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

Mar 2022

Project Reference Number

NIA_WPD_065

Project Registration

Project Title

Demand Forecasting Encapsulating Domestic Efficiency Retrofits (DEFENDER)

Project Reference Number

NIA_WPD_065

Project Licensee(s)

National Grid Electricity Distribution

Project Start

March 2022

Project Duration

1 year and 5 months

Nominated Project Contact(s)

Nick Devine

Project Budget

£915,989.00

Summary

Net Zero decarbonisation of domestic buildings will happen through low carbon heating, smart tariffs and energy efficiency retrofits of building fabric. The representation of the interactivity between these measures is limited in forecasting tools. Future demand, and network reinforcement requirements, may currently be overestimated. It is also unknown if there are opportunities for DNOs to promote energy efficiency as an alternative to reinforcement.

DEFENDER will seek to address these issues through two workstreams. Workstream 1 will create an analysis tool capable of generating pre- and post-retrofit load profiles based on actual domestic data for use in network forecasting. Workstream 2 will carry out an economic analysis of opportunities for electricity networks to promote energy efficiency retrofit within current and future commercial and regulatory arrangements.

Third Party Collaborators

Carbon Trust

Hildebrand

GHD

Frontier Economics

Problem Being Solved

Net Zero decarbonisation of domestic building stock is expected to be achieved through a combination of: low carbon heating (primarily through electrified heat pumps); smart tariffs and demand management incentive schemes; and energy efficiency retrofits of building fabric. Understanding the net effect of these measures in combination is crucial for accurate electricity network forecasting, but the representation of this interactivity in forecasting best practice is minimal. In particular, the influence of building fabric on heat

pump performance, as modulated by energy efficiency retrofits, is captured in limited fashion. As such, future domestic electricity demand, and therefore network reinforcement requirements, may currently be overestimated. Furthermore, it is currently unknown where there is a business case for DNOs promote adoption of energy efficiency measures as a cost-effective option to mediate or obviate reinforcement or flexibility costs.

Method(s)

The DEFENDER project will develop, through two workstreams, the capability of electricity networks to accurately assess the impact of energy efficiency retrofits on current and future demand, and understanding of the business case for retrofit investment as an alternative to reinforcement.

Workstream 0 – Specification

This workstream will carry out workshops with all project partners and WPD engineers to produce the specification for the Workstream 1 demand profiling tool and the Workstream 2 investment appraisal tool.

Workstream 1 – Development of Pre- and Post-Retrofit Profiling Tool

This workstream will create an analysis tool capable of generating domestic ADMDs and load profiles based on actual heat data for a large number of property types for use in network forecasting and planning. This will be achieved through integrating a number of inputs:

- A smart meter database of 15,000 homes' gas and electricity consumption data owned by Hildebrand, a project partner.
- Heat Transfer Coefficients (HTC) from the SMETERS project, which used BEIS validated algorithms to calculate building thermal performance from smart meter data.
- A Building Decarbonisation Options Appraisal Tool developed by Carbon Trust, a project partner, which can determine the impact of retrofit measures on the building's heat loss factor (U value).
- The Energy Performance of Buildings Register, which contains EPCs for homes in England and Wales, which include heating and fabric data amongst other useful information.
- Local weather data.

The workstream will consist of the following work packages:

WP1.1. Tool development part one: Pre- and post-retrofit demand ADMD and half-hourly profiles.

This work package will develop the capability for simulating historical and future power demands, taking into account different energy efficiency measures. A model will be trained on the smart meter dataset to be capable of deriving before and after building fabric retrofit heat demand and quantify this as historical and future ADMD and load profiles, including transference of gas demand to electricity demand.

WP1.2. Tool development part two: Network planning outputs

This work package will develop the capability for using machine learning techniques on the profiles developed in WP1 to cluster houses into housing archetypes and calculate mean annual load profiles and ADMDs for each archetype with and without energy efficiency measures.

WP1.3. Testing of profiling tool

This work package will develop, agree and implement a system integration and user acceptance (UAT) process for the profiling tool between project partners. Following successful approval of the tool after testing, it will develop the necessary handover materials.

WP1.4. Applying the profiling tool to DFES forecasting

This work package will define a methodology will be defined for applying the outputs of the profiling tool to Distribution Future Energy Scenario (DFES) modelling. The utility of the new profiles will then be analysed with a network case study. The outcomes of these studies will be compared and contrasted with WPD's existing forecasts using its current profiles and alternative approaches as identified by a literature review.

WP1.5. Cost-benefit analysis of energy efficiency improvement

This work package will carry out a cost-benefit analysis of the value to network operators of investment in the energy efficiency of homes. This will be done in two ways: firstly by conducting a CBA of investment in energy efficiency per house archetype and the case

study area in WP1.4, and secondly by transforming the outputs of the profiling tool into inputs to the retrofit investment tool developed in Workstream 2.

Workstream 2 – Appraising Investment in Energy Efficiency

This workstream will carry out an economic analysis of the business case and opportunities for WPD to promote energy efficiency retrofit. It will support this analysis with the creation of a tool for constraint management optioneering capable of assessing the value of energy efficiency retrofit, while accounting for the uncertainty in investment outcomes. This tool will be developed for a limited area of WPD's network, with a view to ensuring its building blocks are reusable as part of potential further economic analysis around energy efficiency.

WP2.1. Development of investment appraisal tool

This work package will develop the economic assessment methodology and investment appraisal tool in R or Python in agile fashion, based on the specification document, with regular feedback to WPD and updates to the design document.

WP2.2. Analysis and insights

This work package will carry out an economic analysis using the investment appraisal tool to consider the conditions where the value from energy efficiency retrofits is most certain for electricity networks. It will evaluate the outputs of the investment appraisal tool and assess what the outcomes mean at various scales (e.g. strategic business plan level vs day-to-day operational) and will analyse the remaining knowledge gaps. It will capture the existing regulatory and commercial context for electricity networks on energy efficiency, assessing the possibilities within existing strictures and the opportunities that may develop in the future.

Scope

Absent network monitoring on the HV and LV networks to provide measured load data, network loading is typically forecast using a profile class-based allocation method. Load growth due to LCT connections such as heat pumps is calculated from technology baselines and added to these profile classes. Traditional network connection costs are met by both the user and the DNO and its customers. As such, when connection assessments identify reinforcement needs, the costs to both increases. It is likely that current methods are overestimating these requirements by overstating the existing and future demand on these networks by not incorporating demand shifts due to energy efficiency retrofits.

Incorporating real pre- and post-retrofit energy demand data, into network modelling will provide a more realistic picture of the current and future demand of domestic buildings. It is expected that these profiles will lower the overall forecast demand, both in maximum demand and in representative daily profiles. This would allow for significant cost saving in new connection and general reinforcement expenditure by reducing the need for both. In the long term, these savings can be passed along to customers in DUOS charge reductions. Savings may also be passed along to connection applicants and customers by reducing or eliminating reinforcement charges.

Currently, within the RIIO-ED2 Business Plan it is projected in WPD's Best View that there will be an approximately increase in peak demand of more than 2GW, resulting in a primary and secondary reinforcement spend in ED2 of £635m, at a cost of approximately £318k per MW. Around 600k heat pumps are expected to be installed within the same period, increasing electrical demand from heating by approximately 1.8GW under current modelling estimates. A 6% reduction in this demand due to energy efficiency retrofit, as per a 2020 Committee on Climate Change study on residential heat decarbonisation trajectories, could result in an estimated £38m in reinforcement savings in ED2 alone.

Objective(s)

Develop an understanding of the electricity demand profile of UK domestic building stock pre- and post-retrofits to building fabric.

Produce a methodology for integrating pre- and post-retrofit domestic demand profiles into network forecasting.

Assess the potential savings on network reinforcement and flexibility from accounting for energy efficiency in demand forecasting.

Perform an economic assessment of the potential benefits to networks from increased penetration of domestic retrofit interventions.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

N/A

Success Criteria

A profiling tool will be delivered which is capable of generating archetype demand profiles for domestic buildings pre- and post-retrofit, including transference from gas to electric heating.

An investment appraisal tool will be delivered which is capable of supporting analysis of the business case for WPD investing or promoting energy efficiency as constraint management option.

The economic assessment will identify what, if any, are the most certain potential benefits to networks from energy efficiency.

The economic assessment will identify what, if any, are the opportunities to pursue these benefits within the existing regulatory and commercial landscape.

The profiling tool will be reusable and can be re-run with updated data.

The outputs of these tools can be integrated into distribution network forecasting and planning.

The methodology for the tools will be replicable across all distribution networks.

Project Partners and External Funding

Carbon Trust
Hildebrand
GHD Consultants = £22,000
Frontier Economics = £31,000

Potential for New Learning

Parties are expected to learn from this project the impact of energy efficiency retrofit on current and future domestic demand, how the findings may be implemented in network modelling and the overall effect on forecasting planning this would have. Furthermore, the project will develop learning of the network benefits to customers from increased uptake of energy efficiency and how networks may best access the benefits.

Learning from this project will be published within the DEFENDER final reports. These reports will contain a summary of the learning and descriptions of the approach used to create the tools developed by the project. The learning will also be presented at WPD Innovation Showcase events. This knowledge and information will allow DNOs to develop a similar approach to domestic building modelling and more accurately identify their own reinforcement needs due to changes in energy demand.

Scale of Project

This project will be desktop only, encompassing a data analysis exercise on a pre-existing dataset and development of two software tools. The development of software tools will increase the value compared to a one-off analysis by allowing the learning to be continually updated with real data, which justifies the additional cost. No data collection will be required specifically for the project, as it will use Hildebrand's existing dataset.

Technology Readiness at Start

TRL4 Bench Scale Research

Technology Readiness at End

TRL8 Active Commissioning

Geographical Area

The data used in the project will relate to properties linked to Hildebrand's smart meter database, which comprises 15,000 homes within and without WPD's four licence areas. The network area for a case study will be identified during the project and may be drawn from models of any of the four licence areas. The tools developed in the project will be applicable across all four licence areas.

Revenue Allowed for the RIIO Settlement

N/A

Indicative Total NIA Project Expenditure

Total project cost = £968,989

Agreed partner contributions = £53,000

Sub total = £915,989

WPD DNO Contribution = £91,599

Funding from NIA = £824,390

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)

Currently, within the RIIO-ED2 Business Plan it is projected in WPD's Best View that there will be an approximately increase in peak demand of more than 2GW, resulting in a primary and secondary reinforcement spend in ED2 of £635m, at a cost of approximately £318k per MW. Around 600k heat pumps are expected to be installed within the same period, increasing electrical demand from heating by approximately 1.8GW under current modelling estimates. A 6% reduction in this demand due to energy efficiency retrofit, as per a 2020 Committee on Climate Change study on residential heat decarbonisation trajectories, could result in an estimated £38m in reinforcement savings in ED2 alone.

While not quantifiable until the outcomes of the project are produced, should the economic analysis identify opportunities to derive network benefits by increasing uptake of efficiency retrofits, this may allow customers to save on the costs of the net zero retrofit of their homes. UK wide, this is estimated to require £330bn investment.

Please provide a calculation of the expected benefits the Solution

While including development of software, the tools created will not be sold as a commercial product.

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

The approach is replicable across DNOs. The estimated savings may vary with the assumptions used by other DNOs in their forecasting approaching. However, it is reasonable to assume that other DNO will be taking a similar worst-case approach, and as such this more data-driven methodology will similarly reduce estimated reinforcement requirements.

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

The project will include a cost-benefit analysis of the full BAU rollout of latency flexibility and will ensure the cost-effectiveness of the product is calculated before recommendations for implementation in BAU or further NIA projects.

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

The methodology for generating the demand profile outputs will be developed so that any DNO may implement the same approach within their own forecasting. The profiling tool will be open source for adaptation for different datasets. Furthermore, the methodology for integrating the outputs into DFES will be shared so that DNOs may adapt it for their own forecasting tools. As such, the cost benefit of the outcomes of this project will be applicable across all DNOs.

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

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 methodology for DEFENDER has been reviewed against other projects registered on the Smarter Networks Portal and circulated with other DNOs and TNOs ahead of registration to ensure no unnecessary duplications will occur.

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

UKPN's Heat Street project included in its methodology an approach for integrating uptake scenarios for energy efficiency measures into DFES. However, the demand impacts were modelled from high-level datasets such as NEED. DEFENDER will use machine learning to generate demand profiles from real smart meter data using a new HTC algorithm developed in SMETER.

Additional Governance And Document Upload

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

This project will take an innovative approach to generating ADMDs and load profiles for domestic buildings for use forecasting and modelling based on real smart meter data. Previous approaches in NIA and BAU are based on static assumptions and profiles (e.g. linear scaling of Elexon profiles) or from high-level datasets (e.g. NEED framework) and are not drawn directly from real, granular data. Furthermore, the business case for energy efficiency interventions is not currently established within tools such as the Common Evaluation Methodology.

Relevant Foreground IPR

The Relevant Foreground IPR is:

- All summary reports and technical documentation produced for the work packages described in section 2.2.
- The demand profiling tool, the code for which will be made open source
- The investment appraisal tool

The Relevant Background IPR required to produce this is:
- Hildebrand's smart metering database
- The HTC algorithm learning from the SMETER project, as described in section 2.2
- Carbon Trust's Building Decarbonisation Options Appraisal tool, as described in section 2.2

Data Access Details

Hildebrand's smart meter dataset will not be shared with any project partners, instead adopting a 'walled garden' approach whereby only the algorithm learnings will be shared externally. This approach would need to be adopted by any interested parties.

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

WPD does not normally fund the generation of new demand profiles in BAU activities, as historically demand profiles are matched to the Elexon profile set. The business case for and validation of a new approach is not proven, and as such is too high risk for BAU.

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 model to be developed in DEFENDER for creating profiles is unproven, and there is inherent risk that the approach does not meet validation criteria. Additionally, there is a risk that even if valid, the business case is not justified for adopting the new approach over existing methods. The development of pre- and post- retrofit demand impacts requires external knowledge of building retrofit not inherent to WPD, and an innovation trial with key specialist skills is the most sensible approach.

This project has been approved by a senior member of staff

☑ Yes