Date of Submission

March 2021

Project Closedown Report Document

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Project Title	**Project Reference**
Low Carbon Heating Uptake Modelling (HEAT-Up)	**NIA_SPEN_0037**

Funding Licensee(s)	**Project Start Date**	**Project Duration**
SP Distribution and SP Energy Networks	August 2020	8 Months

Nominated Project Contact(s)	**Year**
Jack Haynes, Milana Plecas	February 2021

Scope

The decarbonisation of heating in our homes will be a significant driver towards meeting Scotland's 2045 and the UK's 2050 Net Zero targets. The transition to Low Carbon Technologies (LCT) such as heat pumps will put increasing pressure on the low voltage (LV) networks through increased demand for electric heating. To ensure the network continues to provide the high level of service required for customers, there is an increasing need to improve forecasting to enable targeted investment decisions to be made at the lowest overall cost, whilst at the same time minimising network risk.

HEAT-Up is designed to model the scale of challenge facing the electricity network from the increased demand created by this shift from gas and oil to low carbon heating. Heat-Up has developed a methodology to model expected heat demand across the entire SP Energy Networks area. The model is hyper-granular and provides demand outputs which can be assessed against current supply capacity.

HEAT-Up will contribute to the development of data sets to improve understanding of customers' ability to transition to different types of low carbon heating. This will enable SPEN to have greater visibility of the network areas most likely to see increased domestic demand, therefore better informing the prioritisation of future investment programmes.

The core scope of the Heat-Up methodology included:

- Identifying and sizing properties
- Categorising properties
- Assigning properties to adoption groups
- Demand impact calculations
- Applying demand calculations to the adoption scenario

Heat-Up utilises the same platform and a similar methodology to the recently completed EV-Up (Electric Vehicle Uptake Modelling) project which provided an understanding of customers' likelihood to transition to electric vehicle use.

Objective(s)

- Development of data sets and methodologies to improve understanding of customers' likelihood to transition to different types of low carbon heating technologies
- Creation of an accessible toolwhich can model where and in what quantity, heat pumps and other forms of electrified heating will come online across the SP Energy Networks distribution areas.
- Create a model which will calculate the resulting demand on the LV network.
- Enablement of a workflow which has the flexibility to incorporate new changes to legislation, customer behaviour and technology advancement into the model.
- Creation of outputs which can be used to identify the areas of the network requiring reinforcement intervention.
- Provide consistent outputs across Heat-Up and EV-Up to enable combined analysis of the impact of low carbon heat and transport technologies on the network.

Success Criteria

- The Heat-Up product can be used by SPEN as a business as usual forecasting tool
- The outputs from the tool are considered powerful enough to be used in discussions with the Scottish Government and other influential stakeholders

Performance Compared to the Original Project Aims, Objectives and Success Criteria

The project has successfully delivered the following:

1. Research and development into datasets which can be used to assist in the modelling of future energy scenarios.
2. A robust methodology and model to predict and understand where heat pumps and other low carbon heating technologies will come online across the SP Energy Networks distribution areas.
3. An ability to incorporate new changes to legislation, customer behaviour and technology advancement into the model.
4. Output datasets which can be combined with SPEN network capacity models to identify the areas of the network that require reinforcement/ intervention.
5. Output datasets from Heat-Up and EV-Up which combined can provide demand data which can be integrated with the supply side network capacity models to inform the impact of low carbon technologies on the network.
6. Output Dashboards which provide a quick and clear view of the overall impact of each modelled scenario.

Heat-Up Approach in Detail

In addition to delivering the Heat-Up product itself, the project has documented the methodology and calculations used to ensure transparency and enable users and other stakeholders to understand in detail how the model works. The next section outlines those methodology steps and calculations at a high level.

The Heat-Up methodology is significantly more complex than that created for EV-Up. At its highest level, it consists of two elements:

1) The setting up of a core dataset where properties are categorised and assigned a series of flags relevant to the calculation of their low carbon heating demand.

2) A calculation model which takes user input forecasts of future adoption levels and uses the core dataset to calculate the resulting additional demand those future adoption levels will generate. Those calculated outputs are then provided both as a dashboard and dataset.

Those two elements consist of a series of interconnected processes and calculations which are described in detail below.

Core Dataset Creation

Identifying and sizing properties

The first step in the process was to identify in-scope properties and add some key attributes to those properties for use later in the methodology. This was done using the highest quality OS topographic and address data available. The key steps were to:

1) Identify SPEN Area Properties
2) Identify properties that share a building
3) Calculate the number of storeys in a building
4) Calculate property square meterage
5) Identify number of external walls

Categorising properties

Once key property characteristics were defined, properties were categorised to help define when they might adopt an LCT heating solution. This was primarily completed using Experian Mosaic data

1) Identifying and flagging properties for size
2) Identifying and flagging properties for ownership type (owned/rented etc.)
3) Identifying and flagging properties for the Legal and Taxation Environments
    - Adoption of LCT heating is often likely to be encouraged through legislation or taxation. However, this will vary depending on demographics - e.g., large homeowners may get tax incentives whereas landlords providing social housing may be forced to switch through legislation designed to protect tenants.

Assigning properties to adoption groups

Building on the above categorisation, a set of "Adoption Groups" were defined. Each property was then assigned to the adoption group it was deemed most likely to be part of (via a set of agreed business rules). This ensured a level of market segmentation to enable the application of modelling parameters appropriate to that particular adoption group. The groups identified were:

- Off gas
- Small social
- Medium and large social
- Large owned or rented
- Medium owned or rented
- Small rented
- Small owned

Applying appropriate demand calculations

The amount of electricity demand generated by LCT heating alternatives varies significantly depending on the type of property, insulation levels, the outdoor ambient temperature, and the type of LCT heating used. The key demand calculations processed by the Heat-Up module calculate the following values for each property:

- Annual heat demand – the heat energy in kWh required to heat the property for a year
- Max draw – the instantaneous draw in kW the property heating source will draw at the point of connection
- Annual electrical consumption – the electrical energy in kWh required from the electricity grid to heat the property for a year

- Seasonal electrical consumption – the electrical energy in kWh required from the electricity grid to heat the property for each season (spring, summer, autumn and winter)

Specifically, the property characteristics considered when calculating the demand figures are as follows:

- Square meterage
- Storeys
- External walls
- Levels of insulation in the roof, window, walls and floor
- External ambient temperature

Model Calculations

Demand calculations by LCT heating type

The type of property, type of insulation and external ambient temperature all impact the amount of electricity required by a given LCT heating device. Regression analysis was used to calculate a series of demand curves for heat pumps, electric radiators and district heating. Informed assumptions were used in the creation of these curves.

Heating type calculations

Electrical energy consumption varies depending on heating type and the model considers each property to have a likelihood of:

- Heat pumps
- Radiators
- District heating

No golden record exists for determining what heating type will be used by which adoption group so a series of informed assumptions was used to derive the following table detailing the assumed split of heating types across adoption groups.

Seasonal electrical consumption calculations

The seasonal electrical consumption for different LCT heating alternatives varies and the data around this variation is scarce in the public domain. To calculate this in the model, historical gas usage data from X0Serve was used as the baseline for the seasonal split.

Allocating a fraction of a heat pump to properties

As it is impossible to know exactly which properties will specifically adopt a particular LCT heating type, each property was applied an adoption fraction. The adoption fraction is calculated for each combination of adoption group and legal environment depending on the forecast number of adoption candidates entered by the user. The adoption fraction is used to modify the max draw, consumption and demand values for each property.

Running the Model

Model Scenarios

To run a forecast scenario through the model, the user is provided with a simple user interface. Typically, the user will have a set of forecasts (such as the Future Energy Scenarios) to model. E.g., In 2030 under steady progression, there will be x number of households adopting LCT heating in the SPD district. Setting up the model is a simple three step process.

Step One is to set up the model with a run name, the year being modelled, a description and to select the area to be modelled. Typically this will be either the entire SPD or SPM areas but it is possible to select any combination of districts

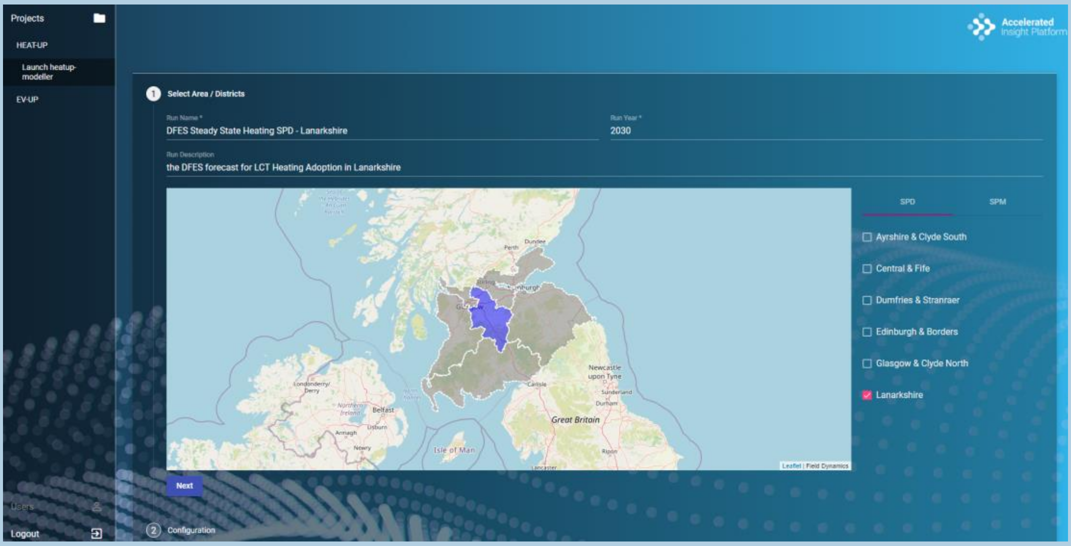

Fig 1. Heat-Up Model setup screen

Step Two is to then complete the forecasts for all adoption groups. This is the main input screen enabling the user to either choose a percentage adoption or input an actual number. The model then cascades the top level number across the adoption types ensuring that no adoption group is over populated. Significant input validation ensures only valid forecasts can be entered (ie; not more than 100% for any group) .The user is also able to select a retrofit environment which then sets the efficiency of the heating devices and informs the electricity demand figures calculated (i.e., a poor retrofit environment results in lower efficiency and therefore greater demand).

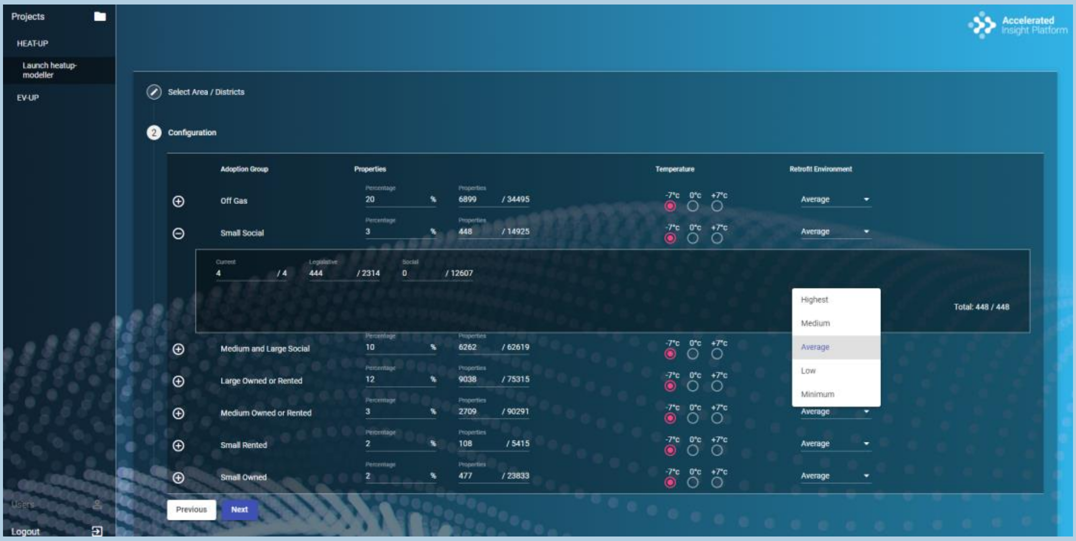

Fig 2. – Heat-Up model configuration input interface

A final run summary is then provided to the user in Step Three

Fig 3. Heat-Up Scenario Summary Screen

Having had the chance to review their inputs for this scenario, the user simply submits the scenario to be run. Once the model is running, the user can view its status on the run summary screen shown below

Fig 4. Heat-Up Scenario Summary Screen submit button

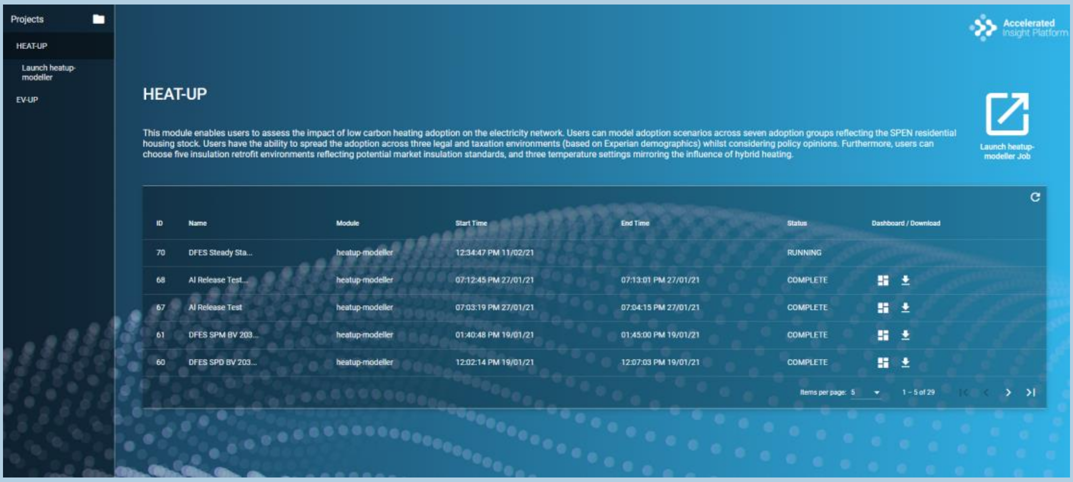

Fig 5. Heat-Up Run List Summary Screen

Once the scenario run is complete, which typically takes a few minutes, the user then has the option to download the hyper-granular dataset or view the summary dashboard for that run. The map view on the dashboard is styled to show where the greatest impact is and key summary demand statistics are provided both on the map window and in more detail on the sidebar.

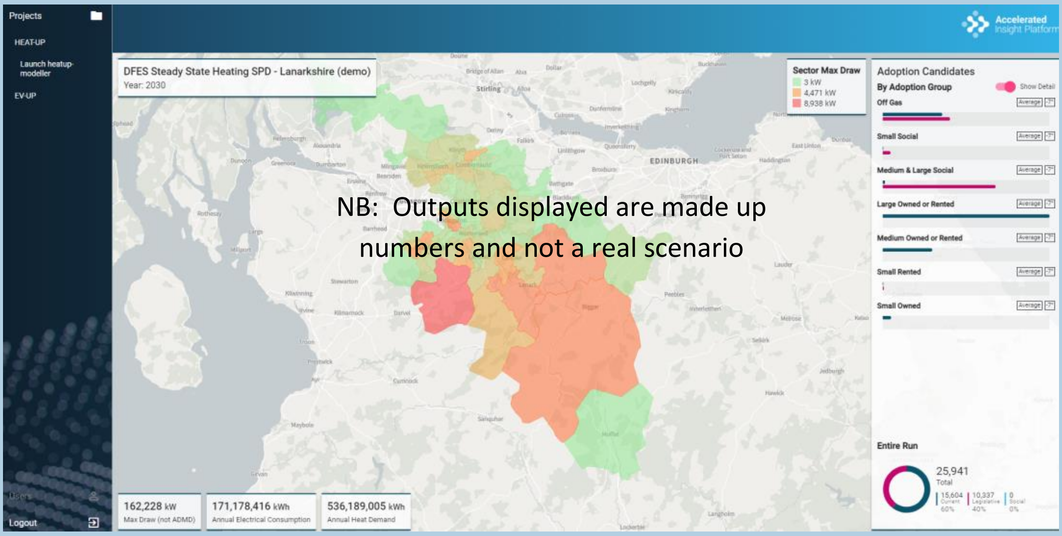

Fig 6. Heat-Up Output Dashboard

Hyper-granular Output

Not only does the model provide a high level dashboard for a more whole system view, but also a hyper-granular output file that allows SPEN to overlay the outputs from Heat-Up onto their electricity network. **Fig 7** below demonstrates an example of this where a house-by-house hyper-granular output with varying levels of Low Carbon Heating uptake can be seen. This is used to inform optimised business plans and targeted reinforcement.

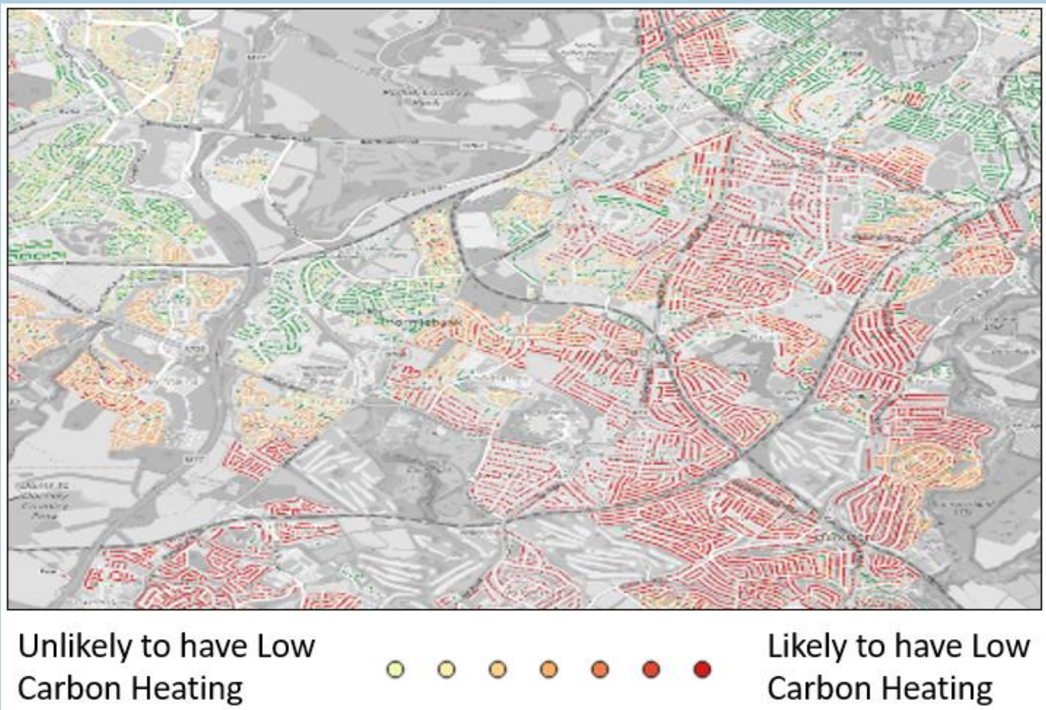

Fig 7. Heat-Up Hyper-granular Output

In addition to SPEN's own internal use, outputs from Heat-Up will be useful for Government and Local Authorities as the model will outline the scale of the task and levels of investment required to meet their targets in a given area. This will allow them to ensure legislation in relation to heat is as appropriate and effective as possible.

The methodology, model and outputs are easily transferrable to other DNOs if they also wished to use it to improve their understanding of the impact of decarbonisation of heat on their networks.

Details of how the Project is investigating/solving the issue described in the NIA Project Registration Pro-forma. Details of how the Project is performing/performed relative to its aims, objectives and success criteria.

Required Modifications to the Planned Approach During the Course of the Project

The early phases of the project encompassed a significant amount of research and development as various datasets were acquired and analysed. In particular, there were three aspects of the approach which were subject to refinement during this phase:

1) Identification of Off Gas properties
   The original expectation of the approach was to use the X0Serve dataset identifying postcodes with no properties on the Gas network as the identifier for these properties. However, the emergence of an additional group – postcodes where some properties were off gas was identified through use of a dataset from the Dept. of Business, Energy and Industrial Strategy. It was therefore decided that the method needed to incorporate additional areas over and above the X0Serve dataset to increase the accuracy relating to identification of Off-Gas Properties
2) Splitting of Legislative and Taxation Environments
   It became clear during research that properties who may switch to LCT as a result of legislative or taxation change required further granularity to avoid over-generalisation. As a result, this population was further categorized using Experian data to ensure different legislative or taxation changes would be applied in a more targeted manner
3) Retrofit Flexibility
   In an ideal world, heat pump installations would be accompanied by significant retrofit work to ensure maximum efficiency of the device. However, it was recognised that the way in which legislation or incentives are applied may not always result in retrofit and installation to occur hand in hand. As a result, additional capability was added to the model to enable the modelling of installation combined with a range of retrofit environments.

The Network Licensee should state any changes to its planned methodology and describe why the planned approach proved to be inappropriate.

Lessons Learnt for Future Projects

The Heat-Up tool, with some slight amendments, could be used by other DNOs in future to enable greater granularity and understanding of the expected spread and demand of decarbonised heating on their respective regions. The accuracy of the tool, whilst already at a very high level could in future be amended/ updated when more detailed information on the decarbonisation of heat becomes available. This is unlikely to be however until these types of LCTs are more widespread.

Recommendations on how the learning from the Project could be exploited further. This may include recommendations on what form of trialling will be required to move the Method to the next TRL. The Network Licensee should also state if the Project discovered significant problems with the trialled Methods. The Network Licensee should comment on the likelihood that the Method will be deployed on a large scale in future. The Network Licensee should discuss the effectiveness of any Research, Development or Demonstration undertaken.

The Outcomes of the Project

Heat-Up has created a model which allows SP Energy Networks to start gaining data-driven insight into the impact of Low Carbon Heating Adoption. In doing this, it has also delivered a number of other outcomes that could potentially be further developed or used in related analysis. These include:

- An enhanced "Off-Gas" dataset along with a methodology to more fully understand the numbers and locations of Off-Gas properties
- A workflow which combines a number of significant datasets into a single dataset covering all properties in the SPEN districts, segmenting those properties in various ways which again could be used in other analysis
- Enabled a consistent approach for modelling Low Carbon Heating adoption but with the flexibility to be changed depending on future forecasts or even respond to as yet unknown changes (such as Legislation).

The project has delivered the core dataset and models in such a way that it can be used as a BAU application for SPEN forecasting teams to use in future years. Although both the model and dataset are complex, the ability to leverage their intelligence has been delivered in a usable application with an easily configurable input user interface. A clear and straightforward dashboard delivers key metrics in a format that can easily be shared with stakeholders, used in reports or for presentations whilst the hyper granular data output can be leveraged by analysts looking to understand where demand outstrips supply.

Whilst the modelling of the impact of Low Carbon Heating is still subject to many unknowns, Heat-Up provides a structured approach using the best and most accurate data available, combined with a series of researched and evidence-based assumptions to enable SPEN to more accurately understand the scale of challenge faced by SPEN as adoption of Low Carbon Heating increases over the next 3 decades.

When available, comprehensive details of the Project's outcomes are to be reported. Where quantitative data is available to describe these outcomes, it should be included in the report. Wherever possible, the performance improvement attributable to the Project should be described. If the TRL of the Method has changed as a result of the Project this should be reported. The Network Licensee should highlight any opportunities for future Projects to develop learning further.

Data Access Details

SP Energy Networks has been leading various innovation projects to provide solutions to the challenges which our electricity network is facing due to the changes in the way we consume and generate energy. The projects are to support the UK government targets for low carbon economy and are predominately funded by Ofgem innovation fund mechanisms. The learnings and outcomes of the projects are typically disseminated through workshops, conferences and the SP Energy Networks innovation website, to allow knowledge sharing in wider UK applications. Our innovation website provides access to the key documents on the projects.

In addition to this, there may be data generated and collected as part of these innovation projects. It is our intention to share said data with relevant and interested parties who can demonstrate that their use of this is in the best interest of UK electricity customers. The provision of data is subject to anonymisation and/or redaction for reasons of commercial confidentiality or other sensitivity.

Access to this data must be requested by contacting SPInnovation@spenergynetworks.com. Please provide the following information in your request:

- Affiliation, position and contact details of requesting party
- Relevant project and type of data required
- Reasons for requesting this data and evidence that this data will be used in the interest of the UK network electricity customers
- How data will be shared internally and externally by the requesting party

Any data request deemed unsuitable for sharing will be highlighted to the appropriate requesting party. After receiving the request, we will provide the estimated date for completing the data provision based on other requests and our team workload at that time. All requested data remains the property of SP Energy Networks.

A description of how any network or consumption data (anonymised where necessary) gathered in the course of the Project can be requested by interested parties. This requirement may be met by including a link to the publicly available data sharing policy.

Foreground IPR

The following documents have been produced and will be made available.

- NIA close-down report

Further information can be requested for the SP Energy Networks Future Networks team;

A description of any foreground IPR that have been developed by the project and how this will be owned.

Planned Implementation

Heat-Up has delivered a new and highly granular approach to network modelling and has delivered significant benefit and improved understanding for a range of core work streams. The project has delivered a new and innovative data set which has greatly improved LCT network modelling in a repeatable and transparent manner.

Key work streams which have benefited from the outputs and continued work include;
Distributed Future Energy Scenario (DFES) modelling analysis and stakeholder engagement. Output from Heat-Up will be fed to further the creation of a supply and demand model at all voltage levels

LV Network Modelling: Data has been incorporated to improve understanding of average demand profiles for groups of houses types – improving network design studies and delivering real benefits for connected and future customers

Strategic Partnership with Scot Government: A partnership on Heating Strategy between Scottish Government and SP Energy Networks is being consulted on and developed and this project will be a key enabler to beneficial outcomes for customers from this partnership

Other Comments

Nil

Standards Documents (Electricity projects only)