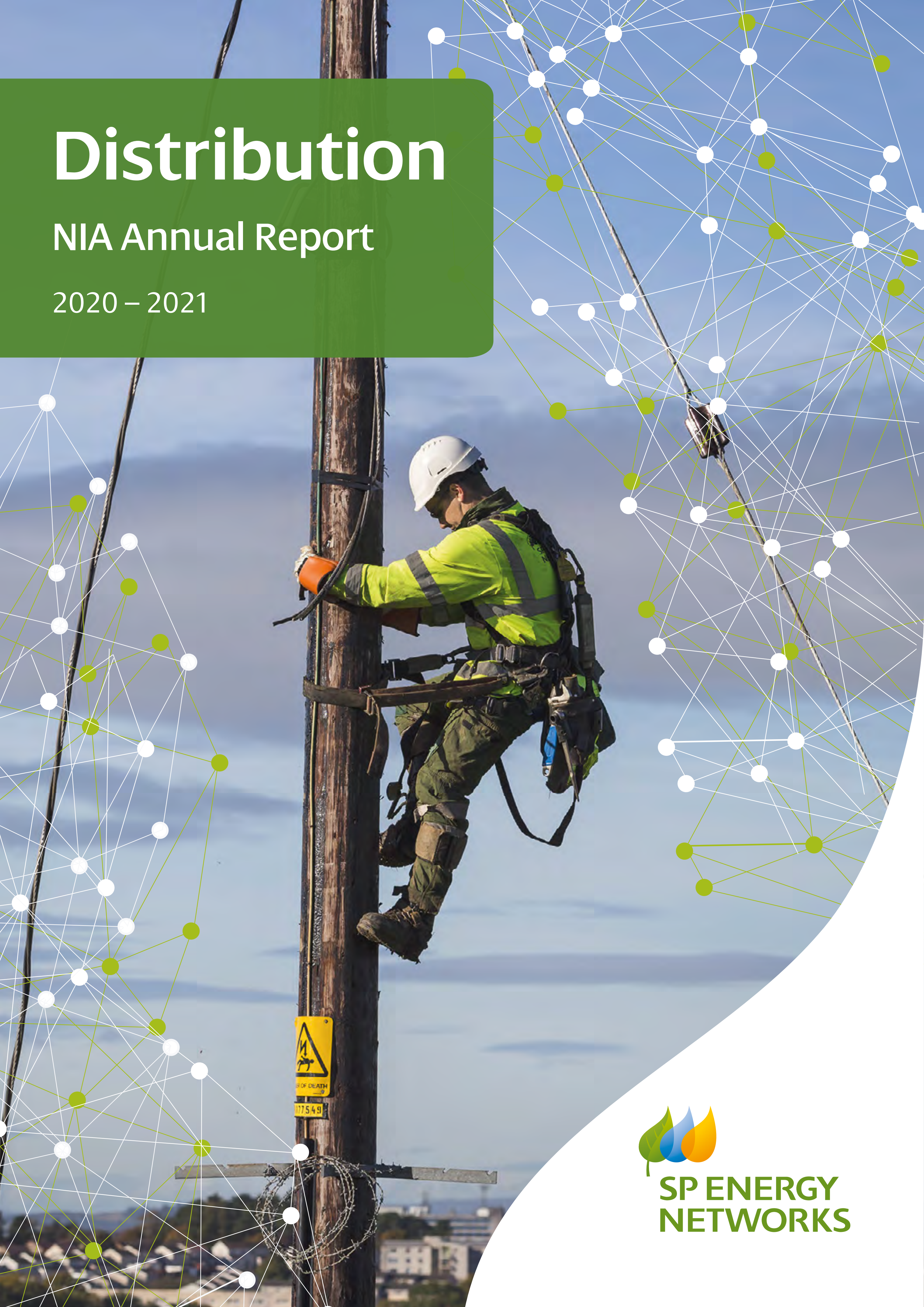
Distribution

NIA Annual Report

2020 – 2021



SP ENERGY NETWORKS

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Foreword

At SP Energy Networks we are committed to maintaining an electricity distribution network that can help deliver the Net Zero future that is so important to our business, our society and indeed to the survival of our planet.

Our portfolio of innovation projects underpins our activities in a number of key areas, including the decarbonisation of transport and heat, and our efforts to accelerate the journey to Net Zero.

This is our sixth Network Innovation Allowance (NIA) Annual Distribution Report and it provides an overview of NIA innovation projects which cover our SP Distribution networks in Scotland, England and Wales that were initiated, worked on and completed during the regulatory year 2020-21.

It was an extremely challenging year, for our business certainly the most challenging in living memory. It began with the country going into lockdown and the onset of the coronavirus pandemic, and we continue to operate in challenging circumstances. However our people have risen to the challenge and have gone above and beyond to ensure that we continue to provide our customers with value for money, a secure and stable electricity supply, and support for our most vulnerable customers.

One of the key focus areas for us as we delivered our innovation portfolio in 2020-21 has been transitioning our innovation projects into Business as Usual (BaU), where possible, in order to unlock their true value and full range of benefits. We have continued to engage with key stakeholders, making every effort to ensure that the knowledge and learnings we take from these projects are shared more widely for the benefit of other distribution network operators (DNOs).

While our NIA projects are important to our business in their own right, they also support our bids for Network Innovation Competition (NIC) funding and will feed into our RIIO-ED2 business plan, which covers the period 2023-28 and is due to be published later this year.

ED2 is the regulatory settlement that we agree with Ofgem, our regulator, and it sets out our investment, income and the performance targets we need to deliver on. A key element of our business plan is the Distribution Innovation Strategy and this will reflect both the greater focus on innovation in comparison to ED1, and the ambition needed if we are to tackle the challenges we face from 2023-28.

The UK energy and networks sectors are being placed under the spotlight like never before this year as our home city of Glasgow gears up to host the COP26 climate conference.

Net Zero will be top of the agenda and rightly so. It is a positive development that Net Zero is now driving the decisions made by governments, regulators and businesses, and this too is reflected in our own decision making and in our ED2 business planning.

With a greater focus now also on decarbonisation and environmental sustainability, our innovation activity will be crucial to ensure we can connect more renewables, create more capacity in our existing assets before they need to be reinforced or replaced, and help to facilitate the decarbonisation of transport and heat.

I have no doubt that more challenging times lie ahead but we have demonstrated that we can adapt to changes in our operating environment in order to continue focusing on what we do best – maintaining safe and resilient electricity networks, focusing on innovation and delivering the highest levels of customer service.

If we continue to focus our effort in these areas then SP Energy Networks will be at the forefront of efforts to drive a Green Recovery and help deliver that Net Zero future.

Colin Taylor
Director
Processes and Technology

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Executive Summary

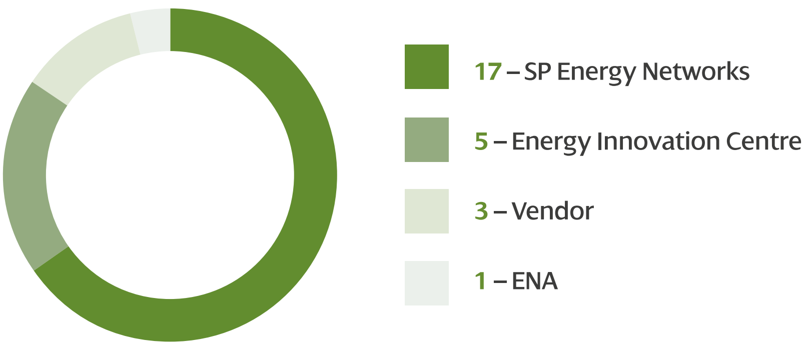
This Network Innovation Allowance Annual Distribution (NIA D) Report has been compiled in accordance with Ofgem's Electricity Network Innovation Allowance Governance Document which sets out the regulation, governance and administration of the Electricity NIA. This sixth NIA D Annual Report presents an overview of the projects we have initialised during the regulatory year 2020-21 and an update on those projects reported during 2019-20 which are still active.

We collaborate with other GB network companies to ensure that all customers benefit from customer funded innovation projects.

Collaboration

As part of the overall strategy for our technology portfolio, SP Energy Networks aims to have a balanced mix of projects that originate from other sources and not just from within SP Energy Networks, as illustrated below.

Project Origin




DANGER OF DEATH
4

1 | Introduction

We recognise the need to be innovative in order to get more out of our electricity distribution network and deliver value for money for our customers.

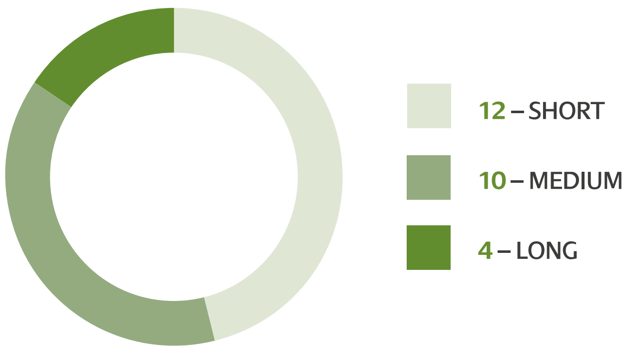
Under the NIA, we are concentrating on a smaller number of higher value projects, with higher technology readiness levels that offer the prospect of earlier business benefits.

SP Energy Networks is committed to identifing innovative performance improvements across all aspects of our business.

In ED1 there is increased need to ensure that innovation is embedded into all business function, as such the role of our Innovation Board is to ensure increased participation from all business functions and to allow innovation projects to be completed and integrated into BaU. Our Think Big, Start Small, Scale Fast approach to innovation enables us to be at the forefront of innovative practice and is embodied in our guiding values. At SP Energy Networks we believe in the power of innovation to enhance all aspects of our business and improve our service for the benefit of both our internal stakeholders and customers.

SP Energy Networks recognise that consideration needs to be given to not only the RIIO-ED1 period and stakeholder's immediate needs, but also how we address the longer term issues which the Distribution network may face. This is being addressed through a balanced portfolio of innovation projects where we are considering some of the longer term issues which may involve technology and techniques at a lower technology readiness level as well as challenges to be faced over the next decade.

Estimated Time Frame to Adoption for Project Portfolio



2 | Progress Summary

During the reporting year 1st April 20 to 31st March 21 SP Energy Networks registered the following five NIA Distribution projects:

Project No.	Project Name	Project Start Date
NIA SPEN 0050	***Real Time Fault Level Monitoring Stage 2*** *ENA Smarter Networks Portal - SPEN 0050*	*May-20*
NIA SPEN 0052	***A Substation of the Future*** *ENA Smarter Networks Portal - SPEN 0052*	*May-20*
NIA SPEN 0055	***On-Site Non-Intrusive Polychlorinated Biphenyls (PCB) Tester*** *ENA Smarter Networks Portal - SPEN 0055*	*Nov-20*
NIA SPEN 0056	***Flexible Tower Block*** *ENA Smarter Networks Portal - SPEN 0056*	*Feb-21*
NIA SPEN 0058	***ReHeat*** *To be reloaded to ENA Smarter Networks Portal*	*Mar-21*

The following sections provide a short overview of each active NIA Distribution project and summarises the progress made on them. Further details on SP Energy Networks Innovation activities can be found on SP Energy Networks's website (www.spenergynetworks.co.uk/pages/innovation.asp) and on the ENA Smarter Networks Portal (www.smarternetworks.org). Key learning associated with these projects is summarised in ***Section 5***.

3 | NIA Projects Led By SP Energy Networks

3.1 | NIA SPEN 0008 Environmentally Acceptable Wood Pole Pre-treatment Alternatives to Creosote (APPEAL)

Project APPEAL was registered in March 2016; it is a collaborative project between SP Energy Networks, ENW, NPG and SSE and managed by the Energy Innovation Centre (EIC). This project aims to assess the performance of environmentally friendly alternatives to creosote for wood pole preservation. It is expected that the outcome of this project will influence UK DNO policies for the replacement of wooden poles.

The project consists of three stages with individual objectives:

Stage 1 – Literature Review: This stage will provide a comprehensive review of candidate replacements for creosote, enabling the DNO partners to select the solutions to take forward for testing.

Stage 2 – Accelerated Testing: This stage involves the creation of a 'fungal cellar facility' to provide a test environment to simulate >20 years of exposure to the elements for wood pole samples. This test bed will then be utilised to test several creosote alternatives side by side as well as wood pole samples treated with creosote.

Stage 3 – Final Report: This stage looks to collate and formally report on the key findings on the previous two stages and make recommendations based on the results obtained.

3.1.1 | NIA SPEN 0008 Project Progress

The second uplift report was previously circulated that shows the visual/statistical analyses of the second set of timber stakes recovered from the Project APPEAL trial. The first set of stakes (128 out of a total 1024) was recovered after 12 months exposure to the conditions of the trial, and the second set of stakes (a further 128) have been recovered after 24 months exposure. The trial is planned to proceed for a total of 48 months (Oct. 2017– Oct. 2021) and allow 4 sets of stake recoveries.

The stake samples recovered from the accelerated decay chamber were visually examined for any obvious decay before being processed prior to drying and being subjected to breaking tests to assess the impact of any decay on Modulus of Rupture (MOR). The determination of MOR was undertaken via a modification of the standard static bending test for small clear specimens of timber (BS 373 (1957). Identically treated stakes that had been stored in a dry environment, and therefore not subjected to any decay processes, were included in these tests to give baseline MOR values for each sample type.

After the breaking tests were completed, untreated control stakes that had been encapsulated in the copper lined CAPTURA sleeve type were chemically tested to identify any copper migration to the untreated timber surface. After completion of all tests, all stake samples were treated as hazardous waste and disposed of as appropriate.

The third uplift report was due March 2021, however it has been delayed as a result of the coronavirus pandemic restricting access to the University for the breaking tests.

Wood Poles With Preservative Creosote

3.2 | NIA SPEN 0012 SINE Post

DNO business practices can, at present, require experts to undertake several manual activities which are time consuming and labour intensive.

Focusing on power quality monitoring, the scope of the project is to develop and demonstrate an expert system "SINE Post" for the more efficient location of overhead line faults, improved assessment of circuit breaker maintenance requirements and the improved assessment of power system harmonics, before and after Distributed Generation (DG)/ Low Carbon Technologies (LCTs) have connected to the distribution network. This system will overcome current business challenges due to limited numbers of experts and the labour-intensive time needed to carry out some power quality monitoring-related tasks at present.

SINE Post will demonstrate the automation of previously time consuming and labour-intensive tasks often undertaken by valuable experts. This will give design engineers, asset managers, control room staff and field staff within SP Energy Networks timely access to processed information, allowing them to make informed decisions more quickly. Ultimately, this will deliver performance benefits to SP Energy Networks business (e.g. efficient data processing from multiple systems at scale) and its customers (responding to 11kV faults more quickly, enabling DG / LCT customers to connect to the network more quickly and cheaply).

SINE Post has the following objectives:

- Development and demonstration of an IT and hardware architecture (infrastructure and interfaces) that will allow data to be gathered from remote sites, processed efficiently and used, together with data from existing systems (such as GIS), to unlock business planning and operational efficiencies;
- Use data sets from multiple sources corroboratively to support planning and operational decisions;
- Trial various communications methods to assess their reliability, compliance and performance as enablers for gathering data into the expert system;
- Understand and document the effectiveness of developing and demonstrating SINE Post for 11kV fault location, circuit breaker maintenance decisions and harmonic analysis.

3.2.1 | NIA SPEN 0012 Project Progress

This project has completed development and is now in operational evaluation. Early results are promising and work is ongoing to fine tune the system.

3.3 | NIA SPEN 0014 Active Fault Level Management (AFLM)

The management of fault levels can be challenging and problematic. Fault level management is particularly challenging given the safety criticality implications as they can result in catastrophic equipment failure and represent a serious personnel and public safety risk. While conventional practice has been to establish system fault level design limits in line with accompanying plant specification, novel approaches that enable full utilisation of the existing headroom must be developed to facilitate a timely decarbonisation of the economy.

Due to unprecedented growth in distributed generation, fault level headroom constraints are becoming increasingly challenging, often requiring major reinforcement schemes. Fault levels can act as a barrier to the connection of renewable generation and have become a decisive factor in determining the financial viability of distributed generation connections.

There are distinct approaches to Fault Level Management, with variation in the means of management and operational characteristics. Each of the following approaches have a role in the proposed AFLM Toolbox:

Model: where power system modelling is used to support Fault Level Management, either as:

- An operational means of FLM;
- An input to FLM; or
- for FLM.

Monitor: where fault-level measurement methods either:

- Enable the verification of network modelling methods and assumptions; or
- Facilitate the online measurement of fault level for operational management purposes.

Mitigate: where various techniques for fault current limitation are taken in real-time through physical fault current limitation or via protection actions.

Manage: where control systems provide preventative avoidance of fault level infeed exceedance through control of demand and renewable generation to reduce fault level and create network headroom.

The project will aim to develop an AFLM Toolbox based upon the Manage approach, using elements of Model and Monitor, with opportunities to work in co-ordination with Mitigate techniques.

3.3.1 | NIA SPEN 0014 Project Progress

The AFLM project is tasked with demonstrating an innovative solution to Fault Level Management by automatically controlling network equipment and customers in real time. This constrains network fault levels within equipment limits and will enable acceleration of flexible non-firm connections into fault level constrained areas of the network.

Phase 1 of the project considered a toolbox of solutions for the development of active fault level management systems, including modelling, measurement, mitigation and management techniques. A range of networks were assessed with the toolbox of techniques, and cost benefit analyses were undertaken on the concept designs.

Phase 2 of the project has progressed a solution design with prototyping and laboratory based testing. This has refined the AFLM concept and use cases, including development of the AFLM specification, requirements, design principles, and high level commercial principles of access. Development of a prototype AFLM solution has been progressed. This prototype has undergone laboratory based testing.

An area of network (Warrington) has been selected to refine the solution. Long run tests, network and system studies and scalability assessments have been undertaken to provide a foundation for a production grade AFLM network trial in Phase 3 of the project.

Phase 3 is now started with the development of the network architecture and functional specification. The detailed design specification is now in progress, defining all operational requirements for deployment of the trial. Some delays have been encountered, however the trial is still expected to go live in the summer of 2021.

3.4 | NIA SPEN 0023 Connected Worker Phase 1 – Field Data Automated Capture

It is widely recognised within the industry, the importance of acquisition of field data to support and impact on decision making. However, due to the reliance on field staff to do this job, this generally comes with the consequences of accuracy and timeliness, as it is not something with which they are trained to do.

Through this project the business aims to find a new way to improve the quality, accuracy and timelessness of data collected by the field staff, whilst also reducing the burden on those staff simultaneously. As is the case with many innovation projects, the focus will be placed upon new technologies and applications of existing technology in order to improve data acquisition. Although at present field operatives enter some data via electronic devices, it is not yet widespread and in certain cases much of the manually collected data requires specific action by the field staff, especially when dealing with linear assets such as cables and overhead lines.

However, there are technologies which are widely available – for example GPS, geo-fencing and barcoding – which could be used to improve the quality of data collected by our field staff in a more direct manner.

For this project specifically, the data collected will relate to work on-site regarding underground assets that would be consumed and utilised by the Work Management System (SAP) or the Geospatial Management System (ESRI) to include both installed and decommissioned assets.

3.4.1 | NIA SPEN 0023 Project Progress

The project has delivered a functional specification in late 2020, which is now being assessed against the current versions of ESRI that the business has, and how these will be developed in the coming years. The opportunity has been taken to align these functional requirements within another internal project collecting field asset data and is currently being assessed on establishing a parallel pilot process during summer of 2021.

There are now a number of mobile data projects within the same functional space and over time it will become clearer whether this project exists in its own right, or the work done to date is incorporated into a wider initiative.

3.5 | NIA SPEN 0024 Endbox G38 Level Detection Phase 2

Upon proving that the technology for the project was in fact working successfully, and in order to ensure that this is suitable for use on the network, the testing boundaries must be increased, and as such Phase 2 aims to extend the trial of this technology across a wider range of voltages, and types and sizes of G38 apparatus across the network.

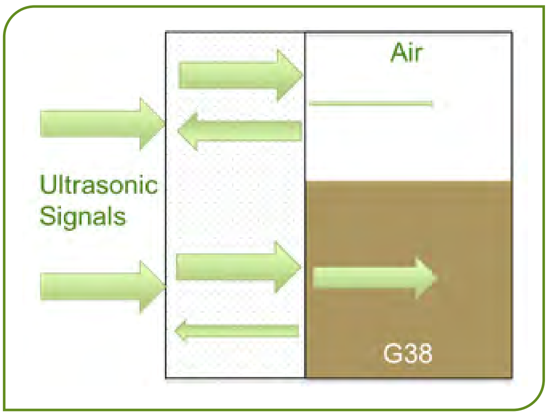
Upon the extension of this trial further across the network, this measurement technique will need to be validated, which is a vital step in preparation for integration into BaU. This trial will involve testing this approach on a representative sample of switchgear across both licence areas, SP Distribution (SPD) and SP Manweb (SPM).

Furthermore, within this trial, the methodology for the determination and classification of the status of endboxes will be developed. This should enable the objective of determining a method to classify the criticality of the endboxes, depending on the G38 levels within and whether the exposed conductors are fully covered and insulated.

3.5.1 | NIA SPEN 0024 Project Progress

SP Energy Networks have been carrying out a series of tests across our substations to use ultrasound monitoring to determine the level of G38 in the endboxes. This is an ongoing process, but this has raised a number of instances where the G38 level was close to being below a safe level, allowing for remedial action to be taken. These tests will be continuing across our districts, leading to work on how this detection can be taken through to being a BaU monitoring technique.

The focus of this project has now moved on to the integration of the testing process into the business as an internal activity. This has brought some challenges, as non-destructive testing is a highly specialised practice, and as such must be properly qualified to ensure that it is carried out correctly.



In 2020-21, the project has faced a number of issues, mainly stemming from the restrictions and limitations imposed by the coronavirus pandemic. As a result, the surveys which we had hoped to carry out were not possible.

In 2020, we purchased two ultrasonic devices to use internally, providing training for our staff and running a number of tests to trial these surveys as an internal activity. These tests were not successful due to the complexity of the measurement device and of ensuring the tests were carried out accurately, and it has proven to be too complex a task without specialist training and management.

As a result of this, the project is currently on standby, with discussions ongoing on how to progress with the monitoring. The management and monitoring of G38 assets is still an important issue for the business.

3.6 | NIA SPEN 0029 Secondary Telecommunications Phase 3 – Trial of Hybrid Telecoms

Transitioning from a DNO (Distribution Network Operator) to a DSO (Distribution System Operator) will require significantly increased real-time monitoring and control of remote electrical assets than is currently in place.

This will be of critical importance in order that the continued adoption of distributed renewable generation and electric vehicle utilization can be maximised without inadvertently destabilising the UK electricity grid or putting the security of supply at risk. The need for much improved monitoring and control in the future is well documented. There are six main criteria which must be satisfied and the current telecommunications solutions which are available to DNOs do not adequately do so. Furthermore, without a reliable and fit for purpose telecommunications network in place, it is not possible to capitalise on the possibilities that are presented by the 'Smart Grid', and this would also severely delay the DNO to DSO transition.

Previous work in this area (by SP Energy Networks, UKPN and WPD) has concluded that a single technology solution (which can cost effectively satisfy all of the technical and commercial criteria) is unlikely to be suitable. It is likely that a hybrid approach to the solution will be most cost effective and will 'future proof' the solution to the greatest extent possible. Similarly, arguments around the pros and cons of self-build vs third party solutions are not straightforward and the optimum is probably an intelligent combination of both.

3.6.1 | NIA SPEN 0029 Project Progress

The fourth endeavour to secure effective private spectrum for the trial was accepted by Ofcom in July 2020 for rural locations only. Specifications for equipment and installation have been drafted and are being priced. Public mobile network operator (MNO) connectivity has been achieved and tested with three sites live in the field. Data usage, response times and reliability are being assessed.

VHF and 10.5Ghz comms infrastructure has been installed and is available to compare against encrypted public cloud installation.

Research into the practicalities of failover between public and private networks using the available frequency options is ongoing.

3.7 | NIA SPEN 0030 Zebedee Sectionaliser Device

When performing maintenance on the network it is vital that interruptions to supply to customers be kept to the absolute minimum.

The maintenance of sectionaliser smart links is a minor task which can have a major impact on supply for connected customers, particularly in rural areas. This device aims to reduce customer interruptions by providing a means to temporarily bypass the smart fuse which is undergoing a removal and replacement. This will be applied by using the same equipment as used to apply and remove smart links. It will consist of a conductor, surrounded by a spring, with a rigid, telescopic, insulated container and will have the relevant connectors to allow it to be attached using standard short or long stick apparatus.

3.7.1 | NIA SPEN 0030 Project Progress

We have now transitioned into a BaU trial of the Zebedee devices in the field across all of our regional districts to test the effectiveness of the device, and its ease of use. There have been some issues which have arisen from these trials (for example, wind causing the device to swing while being applied, which could cause a phase-to-phase short), but these have been managed with minor redesigns of the Zebedee. This has caused some delays in final approval, but this project is now considered closed and is in the process of fully transferring into BaU.

Zebedee Sectionaliser Device

3.8 | NIA SPEN 0031 Radiometric Arc Fault Location RAFL 2

Transient faults on the overhead line distribution network can be difficult to locate, costly to repair and can have an adverse impact on customer service and quality of supply. Certain transient, intermittent faults are not easily detected through a line patrol, and can be onerous to narrow down using fault passage indicators on a network with numerous branches. When the circuit repeatedly trips, field staff manually reset and re-energise, but this does not address the root cause. These faults are frustrating to both customers and staff, and are time consuming and costly to locate.

This project builds on an earlier proof of concept project (NIA_SPEN005) which SP Energy Networks undertook to investigate the feasibility of a Radiometric Arc Fault Locator (RAFL) based on fixed hardware to detect transient faults.

This project culminated in a field trial of the RAFL system which was permanently mounted to wooden poles supporting transformers on an 11 kV overhead line circuit.

Despite this circuit being selected due to its historical poor performance, no faults were recorded during the trial period. Nevertheless, the trial demonstrated that the hardware was reliable and suited to the purpose of detecting impulsive radio frequency emissions from power system arcing.

The project will develop RAFL system hardware and software and expand on the NIA SPEN 005 project learning to develop a low cost, portable, battery powered version of the RAFL system field deployable unit that can be rapidly redeployed in service.

FDU Deployed on Wooden Pole During Field Test

3.8.1 | NIA SPEN 0031 Project Progress

Work commenced on the RAFL 2 project in July 2018. In the reporting period the following tasks have been successfully completed:

Hardware design and software programming of FDUs

The hardware design and software development has been completed and 24 FDUs have been constructed and tested. Additional work has been conducted on improving the battery runtime.

Software programming of web server

The web server coding is now finalised. The user interface has been further developed, based on the experience gained from field testing.

Accuracy testing

A comprehensive series of tests within Strathclyde Business Park and using the PNDC facility has been completed. The results demonstrated that the effect of switching a 40m length section of de-energised 11kV overhead line using a pole mounted disconnector could be detected and located to an accuracy of 64m when the furthest FDU was 5km distant from the disconnector.

Utility field trials

All FDUs have been delivered to the utility funders (SP Energy Networks and UK Power Networks). Field trials for the project are currently under way.

PNDC Test Result

3.9 | NIA SPEN 0033 CALISTA

CALISTA (Cable Asset Life by Integrating STAtistical failure models) is a three-strand project being run with Glasgow Caledonian University.

The first work package of CALISTA will develop an analytic model to predict cable asset lifespan through analysis of the cable parameters. This will allow the remaining lifespan of cable assets to be forecast, and allow an asset management tool to be developed for asset managers to make informed decisions on the replacement of cable assets. This work will be carried out as a PhD study. The second project strand will seek to support this study through monitoring the partial discharge in 33kV cables, particularly across trifurcating joints. This will also support work to monitor and manage failures in these joints.

The final strand of this project will look at using the techniques behind wireless charging to facilitate the location of cable faults. This will also be carried out as a PhD project.

3.9.1 | NIA SPEN 0033 Project Progress

The project has progressed, with a large amount of work having been carried out on the classification and understanding of failure modes for cables, and the modelling of this to allow predictive analytics to be carried out.

Glasgow Caledonian University have completed the following:

- An analytical model of cable insulation lifespan and aging mechanisms, with statistical approach to the failure mechanisms;
- An asset management model which can assess a circuit's remaining lifespan based on its present operating condition; and
- A software package which incorporates both of these models to enable asset managers to evaluate individual circuits remaining lifespan.

This work will continue through 2021, with further development of academic papers and improvements to the software packaging, with a forecasted end date in early 2022.

3.10 | NIA SPEN 0034 NCEWS 2

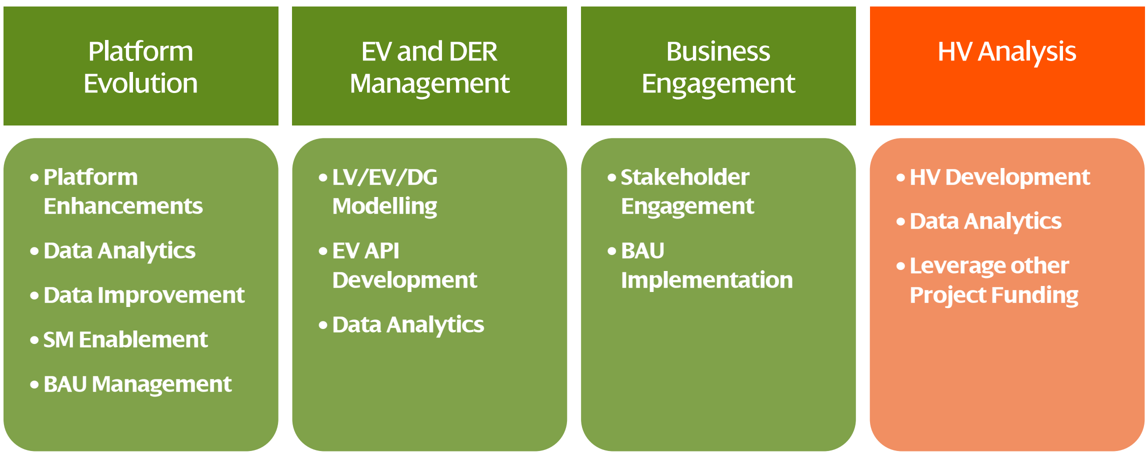
Management of network access for the expected volumes of new and resultant increases in customer energy requirements continues to be the key theme for the Network Constraint Early Warning System phase 2 (NCEWS2) project. Continuing from the original NCEWS project key goals for the next phase are;

1. Develop data analytical support for key business process use cases:

- **a.** Provision of a new IT supported innovation test platform called Network Analysis and View (NAVI);
- **b.** Ongoing development of improved data visualisation, data gathering and Application Program Interface (API) data export functionality;
- **c.** Identification, training and logging of feedback on the platform from key business stakeholders;
- **d.** Prioritisation and delivery of functionality identified through stakeholder engagement; and
- **e.** Explore existing gaps in data analytical capability with initial investigation of HV network requirements.

2. Data science investigation of network constraint risk from the growing volumes of observable energy data supplied through Smart Meters (SM's) and LV network monitoring:

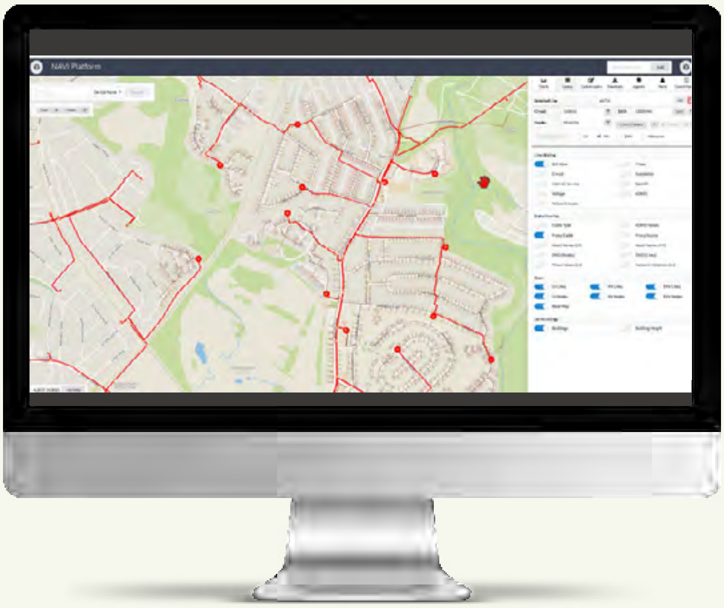
- **a.** Initial use of SM data for constraint analysis through the use of underlying network impedance understanding and extrapolation of SM Voltage;
- **b.** Connection constraint risk modelling through the combination of applied After Diversity Maximum Demand (ADMD) modelling data, improved through background property analysis along with the growing input of real observation data; and
- **c.** Use of observable energy data and underlying network asset data (impedance) to investigate data analytical techniques for network running and phase identification connectivity improvement.



NCEWS2 Revised Project Structure

3.10.1 | NIA SPEN 0034 Project Progress

Focus within the NCEWS2 project has been to develop a fully connected LV network model that was suitable for supporting detailed analytics and data extracts to identify network issues. The initial aim of the solution was to provide a mechanism to annotate smart meter data to a network reference model to allow analysis and to provide the foundation for understanding the operation of an instantiated network model which sits outside core operational systems such as ADMS and GIS. The solution proved very useful within the business and hence was extended to cover SP Energy Networks full network at HV and EHV.



NAVI platform visualisation showing circuit connectivity at LV and HV with some example rationalised cables

One key feature of NAVI is the way in which we have rationalised and backfilled asset data within the network model. Asset information from GIS is used and processed through a set of rules defined by SP Energy Networks to identify the "proxy_cable_type" and assign the correct impedance and rating values. The rules have been created for LV and HV assets up to 33kV. A fully rationalised network model has a multitude of benefits including identification of potential risks on the network and the need for reinforcement and faster identification of suitable points of connection.

Since transitioning to BaU operation in 2020, the solution has formed a key part of many projects including LV connection and scenario analysis, HV tracing to assist earthing studies and has acted as the main feed of pre-analysed GIS data to several other internal projects.

With more smart meters and substation monitors now installed within the SP Energy Networks licence areas we are able to analyse voltage profiles to help with phase identification more accurately. By correlating the smart meter data, monitor data and the various data sets annotated to the NAVI network model (including Customer Numbers, MDI and ADMD data) we have developed a methodology to highlight and prioritise potentially at risk areas of the network and present the results in a manner easily consumed by the business. By bringing the smart meter voltage reads into the NAVI Platform it can also help to provide visibility of the current demand on each section of the network and therefore assist with connections analysis and decisions.

Work is ongoing on the improvement of LCT ADMDs with the hope it will provide the final risk analysis capability that will then be tested through stakeholder engagement with connection designers.

3.11 | NIA SPEN 0036 A Holistic Intelligent Control System for Flexible Technologies

This project will investigate the potential use of a Holistic Intelligent Control System for the power network. There is a strong drive for DNOs to facilitate the ambitious UK Government and Scottish Government target to ban all new petrol and diesel cars and vans by 2040 and 2032 respectively, and also rely on renewable energy resources for heat and transport. The way energy is consumed and generated is changing and customers are becoming an active player in the energy electricity system. Distribution networks are increasingly important to facilitate these changes in a most cost effective manner and provide the best value to customers. Providing active network operation and transition to a distribution system operator (DSO) arrangement are in the road maps of all the UK DNOs to accommodate the changes in electricity customers behaviour in line with the UK Government Carbon Plan. There has been growing integration of flexible and smart solutions in electricity distribution networks to enhance the utilisation of network assets. In addition, the growing controllable nodes and visibility in the distribution networks are the enablers for transition to DSO where network flexibility offers an adaptive system to customers' needs and facilitating the competition in the energy market.

UK DNOs have been trialling different technologies that allow controlling network parameters such as voltages, power flow and network topologies in real-time e.g. Fun-LV, Active Response, LV Engine, Angle-DC and Equilibrium. Usually each flexible solution/technology requires its own controller which in principle aggregate the local and/or remote monitored data and uses an optimisation algorithm to determine the set points for the controllable devices. The control system architecture often consists of a Master and a number of slave controllers. Typically, the master controller uses regional input data, whereas slave controllers use data available locally.

There are similarities between these controller units in terms of their function, i.e. the control algorithms and the communication requirements. However, due to lack of a holistic smart control system, each flexible solution is currently independently designed, tested and taken through performance checks for a period before it can be trusted for BaU adoption.

This can result in the following technical and commercial issues:

- Incurring additional and unnecessary costs for a duplicate effort in designing the control systems for every solution;
- Delaying the BaU adaption of the solution as the control system should go through a period of tests and refinement;
- Incurring additional maintenance and training cost for operation staff as they have to deal with multiple systems provided by different vendors; and
- Sub-optimum network operation as each solution only limited to specific objectives, network area or voltage levels.

A proposed solution can be a DNO (DSO) owned Flexible Holistic Intelligent Control System (HICS) that:

- Sets out the control signal hierarchy and overall network operation optimisation by considering the controllability and impact envelopes of controllable nodes and also the customers flexibility offer through aggregators.
- Can be flexibly adapted to coordinate different optimisation objectives, of controllable devices, to enhance network performance, reliability and also provide commercial signals to other network flexibility providers (e.g. aggregators).
- Some of the high level network operation objectives can be network losses, wide area voltage optimisations, maximum network headroom capacity etc.
- Have the capability of machine learning or using artificial intelligence so it can be adaptive to network changes, robust against missing or real time data loss through loss of network communications and be functionally independent safely.
- Provides a core control module which can flexibly and securely integrate the new technologies and interact with other DNO systems (data historian, Network Management System, Data integration platform etc.)
- Provides a level of interoperability, allowing communication and integration with various network monitoring equipment offering a vendor agnostic solution.
- Is a DSO enabler and capable of providing market commercial signals and technical requirements associated with the DSO transition.
- Identifies the corresponding international standards and forums, including but not limited to CIGRE B4, C4 studying committee, IEC and SQSS, to inform and influence the ongoing discussion and standardisation when applicable.

It is envisaged that the Holistic Intelligent Control System (HICS) consists of the main (master) controllers providing overall coordinated network optimisation and local (slave) control units providing fail-safe function and set point adjustments based on local data. This project aims to identify the system architecture, optimisation algorithms HCIS and also trial of HICS within the distribution network demonstrating its performance at different voltage levels.

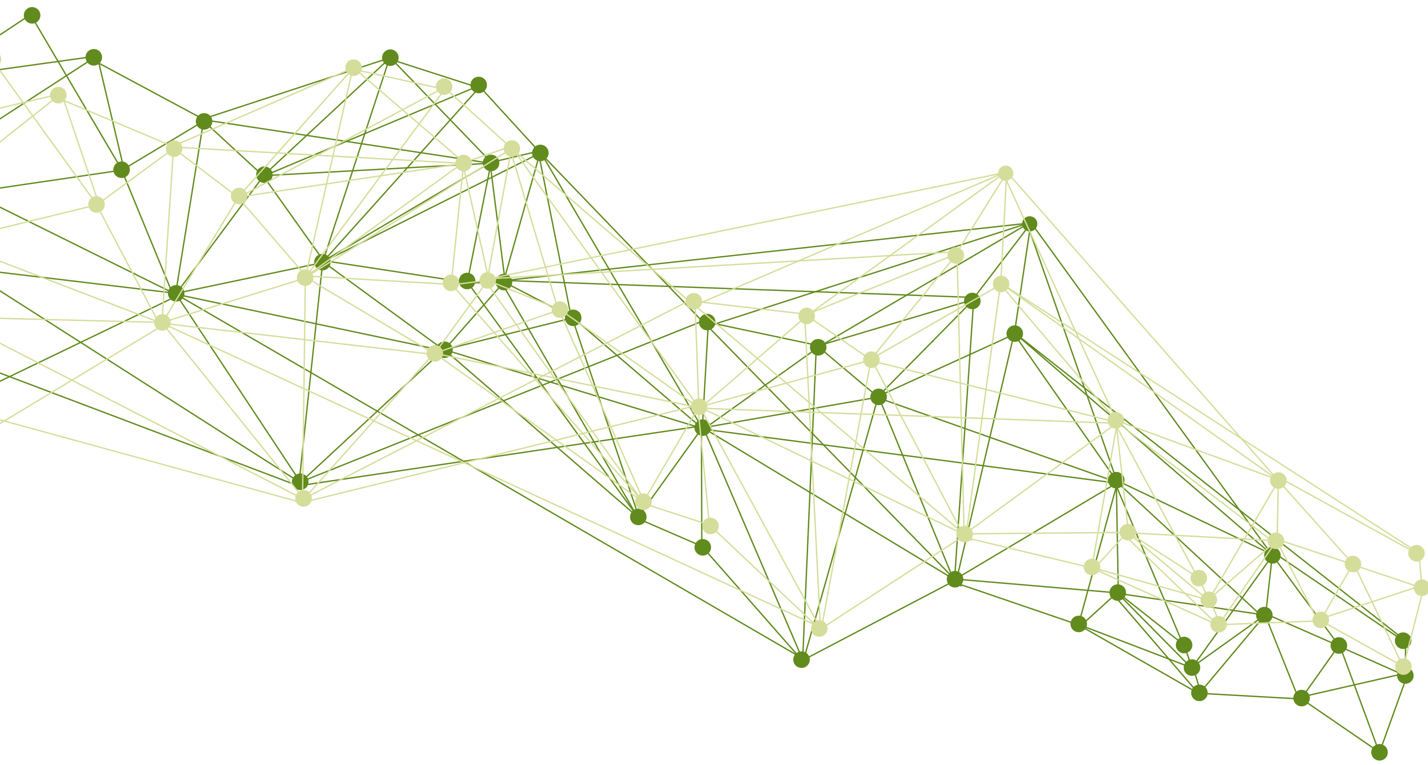
The objectives of the project are to:

- Identify the features required for a Holistic Intelligent Control system owned by a DNO (DSO) Technology Readiness Level at Start TRL 6 Technology Readiness Level at Completion TRL 8;
- Analyse the evolving characteristic of distribution network with uptake of renewable generation, energy storage and electric vehicles;
- Define the existing and future control technical requirements to future proof the controller functional design;
- Scoping and specifying the control interfaces depending on the engineering and/or commercial relationship; and
- Review and Identify the common control algorithm.

3.11.1 | NIA SPEN 0036 Project Progress

This project aims to carry out a feasibility study, technical requirements and implementation of a Holistic Intelligent Control System (HICS). There are a number of control systems being developed for controllable devices but there are similarities between these control units in terms of their control algorithms, hardware and the communication requirements. As reported previously LV Engine and Angle-DC were selected as two pilot projects where similarities between them can contribute directly to the HICS developments with focus on distribution networks covering both LV and HV networks. Since the last reporting period, the following progress has been made:

- Nortech were appointed to develop the feasibility study and technical specification of the HICS. The initial documents are still subject to further development;
- A collaboration agreement among three projects HICS, LV Engine and Angle-DC were established in order to achieve the best value for customers to ensure any development in one project can be used in other projects and achieve the ultimate goal which is a holistic control approach for distribution;
- The server which has been used for Angle-DC central control system (CCS) will be also used for HICS. The CCS server has now been built and passed factory acceptance tests. In order to align this development with other BaU solutions which are under development in IT and OT system, we are planning to commission the CCS in early Q1 2022. The system architecture embracing all the communication requirements, third party access, remote control through PowerOn have now been agreed;
- All necessary telecommunications are now in place providing the two way monitoring and control communication with SCADA; and
- The control philosophy of LV Engine in line with requirements in HICS has also been developed and the final report is now under review.

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3.12 | NIA SPEN 0037 Electric Vehicle Uptake Modelling (EV-Up)

The transition to electrified transport along with greater penetration of other LCT such as heat pumps will put increasing pressure on the low voltage networks as demand increases in the future. To ensure that the network continues to provide the level of service required for customers, there is an increasing need to improve forecasting to enable investment decisions to be made at the lowest overall cost, whilst at the same time minimising network risk.

Currently however, with immature EV market conditions and rapid technology change, accurate forecasting is extremely challenging and there is a need to model a range of adoption scenarios over an extended timeframe which increases this complexity. The EV market is new, evolving quickly and is driven by multiple unpredictable factors. Consumers are only just starting to decide what sort of vehicle they want and how they want to use them. Equally, suppliers of vehicles and services are inconsistent in what they offer and how well they match the developing consumer appetite. The result of these clashing variables is that meaningful predications can be extremely difficult to model.

Electric Vehicle Uptake Modelling (EV-Up) will contribute to the development of data sets to improve our understanding of customers' ability to transition to EVs based on off-street parking opportunities and customer demographics. This will enable improved understanding on the likely network areas which will see increased domestic demand and better inform and prioritise future investment programmes.

The project investigated the following areas;

- Probability of a household being able to park and charge at home
- Demographics, including income and behaviours
- Household mileage and the resulting charge demand

Combining these data sets together in a transparent methodology, will enable improved understanding as to the likely assets and network areas expected to experience increased domestic demand. This will better inform and enable prioritization of future investment programmes.

3.12.1 | NIA SPEN 0037 Project Progress

While the project has delivered on the original objective of using data to more accurately model future impacts on the distribution network as a result of the transition to EVs (reported previously in NIA Distribution Annual Report 2019-20) the project was subsequently extended to include forecasting of Heat Pump uptake (Heat – Up) as SP Energy Networks require examination on whether this will improve the usefulness of EV uptake forecasting. It is anticipated that where EV uptake coincides with Heat Pump uptake is where the greatest networks problems are likely to arise. Therefore, it is pivotal to be able to model/forecast effects of both EVs and Heat pumps simultaneously.

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 LCT such as heat pumps will put increasing pressure on the LV network 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 SP Energy Networks 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 project is now complete and has successfully delivered the following:

1. Research and development into data sets 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 data sets which can be combined with SP Energy Networks network capacity models to identify the areas of the network that require reinforcement/ intervention;
5. Output data sets 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 LCTs on the network; and
6. Output Dashboards which provide a quick and clear view of the overall impact of each modelled scenario.

https://www.spenergynetworks.co.uk/pages/evup.aspx

https://www.spenergynetworks.co.uk/pages/heatup.aspx

3.13 | NIA SPEN 0039 THOR Hammer

Over the last ten years in partnership with Industry and Academia, Groundline Engineering has developed a seismic pole tester, "THOR", capable of non-destructively evaluating the in situ health of timber poles. The real value of this device is its simplicity of use – being as close as possible to the traditional hammer test that the linesmen are used to performing, while still providing the following potential outputs:

- Presence and extent of any internal decay, including below ground level without excavation;
- GPS-tagged measurement results provide confirmation of measurement location for auditing purposes;
- Predicted end of life for refurbishment investment planning;
- Accurate pole condition assessment, making pole climbing activities safer; and
- Pole embedment depth and foundation stiffness.

At present, all results obtained are assessed using both qualitative and quantitative assessments. Qualitative assessment includes a review of the pole hammer input trace and its velocity (output) response in the time domain. The Quantitative assessment of the pole is undertaken using parameters directly obtained from the THOR unit, and once real engineering units are applied, then mechanical impedance parameters such as hammer force input, duration, mobility and dynamic stiffness can be compared against similar pole populations to identify poles requiring further attention or identifying that poles are indeed healthy and sit within a normal admittance range.

Poles tested to date have allowed for the building of a large database of poles and the establishment of health indices for the various parameters in determining if the pole is an "outlier" or outside of the norm. Barriers to BaU application for the device, to be overcome during the project, include:

- Output given as a reduction of diameter; needs modifying to output reduction of strength to allow asset management decisions to be made;
- Detailed analysis is manual, time-consuming and reliant on a small number of people. The feature that enables embedment depth to be measured can only be obtained with detailed waveform analysis at a later date following the test. In addition, the on-site indication currently provided cannot be 100% relied upon so post-test analysis is recommended;

- The instrument was developed in Australia where a different type of wood is used for the pole (hardwood vs softwood) and different issues are encountered (e.g. termites). The technique and analysis parameters need measuring and confirming for GB standard wood poles, and the effectiveness of the technique needs to be proven;
- The measured output then needs to be turned into something meaningful, i.e. integrated with existing asset management methodologies such as CNAIM.

Currently, the device and service outputs the condition of the pole in terms of a reduction in diameter. In order for this to be integrated into the GB electricity industries' current policy, this needs to be taken a step further and used to calculate a remaining RSV for the pole. This will be the first deliverable for the project. Further works are currently undertaken for the automation of pole analysis – preferably at the time of test. This could be achieved with machine learning approach. The machine learning technology will convert the conventional way of analysing or processing pole data in, to a faster and potentially accurate output in a timely manner for the industry. The deliverable will be a self-contained unit that provides all of the above analysis, automatically and at the time of test.

Alongside the above, some consultancy work is required to review existing processes and the definition for an end of life pole, i.e. 80% remaining residual strength. The deliverable will be an agreed policy to use going forwards.

Training and dissemination will then be undertaken followed by a period of monitoring to ensure a smooth transition into BaU and that the expected benefits to the business have been realised.

3.13.1 | NIA SPEN 0039 Project Progress

The project to date has delivered virtual training to several staff in all participant DNOs. This was delivered via Microsoft Teams by Groundline due to the coronavirus pandemic restricting travel. Despite the difficulties of this, training in the use of the THOR device was delivered successfully. From July 2020, a significant number of tests have been completed on wood poles across the 3 DNOs. A destructive test rig was set up by NG Construction in March 2021 with a view to performing destructive pole testing which will validate the THOR device tests on UK wood pole. The results of this testing will also contribute to the further development and refinement of the Residual Strength Value calculation which will be a newly integrated output for the THOR device as part of this project. These destructive tests are due to take place in the summer of 2021.

3.14 | NIA SPEN 0040 Improving Storm Resilience and Readiness through Data Analytics

This is a Proof of Value project demonstrating a GE application which uses weather and historic outage data to predict which areas of the network will be worst affected during a storm.

The data generated in this application is displayed over GIS data, providing a heat map of the areas which will be affected.

Benefits will arise due to more efficient and proactive allocation of resource; this will allow faster restoration and allow remedial work to be carried out faster than previously.

Storms can represent a major challenge to utilities, often posing major threats to continuity of supply to customers, and with the potential to cause major damage to network assets. Currently, utilities act in a responsive manner to storms, relying on customer reports to know where work and action is required. The rollout of smart meters and other smart technology has helped improve reaction times to these issues, but in the future, utilities will need to work in a more proactive manner to ensure fast restoration of customers and efficient use of resources.

In this project, we will trial a data analytics application, which uses localised weather models, historical outage data and asset records (among other data sets) to improve the accuracy of prediction of where storms may affect the electrical network. This will act as a proof of value of the models, which can then be evaluated and validated prior to rollout across the business.

The main objectives for this project are as follows:

1. Development of a data requirements specification, including a target mapping document, and assessment of data source quality;
2. Development of a pilot of the Analytic model to allow trial via a storm readiness application. This will also include machine learning algorithms to allow continuous improvement; and
3. Development of a dashboard to allow the model outputs to be viewed as a map and with KPI indicators. This will also allow previous storm data to be "replayed" to allow it to be viewed and analysed.

3.14.1 | NIA SPEN 0040 Project Progress

The key expected outcomes of the tool are shown below.

- Optimise field crew staffing, positioning and pre-staging decisions;
- Enable targeted customer impact warnings, which can improve customer satisfaction; and
- Reduce Customer Interruptions (CI) and Customer Minutes Lost (CML).

Due to various reasons mentioned below, the above benefits could not be fully proven during the trial but the potential to achieve them could definitely be seen.

Issues/delays encountered included incorrect methodologies being initially chosen to split the SPM licence area by postcode which resulted in very poor prediction accuracy levels and delays to release the tool for trial. The task of extracting GIS and OMS data and developing methodology to associate an incident to a geographical location was also underestimated.

As a test of the tool, analysis was performed after a severe storm to review the accuracy of Storm Readiness' predictions during this period of adverse weather. The results of these, for the most part, confirmed the theory that inland districts predicted less accurately than coastal ones due to there being much less weather-related outage data available to train the tool for these areas.

3.15 | NIA SPEN 0041 Proof of Concept Tarmac Reinstatement Tester

Currently, when the quality of asphalt reinstatement is investigated no non-destructive on-site analysis is used. Instead, core samples of 100mm diameter are extracted from the site and sent for laboratory analysis. The core sample analysis will give an indication of the depth of surface and binder layers but also whether the air void density falls in between the acceptable minimum and maximum tolerances; depending on the material, in the range of 2 to 13% respectively. This method is destructive, intrusive, labour intensive and limited in coverage. Hence, a method that is non-destructive, non-intrusive, and enables accurate measurement of the air void density and layer thickness of the pavement, would be of great interest for the industry.

The Project will look to develop a technique based on combining ground penetrating radar (GPR) technology with a survey technology that has been successfully used in seismology, i.e. the multi-offset antenna array method. This development work will initially be limited to proof of concept. If successful further development will be required to deliver a BaU device.

The Project initially will be limited to laboratory work to develop the proof of concept. This research and development work will be split into four work stages.

Stage 1 – A list of specifications regarding the system requirements and the samples specifications will be established. Theoretical and simulation work will be carried out to determine the conditions under which the tests will be performed, such as signal power, frequencies, number and shape of bespoke antennas and the offset distances.

Stage 2 – When the main parameters relating to the tests have been established the laboratory tests will be undertaken. Signal generators-receivers and bespoke antennas will be used to perform tests on air gaps, gypsum and concrete plates to optimize the antennas characteristics.

Stage 3 – After the optimal characteristics of antennas have been determined the next step will be to test real pavement samples. Possible field tests may also be carried out.

Stage 4 – The results of the project will be incorporated into a final report which will inform on whether any technique developed within the project could be taken further.

3.15.1 | NIA SPEN 0041 Project Progress

So far the project has seen stage 1 successfully completed with the specification for the system requirements defined as well as identifying the various reinstatements that the system will have to detect in terms of air void densities and thicknesses. Stage 2 of the project involved reinstatement core samples provided to NDT consultants for further development of the prototype equipment. The core samples were a mixture of internal SP Energy Networks samples and laboratory samples supplied by third party. The samples were used to successfully further develop the equipment. During the laboratory tests impedance analysis was used to measure air void density in the surface layer and GPR to measure the layer thickness. Concrete slabs, printed plastic samples and asphalt samples were all studied.

To date the prototype equipment has been very accurate in predicting the thickness of reinstatements, with some promising initial lab results predicting the air void density of samples. The project is planning a field trial to test the accuracy of the equipment developed to date compared to core destructive lab results. The results of these trials will be included in the project closedown report and will inform any follow-up project.


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3.16 | NIA SPEN 0042 Novel Temporary Earthing and Bonding Solutions

There are two separate but similarly themed problems that the Novel Temporary Earthing and Bonding Solutions project is looking to address:

1. Portable earths consist of an arrangement of leads and clamps that can be heavy and cumbersome to handle and apply, particularly on overhead line networks and outdoor substation plants during windy conditions. The materials used are typically copper or aluminium, and are required to meet particular short circuit current ratings that are defined in ENA TS 43-81. To meet this standard, there are certain cross-sectional areas for the leads and clamping forces that must be adhered to. The combination of these factors results in the use of heavy and difficult to use apparatus, adding to these issues there is the need to use extended insulated fibreglass rods.
2. Network operators use mobile generators to manage prolonged outages as part of repair and restoration. As part of the use of these generators, a reference earth must be provided at the point of generation and this is often supplied by connecting to the system earth. There is a particular challenge that arises when substantial damage has been inflicted on the low voltage network resulting in the system earth being unavailable. In these cases, a temporary earth is created by driving earth rods into the ground until a suitable earth value is found. Often, due to location on the network and the physical location of the generator, this is not practical.

Here are two separate and parallel work streams (WS):

- WS1 – Temporary earthing for overhead lines
- WS2 – Temporary earthing for mobile generation

Both work streams will focus on the current working practices and equipment used by UK network operators. Further work will be carried out to understand best practice used in Europe, US and Australia.

Research will be carried out into current standards and if there are potential products available that can better meet these standards. Depending on how successful this research is, and the availability and cost of new products, trials and demonstrations will be carried out as part of the project.

3.16.1 | NIA SPEN 0042 Project Progress

The project has assessed the current working practices, equipment and standards used by the UK network operators as well as global practices and standards. Internal questionnaires were completed within the DNOs to gather information on existing equipment and practices. This has been completed for both WS1 and WS2. As part of the second stage, the project has researched and identify new equipment and products that will improve the practices within WS1. A virtual demonstration was carried out via Teams to show the products being utilised. All DNOs involved in the project attended the demonstration to assess the applicability of the products to current practices and where efficiency benefits would be possible. New types of line end clamps, earth end clamps, operating poles and earthing leads were all demonstrated as part of this event. Risk assessments were also completed for these products as part of the project.

As part of WS2, trials were undertaken of several methods of achieving portable generator earthing without using earth rods. Field tests were carried out using plate electrodes in a variety of conditions and configurations, with earthing values recorded for each test. There was limited success in achieving the required earthing values during the trials. The project recommends further trials if this type of solution is to be taken forward.

The project has now finished and all findings/recommendations can be found in the project closedown report.

3.17 | NIA SPEN 0043 Bethesda Home Hub

This project is exploring a method to look to customers to shift their electricity usage to times of the day or night when demand on the network is traditionally lower. This involves changing people's routines and habits until they feel they are getting all of the electricity they need, for minimal inconvenience, while also avoiding peak usage times when possible. This project will explore this specific problem and trial a novel commercial arrangement as part of a potential solution.

The objectives for this project are:

1. Demonstrate the impact of DSR for local balancing and its ability to manage constraints ahead of safety critical active network management schemes at LV. Demonstrate how flexible solutions and business models benefit the network and deferment of reinforcement. Model of the impact at scale;
2. Demonstration of how readings from meters at remote points of the network and forecasts of demand and generation can be used for network management or planning and provide more accurate planning and lower cost connections;
3. Development of new parameters to quantify the impact of DSR for planning purposes and how these can be used in network planning in future. This can defer reinforcement via flexible solutions;
4. Test a practical framework (a penalty and reward scheme) to encourage efficient behaviour on the network and demonstration of how it can be implemented within dataflows. Evidence for the impact of reward and penalty scheme for Ofgem. This will encourage more efficient behaviour to reduce network reinforcement;
5. Demonstration of how DSR and flexible solution can help tackle fuel poverty and transport poverty; and
6. Better interaction and understanding of the network by communities.

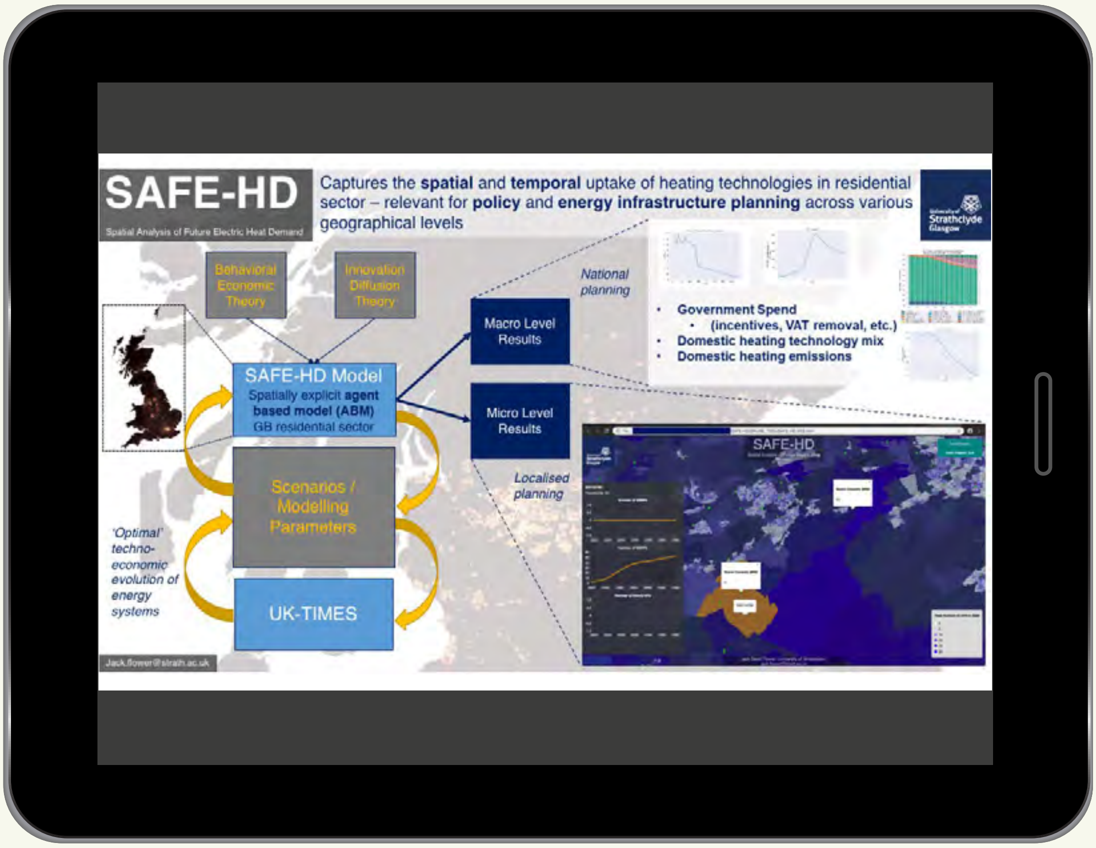
3.17.1 | NIA SPEN 0043 Project Progress

Energy Local, who are key suppliers in the project, have been developing a domestic home hub to allow households to schedule appliances to run at the optimum times. Progress has been made, however installation of these home hubs in the selected trial areas has been delayed due to the coronavirus pandemic restricting access to properties with only one property having a Homehub installed. The household used has generation installed with an aim to install a heat pump. This household will be used as a test case to highlight benefits of the homehub.

Energy Local and Electralink have been assessing the role that communities could play within flexibility services. Electralink have analysed community data and assets to determine how a community could be a service provider of flexibility. The intention is to test the viability of a community led flexible service provider role which could generate potential community income using the home-hub as a tool to analysis people's behaviour and availability of generation assets.

A proof of concept LorWAN-1 test has also taken place to allow the Home-hub to talk to Hydroelectric generation in the area. The communication between the two has been proven with future work to assess whether the system could also check network conditions or faults.

3.18 | NIA SPEN 0045 SAFE-HD (Spatial Analysis of Future Electric Heat Demand)



This project explores the heterogeneity of residential heat demand, and assesses how this diversity, along with social demographic and dwelling characteristic diversity relates to the suitability and cost effectiveness of heating technologies. This knowledge will be used to better understand how, against a backdrop of demand, policy and cost uncertainty, likely uptake of electrical heating technologies will impact future network infrastructure requirements.

The Committee for Climate Change (CCC) has, in its 2018 review of UK progress towards meeting carbon targets, continued to highlight the ongoing difficulties and lack of progress in decarbonising the heat sector. Decarbonisation of heat within domestic buildings provides one of the greatest challenges to overcome the 'lock in' barrier of natural gas-fired heating. The CCC strongly promotes the uptake of heat pumps as part of the solution and has recommended that no new homes be connected to the gas network by 2025 at the latest. Electrifying large amount of heat demand is expected to impact future network infrastructure due to the scale and seasonal nature of heat demand.

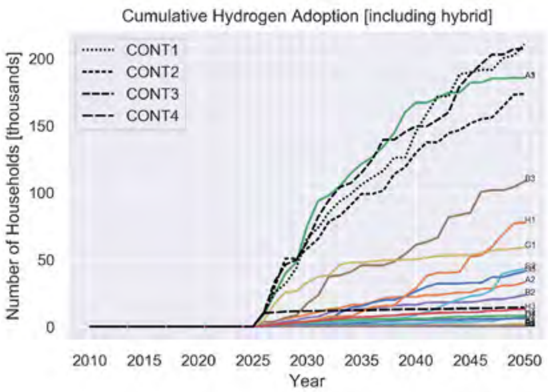
This project is developing and applying methods to explore optimal decarbonisation pathways to determine likely future heating technology mixes against a backdrop of policy, cost and demand uncertainties.

It is being delivered in several stages including:

- **Geospatial Analysis:** An examination of the heterogeneity of UK heat demand, dwelling characteristics, social demographics and how these relate to existing heat pump uptake. Analysis will be performed using geospatial analysis software.
- **SAFE HD Model:** Building on the Geospatial analysis, a spatially explicit agent based model (ABM) of the GB housing stock model will be developed to explore future electric heat demand. The model will be soft linked with the whole energy systems model called UK-TIMES (UKTM) in order to account for wider energy system interaction.

3.18.1 | NIA SPEN 0045 Project Progress

Good progress has been made on model development and useful learning has sucessfully been generated, with the SAFE_HD project entering the final stages. Construction of the SAFE-HD model is now complete and it has been calibrated and validated. The SAFE-HD project will be packaged for external use as an interactive mapping tool (the aim is to host this on the University of Strathclyde website). The project is being peer reviewed within the University of Strathclyde at the time of writing and the expected finish date is towards the end of 2021.



Interim SAFE-HD modelling results showing cumulative hydrogen adoption by scenario for GB owner occupied households. Note, it is assumed that there is only one gas conversion programme in GB (that is blue hydrogen) starting in the same location with a fixed conversion rate for all scenarios modelled (as per Leeds City Gate study).

3.19 | NIA SPEN 0047 A Transition to LVDC – Phase 2

LVDC Phase 1 explored the potential benefits that lie in converting Low Voltage AC circuits to LVDC. The advantages being releasing extra power transfer capacity in the cables, allowing LCTs to connect more readily, reducing/negating conversion losses and facilitating longer LV feeders in rural areas. Huge cost, time and environmental benefits can be realised through conversion to LVDC as opposed to conventional network reinforcement. Furthermore, the considerable expected increase in LCT uptake in coming years can be more easily facilitated with the aid of a LVDC network.

LVDC phase 2 will conduct laboratory tests on the cables and network apparatus most prevalent on SP Energy Network's network to gain an understanding of how SP Energy Network's LVAC cables and network apparatus behave when energised with LVDC. The outcome of the tests will then inform which areas of the network would be suitable for conversion to LVDC.

LVDC Phase 2 – Deliverable 1

To compile a testing specification which covers the predominant AC assets within the LV network. This involves understanding the most populous LV cables, joints and link boxes found on the LV Network as well as understanding what value they present to potential conversion to LVDC from LVAC.

LVDC Phase 2 – Deliverable 2

Conduct a tender exercise for a testing facility to complete the testing specification created. This involves searching the UK and beyond for specialised facilities that can provide the equipment, expertise and availability to complete the rigorous testing regime required. As these tests are UK first (if not world first) then there is a very limited number of facilities around the UK that meet the necessary criteria.

LVDC Phase 2 – Deliverable 3

To complete the testing programme as per the testing specification and compile a report on the findings from the laboratory testing. After the testing facility has been procured the detailed testing programme on the LV cables, joints and link boxes will be completed in order to gain a deep understanding of how they will perform when energised with LVDC.

LVDC Phase 2 – Deliverable 4

To create a series of case studies and a cost-benefit analysis which will conclude where converting existing assets to LVDC would be technically and economically viable. This involves comparing the cost of LVDC conversion to traditional LVAC reinforcement in a wide range of scenarios / network areas. There are number of financial, environmental and social instances where LVDC outperforms LVAC and these will all be included in the cost benefit analysis.

3.19.1 | NIA SPEN 0047 Project Progress

Deliverable 2

"Conduct a tender exercise for a Testing Facility to complete the testing specification created."

The tender process was completed in October 2020 and the University of Strathclyde's Power Networks Demonstration Centre (PNDC) was the preferred candidate as they demonstrated the technical expertise required coupled with the facilities needed to complete the testing, at the lowest cost that the market was able to deliver.

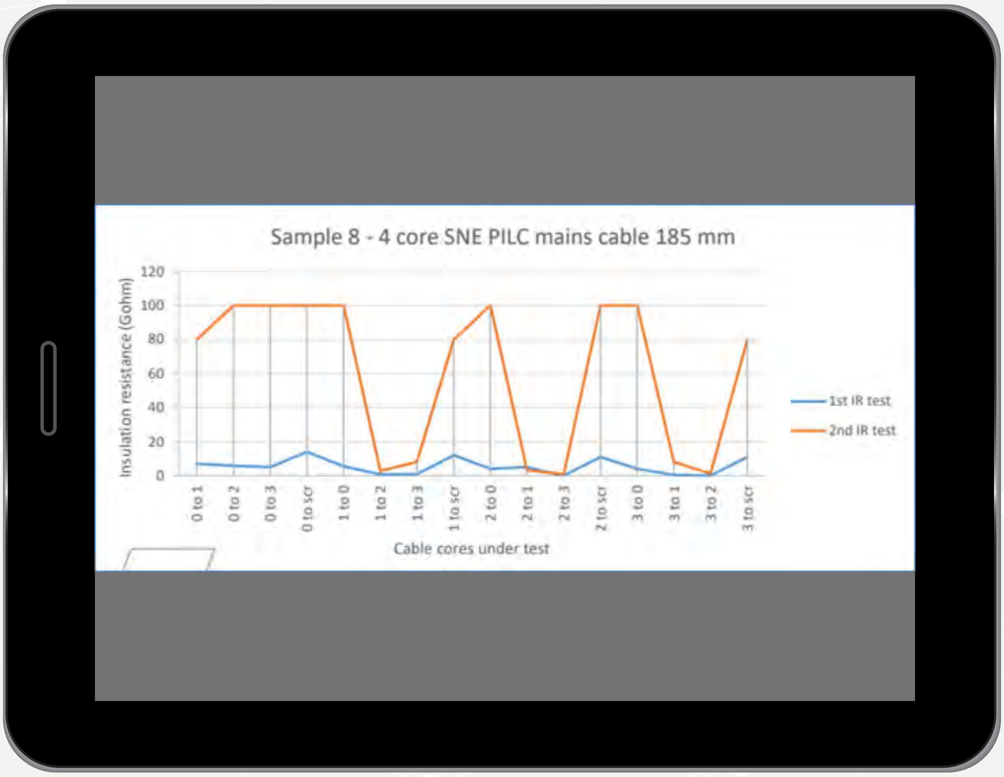
Deliverable 3

"To complete the testing programme and compile a report on the findings from the laboratory testing."

There was some delay in starting the testing regime due to the impacts of the coronavirus pandemic. However, all the LV Network Assets were successfully delivered to the PNDC just before Christmas 2020. Following the turn of the year the agreed testing regime began.

The assets first subjected to the DC loading schedule were some of our more risky/ aged assets, setup in a mini network formation. At the time of writing a 40-50-year-old PILC cable, joint and linkbox that were recovered from various points of the SP Energy Networks network have been subject to 1414VDC bipolar at varying current from minimum to maximum rating. This was then followed by accelerated aging which increases the voltage even further to simulate years of asset life in a number of days. Generally, one day of accelerated aging at the increased DC voltage at PNDC is equivalent to one year of standard service for the asset. To date the assets have been subjected to 10 years equivalent of DC accelerated aging.

Whilst one core of the linkbox failed the rest of the assets have performed extremely well thus far. The failure in one of the linkbox cores is thought to have been caused by damage done to the asset either in transit or during testing. Further investigation following destructive testing may shed more light on the failure of this core. However, it is important to note the other linkbox cores are performing well. The graphs below demonstrate over time the assets' health assessment. It can be seen from the graph that the insulation resistance (one of many tests done to ascertain asset health) of the PILC assets is considerably consistently higher than the minimum requirement.



The testing will continue on these assets before the same programme will be carried out on the remaining asset groups. Further updates will be given following project completion.

Deliverable 4

"To create a series of case studies and a cost-benefit analysis which will conclude where converting existing assets to LVDC would be technically and economically viable."

Numerous cost benefit analysis have been carried out comparing the cost of LVDC reinforcement against traditional LVAC reinforcement. In the retrofitting environment LVDC consistently comes out as the financially preferable option however further study and technological improvement/ procurement would need to be carried out to make certain.

Cost Benefit Analysis has also been carried out comparing LVDC against LVAC network design for new build developments. Due to the higher cost of the innovative LVDC assets, LVAC is predominantly still the preferred option for new builds. This may change when further study/ procurement of the technologies required to enable LVDC have been carried out.

3.20 | NIA SPEN 0048 The Chatter Tool

Stakeholder engagement and customer feedback is important to underpin our strategy and plans with actionable insight across the widest cross section of our customer base and interested parties and understanding this at a local level. The traditional methods of stakeholder engagement at low volumes can, however, be expensive, and may not be the most effective way to leverage our knowledge and data.

In this project, we will build a data-driven solution. This tool will allow feedback to be layered across the different sources and viewed at a local level, so we can understand the priorities, key issues, and reputation at a local level giving a view at district level, local council and local government level.

The tool will take a scrape of all customer feedback, social media, web posts, political feedback and media coverage relating to the DNO which will allow us to demonstrate a greater reach than would otherwise be achieved through solely traditional engagement methods.

This tool would then use natural language processing algorithms to identify the topic being discussed, identify positive/negative feedback and identify the root cause. Whilst this technology is not new, the way in which it is being applied is new, in that it is bringing together a multi-dimensional data set into a bespoke dashboard that can provide new and unique insight.

This tool will give the ability to demonstrate the reach to a much wider population of customers which could not be achieved solely through traditional methods.

3.20.1 | NIA SPEN 0048 Project Progress

The Chatter tool has now been fully developed, finalised, and is in use in the Customer Service department of SP Energy Networks. It has been successfully used in stakeholder engagement through the scrape of customer feedback.

3.21 | NIA SPEN 0049 iDentify

iDentify will address issues with reporting of faults in customer's cut-outs. The following issues are common when considering this:

1. **Asset data collection** – There are unknown quantities of customer devices with no straightforward method of data collection. Cut-out types and quantities are also unknown without major expenditure to gather information manually.
2. **Aborted calls** – SP Energy Networks staff are often sent to site for "check for safety" when the issue is a non-SP Energy Networks asset or pole, or where the customer has tripped switches.
3. **Ageing assets and younger workforce** – there are some situations where switchgear won't operate as it takes some more experience than our operating manual offers, particularly for old equipment which is no longer installed but has not been replaced.

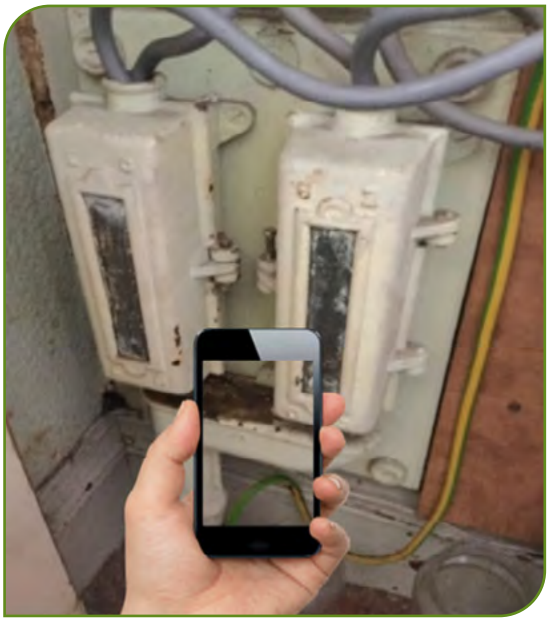
This project will exploit artificial intelligence (AI) Recognition technology and augmented reality to:

1. Crowdsource data on SP Energy Networks assets and customer devices to aid in updating the SP Energy Networks asset records;
2. Identify 3rd party assets to reduce aborted calls, and
3. Offer training, support and guidance to field staff on SP Energy Networks assets.

It will do this through the development of an app which will identify the asset it is trained on, and will provide either useful asset data or problem-solving guidance to the user.

3.21.1 | NIA SPEN 0049 Project Progress

The artificial intelligent (AI) image recognition system has had its proof of concept stage completed in the past year. In this proof of concept, two types of cut-out were identified successfully after a process of algorithm training.



The current phase of the project is now taking this AI recognition into a fully developed app for wider usage. This is being taken GB-wide by the ENA with the existing use-case and development of new uses. This is to be adapted as part of the process to survey and install EV chargers and heat pumps, with the intention to replace the paper application forms on their website. The project is due to be finished in 2021.

3.22 NIA SPEN 0050 Real Time Fault Level Monitoring Stage 2

This project is a follow on from the Stage 1 project (NIA_SPEN0015). The main outcome of the Stage 1 project was a proof of concept design to measure network Fault Level in real time. This has been clearly demonstrated.

To maximise the benefits of this innovation and achieve widescale BaU rollout and move to TRL9, the scope of Stage 2 (NIA_SPEN0050) is to:

- Expand the network trial locations, to assess the performance of the devices and compare measured fault level values to existing practices for multiple network configurations.
- It is known that there are approximations in the existing practices (modelling) for determining Fault Level. Controlled tests at a suitable test network at which real fault current can also be measured would enable calibration / approval of measured results to be used as the primary information source when managing the network.

Real Time Fault level monitoring prototype

3.22.1 | NIA SPEN 0050 Project Progress

The project has progressed well in spite of the coronavirus pandemic. A key milestone was completed in October 2020 with the completion of algorithm fidelity tests at the Power Networks Demonstration Centre (PNDC). PNDC has published a report on the findings which were positive from both an accuracy and operational deployment perspective.

A follow up set of tests at a live test facility in Hungry (or Australia) was then scheduled for February 2021 however this has been delayed due to the coronavirus pandemic travel restrictions. This was rescheduled for July 2021.

Further to the above, design and build on further devices for test and deployment on both SP Energy Networks and UK Power Networks distribution netwo rks has also progressed well with some key design improvements made during the process.

3.23 NIA SPEN 0052 A Substation of the Future

The Substation of the Future project will purchase and install alternative non-SF6 Stand Alone Panels, as part of the re-design of a secondary substation to account for the non-SF6 Panel and low carbon transformer and other standard components. The project will investigate the Life Cycle Analysis of the non-SF6 unit and novel substation arrangement and develop learning of commercially available options to enable the solution to be optimised for rollout.

Current expectations are for SF6 to be banned for new installations come 2025. A review of current legislation took place in 2020. As this EU review incorporates up to 52kV it will have a large impact on DNOs as this is where SF6 alternatives are scarce and thy will need to act fast to propose new solutions to the alternative installation of gas insulated equipment. From the RIIO-T2 submissions there has been an incentive to UK TNOs from the regulator, OFGEM, to install alternative gas insulated technologies. It is expected that the same will happen when RIIO-ED2 takes effect and the same principles in consideration of CO2 emissions will be applied. Non-SF6 alternatives exist but their integration into BaU has not yet been seen. Doing nothing now means potentially having to rapidly rollout an unfamiliar solution when the issue becomes imminent.

The project scope of work includes:

- **Procurement** – The procurement process will include engagement with suppliers to obtain the novel equipment required for the substation;
- **Identification** – To identify and specify the optimal demonstration site for trial;
- **Design** – To design and approve the novel arrangement for the substation; this will also include analysis of the offset carbon from the approach;
- **Deploy** – To deliver, install and commission at the selected site; and
- **Review** – To review the project learning to inform future rollout.

3.23.1 | NIA SPEN 0052 Project Progress

Procurement, identification and design aspects of the project are now complete. The substation components are procured and the substation location has been identified. The project is on track for installation and commissioning prior to the CoP26 conference which will be held in Glasgow in November 2021.

3.24 NIA SPEN 0055 On-Site Non-Intrusive Polychlorinated Biphenyls (PCB)

The European Union has issued a directive for the elimination of all HV equipment containing polychlorinated biphenyls (PCB) contaminated oils that have a concentration of above 2 parts per million; the UK deadline is 2025. GB DNOs have large fleets of oil filled Pole Mounted Transformers (PMTs). To meet their legal responsibilities, they need to confirm the levels of PCB contamination to enable appropriate asset management including the required asset replacement planning and appropriate disposal. Chlorinated hydrocarbons are only present if PCBs are present in the oil. The project will target chlorine concentration measurement remotely based on radionuclide decay using gamma ray detection.

The proposed solution is intended to be a non-intrusive method of determining the PCB levels in the field without the need to return samples to the laboratory. The method does not require obtaining an oil sample from the asset or any interference with the fabric of the asset.

The project will enable EA Technology to present a service to the UK DNOs that if adopted will enable UK DNOs to manage their fleet of pole mounted transformers and meet the requirements of environmental legislation.

The project comprises of four stages:

Stage 1 – Sourcing of and purchase of suitable detector instrument and associated consumables: The output will be the delivery of equipment to EA Technology (the ownership is retained by the Energy Innovation Centre (EIC) partners) and functional specification of the detector instrument will be documented.

Stage 2 – Theoretical Undertakings and Equipment Calibration: Investigation of theoretical aspects of establishing the algorithm for converting the gamma ray activity into PCB Aroclor concentration will be investigated. The output will be a report detailing the findings of the stage to establishing a theoretical algorithm. The necessary information will be available to decide on the likely success of the project, at which time the project could be terminated or continued with the agreement of the partners.

Stage 3 – Completion of Algorithm Verification and Laboratory Trails: Testing of the theoretical algorithm against experimental data and identify any correction required and verify the model. The output will be a written report detailing the findings of the stage and producing the working algorithm.

Stage 4 – Completion of Field Trials and Training: Equipment will be adapted for field testing and field trials will be performed to assess the methodology, accuracy of detection and logistics of completing the tests in the field. The procedure and future service offering will be fully documented and training provided to SP Energy Networks staff. The output will be a report including documented working methodology for the onsite procedure.

Benefits – The partners will own the detector instrument and a functional specification of the detector instrument will be produced. The project will enable the partner DNOs to collect the required data from the field for EA Technology to process using the algorithm determining the PCB concentration. This will enable the partner DNOs to manage their fleet of pole mounted transformers and meet the requirements of environmental legislation. In addition the methodology will aid reducing the number of interruptions to customers, while ensuring network companies maintain a sustainable and resilient electrical network. The cost savings associated with this method compared to obtaining an oil sample from the asset is estimated to be millions of pounds for the UK DNOs. Furthermore there is very little safety impact of utilising the non-intrusive method compared to obtaining an oil sample from the field.

The project will commence at Technology Readiness Level (TRL) 2 and complete at TRL 8.

3.24.1 | NIA SPEN 0055 Project Progress

At the time of reporting, the project was at the contract signing stage and being coordinated by the EIC.

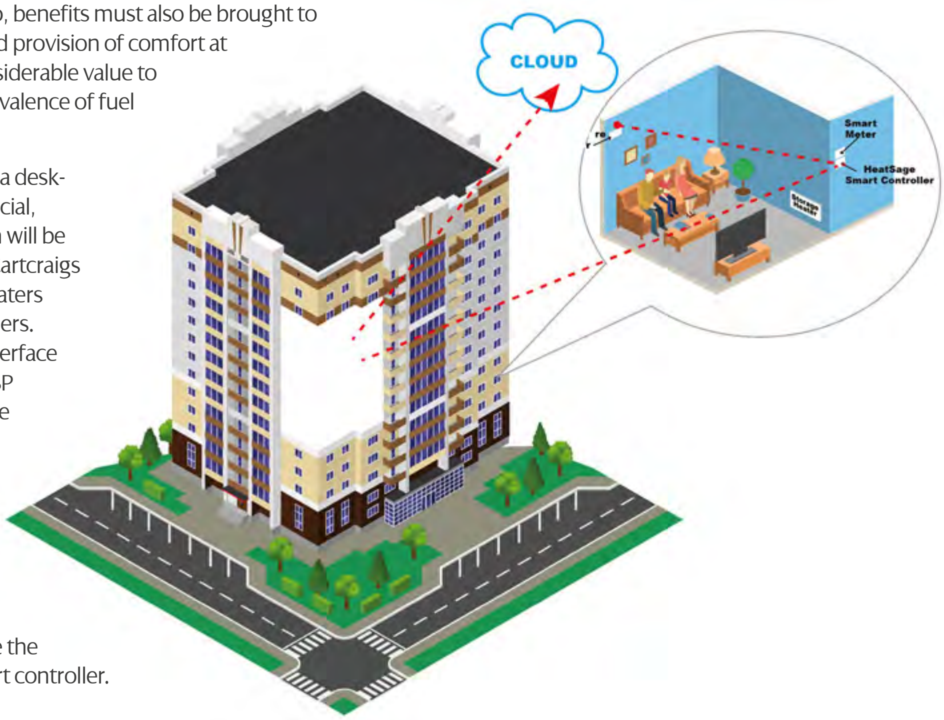
3.25 NIA SPEN 0056 Flexible Tower Block

The Flexible Tower project will investigate how SP Energy Networks can support and benefit from smart controls to influence the timing of storage heater charging. The project will benefit the customer through the ability to lower bills; and benefit the network by opening up a largely untapped resource to the flexibility market. We have partnered with Glasgow Housing Association (GHA), Scotland's largest social landlord, to deliver the Flexible Tower project. GHA are currently investing in smart heating control across their properties in Glasgow and one of these properties, Cartcraigs Tower in the south of Glasgow, has been selected to form the basis of the study and trial.

Storage heating is currently seen as a non-flexible load and vulnerable customers are suffering as a consequence of night-time-only charging, poor heating performance and expensive. On peak supplementary heating is often required at the daily evening peak. Therefore, the experience for customers can be improved by introducing flexible storage heater charging in conjunction with tariffs to achieve better heating profiles and costs. Around 260,000 households in Scotland have electric storage heaters installed and a significant proportion are likely 'here to stay' in the long term.

Smart storage heating controls offer wider whole system benefits to the DNO and to electricity suppliers. In doing so, benefits must also be brought to householders – through improved provision of comfort at a lower cost. This could be of considerable value to these householders given the prevalence of fuel poverty in Scotland.

The scope of the project includes a desk-based study focusing on commercial, market and business issues which will be complimented with a trial in the Cartcraigs tower block which has storage heaters fitted with smart in home controllers. The project will develop an API interface between in home controller and SP Energy Networks which will enable trials to be run on the tower block storage heater use against typical EV charging and constrained wind data sets. Monitoring will be undertaken within a percentage of the tower block properties and at feeder level in order to evaluate the performance of the in home smart controller.

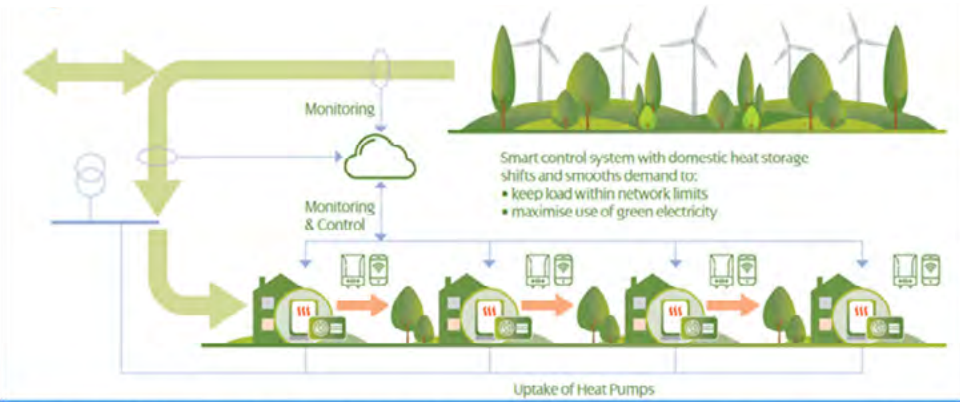


3.25.1 | NIA SPEN 0056 Project Progress

The project commenced in March 2021. The initial task is a desktop study investigation which is being carried out by Delta-EE. Connected response have been engaged by the Glasgow Housing Association (GHA) to supply in-home smart controllers.

3.26 NIA SPEN 0058 ReHeat

ReHeat is the first DNO-led large-scale trial of electrified heat which will develop combined technical and commercial solutions to make heat demand flexible, reducing the peak demand on the electricity network. ReHeat is a strategically significant project being a first of its kind to investigate the impact of full electrification using technology such as Air Source Heat Pumps (ASHPs) and thermal storage to maximise the usage of existing assets by deferring and optimising the conventional network reinforcement needs. ReHeat will demonstrate tools to enable an accelerated deployment of low carbon electrified heating at an efficient cost to customers, and release the whole-system benefits of flexible heat, providing timely evidence to inform national policy and electricity networks' investment strategy.



The solution includes smart grid controls and smart heating management with domestic heat storage to reduce peak electricity demand as a customer friendly and cost effective alternative to network upgrades

The primary technical method that will be trialled in ReHeat is the deployment of domestic thermal storage in conjunction with smart control as an alternative to conventional network reinforcement. A high temperature ASHP and Phase Change Material (PCM) thermal storage will be supplied to around 150 off-gas households across Scotland as part of the live demonstration. Each property will be provided with an in-home controller to co-ordinate the ASHP and PCM thermal storage to meet customer heating needs whilst ensuring the Distribution network is not overloaded. The project will demonstrate how cost optimal solutions can be put in place to enable the transition to renewable heat. The tools developed by the project will enable DNOs working in conjunction with Scottish Government and other stakeholders.

3.26.1 | NIA SPEN 0058 Project Progress

We commenced pre-delivery work in the latter part of 2020 undertaking contractual discussions with our suppliers and initial engagement with the Local Authorities in which trials will be run. We have submitted our application for funding from the Low Carbon Infrastructure Transition Programme (LCITP) run by the Scottish Government. This funding is critical to our ability to procure behind the meter assets for the project. On receipt of the LCITP funding approval we will commence delivery.

4 | NIA Activities Linked to SP Energy Networks Innovation Strategy

SP Energy Networks has been actively working with the ENA and contributed to the collective innovation strategy for the GB energy sector.

While this report links our NIA activities to SP Energy Networks Innovation Strategy with regards to the ENA Innovation Strategy, we are looking to ensure that our existing and new projects can contribute directly to the five focus areas in the near-term:

- Facilitate the adoption of flexibility and smart systems.
- Facilitate and enable the electrification of heat and transport.
- Facilitate the efficient connection of low and zero carbon electricity generation.
- Understand the operational impact of long duration reserve services on the network.
- Contribute to a UK-wide methodology for calculating the cost of carbon.

4.1 | From Inspiration to Solution

*Our approach to innovation development (From Inspiration to Solution) is summarised in **Figure 1** below which contains five steps:*

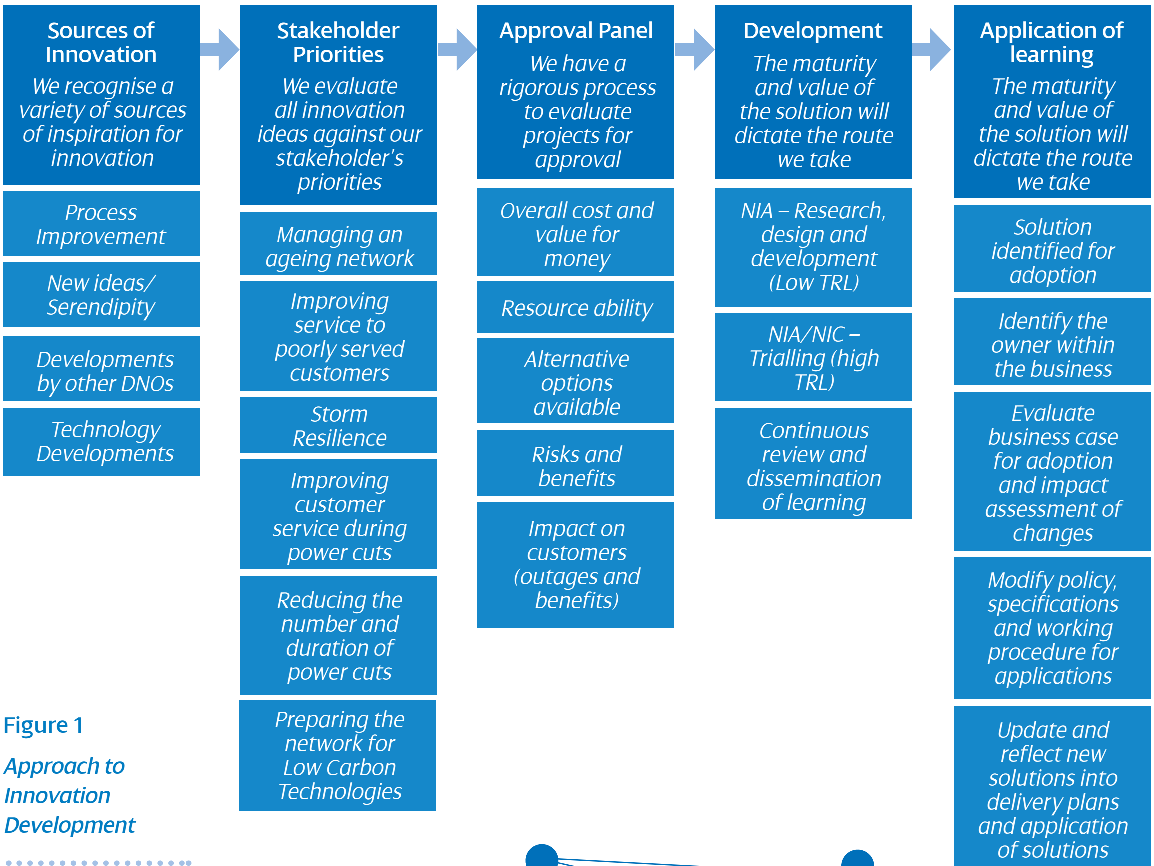


Figure 1

Approach to Innovation Development

The five key steps of our innovation process are:

1. Idea Generation: Ideas can come from a variety of sources. These sources can include technology developments by suppliers or academia and developments by other network companies and wider industry.

2. Evaluation: We use the priorities of our stakeholders as the main evaluation criteria for new projects. We will ensure that all new projects align with at least one of the areas listed in Figure 1 under stakeholder priorities. Operating our network safely, providing value for money and delivering excellent customer service are all implicit requirements in what we do.

3. Approval: Our Innovation Board reviews all technology innovation projects before they progress with NIA/NIC funding. This is to ensure that the project aligns with our strategy, offers value for money, and is expected to deliver benefits that will justify the cost and risk. We also use the approval process to identify any other activity which has synergies to avoid any duplication, and identify resources from the wider business that may need to be involved.

4. Development and Delivery: A project manager and project team identified for each project to deliver the day-to-day project activities. Business Sponsors help to facilitate the integration of proposed, existing and completed project into BaU. Projects are monitored through their life cycle and, in the event that anticipated benefits do not arise, projects may be terminated. Technology readiness levels and project scale will be used to determine the appropriate funding route, be it NIA, NIC or other funding steams such as research grants.

5. Application of Learning: There is a need to ensure that innovation is embedded into all business function, as such the role of the innovation board is to ensure increased participation from all business functions and to allow innovation projects to be completed and integrated into BaU.

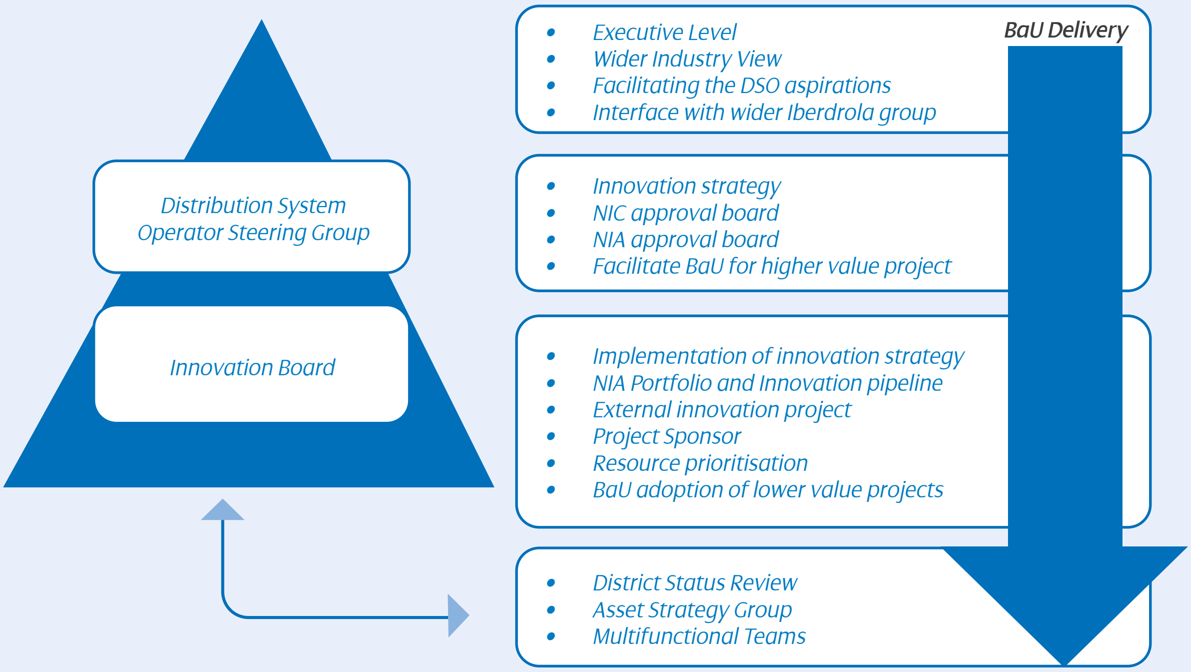


Figure 2

Our innovation governance structure and project approvals process, Figures 2 and 3 respectively, helps to ensure the following:

Projects involve the Research, Development, or Demonstration of at least one of the following:

- A specific piece of new equipment.
- A specific novel arrangement or application of existing equipment.
- A specific novel operational practice directly related to the operation of the network.
- A specific novel commercial arrangement.

A Project must also meet all of the requirements

- Has the potential to develop learning that can be applied by all Relevant Network Licensees.
- Has the potential to deliver net financial benefits to electricity Customers.
- Does not lead to unnecessary duplication.

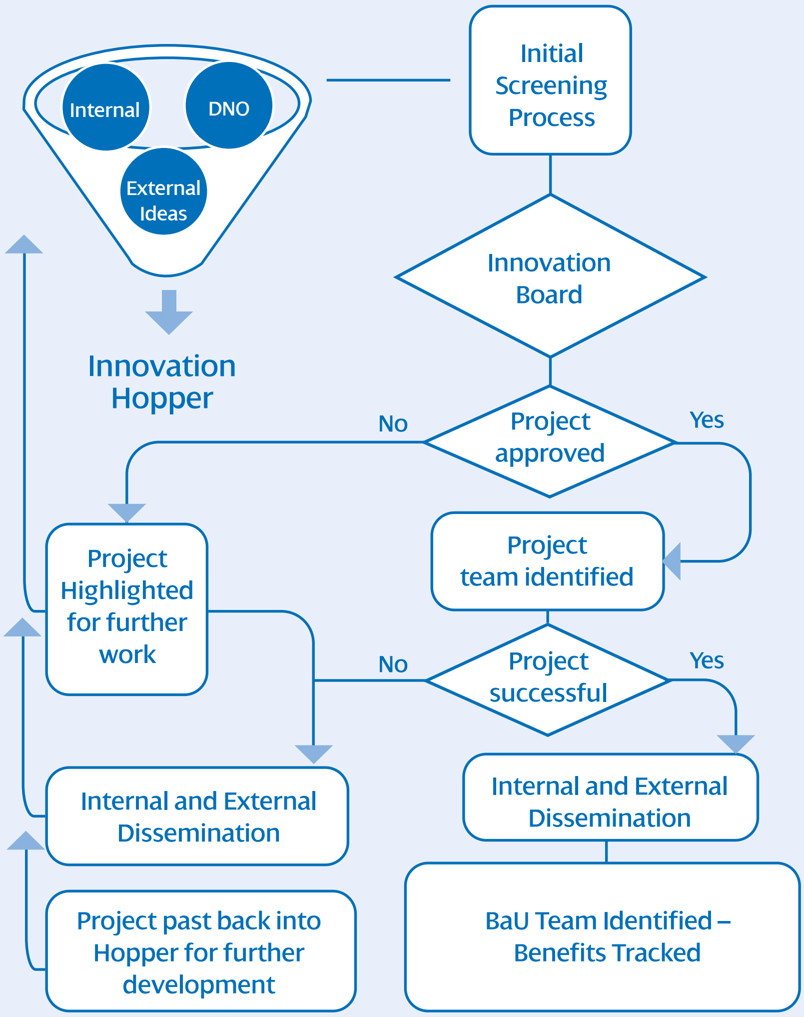


Figure 3

Ideas Generated

4.2 | SP Energy Networks NIA Project Mapping with Innovation Strategy

4.2.1 | Informed by Our Stakeholders

We are acutely aware that the funding we access through the various innovation mechanisms is sourced from our customers. In developing our Electricity Distribution Network Innovation Strategy 2018 we have not only ensured that our innovation activity is focused on areas which customers most value, but also that customers are willing to invest more in these particular areas in the short term, to allow the longer term benefits of innovation to be realised. Our Innovation Strategy uses the priorities identified through our stakeholder engagement process.

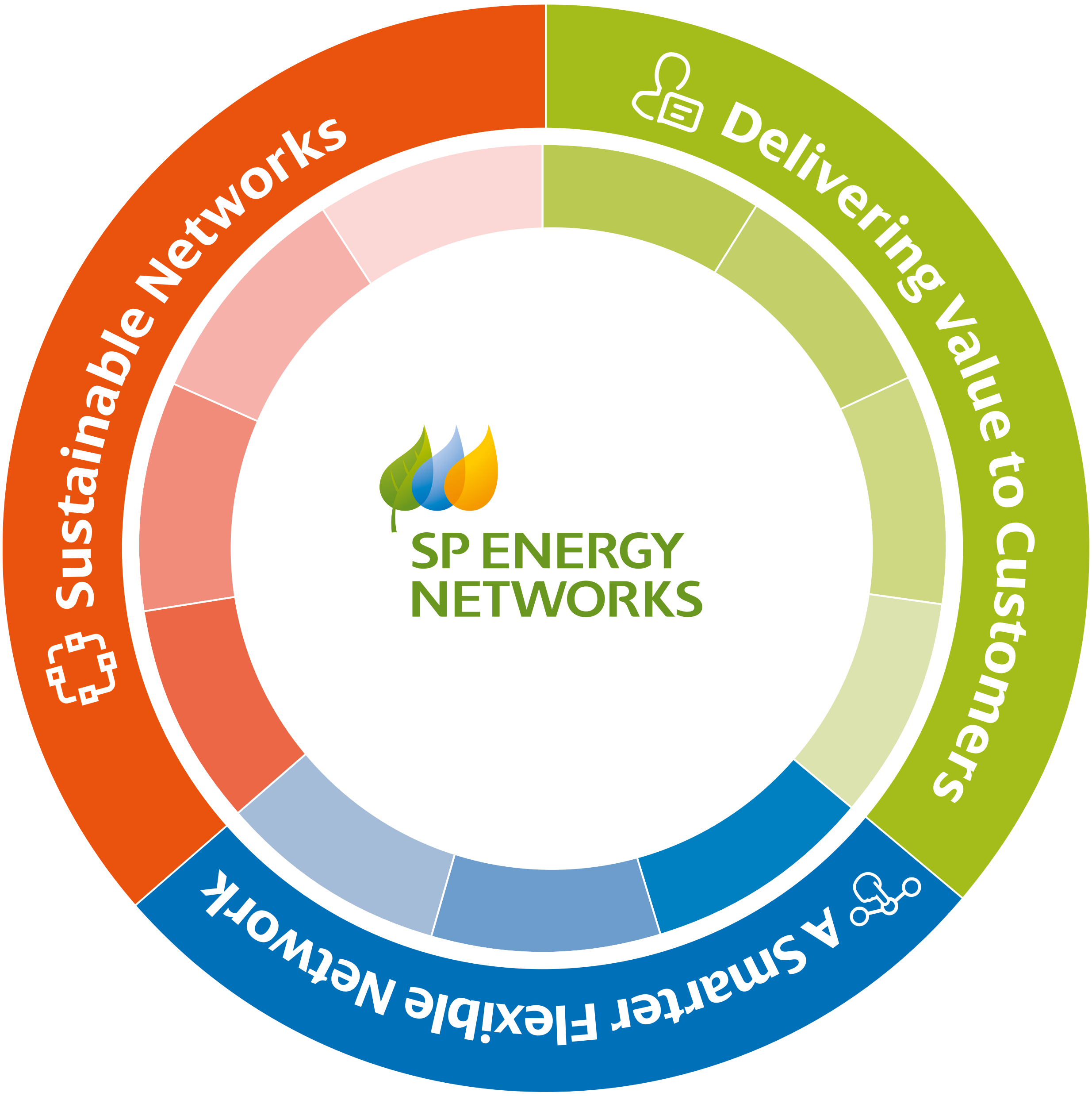
Of all the areas identified, stakeholder feedback identified the following specific priorities:

1.	Managing an ageing network
2.	Reducing the number and length of power cuts
3.	Investing for storm resilience
4.	Improving customer service during power cuts
5.	Improving service to poorly served customers
6.	Preparing the network for LCTs

We have aligned our innovation strategy to these areas and will use this as a key feature of the selection process for new projects. These areas will be addressed within the context of a continued focus on health, safety and the environment.

In mapping our innovation projects onto the priority areas identified with our stakeholders, we took into account the following factors:

- Many of our innovation initiatives will fulfil more than one priority at a time;
- Individual projects will be assessed relative to others in terms of the overall cost, effort, risk and benefit to customers and the network;
- The learning from innovation projects will be an important input to the ongoing strategy; and
- What we learn from our innovation initiatives will have an impact on the overall innovation priorities. Where we have addressed a problem the priority may become less relevant, or if an initiative is unsuccessful that priority may require greater focus.



- Delivering Value to Customers

- Managing an Ageing Network
- Maximising the benefit of data
- Network Control and Management
- Reducing the number and length of power cuts

- A Smarter Flexible Network

- Faster, Easier, Accurate Connections
- Network, Flexibility and Communications
- Preparing the network for Low Carbon Technologies (LCTs)

- Sustainable Networks

- Minimising the Environmental Impact of Assets and Activities
- Modernisation of Work Practices and Business Systems
- Our People - Skills and Resources
- Socially Responsible Member of the Local Communities We Serve

4.3 | SP Energy Networks NIA Project Mapping with Innovation Strategy

No.	Project
01	NIA SPEN 0008 APPEAL
02	NIA SPEN 0012 SINE Post
03	NIA SPEN 0014 Active Fault Level Management
04	NIA SPEN 0023 Connected Worker Phase 1 – Field Data Automated Capture
05	NIA SPEN 0024 Endbox G38 Level Detection Phase 2
06	NIA SPEN 0029 Secondary Telecommunications Phase 3 – Trial of Hybrid Telecoms
07	NIA SPEN 0030 Zebedee Sectionaliser Device
08	NIA SPEN 0031 Radiometric Arc Fault Location RAFL 2
09	NIA SPEN 0033 CALISTA
10	NIA SPEN 0034 Network Constraint Early Warning Systems (NCEWS 2)
11	NIA SPEN 0036 A Holistic Intelligent Control System for Flexible Technogies
12	NIA SPEN 0037 Electric Vehicle Uptake Modelling (EV-Up)
13	NIA SPEN 0039 THOR Hammer
14	NIA SPEN 0040 Improving Storm Resilience through Data Analytics
15	NIA SPEN 0041 Proof of Concept Tarmac Reinstatement Tester
16	NIA SPEN 0042 Novel Temporary Earthing and Bonding Solutions
17	NIA SPEN 0043 Bethesda Home Hub
18	NIA SPEN 0045 SAFE-HD (Spatial Analysis of Future Electric Heat Demand)
19	NIA SPEN 0047 A Transition to LVDC – Phase 2
20	NIA SPEN 0048 The Chatter Tool
21	NIA SPEN 0049 iDentify
22	NIA SPEN 0050 Real Time Fault Level Monitoring Stage 2
23	NIA SPEN 0052 A Substation of the Future
24	NIA SPEN 0055 On-Site Non-Intrusive Polychlorinated Biphenyls (PCB)
25	NIA SPEN 0056 Flexible Tower Block
26	NIA SPEN 0058 ReHeat

Delivering Value to Customers				A Smarter Flexible Network			Sustainable Networks			
Managing an Ageing Network	Maximising the Benefit of Data	Network Control and Management	Reducing the Number and Length of Power Cuts	Faster, Easier, Accurate Connections	Network Flexibility and Communications	Preparing the network for Low Carbon Technologies (LCTs)	Minimising the Environmental Impact of Assets and Activities	Modernisation of Work Practices and Business Systems	Our People – Skills and Resources	Socially Responsible Member of the Local Communities We Serve
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5 | Areas of Significant New Learning

The following identifies areas of learning on a project by project basis.

5.1 | Project Learning: NIA SPEN 0008 APPEAL

Due to delays as a result of the coronavirus pandemic, there is no further learnings to present until the third uplift report is published.

5.2 | Project Learning: NIA SPEN 0012 SINE Post

This project has demonstrated that it is possible to automate the use of data from multiple systems to interpret fault monitoring data and provide advice to control engineers. The project has also demonstrated that network data quality is crucial to the operation of these types of solutions and continuous data improvement activity is required.

5.3 | Project Learning: NIA SPEN 0014 Active Fault Level Management (AFLM)

Phase 2 of the project has refined the concept design for an AFLM system. The project has developed the specification, requirements, design principles and high level commercial principles of access for the AFLM system. These provide key learning and insights on the AFLM design and how it can be applied.

Phase 3 is now exploring the technical requirements surrounding deployment of a live trial. This will provide valuable learning for wider deployment of the solution in future if successful.

5.4 | Project Learning: NIA SPEN 0023 Connected Worker Phase 1 – Field Data Automated Capture

Project learnings are limited to date based on the current status of the project.

5.5 | Project Learning: NIA SPEN 0024 Endbox G38 Level Detection Phase 2

The main lesson learned from this project has been the proof of the non-destructive monitoring being an effective tool for measuring levels of G38 within endboxes and similar equipment.

To make effective use of the testing within the business, the equipment, process and personnel must be properly qualified. For this, we will be engaging with an NDT consultant, and will share the outputs of these discussions once the full process for effective use of ultrasound testing has been established.

The use of ultrasonic non-destructive testing is a highly specialised field which has stringent testing and training requirements in other industries. This isn't a widespread qualification in the electricity distribution and transmission industry, and there are few similar activities which are generally carried out. As such, training in this field was always going to be a challenge, particularly in ensuring that the training was kept appropriate without requiring a large amount of prior knowledge of the NDT field. This, combined with the complexity of the ultrasonic device proved to be too large a hurdle. As such, one key lesson for future projects is that, if a new type of testing or monitoring is to be carried out, consider developing a new tool or device which will minimise the possibility of user error, or the possibility of not effectively setting the device up for use.

5.6 | Project Learning: NIA SPEN 0029 Secondary Telecommunications Phase 3 – Trial of Hybrid Telecoms

A number of valuable insights have been made during this reporting period:

- End to end security required development by suppliers in the marketplace;
- Site survey information can be used to optimise which public carrier is best suited to a given site – the strongest signal is not necessarily the best;
- Skillsets within the business need to migrate to incorporate network/internet work skills to support deployment of smart grids; and
- The complexity of integrating public networks into existing network designs whilst maintaining security and operability.

5.7 | Project Learning: NIA SPEN 0030 Zebedee Sectionaliser Device

As this project is creating a device to facilitate online sectionaliser maintenance, there are few lessons to be taken from the development process. However, it can certainly be observed that there is potential for development of new use cases for the device – such as preventing ferroresonance – which were not initially considered. This was discovered through business engagement wider than just the user base. As such, it is clear that restricting engagement when developing new devices could restrict effective development of the device, and prevent making full use of the device's potential.

The technical drawings from this project for the Zebedee device have been transferred to SP Energy Networks, and are able to be accessed by the other DNOs now that the project is completed.

5.8 | Project Learning: NIA SPEN 0031 Radiometric Arc Fault Location RAFL 2

This stage of the project has dealt with the further development of the system to perform correctly under field service conditions.

The main learning points are:

- The project has demonstrated that arcs generated by utility switching can be located to an accuracy of 64 m when the FDU is located 5 km from the arcing source;
- In order to allow the system to work at distances of ~5 km it is necessary to increase the sensitivity of the FDU, which results in a large number of triggers being recorded;
- The PNDC testing demonstrated that recording a large number of triggers does not result in any false source locations: the occurrence of matching signals from the FDUs only occurred during PNDC switching events;
- Large numbers of triggers can prevent the system from running in real-time since, on occasions, the 4G network could not keep up with the trigger uploads to the server, leading to a 'backlog' of data; and
- The backlog issue can be addressed by either:
    - Desensitising the FDUs – this could potentially lead to a reduction in operational range (i.e. less than 5 km). This approach is presently being trialled.
    - Uploading the data on demand – in this case the server would request the FDUs to upload the relevant data. This approach requires the time of the fault to be known.

5.9 | Project Learning: NIA SPEN 0033 CALISTA

An Academic paper on "A Method for Cable Failure Analysis based on Ageing Model and with Consideration of Daily Temperatures" has been prepared from the CALISTA project, and was presented at the CMD 2020 conference. Further papers will be produced and presented as the project goes forward.

5.10 | Project Learning: NIA SPEN 0034 Network Constraint Early Warning Systems (NCEWS 2)

Due to the slower than anticipated rollout of SMETS2 meters in the UK some of the connectivity improvement Data Analytical techniques that the project wished to explore have only recently started, with the anticipated methods having to be revised based on actual data volumes. By working with other SP Energy Networks innovation projects we are utilising data sets available, including that from substation monitors, to try and create a more complete picture of the network. This will assist with the growing requirement for verification and near real time connectivity understanding, including phase identification, which continues to be a major requirement within this project to maximise the benefit of LV data analytics going forward.

Adopting an agile approach to development also ensures we remain on track and focused on the key business requirements, but also provides the ability to adapt to ever changing priorities. Involving key users in the testing of functionality enabled a smooth transition from project to BaU as the wider business has been part of the journey.

5.11 | Project Learning: NIA SPEN 0036 A Holistic Intelligent Control System for Flexible Technologies

- The dataset required for any control purpose at LV (those identified by LV Engine) have some differences with those identified for the control at HV networks. There are more monitored points and a larger volume data at LV networks which should be compiled, analysed and reduced in size before inputting to any central control algorithm. This volume of data may not need to be communicated directly with Operation Management Zone (Real Time System) to avoid heavy data traffic, instead some of the data filtering and analysis may take place locally then data transferred first to the Enterprise Zone. Energy Smart Meter data also available to the Enterprise Zone as the main DNO interface with Data Communication Company (DCC). A data transfer between the Enterprise Zone and Operation Zone is expected to provide LV data to HICS.
- Cyber security requirement does not allow a direct access of the suppliers to the central control system, instead an indirect arrangement have been set up for the HICS, this can be a template for any future smart solution.

5.12 | Project Learning: NIA SPEN 0037 Electric Vehicle Uptake Modelling (EV-Up)

The learning from EV-Up was reported previously in NIA Distribution Annual Report 2019/20. The learning reported here is for the project extension to include forecasting of Heat Pump uptake (Heat-Up).

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 data sets into a single dataset covering all properties in the SP Energy Networks districts, segmenting those properties in various ways which again could be used in other analysis; and
- 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 SP Energy Networks 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 SP Energy Networks to more accurately understand the scale of the challenge faced by the Business as adoption of Low Carbon Heating increases over the next 3 decades.

Example outputs:

Once a 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.


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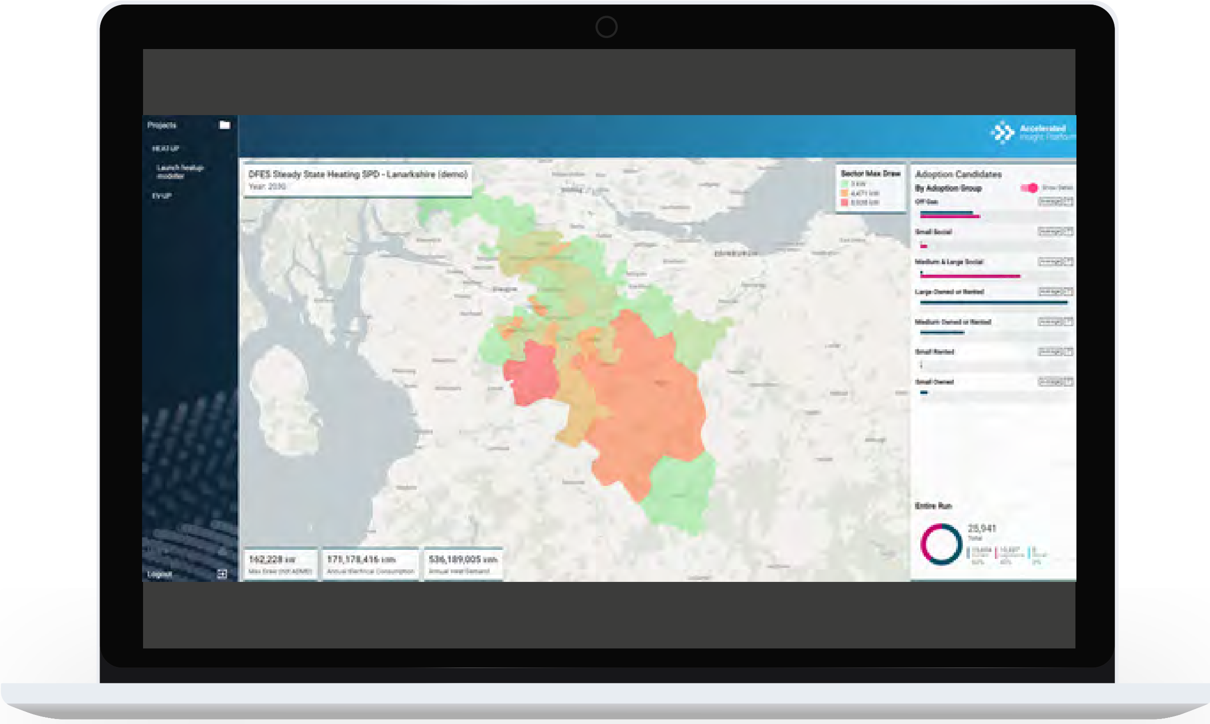


Heat-Up Output Dashboard

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 SP Energy Networks to overlay the outputs from Heat-Up onto their electricity network. The illustration 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.

5.13 | Project Learning: NIA SPEN 0039 THOR Hammer

The project has learnt significantly from the virtual training that was delivered. Difficulties in demonstrating the use of the THOR device but live field trials via Microsoft Teams proved successful in training the technique to DNO staff.

Early destructive testing has shown some good correlation between the strength of the pole found during the destructive bending tests and the remaining strength of the pole determined by the THOR device. More testing is planned for further validation.

5.14 | Project Learning: NIA SPEN 0041 Proof of Concept Tarmac Reinstatement Tester

During the laboratory tests impedance analysis was used to measure air void density in the surface layer and GPR to measure the layer thickness. The GPR measurements of the layer thickness showed good correlation. The objective of the impedance analysis measurements was to determine the material dielectric constant (permittivity) and correlate it to the air void density in the samples. Two methods were used to determine the material permittivity: capacitance measurement and measuring complex reflection coefficients that were made by using a Vector Network Analyser. The capacitive method showed good correlation between the measured permittivity and the air void densities of the asphalt samples. Using the vector network analyser showed some good correlation but further work would be needed to refine the method and improve the results.

Further details of these analyses, including the field trial, can be found in the project closedown report. The findings from this project suggest that there is promise in the techniques analysed but further work is needed to develop equipment that will be accurate and easy to use in the field.

5.15 | Project Learning: NIA SPEN 0042 Novel Temporary Earthing and Bonding Solutions

The project has researched and assessed the current practices and standards within UK network operators. This has identified the areas of focus for the next stage of the project, where improvements in practices can be developed along with the assessment of new products and equipment for use in temporary earthing of overhead lines and mobile generation. The areas of focus for the second stage of the project were:

- Conductor end clamps (all types) – UK and overseas suppliers;
- Telescopic earthing poles – UK and overseas suppliers;
- Systems enabling safe earthing from ground level – UK and overseas suppliers;
- Robustness of terminations between earth lead and end clamps – compare methods of attachment across the Electricity Supply Industry;
- Simple methods of marking and accurately recording position of applied drain earths on the job-site; and
- Review methods of obtaining reference earth using plate electrodes.

Several new pieces of equipment were demonstrated for use in temporary earthing of overhead lines including earth clamps, earthing lead and operating poles/earth application systems. This demonstration was successful and showed that several of the pieces of equipment could reduce the time and effort needed by personnel in applying and removing temporary overhead line earths. Further trials are required in the field to compare any potential new practices with existing practices/equipment to accurately assess any efficiency savings. These trials will take place outside of the project, as part of a BaU transition.

There was minimal success in achieving suitable earthing values for portable generators using plate electrodes as part of Workstream 2. Further design and trials are required to assess if there is any possibility of using this method to achieve the required earthing values.

5.16 | Project Learning: NIA SPEN 0043 Bethesda Home Hub

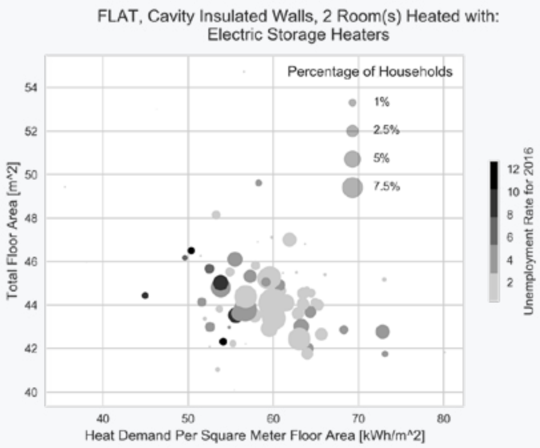
There is the potential for communities to be involved in flexibility service provision. The project will determine the viability and benefits for a community in addition to usual practices.

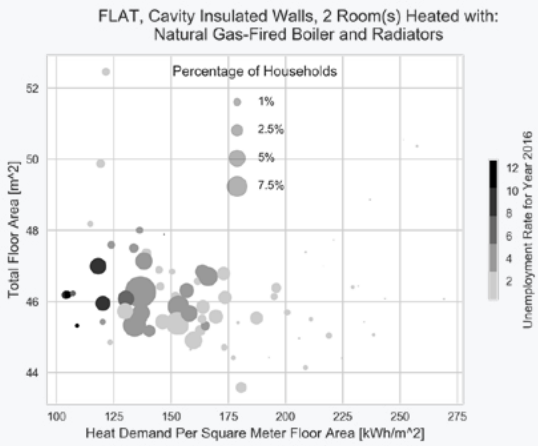
5.17 | Project Learning: NIA SPEN 0045 SAFE-HD (Spatial Analysis of Future Electric Heat Demand)

The uptake of electrified heat is a complex matter and will be subject to developments in policy, technical and economic factors varying across different demographics. The high spacial resolution of the agent based model allows the intricacies of future energy scenarios to be addressed on a street level. The project will enable sensitivities within projected uptake to be modelled and assessed by network planners when considering the implications that the electrification of heat will have on future demand growth.

The SAFE-HD model will notably be used as part of work package 3 for the CREDS Flex Fund research programme that is broadly concerned with assessing post coronavirus pandemic impacts on demand, flexibility and infrastructure. As part of the planned CREDS project, as well as other potential academic activities at Strathclyde, the major SAFE-HD model updates will hopefully include:

- A revision of model inputs and the re-calibration of agent investment behaviour in line with state-of-the art research on post coronavirus pandemic demand and energy systems changes for Net Zero;
- An increased consideration of stakeholder agency beyond owner occupied households;
- Additional heating technologies; and
- Additional energy tariffs available to households.





The above graphical results show average annual heat demand, normalised by floor area, for each residential-based area classification for cavity walled flats with two heated rooms. The left graph is for households with electrical storage heaters and the right graph is for households with natural gas-fired boilers and radiators. The colour gradient indicates the rate of economically active population claiming Job Seekers Allowance (JSA). Note the graphs have different axis values so that the diversity for each heating type can be more clearly depicted.

5.18 | Project Learning: NIA SPEN 0047 Transition to Low Voltage DC Distribution Networks – Phase 2

The coronavirus pandemic caused many understandable delays to the project, particularly during lockdown as the testing facilities doors were closed. However, as the testing has progressed some initial valuable learning has been gained. Some of the more aged/ poorer condition assets have been subject to substantial DC voltage and currents, nearly 6 times their usual voltage in some cases. It is very encouraging that during this initial testing the assets are not only surviving the tests but not showing any additional degradation when compared to what would be expected under standard LVAC conditions.

It can be said then with relative confidence that the remaining better condition/ newer assets will survive the tests in the same manner. This supports an evidence base for LVDC to be a viable alternative to LVAC for the home of the future. SP Energy Networks will continue to pursue advancements in this area to bring the benefits to all customers.

5.19 | Project Learning: NIA SPEN 0048 The Chatter Tool

The Key lesson which can be taken from the Chatter Tool project is that the above method of stakeholder engagement is effective in gathering feedback from a greater range than would have been possible previously.

5.20 | Project Learning: NIA SPEN 0049 iDentify

The major learning from this project has been on the use of Artificial Intelligence and image recognition to identify what an asset is. This also has recognition of whether action may be required. This has a number of applications which could be explored across the industry, with some of these being explored further through the ENA.

5.21 | Project Learning: NIA SPEN 0050 Real Time Fault Level Monitoring Stage 2

All research, development and technology demonstrations undertaken as part of this project thus far have been effective in meeting the aims of the project. Inherent algorithm accuracy has been independently verified as being within ~1% of actual fault level, and various deployment options are being explored.

5.22 | Project Learning: NIA SPEN 0052 A Substation of the Future

The project will generate user experience in non-SF6 ring main units (RMUs) and new arrangements which will be valuable to the wider industry as we look to reduce reliance on SF6 technologies and integrate new switchgear with our existing designs and policies.

5.23 | Project Learning: NIA SPEN 0055 On-Site Non-Intrusive Polychlorinated Biphenyls (PCB)

The project is intended to determine a non-intrusive method of determining the PCB levels in the field without the need to return samples to the laboratory. The method does not require obtaining an oil sample from the asset or any interference with the fabric of the asset. Depending on the success of the on-site non-intrusive tester, the use of the device can be extended from pole mounted transformers in SP Energy Networks to all UK DNOs as well as to any other assets deemed at risk of PCB concentration. This will aid reducing the number of interruptions to customers, while ensuring network companies maintain a sustainable and resilient electrical network.

5.24 | Project Learning: NIA SPEN 0056 Flexible Tower Block

Post-trial, the learnings from the Flexible Tower Block project will be shared with network licensees which will help in developing common approaches to assist stakeholder deployment of electrification of heat at scale. The learnings provided by the project will be directly transferrable to similar households across GB and therefore all network license areas.

5.25 | Project Learning: NIA SPEN 0058 ReHeat

ReHeat will deliver significant new learning which will reduce the costs of network upgrades for both customers and network operators and accelerate the deployment of electrified heat.

ReHeat will generate new learning in the following areas:

- Improved understanding of load profiles and after diversity maximum demand (ADMD) for heat pumps, considering; geographical location, housing archetype, customer demographic.
- Proven techniques as alternatives to conventional reinforcement that can support the wide scale deployment of electrified heat in areas of network constraint, refined and improved thanks to extensive trials.
- Solutions that work for customers. Through learning derived from the significant amount of customer engagement and research that will be undertaken around the different technical and commercial approached trialled.
- Recommendations for GB-wide implementation. Including policy implications, regulatory requirements, and funding considerations.

The project will generate learning for SP Energy Networks, the other distribution network operators, transmission network operators, National Grid in their role as GB System Operator, aggregators, energy retailers, academia, devolved governments, local authorities and other industry stakeholders such as the heat supply chain, Energy Networks Association, Energy Retail Association, the Department for Business Energy and Industrial Strategy (BEIS), consumer bodies and Ofgem. To ensure that learning is captured and effectively disseminated throughout the project, a Stakeholder/Dissemination Manager will work with the Project Manager, fulfilling a key role within the project delivery team.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