak winter condition, and the flexibility that these may deliver.
- Area typology modelling - assess the impact that heat electrification will have on four local distribution network typologies.
- Cost benefit Analysis, analysis and recommendations - drawing together all the findings from the research. This will include conducting a high-level CBA to identify the potential lowest cost options.

Project Benefits

- Up to £255m could be saved by 2030 in the form of avoided network reinforcements based on the learnings of this project.
- Carbon saving benefits (and increased speed of decarbonisation)
- Potential for more reliable service as the dynamics of heat pumps uptake are better understood and anticipated.
- Helping customers to decarbonise their heating.

PEA Version	**1**		
	Name and Title	**Signature**	**Date**
Prepared by	Ricky Duke – Innovation & Low Carbon Network Engineer		05/01/2021

Approved by			