SP ENERGY NETWORKS

DISTRIBUTION

NIA Annual Report
2019 – 2020

Enquiry please contact

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Foreword

SP Energy Networks is committed to delivering the Distribution Network of the future in our two license areas (SP Distribution plc. and SP Manweb plc.) and is leading the industry across a number of areas with our wide and varied innovation portfolio. We have a continued drive, ambition and capability to be at the forefront of innovation in the best interests of our customers and wider stakeholders.

This is our fifth Network Innovation Allowance (NIA) Annual Distribution Report and is an overview of the projects we have initialised during the regulatory year 2019/2020 and an update on those projects reported during 2018/2019 that are still active.

In addition to its function of supporting small scale innovation projects, NIA also plays an important role in fostering robust Network Innovation Competition (NIC) proposals.

Given the urgency to deliver the UK's ambitious net zero carbon emissions we are continuing to build upon our award-winning innovation portfolio to develop cutting-edge solutions. In response to the increasing electrification of transport we have been focusing on the delivery of our successful NIC project submission "Charge". This project aims to engage with relevant stakeholders across network, transport, and planning to develop and trial electric vehicle charging solutions. The project will investigate the ability of smart control, storage, and active network management systems to provide lower connection and operational costs to customers.

In response to the increasing electrification of heat we are developing our Re-Heat NIC project proposal, which will explore and test how we can accelerate the deployment of domestic electric heating while minimising network and consumer costs and ensuring the needs of the customer are protected. Re-Heat will explore how electricity networks can facilitate the large-scale electrification of heat, and allow networks to reduce peak demand in areas of the network while reducing some of the constraints on renewable generation.

SP Energy Networks has been actively working with the ENA and contributed to the collective innovation strategy for the GB energy sector which can be viewed at: https://www.spenergynetworks.co.uk/userfiles/file/Electricity_Network_Innovation_Strategy.pdf

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.

In December 2019 we published our Digital Innovation Strategy which maps out how we are transforming traditional operations with digital innovation to help realise a smarter, more agile network that will support the UK's low carbon aspirations.

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

Innovation and technology advancements will generate more and improved data across our network which represents a great opportunity to realise operational benefits. One such digitalisation example is our NIA SINEPOST project which will collate information from multiple systems and new monitors to identify a more precise location for 11kV faults.

In 2019 we launched our Year of Innovation, and we continue to build on this success in 2020 to ensure that we continue to focus on our people, who are crucial to the development and delivery of any innovation. We have seen success already by strengthening our culture of innovation with more people actively engaged in innovation across the business.

We have successfully built a champion network with over 100 of our employees who make innovation real at a local level and engage their teams to pull out ideas of how we can do things differently. In addition, we have led a series of high-profile campaigns to tackle some of our most prevailing challenges.

In support of our innovation ambitions, SP Energy Networks welcomes third parties to submit innovative ideas for potential NIA and NIC projects.

Colin Taylor
Director
Processes and Technology

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Executive Summary

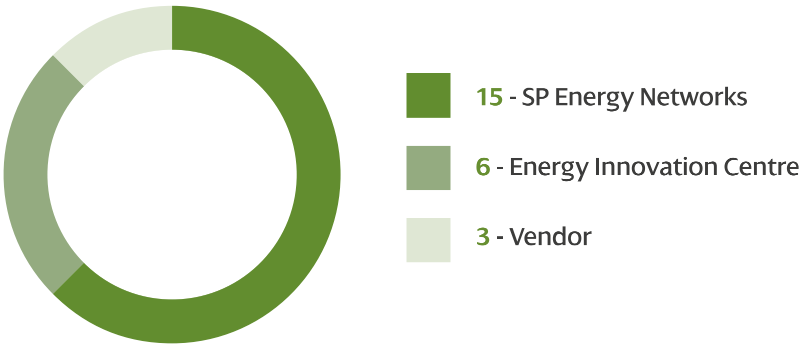
This Network Innovation Allowance Annual Distribution (NIA D) Report has been compiled in accordance with Ofgem's Electricity Network Innovation Allowance Governance Document which sets out the regulation, governance and administration of the Electricity NIA. This fifth NIA D Annual Report presents an overview of the projects we have initialised during the regulatory year 2019/2020 and an update on those projects reported during 2018/2019 which are still active.

We collaborate with other GB network companies to ensure that all customers benefit from customer funded innovation projects and, consequently, this report also provides details of NIA D projects, led by other DNOs in which we are a collaborating party.

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




SP ENERGY
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1 | Introduction

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

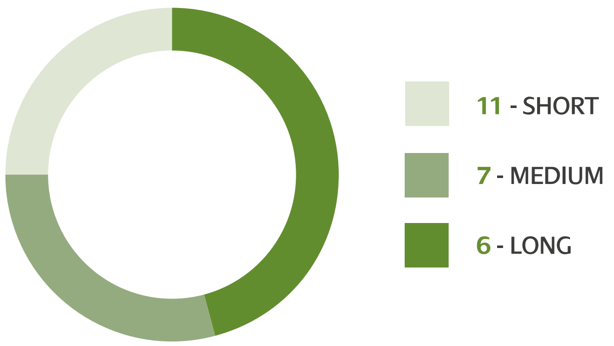
Under the NIA, we are concentrating on a smaller number of higher value projects, with higher technology readiness levels that offer the prospect of earlier business benefits.

SP Energy Networks is committed to identify 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 Business as Usual (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 19 to 31st March 20 SP Energy Networks registered the following nine NIA Distribution projects:

Project No.	Project Name	Project Start Date
NIA SPEN0039	**THOR Hammer** https://www.smarternetworks.org/project/nia_spen_0039	Jun-19
NIA SPEN0040	**Improving Storm Resilience through Data Analytics** http://www.smarternetworks.org/project/nia_spen_0040	Jun-19
NIA SPEN0041	**Proof of Concept Tarmac Reinstatement Tester** https://www.smarternetworks.org/project/nia_spen_0041	Jun-19
NIA SPEN0042	**Novel Temporary Earthing & Bonding Solutions** https://www.smarternetworks.org/project/nia_spen_0042	Jun-19
NIA SPEN0043	**Bethesda Home Hub** https://www.smarternetworks.org/project/nia_spen_0043	Oct-19
NIA SPEN0045	**SAFE-HD (Spatial Analysis of Future Electric Heat Demand)** https://www.smarternetworks.org/project/nia_spen_0045	Aug-19
NIA SPEN0047	**A Transition to LVDC - Phase 2** https://www.smarternetworks.org/project/nia_spen_0047	Nov-19
NIA SPEN0048	**The Chatter Tool** https://www.smarternetworks.org/project/nia_spen_0048	Dec-19
NIA SPEN0049	**iDentify** https://www.smarternetworks.org/project/nia_spen_0049	Feb-20

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 SPEN0008 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 SPEN0008 Project Progress

The second uplift report has now been 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 appropriately.

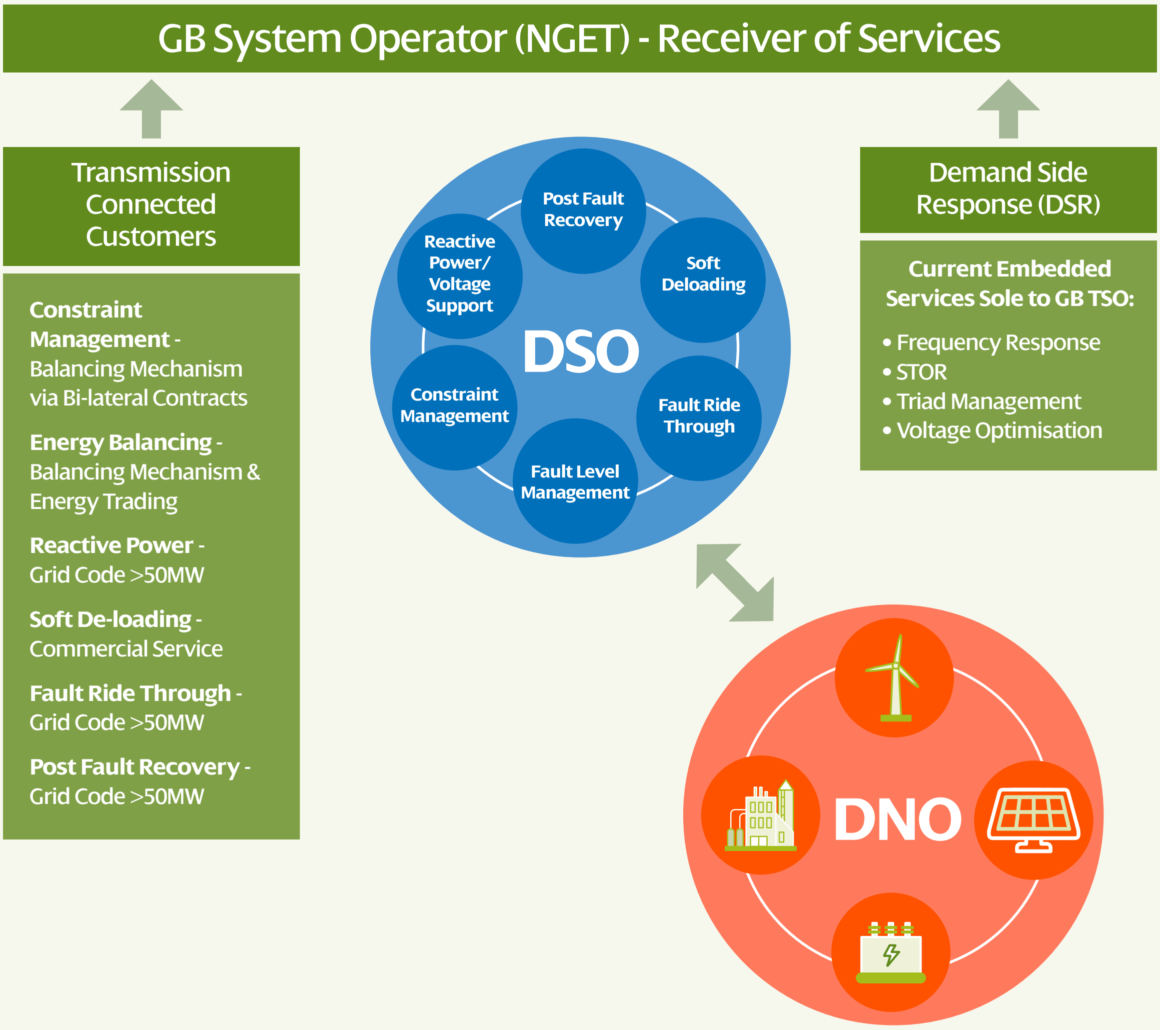
Wood Poles With Preservative Creosote

3.2 | NIA SPEN0010 EVOLUTION

It is acknowledged that our energy sector is transforming fast. With a strong energy policy focused to meet tight environmental objectives and reduce carbon emissions, the penetration of distributed generation is constantly increasing. New players are emerging in the electricity landscape: prosumers (producer/consumer), aggregators (who provide services to National Grid) and distributed storage providers are examples of new participants that are starting to interact and use the networks in a more complex manner.

The role of the System Operator is to balance supply and demand as cost effectively as possible. Historically, this active role has been confined to National Grid; working with predictable demand levels and substantial large scale generation supplies such as nuclear and coal-fired power stations. The output from low-carbon technologies is far less predictable and the traditional DNO model means that SP Energy Networks cannot take a fully active role in balancing supply and demand. In recent years there has been significant discussion across the electricity industry globally about the development of a new entity known as a Distribution System Operator (DSO). The DSO will adopt the responsibility of local management of the network, bridging the gap between the current system operator and customers connected to the distribution network.

This transition to a DSO model is a major change coming to all DNOs and will only be made possible through the coordination of the UK electricity energy sector.



3.2.1 | NIA SPEN0010 Project Progress

During the regulatory year of 2019/20, Evolution continued its role as an accelerator and facilitator and played a critical role in fulfilling the two principle purposes of NIA, i.e.

- Facilitate and uplift the TRL of small scale innovation ideas, and
- Support the potential NIC proposals.

A holistic approach of electricity network innovation includes two elements: 1) **Whole System** [the interaction between transmission and distribution, both commercially and technically]; 2) **Multi Energy Vector**, where the electricity network works as the critical coupling point between different energy users, such as heat, transport, gas and water.

3.3 | NIA SPEN0012 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 (LCT) 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.

3.3.1 | NIA SPEN0012 Project Progress

The project has now moved to the implementation phase. SP Energy Networks Smart Data Integration Fabric (SDIF) contract has been placed and a Proof of Concept solution completed.

There has been significant interest in the project and a series of use cases for implementation are under preparation. It is anticipated that the first use case will be delivered this year.

3.4 | NIA SPEN0014 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.

3.4.1 | NIA SPEN0014 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 network. This project is at proof-of-concept, prior to a pilot stage.

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.

The early stages of Phase 3 has now started with the development of the network architecture and functional specification in progress.

3.5 | NIA SPEN0015 Real Time Fault Level Monitoring (RTFLM) – Stage 1

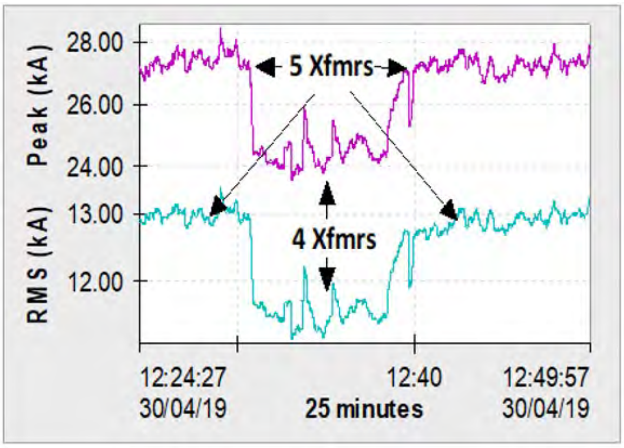
This project aims to develop and trial a novel Real Time Fault Level Monitoring (RTFLM) solution. The solution being developed to:

- Provide reliable and repeatable fault level measurements on-demand
- Be applied to LV --> 33kV networks
- Generate results through the application of an artificial LV disturbance to a transformer coupled to the busbar the fault level is required for
- Understand the impact the artificial disturbance has on the network
- Identify the optimum solution and potential business case following site trials
- One of the key benefits of this innovation is that the solution can be used to obtain Fault Level results continuously, in addition to "on demand".

3.5.1 | NIA SPEN0015 Project Progress

April 2019 saw the continuation of the live network trial at Station View Primary Substation, in Chester. The purpose was to determine whether measurements could be successfully obtained and to then compare those measurements to the values calculated using the IPSA models. At Station View Primary, the target voltage was 11kV. The device is illustrated in situ below.

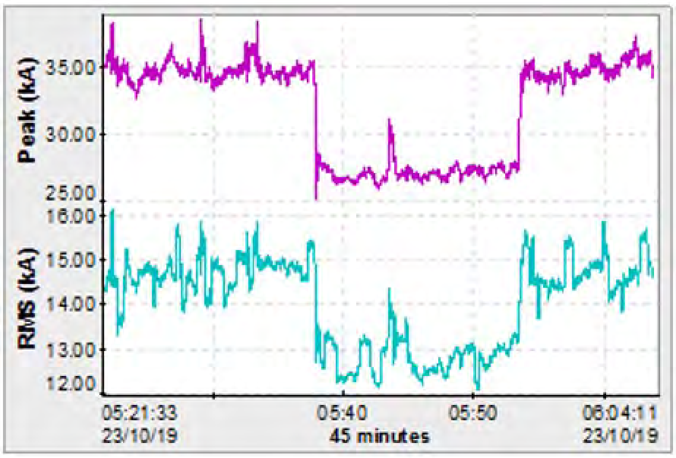
Prospective 10ms make and 90ms break currents were both measured within a 1-2% tolerance to modelled data which is very encouraging. The results were reproducible throughout testing and showed a similar tolerance in multiple network configurations. The percentage change when reconfiguring the network expected to be 10% proved to be within a 1% tolerance when compared to measured values. This is illustrated in the graphic below.



	Station View Running arrangement	Modelled (kA)	Measured (kA)	% difference Modelled V Measured results
Make	Normal configuration	27.49	27.2	-1.06%
	Alternative configuration	24.8	24.66	-0.57%
	% change normal to alternative	9.79%	9.34%	(<1% tolerance)
Break	Normal configuration	12.92	12.89	-0.24%
	Alternative configuration	11.55	11.61	+0.51%
	% change normal to alternative	10.61%	9.94%	(<1% tolerance)

Following this, a second trial location was selected to undertake the same evaluation but with 33kV as the target voltage. Gradwell Street Primary Substation in Liverpool was selected for this.

The prospective make and break fault level measured by the Real Time Fault Level Monitor (RTFLM), returned values that differed from modelled data, the difference being around -13.4% and +6.99%. The results were repeatable, demonstrating that the RTFLM was measuring consistently. During testing, alternative running arrangements were agreed and the network reconfigured. This produced a significant step change to fault level. During the alternative running arrangement, a step change of 23.9% and 12.81% for make and break fault current was expected based on modelled results. The RTFLM measured respective step changes of 22.57% and 12.59% which are within a 1.5% tolerance when compared with the modelled data. This suggests consistency in the measured results relative to a fixed error in the modelled results. More extensive network trials are required to draw full conclusions, this is the proposal for Stage 2. These results are illustrated in the graphic opposite and table below.



	Gradwell Street Running Arrangement	Modelled (kA)	Measured (kA)	% Difference Modelled V Measured Results
Make	Normal configuration	40.52	35.09	-13.4%
	Alternative configuration	30.8	27.17	-11.78%
	% change normal to alternative	23.9%	22.57%	(<1.5% tolerance)
Break	Normal configuration	13.73	14.69	+6.99%
	Alternative configuration	11.97	12.84	+7.26%
	% change normal to alternative	12.81%	12.59%	(<1.5% tolerance)

3.6 | NIA SPEN0023 Connected Worker Phase 1 - Field Data Automated Capture

The acquisition of field data to support and impact on decision making is imperative in this industry and that is recognised. 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.

3.6.1 | NIA SPEN0023 Project Progress

The project is underway and has developed a broad range of requirements after a number of workshops, with internal stakeholders and external contract resources. The full set of requirements have been discussed with ESRI to develop a full functional specification, primarily looking at the process for gathering overhead line field asset data when work is carried out on the network. This will focus on how data is prepared, gathered, updated and then sent to the Geographical Information System for updating.

It is envisaged that the specification will be completed by Summer 2020 and would then proceed to development before commencing a field trial by the end of 2020.

3.7 | NIA SPEN0024 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 of Business as Usual. 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.

3.7.1 | NIA SPEN0024 Project Progress

We 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 business as usual 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.

3.8 | NIA SPEN0025 Low Cost Fault Current Measurement of Wooden Poles

On the SPD and SPM networks, wooden poles are frequently used as the main infrastructure for power distribution. With this project, SP Energy Networks aim to solve two main problems which arise due to their usage.

The poles themselves have failure modes, meaning that under certain conditions they can become live – these conditions include rain or high levels of humidity. This creates a hazard to the workforce and to the public, which is not easy to find. A prime example of this is when the ceramic insulator fails, and the pole becomes the prime path to ground for the current when the moisture levels increase, and become a shock risk.

Another problem with the usage of wooden poles on the distribution network is that the insulators can become damaged over time: this can include cracks when the insulator is ceramic and electrical tracking paths in polymeric insulators. Furthermore, certain weather conditions also have the ability to damage the insulation which can result in flash overs, thus causing the protection systems to operate. These faults can be particularly hard to find as the insulation failure mechanism is weather dependent, hence finding a method to identify fault current passage through the poles is very useful as it would enable the area of inspection to be reduced.

This project will trial a card containing a low cost electrochemical cell device that is able to identify the fault current passage through the pole. This method takes advantage of the fact that impedance of the electrochemical cell is of a much smaller value that the section of wooden pole. As a result, the current will flow through the cell - as current takes the path of least resistance – causing a visible change in the cell, thus providing a semi-quantitative measure of the total current flow.

3.8.1 | NIA SPEN0025 Project Progress

Stage 3 demonstrated that the device performs accurately against the agreed specification, that a current above 0.71mA rms flowing through it for a period of 1 to 2 days will show a clear indicator colour change whereas a current less than 0.71mA rms has no effect on the colour. A complete colour change takes place in approximately 2 days. The ability of the device to indicate current flowing down a wooden power pole due to an insulator fault, by performing controlled tests, has yet to be carried out by the DNOs. Devices were installed by SP Energy Networks, UK Power Networks and Northern Powergrid on their electricity networks but no colour change was observed. As it was difficult to determine whether or not this was due to a lack of leakage current down any of the poles selected in the trial, some additional tests were scoped to artificially create this situation at a test facility or training environment. These tests have not yet proceeded as they involve additional cost. The original target was a 20 year lifespan, however performance of the prototype at the end of stage 3 indicated a useable lifespan of approximately 3-5 years. This is particularly problematic as the standard wood pole inspection cycle is 6 years. Therefore, further work would be required to address the electrolyte loss issue to achieve a 15-20 device life.

3.9 | NIA SPEN0029 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 migration.

Previous work in this area (by SPEN, 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.

3.9.1 | NIA SPEN0029 Project Progress

The third endeavour to secure effective private spectrum for the trial was rejected in March 2020, a revised application has been made for rural sites. Progress has been made on Mobile Network Operator (MNO) public cloud offerings with an end to end connectivity test from control room to field equipment scheduled.

COVID-19 restrictions has curtailed progress on failover design & testing for both public cloud and narrowband Radio/Private cloud. Research into the practicalities of failover between public and private networks is ongoing.

Options available through other frequencies remain subject to limitations on Bandwidth and resilience, but may still form part of the overall hybrid solution.

3.10 | NIA SPEN0030 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.

3.10.1 | NIA SPEN0030 Project Progress

We are now trialling 24 Zebedee devices in the field across all of our regional districts to test the effectiveness of the device, and its ease of use. As part of this, we are trialling with two-person operation, which gives extra stability and accuracy when applying the device. Some issues with installation have been identified through these trials, which will aid the future implementation into business as usual.

Zebedee Sectionaliser Device

3.11 | NIA SPEN0031 Radiometric Arc Fault Location RAFL 2

Transient faults on the overhead line distribution network can be difficult to locate and 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 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 chosen 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_SPEN005 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.

3.11.1 | NIA SPEN0031 Project Progress

Work commenced on the RALF2 project in July 2018. In the period to 1st April 2019 to 31st March 2020, the following tasks have been successfully completed:

1 *Hardware design and software programming of field deployable units (FDU).* The specification from the previous stage has been realised in hardware – see photograph. The electronics have been implemented on 2 pcbs and are powered by a Lithium-ion battery capable of 14 days runtime. The enclosure (IP68) has been custom-built from sheet aluminium and incorporates easy mounting features. The FDUs are fully programmed and communicate with the web server via 4G.

2 *Software programming of web server located within the cloud.* The web server processes data uploaded from the FDUs and presents this information to the user - see example below. Advanced protocols for information exchange have enabled remote control of the FDU functions from the web server. Significant development of the user interface has resulted in an intuitive display of the RALF data.

3 *Construction and testing of prototype FDU.* The operation of the first prototype, uploading recorded data to the web server, has been successfully demonstrated.

4 *Construction of 4 FDUs.*

5 *Accuracy test.* The COVID-19 pandemic has prevented testing at the PNDC, but a series of tests conducted close to Elimpus has demonstrated the basic operation of the system, i.e. the ability of the FDUs to record radio frequency impulsive signals, upload the timestamps to the server and present this information to the user. The graphic opposite shows a screen shot from the server where the red cross denotes the (known) position of the radio frequency impulse source and the intersection of the two hyperbolae represents the RALF system estimate of the source position. In this particular result the error was 4m.

6 *Design review.* A review has been completed and minor changes to the design will be implemented in the next stage.

The project team are now working on the construction of 20 FDUs.

3.12 | NIA SPEN0033 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 to 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.

3.12.1 | NIA SPEN0033 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.

This work will continue through 2020, with further development of academic papers and the development of tools for the prediction of remaining cable asset life.

3.13 | NIA SPEN0034 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

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.

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.

Platform Evolution	EV and DER Management	Business Engagement	HV Analysis
• Platform Enhancements • Data Analytics • Data Improvement • SM Enablement • BAU Management	• LV/EV/DG Modelling • EV API Development • Data Analytics	• Stakeholder Engagement • BAU Implementation	• HV Development • Data Analytics • Leverage other Project Funding

NCEWS2 Revised Project Structure

3.13.1 | NIA SPEN0034 Project Progress

Particular focus within NCEWS2 is to develop the use of the NAVI platform to assist with network modelling, the development of scenarios of growing LCT penetration, and to integrate the platform data analytical functionality within other ongoing innovation projects within SP Energy Networks. We have now developed several exports from the platform to various PSSE tools including WinDebut, DIgSILENT and IPSA, which is allowing trial users to model fully annotated circuits and LV substations within minutes. By annotating numerous related data sets to the platform we are providing users with a complete view of the network in one place, helping us move towards the goal of being a central data management tool. Through stakeholder engagement and tracking of benefits during this project we hope to prove the value of the NAVI Platform and thus role it out to the wider business.

NAVI platform visualisation showing circuit connectivity, ADMD estimation and building understanding, with Smart Meter voltage data.

With more Smart Meters now installed within the SP Energy Networks licence areas we are able to start analysing voltage profiles to help with phase identification and voltage predictions over time and/or at locations without smart meters. 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. To assist the development of the platform, data science exploration of customer energy use estimation will also be explored through improved building type understanding and increasing visibility of LCT. Investigation of the application of improved LCT ADMDs will provide the final risk analysis capability which will then be tested through stakeholder engagement with connection designers.

3.14 | NIA SPEN0036 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 relying on renewable energy resources for heat and transport. The way energy is consumed and generated are 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 check for a period before it can be trusted for Business as Usual (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
- 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 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
- Analysis the evolving characteristic of distribution network with uptake of renewable generation, energy storage and EV
- 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
- Review and Identify the common control algorithm

3.14.1 | NIA SPEN0036 Project Progress

This project aims to carry out a feasibility study and technical requirements (at Phase 1) for 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. Following an internal consultation, a HICS implementation strategy document was developed in and issued in Q1 2020 to detail out the requirements of HICS. LV Engine and Angle-DC as two flagship projects with control system requirements in distribution network, were selected as pilot projects. We are also in the process of selecting a capable consultant for technical support on delivery of Phase 1.

3.15 | NIA SPEN0037 Electric Vehicle Uptake Modelling (EV-Up)

The transition to electrified transport along with greater penetration of other Low Carbon Technologies 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;

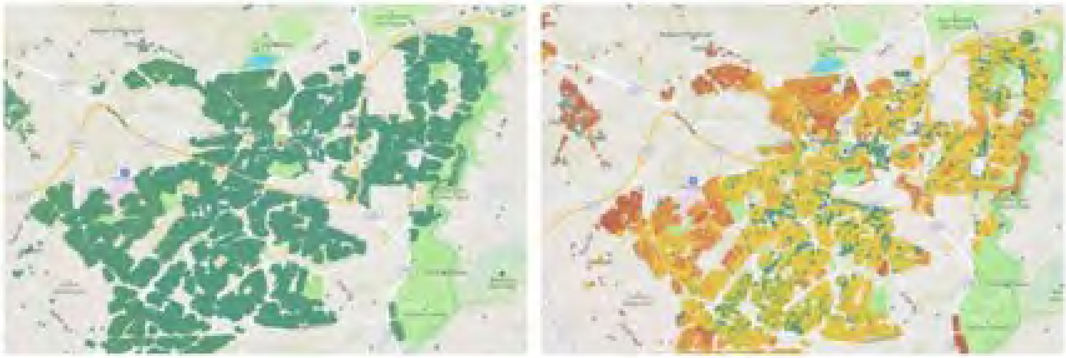
- Probability of a household being able to park and charge at home
- Demographics, including income and behaviours
- Household mileage and the resulting charge demand

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.

3.15.1 | NIA SPEN0037 Project Progress

The project has delivered on the objective of using data to more accurately model future impacts on the distribution network as a result of the transition to EVs. EV-Up has established a robust methodology and model to understand and identify where EV adoption will occur across the SP Energy Networks distribution networks. The bottom-up approach has delivered an innovative approach to this problem, leveraging new data sets to model EV adoption. The project has contributed significantly to our understanding of customers' ability to transition to EVs and importantly has enabled this information to be absorbed into corporate systems.

EV-Up has delivered a new data set and methodology to better predict future network impact as a result of domestic charging – the results have clearly identified where clustering effects will greatly increase electrical demand as EV adoption increases.



EV adoption in East Kilbride 2020 compared with East Kilbride 2030 (20% EV Adoption)

Example output at a household level with representative RAG status of EV adoption probability

3.16 | NIA SPEN1801 Distributed Ledger Technology-enabled Distribution System Operation (Phase 1)

This project will investigate the use of Distributed Ledger Technology (DLT) for smart contracts in Distribution Network Operation.

The DSO transition requires the implementation of efficient, neutral market platforms on the electricity networks, enabling a high penetration of distributed generation, flexible loads and energy storage. Co-ordinating these and balancing the network, will require new solutions. DLT, including block chain, is recognised as a revolutionary approach which is particularly suited to co-ordinating multiple entities in a network, allowing automated contract formation and settlement, and providing security and resilience.

DLT based smart contracts include rules for information exchange, contract formation and value transfer among multiple entities, based on a shared ledger which is easily validated. They could reduce the cost of establishing mutual trust between multiple DER owners and network operators who have agreed to behave in certain ways. DLT could also provide a means to manage electric vehicle charging and the integration of energy storage.

The proposed project will build upon the success of the pilot research activities funded by EPSRC HubNet ("Block chain based smart contracts for peer to peer energy trading using the GB smart metering system") and ENCORE ("Feasibility of applying Block chain and smart contracts technology to distribution grid management in the GB power system") from Cardiff University.

The project aims to create, test and quantify the performance of example agreement mechanisms encoded as DLT based smart contracts for distribution system operation. The project will define rules for interactions between neighbouring system operators (DNO or DSO). Then it will co-ordinate the actions of DERs on a distribution network within the same ownership. Alongside this, a use-case using actual network data will be developed to allow a DNO/DSO to best employ the defined smart contracts. Finally, the whole system will be implemented and demonstrated in software simulation environment, engaging with stakeholders in the supporting networks to raise the common level of understanding.

3.16.1 | NIA SPEN1801 Project Progress

Distributed Ledger Technology-enabled Distribution System Operation (De-DSO) is a Network Innovation Allowance project representing an inclusive, collaborative and future proofing approach to understand the impact of the digital revolution. It is aiming to identify and address the challenges and opportunities involved in using Distributed Ledger Technology (DLT) applications to solve problems facing DNOs today and DSOs in the future. It was registered in December 2017 with a starting date of March 2018. The leading licensee is SP Energy Networks, partnered with SSEN and UKPN. The project duration is 48 months and is aiming to complete by March 2022.

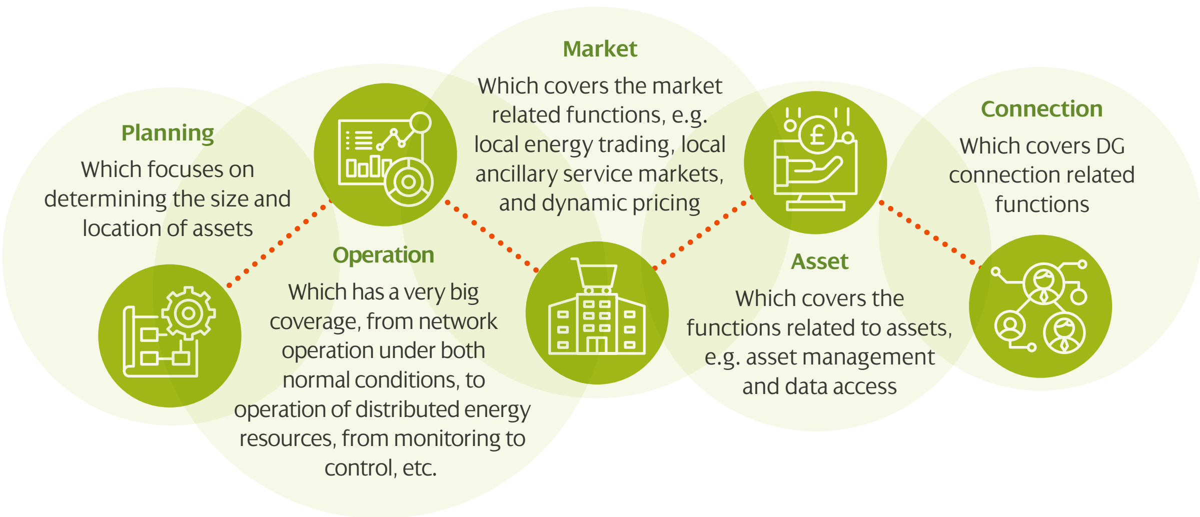
2019/20 is the second year of the project. The project delivery has been on track thanks to the effective support from the Energy Innovation Centre and the two suppliers: Cardiff University and Fraser Nash. The project is now in the process of a successful completion.

The following activities have been undertaken:

The project team benefited from the direct access to a wide SME community and carried out a transparent tender via EIC. Following this tendering, Cardiff University and Fraser Nash were approved to be the supplier for the second phase of this project.

Methodology

Over 100 academic papers and 100 companies in the sector (including those in the energy sector, such as the Iberdrola Group in Spain) were surveyed to ensure the original scope is still valid during the executive phase. Such a thorough review has also placed a solid foundation to inform the simulation and outputs of this phase. The five broad categories within the network business have been shortlisted as the main areas where DLT will have great potentials to benefit customers, namely: Planning, Operation, Market, Asset Management and Connection.



Workshops

One critical mission of the De-DSO is to foster the in-house understanding of this potentially disruptive technology. Despite the challenges associated with COVID-19 pandemic, the project team made steady and on track progress by making full use of on-line tools.

Two webinars have been successfully carried out with SSEN and SP Energy Networks communities. Over 50 senior professional staff joined the sessions, ranging from financial control, renewable connections, DSO planning, asset management and IT departments. Such a strong and overreaching engagement demonstrated the business pull for this technology.

Workshops	Purpose	Date	Location
Workshop 1	Initial Simulation, potential use cases and engagement with key internal stakeholders	25/03/2020	Webinar, Scottish and Southern Electricity Networks
Workshop 2	Initial Simulation, potential use cases and engagement with key internal stakeholders	31/03/2020	Webinar, SP Energy Networks

Use Cases

The project team has been very mindful of the development in the industry and beyond. Efforts were put in to avoid potential duplications, for example, asset management aspect was the focus of another NIA project led by ESO (Distributed Record). The team has further taken on board the feedbacks received during the continued engagements and focused on the following use cases within the identified areas for electricity network users:

- Peer to Peer Energy Trading (P2P), under the category of ***Market***

Peer-to-peer(P2P) energy trading involves novel technologies and business models at the demand-side of power systems, which is able to manage the increasing connection of distributed energy resources (DERs). In P2P energy trading, prosumers directly trade energy with each other to achieve a win-win outcome. From the perspectives of power systems, P2P energy trading has the potential to facilitate local energy and power balance.

- Services Market Facilitation, under the category of ***Market***

This function is the most divergent across the five DSO worlds [set out in the Open Networks initiative under the ENA]. The areas of commonality within Services and Market Facilitation are in the requirements: to define Price Control Methods for distribution network connected flexibility resources; to assess requirements for flexibility services; procure and active flexibility services; and to create a regulatory framework for conflict mitigation and resolution.

- EV Charging Facilitation, under the category of ***Operation***

Serve the need for re-charging batteries of electric vehicles considering more and more (both public and private) charging infrastructure is installed. Currently, the highly fragmented charging market(various apps and different cards to access the charging points), the complex IT and payment processes (complex and costly settlement processes between EV companies) and an overload of power grids have been leading to a poor driver experience.

- Network and Investment Planning, under the category of ***Planning***

Determine location and capacity requirements on the distribution network assets and secure the most efficient means of capacity provision to customers. Coordinate with the NETSO and TOs /DSOs to identify whole system options. These would include commercial DER (Distributed Energy Resources) options as well as distribution network investment.

Distributed Ledge Technology enable DSO roadmap ***(Project Outcome):*** The project team is working on the roadmap and will present this as part of the project Close-down report.

3.17 | 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 business as usual 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; and
- The measured output then needs to be turned into something meaningful, i.e. integrated with existing asset management methodologies.

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 residual strength value (RSV) for the pole. This will be the first deliverable for the project. Further works are currently being undertaken for the automation of the pole analysis – preferably at the time of test. This could be achieved with a 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 business as usual and that the expected benefits to the business have been realised.

3.17.1 | SPEN0039 Project Progress

The project is only at an early stage so project progress is limited.


SP ENERGY
NETWORKS

3.18 | 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 business as usual 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.

3.18.1 | SPEN0041 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. Some initial progress was made on stage 2 of the project with several reinstatement core samples provided to NDT consultants for the development of the equipment. However due to COVID-19 further development of the equipment has not been possible due to supply issues and access to manufacturing facilities. The project is aiming to restart development of the equipment by July 2020 followed by trials on the network and validation of the results.

3.19 | NIA SPEN 0042 Novel Temporary Earthing & Bonding Solutions

There are two separate but similarly themed problems that the Novel Temporary Earthing & 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.

There 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.

3.19.1 | SPEN0042 Project Progress

To date the project has assessed the current working practices, equipment and standards used by the UK network operators as well as global practices and standards. This has been completed for both WS1 and WS2. The next step in the project is to research and identify new equipment and products that will improve the practices within the two work streams. Once any products and equipment that show potential in improving the current practices within the UK network operators have been identified, trials and demonstrations will be completed where possible.

3.20 | 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 the is project are:

1. Demonstrate the impact of Demand Side Response (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 the 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 a 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.
6. Better interaction and understanding of the network by communities.

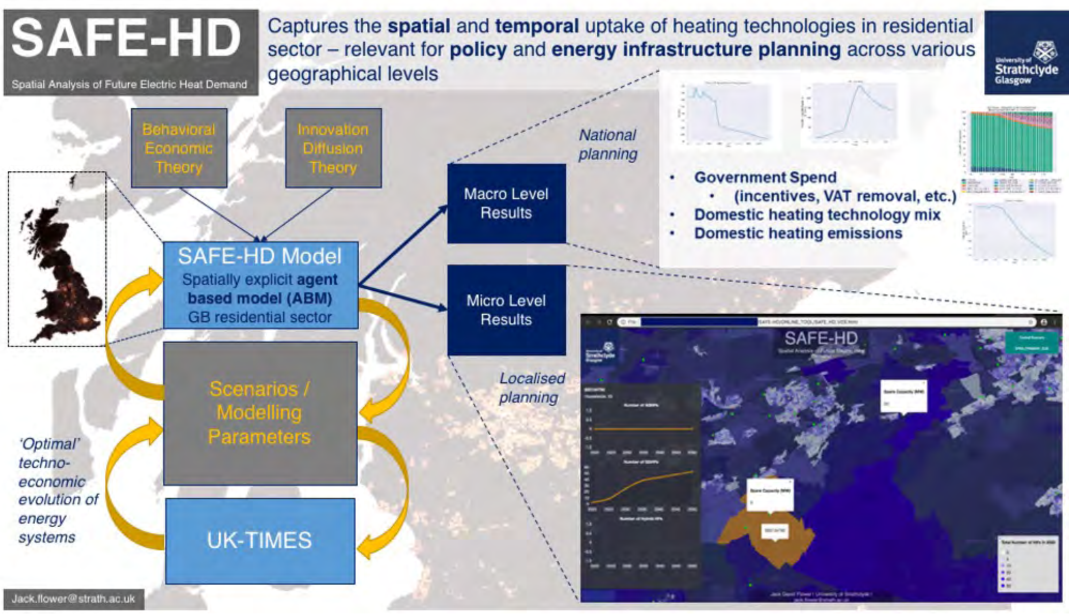
3.20.1 | SPEN0043 Project Progress

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 COVID-19 restricting access to properties. The home hub will send a probability signal out each 24 hours with 48 values to indicate 'how good or bad' each half hour during the day is to use power. This is based on a forecast of the community's demand, the forecast of local renewable generation and a Time of Use Tariff however other parameters could be taken into account. The household can schedule appliances according to when they need an appliance to be finished, how long it takes and whether it can be interrupted.

Alongside this, De Montfort university have begun modelling to develop 'what if scenarios'. This is developing the concept of parameters to give:

- Flexibility - a measure of people's willingness to be flexible at different times of day and for different demographics
- Stayability - a measure of people's ability to maintain new habits over time for different demographics
- These parameters will then provide a method for tracking the success of any trial method to change peoples' habits and maintain them. In addition, the communications in use will enable remote voltage measurements on LV feeders via the meters in real time.

3.21 | SPEN0045 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.

3.21.1 | SPEN0045 Project Progress

The SAFE-HD project is entering into the final stages. The model should be complete in terms of construction in July 2020. Following this, calibration and validation activities of the model will be undertaken (which are an important aspect of the SAFE-HD approach) prior to conducting simulations for results production. 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 around 75% complete and will finish at the end of September 2020.

3.22 | SPEN0047 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 Low Carbon Technologies 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 & 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 (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.

3.22.1 | SPEN0047 Project Progress

Deliverable 1

"To compile a testing specification which covers the predominant AC assets within the LV network."

The testing specification has been completed and includes the most populous cables, joints and linkboxes on SP Energy Networks LV network as well as understanding on the value they present when converted to LVDC. Some important extracts from the testing scope are detailed below.

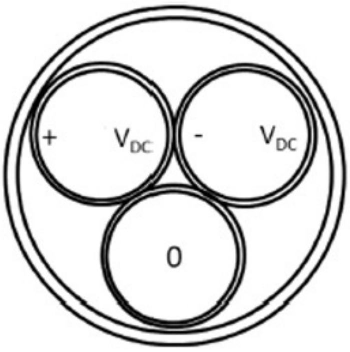


Figure 1. Three Core Bipolar Arrangement

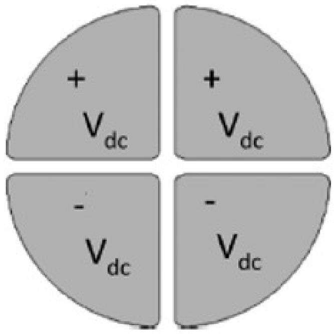
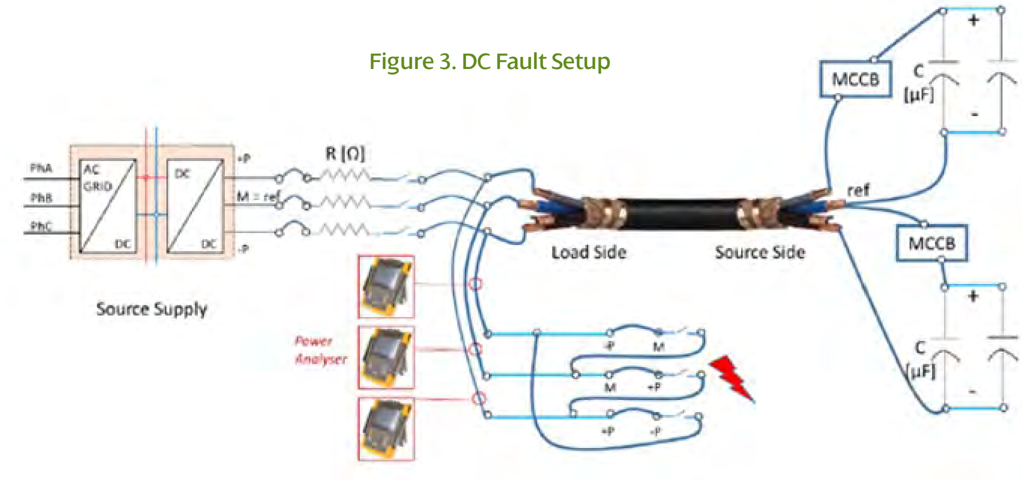


Figure 2. Four Core Bipolar Arrangement

Figures 1 and 2 give an insight into how our LV Mains cables that are traditionally energised with AC will be energised in a bipolar LVDC arrangement. The detailed testing programme will give understanding of how these cables (and further assets) cope when energised in this way, thus informing if they are suitable for conversion from LVAC to LVDC and how long they can be expected to continue to provide reliable and safe supply at various DC voltages.

An example of how one of the tests will be conducted can be seen below in figure 3. In this case that of the DC Forced Fault test. Here, the cable sample is forced to experience a short circuit fault who's major fault current contribution is expected to be from the discharging of DC bus capacitors of power-electronic converters used to interface devices such as EV chargers. This will give insight into how LVDC faults contrast and compare to LVAC faults in terms of fault current released and danger to the surrounding environment for operational practices.

Figure 3. DC Fault Setup



The testing programme that will be completed on each cable, joint and link box type is detailed below in figure 3.

The completion of this programme will give the detailed understanding of suitable apparatus for LVDC conversion, which is the main deliverable of this project phase.

Deliverable 2

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

The tender process for process is currently underway and will be reported on in the next reporting period.

Deliverable 3

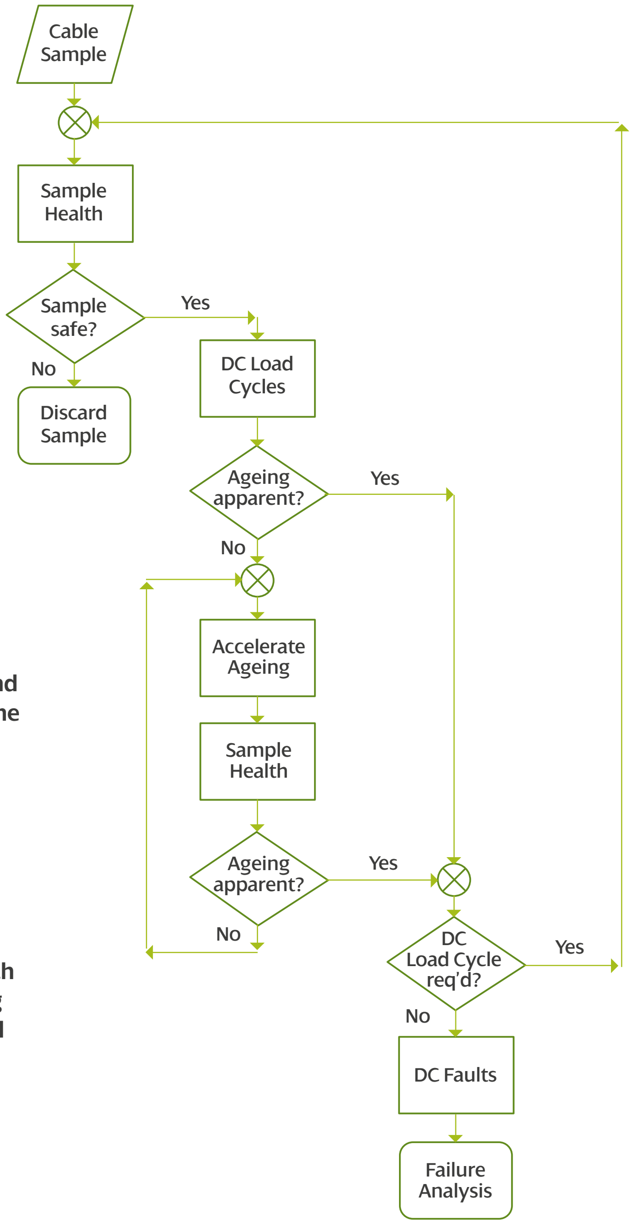
"To complete the testing programme and compile a report on the findings from the laboratory testing"

To begin once tender process has been complete and Testing Facility has been procured as per Deliverable 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"

Methodology in place for cost benefit analysis to be completed simultaneously with testing and particular apparatus counted/ discounted as LVDC conversion appropriate dependent on test results.



3.23 | NIA SPEN0048 The Chatter Tool

Stakeholder engagement and customer feedback is important to underpin our strategy and plans. Actionable insight is required 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, 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.

3.23.1 | NIA SPEN0048 Project Progress

The Chatter tool is currently in the final stages of development, and is planned to be trialled from Q3 of 2020.

3.24 | NIA SPEN0049 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.

3.24.1 | NIA SPEN0049 Project Progress

The project has only just started.


SP ENERGY
NETWORKS

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 4** below which contains five steps:

Figure 4.

Sources of Innovation We recognise a variety of sources of inspiration for innovation	**Stakeholder Priorities** We evaluate all innovation ideas against our stakeholder's priorities	**Approval Panel** We have a rigorous process to evaluate projects for approval	**Development** The maturity and value of the solution will dictate the route we take	**Application of learning** The maturity and value of the solution will dictate the route we take
Process Improvement	Managing an ageing network	Overall cost and value for money	NIA - Research, design and development (Low TRL)	Solution identified for adoption
New ideas/ Serendipity	Improving service to poorly served customers	Resource ability	NIA/NIC - Trialling (high TRL)	Identify the owner within the business
Developments by other DNOs	Storm Resilience	Alternative options available	Continuous review and dissemination of learning	Evaluate business case for adoption and impact assessment of changes
Technology Developments	Improving customer service during power cuts	Risks and benefits		Modify policy, specifications and working procedure for applications
	Reducing the number and duration of power cuts	Impact on customers (outages and benefits)		Update and reflect new solutions into delivery plans and application of solutions
	Preparing the network for low carbon technologies			

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 4 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 appropriate funding route, be it NIA, NIC or other funding steams such as research grants.

5. Application of Learning: Appropriate channels both internal and external will be used to disseminate learning from both successful and unsuccessful projects to a wider audience. We will also seek opportunities to learn from and collaborate, as appropriate, with other DNOs.

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.

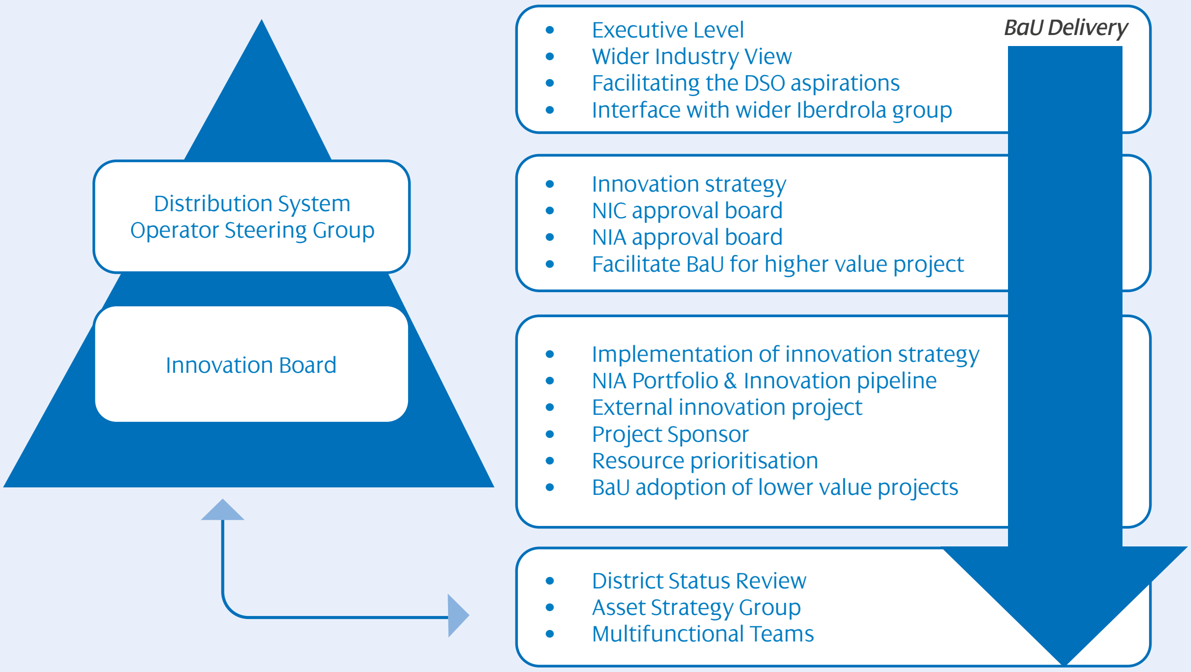


Figure 5. Innovation Governance Structure

Our innovation governance structure and project approvals process Figures 5 and 6 respectively, helps to ensure the following:

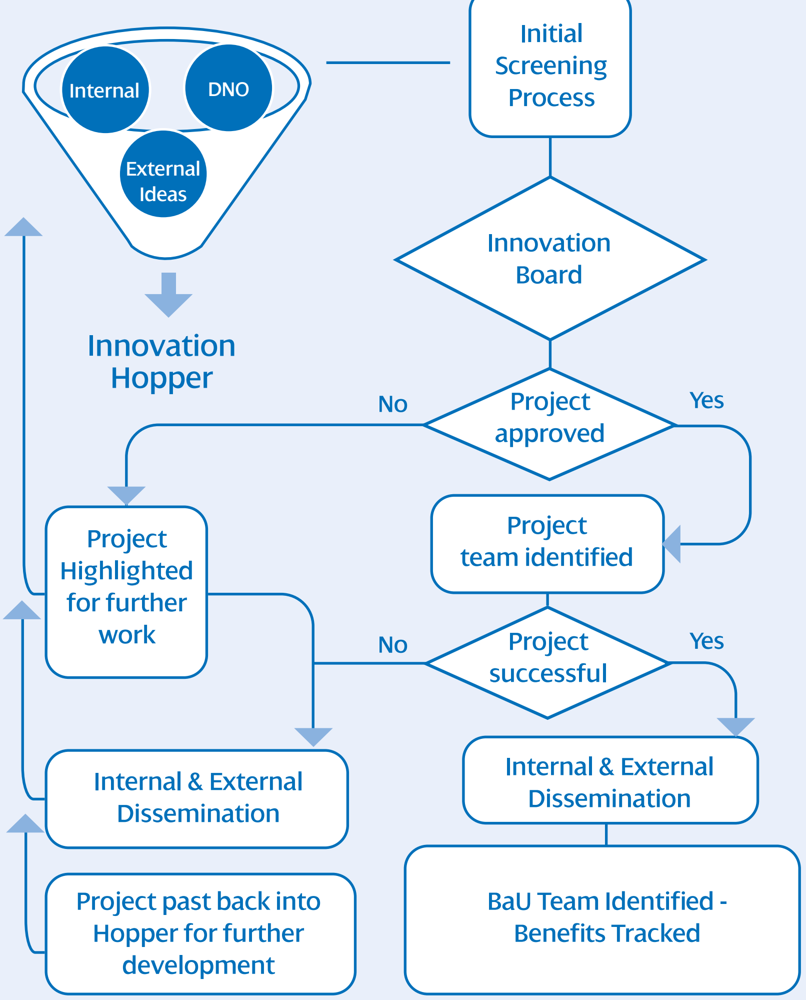
Projects involve the Research, Development, or Demonstration of at least one of the following:

- 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 6. 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.

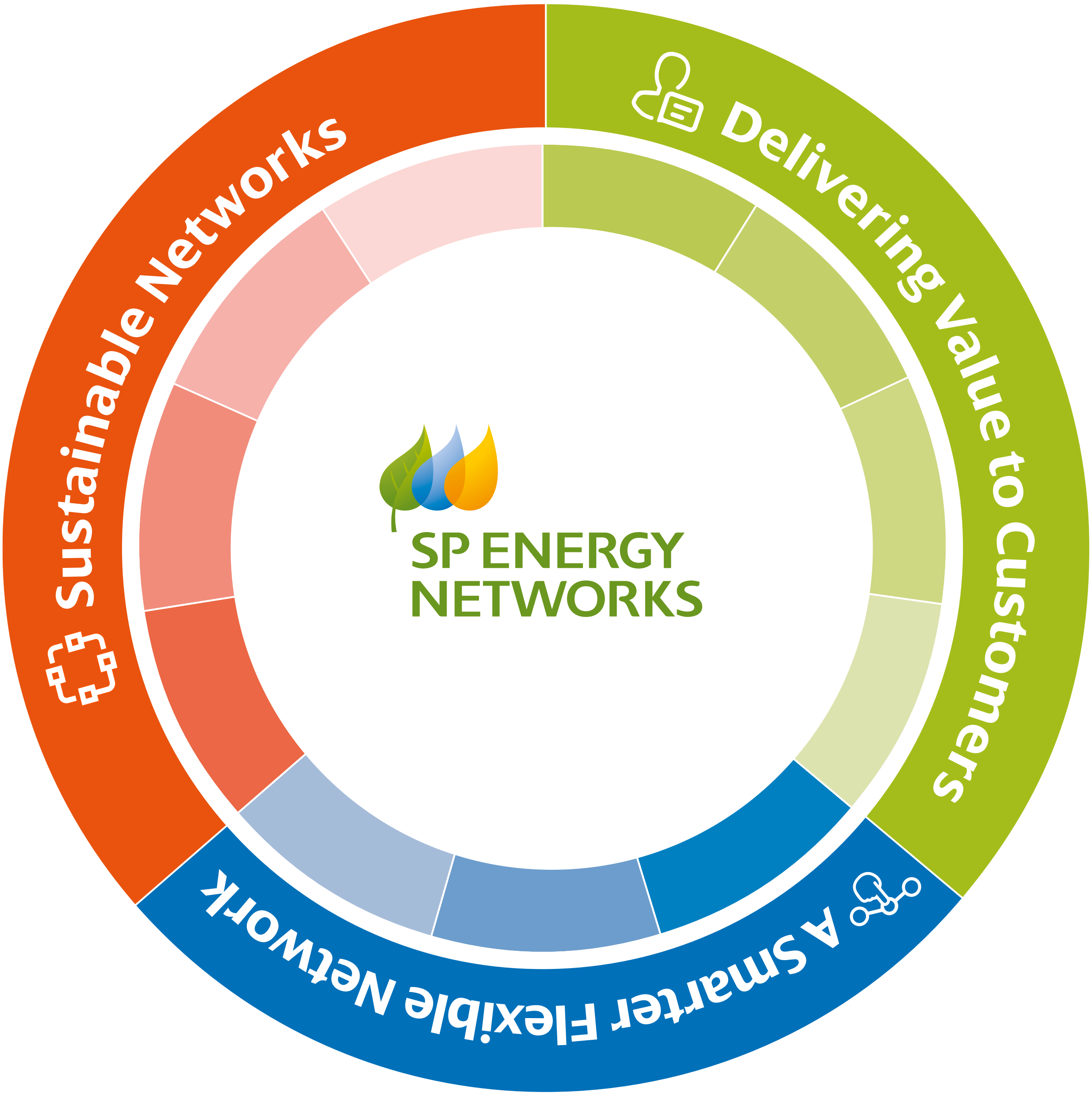
Of all the areas identified, stakeholder feedback identified the following specific priorities:

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 low carbon technologies

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
- 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 & 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 (LCT)

- **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 SPEN0008 Environmentally Acceptable Wood Pole Pre-treatment Alternatives to Creosote (APPEAL)
02	NIA SPEN0010 EVOLUTION
03	NIA SPEN0012 SINE Post
04	NIA SPEN0014 Active Fault Level Management (AFLM)
05	NIA SPEN0015 Real Time Fault Level Monitoring (RTFLM) – Stage 1
06	NIA SPEN0023 Connected Worker Phase 1 - Field Data Automated Capture
07	NIA SPEN0024 Endbox G38 Level Detection Phase 2
08	NIA SPEN0025 Low Cost Fault Current Measurement of Wooden Poles
09	NIA SPEN0029 Secondary Telecommunications Phase 3 - Trial of Hybrid Telecoms
10	NIA SPEN0030 Zebedee Sectionaliser Device
11	NIA SPEN0031 Radiometric Arc Fault Location RAFL 2
12	NIA SPEN0033 CALISTA
13	NIA SPEN0034 NCEWS 2
14	NIA SPEN0036 A Holistic Intelligent Control System for Flexible Technologies
15	NIA SPEN0037 Electric Vehicle Uptake Modelling (EV-Up)
16	NIA SPEN1801 Distributed Ledger Technology-enabled Distribution System Operation (Phase 1)
17	NIA SPEN 0039 THOR Hammer
18	NIA SPEN 0041 Proof of Concept Tarmac Reinstatement Tester
19	NIA SPEN 0042 Novel Temporary Earthing & Bonding Solutions
20	NIA SPEN 0043 Bethesda Home Hub
21	NIA SPEN0045 SAFE-HD (Spatial Analysis of Future Electric Heat Demand)
22	NIA SPEN0047 A Transition to LVDC - Phase 2
23	NIA SPEN0048 The Chatter Tool
24	NIA SPEN0049 iDentify

Delivering Value to Customers				A Smarter Flexible Network			Sustainable Networks			
Managing an Ageing Network	Maximising the Benefit of Data	Network Control & Management	Reducing the Number and Length of Power Cuts	Faster, Easier, Accurate Connections	Network Flexibility and Communications	Preparing the network for Low Carbon Technologies (LCT)	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 area of learning on a project by project basis.

5.1 | Project Learning: NIA SPEN 0008 APPEAL

None of the preservative treated timbers (including Creosote, RV-PWR and Tanasote) are showing any overt signs of significant decay either through visual observation or statistical analysis of Modulus of Rupture values. However, by comparison with control stakes, RVP and Tanasote are demonstrating a better performance than creosote with the better performance of RVP strongly statistically significant at this stage of the trial.

The barrier products are having a significant effect in improving the performance of untreated and creosote stakes. However, there is less evidence of a consistent effect for the new RVP and Tanasote products. Indeed there is clear and statistically strong evidence here that Polesaver application to stakes treated with RVP (the best performing preservative of the three) actually reduces preservative performance. It is too early to say that this will represent actual field performance as the trial has not run its full course, but a reason can be suggested for this result. The RVP product contains a vegetable oil as a waterproofing agent to reduce leaching of the copper component.

It is possible that the high temperatures used in the application of the Polesaver wrap burns away some of this protection and also reduces the adherence of the Polesaver bitumen layer to the treated timber. Such a lack of adherence was not however noted when RVP stakes were being stripped of the Polesaver wraps.

Statistically significant decay was measured in untreated control stakes after 24 months (a result not achieved after 12 months). At this stage, rather than having timbers that have been subjected to conditions equivalent to 20 years in the field, it is considered that they have been subjected to a 10 year equivalent. Therefore the system has not been providing an environment as challenging as that desired. However, with the modifications that have since been undertaken to remedy this there is little doubt that conditions conducive to significant decay have now been substantially ramped up and that the trial will perform as originally intended with the final uplift (uplift 4) providing timbers which have been exposed to conditions close to the 40 years field equivalent.

5.2 | Project Learning: NIA SPEN0010 EVOLUTION

There were significant efforts made to ensure that the scope of the project could keep pace with technology advancement and new findings. It was noted that both the central government and local authorities have a strong willingness to tackle the decarbonisation of heat systems.

LV substation where the monitoring devices were installed

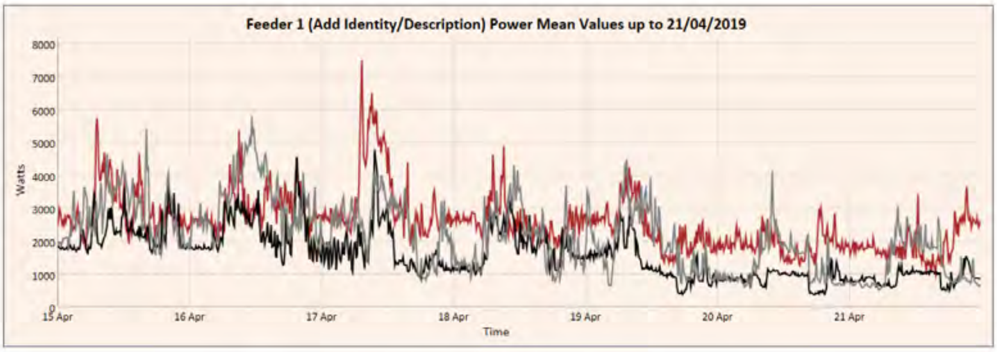
While the original project proposal was focused on the electricity flexibility in a local system level, it was obvious that a holistic approach is now required to generate the maximum benefits for decarbonisation efforts at national level. From an engineering perspective, it is in the customer's interest to understand the potential impacts of electrification of the heat and transport system, and indeed, the active role that could be undertaken by those new vectors in the electricity network.

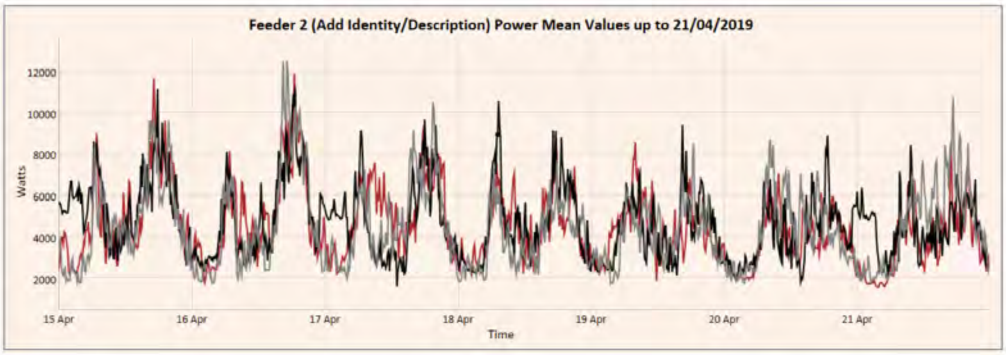
Consequently, SP Energy Networks worked with Cala Homes (a national property developer) and installed monitoring devices to record the impact of heat pumps installed in the new properties in West Scotland. This data is then analysised and compared with the LV feeder regarding harmonics (power quality) and ADMD (maximum demand). The initial findings suggest a promising impact.

The findings have now contributed to an industrial initiative: Re-HEAT, which has been shortlisted by the Regulator under 2020 NIC regime.

1 **https://www.gov.uk/government/publications/heat-decarbonisation-overview-of-current-evidence-base**

2 **https://www.ofgem.gov.uk/publications-and-updates/electricity-nic-2020-initial-screening-submission-re-heat**





Installation of Heat pump at the new property might have positive impacts on ADMD

5.3 | Project Learning: NIA SPEN0012 SINE Post

A significant technical issue that has to be considered is cyber security. The connectivity models have had to be revised to ensure that any device connected to our system has a proportionate and appropriate levels of cyber security. In addition, we are understanding new methods of combining disparate data sets to understand faults in our network.

5.4 | Project Learning: NIA SPEN0014 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.

5.5 | Project Learning: NIA SPEN0015 Real Time Fault Level Monitoring (RTFLM) – Stage 1

The main outcome of the 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, further work is recommended 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.

No significant problems were encountered with the trial methods used by the two prototypes.

Managing fault Level on the UK networks is key to the transition from DNO to DSO and facilitating the uptake of distributed renewable generation. Therefore, it is highly likely that this method will be deployed on a large scale in future hence the appetite to continue development to TRL9 as soon as possible.

All research, development and technology demonstrations undertaken as part of this project thus far have been effective in meeting the aims of the project.

5.6 | Project Learning: NIA SPEN0023 Connected Worker Phase 1 - Field Data Automated Capture

Initial learnings during the elaboration phase are limited, however it has demonstrated that there are a number of applications available which could assist in making the process more efficient, and with enhanced data quality and veracity. A key focus will be to ensure that the field interface to the process is user-friendly and can be adapted to many other use cases.

5.7 | Project Learning: NIA SPEN0024 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 level 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.

5.8 | Project Learning: NIA SPEN0025 Low Cost Fault Current Measurement of Wooden Poles

Due to the performance against the success criteria, several discussions were held to determine a possible solution. All required significant additional funding in the development of the project with no guarantee that all the success criteria would be met. In particular, the unit cost target seemed out of reach, and improving the lifespan to 20 years was highly likely to increase the cost per device, further damaging the cost benefit case.

For these reasons SP Energy Networks and UK Power Networks came to a decision to terminate the project at the end of Stage 3.

However, Northern Powergrid expressed an interest to continue the project with a change of scope that would provide more learning for the project whilst not changing their original budget commitments. The new scope would be to –

- Produce concepts for a device that is expected to have a longer lifetime
- Provide estimates for volume production cost.
- Northern Powergrid to trial in field conditions

Based on this additional information Northern Powergrid believe they will be in a position to decide on whether to continue supporting this proposal. Therefore, with the original lead network SP Energy Networks leaving the project Northern Powergrid will be taking over as lead network.

5.9 | Project Learning: NIA SP Energy Networks 0029 Secondary Telecommunications Phase 3 - Trial of Hybrid Telecoms

A number of valuable insights have been made during the initial phases of the project:-

i) Inability of some services such as Narrow Band Internet of Things (NB-IoT) to support protocols such as Transmission Control Protocol (TCP) traffic

ii) The significant impact which factoring cyber security over the life of the product (i.e. to 2030+) has on the solution

iii) The importance of vendor selection and clear understanding of costs as demonstrated and experienced in current public sector contracts and circulars (ie Huawei and Emergency Services Network (ESN) overspend)

iv) The complexity of integrating public networks into existing network designs whilst maintaining security and operability.

5.10 | Project Learning: NIA SP Energy Networks 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 are being transferred to SP Energy Networks, and will be able to be accessed by the other DNOs once the project is completed.

5.11 | Project Learning: NIA SP Energy Networks 0031 Radiometric Arc Fault Location RAFL 2

This stage of the project has dealt with the implementation of hardware and software to achieve the specification of the RALF system. Excepting the normal developmental issues expected in a project of this nature, the main learning points are:

- A greater degree of testing than originally anticipated was needed to debug the errors in the system. Although extensive factory testing was conducted on individual FDUs, it was only when a cluster of 4 geographically remote FDUs were deployed in a full end-end test with the server that many of the errors could be identified.
- The performance of the 4G network is not always ideal and provision within the server has been made for situations where data from one of the FDUs is unduly delayed.

5.12 | Project Learning: NIA SPEN0033 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 will be presented at the CMD 2020 conference.

5.13 | Project Learning: NIA SPEN0034 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.

5.14 | Project Learning: NIA SPEN0036 A Holistic Intelligent Control System for Flexible Technologies

A summary of the control requirements of the two projects are listed in the table below with a colour coded guideline where similarities are highlighted in **Green** (very Similar), **Blue** (largely similar), **Yellow** (little similarity), **Orange** (considerable differences). Figure 7 reflects the initial understanding, however, the further detailed comparison between functional and non-functional requirements of the projects will be conducted through Holistic Intelligent Control System Stage 1 activities.

Figure 7. Comparison between Angle-DC and LV Engine functionalities

	Item	Angle-DC	LV Engine
System Architecture	Local/Central	Local control unit and central control unit is used	Local control unit and central control unit may be used
	SCADA	Report to exiting PowerOn / Control action by HV control engineer	NMS is yet to be decided for LV – ongoing conversation with GE for LV PowerOn
	IT/OT security	Compliance with UKIT and OT security is required	Compliance with UKIT and OT security is required
	Supplier remote access	Required for troubleshooting and firmware update	Required for troubleshooting and firmware update
	Data storage	PI and local storage	PI and local storage
Voltage Control	Algorithm	**Central** - Voltage Profile Index optimisation using balanced HV system monitoring. **Remote** – None. Setpoint to GE control system used.	Voltage optimisation considering 3phase unbalanced LV system, local and remote monitored data
	Monitored data	RMS average voltage magnitude using standard voltage monitoring equipment	RMS average voltage magnitude using standard voltage monitoring equipment and average voltage reported by Smart Meters installed at customers
	Communication	**Remote** - RTS SCADA 60870 104 via Network Router/RTU **Local** - None, local bus monitoring	SP Energy Networks approved 4G router/RTU, IEC 104 protocol – similar to Secondary Comms infrastructure
	Network model	33kV network model is available in an acceptable accuracy	LV network model can be available with large uncertainty around data accuracy
Power Flow Control	Algorithm	Maximum DER headroom for LCTs and minimum network. Nelder-Mead Process used for all objectives.	Maximum assets headroom for LCTs (import and export)
	Communication	Asset loading and voltages (local and remote)	Asset loading (local and remote)
	Data	**Remote** - RTS SCADA 60870 104. Network Router/RTU **Local** – Local Grid Sites RTS SCADA 60870 104 via Network Router/RTU	SP Energy Networks approved 4G router/RTU, IEC 104 protocol - similar to Secondary Comms infrastructure
	Network model	33kV network model is available in an acceptable accuracy	LV network model can be available with large uncertainty around data accuracy

Project Learning: NIA SPEN1801 Distributed Ledger Technology-enabled Distribution System Operation (Phase 1)

Planning	Operation	Market	Asset	Connection
Investment Planning	**Operation of DER**	**Peer-to-peer Energy Trading**	**System Management** Subcategories: 1. Automated mapping 2. Geographic information systems 3. Facilities management	**Distributed Generation Connection**
Distribution Planning	**Black Start and System Restoration**	**Distribution Market Operations**	**Asset Management**	**Connection Rights**
	Network Reconfiguration 1. Distribution supply restoration 2. Active power loss minimalisation at a given time or energy loss minimalisation over a period of time 3. Load balancing between different feeders or transformers and equalising voltages	**Services/Market Facilitation**	**Data Access**	
	System Monitoring Subcategories: 1. Network topology monitoring 2. Network state monitoring 3. DER state monitoring	**Pricing**	**Platform Technologies**	
	Volt/VAR Control	**Electrical Fraud**	**Renewable Energy Certificates**	
	Outage Management Subcategories: 1. Fault diagnosis and fault location 2. Fault identification 3. Supply restoration			
	SCADA Subcategories: 1. Data Acquisition 2. Monitoring, event processing & alarms 3. Data storage, event log analysis & reporting 4. Control			
	Service Optimisation			
	Relay Protection Re-co-ordination			
	Carbon Footprint			

5.15 | Project Learning: NIA SPEN0037 Electric Vehicle Uptake Modelling (EV-Up)

The project has successfully delivered learning with regards to the following;

1. A robust methodology and model have been developed to better understanding customers' ability to transition to EV which has been validated through onsite and virtual audits.
2. Identification where increasing domestic demand as a result of EV adoption may be expected along with expected magnitude; based user defined uptake scenarios and assumptions
3. Output data with common reference points to enable adoption by corporate systems and programmes of work.

5.16 | Project Learning: NIA SPEN1801 Distributed Ledger Technology-enabled Distribution System Operation (Phase 1)

The detailed analysis of each of identified areas can be found in the table (page 54), and published as the project updates.

5.17 | Project Learning: NIA SPEN0039 THOR Hammer

There has been no learning to date from this project.

5.18 | Project Learning: NIA SPEN0041 Proof of Concept Tarmac Reinstatement Tester

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. Some initial progress was made on stage 2 of the project with several reinstatement core samples provided to NDT consultants for the development of the equipment. However due to COVID-19 further development of the equipment has not been possible due to supply issues and access to manufacturing facilities. The project is aiming to restart development of the equipment by July 2020 followed by trials on the network and validation of the results.

5.19 | Project Learning: NIA SPEN0042 Novel Temporary Earthing & 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 are:

- 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
- Review methods of obtaining reference earth using plate electrodes

5.20 | Project Learning: NIA SPEN0043 Bethesda Home Hub

There has been no learning from this project to date.

5.21 | Project Learning: NIA SPEN0045 SAFE-HD (Spatial Analysis of Future Electric Heat Demand)

Project learnings will be disseminated upon project completion.

5.22 | Project Learning: NIA SPEN0047 Transition to low voltage DC distribution networks – Phase 2

During the construction of the Testing Specification a number of key learnings arose. Firstly, was around the advantages of unipolar and bipolar. After calculating the expected uplift in power transfer capability for both bipolar and unipolar DC energisation, unipolar was discounted from scope of the project as it did not yield as considerable improvements when compared to standard 400V 3-Ph AC energisation. Bipolar DC power transfer capability can uplift power between 45-310% dependant on cable type and number of cores when compared to the same cable running standard AC.

Another key learning was the utilisation of an actual cost benefit analysis case study to verify the benefits associated with LVDC. In this example a real SP Energy Networks LV Network Reinforcement design job was costed for two scenarios 1) Standard LVAC Reinforcement 2) LVDC Conversion Reinforcement. In this particular example all real work operational expenditures such as digging, labour and landing of substations etc. were considered with LVDC demonstrating a 48.3% project cost reduction when compared to LVAC for this case.

An operational learning that was better developed during the Testing Specification phase was understanding of the rejointing required to enable DC Operation for LV cables. Here mains that use 4 core cables will need 2 of every 3 service joints to be deemed suitable for DC energisation with 3 core CNE cables requiring all service joints be rejointed. The costs of this rejointing has been included in the above described cost benefit analysis with LVDC providing substantial potential cost savings.

Many more learnings are expected from this project and will be better understood after the testing, further conversion cost benefit analysis and associated reporting have been completed, over the course of the coming year.

5.23 | Project Learning: NIA SPEN0048 The Chatter Tool

It is too early to report project learning at this stage. Learning will only be realised once the Chatter Tool has been deployed and assessed.

5.24 | Project Learning: NIA SPEN0049 iDentify

The project has only just started so there is no learning to report at this stage.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