NIA Annual Report

DISTRIBUTION

2017 – 2018

SP ENERGY NETWORKS

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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 third Network Innovation Allowance (NIA) Annual Distribution Report and is an overview of the projects we have initialised during the regulatory year 2017/2018 and an update on those projects reported during 2016/2017 that are still active.

In March 2018 we launch our new Distribution Innovation Strategy which was the result of over a year of development and extensive stakeholder engagement, this strategy:

- **Outlines our vision** to pioneer and deliver a flexible, sustainable and efficient network;
- **Serves as a roadmap** to align and coordinate our activities to ensure our shared vision is fulfilled;
- **Fosters collaboration** with stakeholders by providing clarity and transparency on our key areas of focus for innovation; and
- **Outlines our principles** on why, when and how we innovate to deliver value to customers

The strategy underpins all that we do - from improving the day to day reliability and sustainability of our network, to supporting our transition to become a Distribution System Operator. Our innovation strategy is designed to ensure our customers and stakeholders are at the heart of what we do as we become the utility of the future.

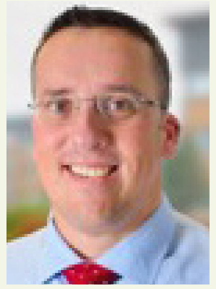
In response to Ofgem's 2017 Network Innovation Competition (NIC), SP Energy Networks had two successful project submissions both of which will address network flexibility:

1. LV Engine which will trial solid state transformers at secondary substations to enhance network flexibility and release additional capacity within the low voltage infrastructure for the connection of low carbon technologies; and

2. FUSION which will test a European market model using the Universal Smart Energy Framework (USEF) for the trading of flexible network services in the North East Fife area of Scotland. This will also offer release additional capacity for low carbon technologies.

Our innovation focus remains the delivery of real value to our customers and developing a network of the future that will offer customers the greatest choice of benefits that low carbon technologies have to offer.

SP Energy Networks welcomes third parties to submit innovative ideas for potential NIA and NIC projects.



Colin Taylor
Director
Processes & Technology

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Executive Summary

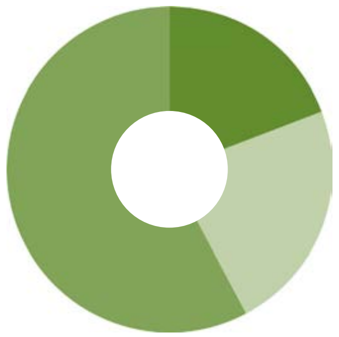
Our Network Innovation Allowance Annual Distribution (NIA D) Report has been compiled in accordance with Ofgem's Electricity Network Innovation Allowance Governance Document which sets out the regulation, governance and administration of the Electricity NIA.

This third NIA D Annual Report presents an overview of the projects we have initialised during the regulatory year 2017/2018 and an update on those projects reported during 2016/2017 which are still active.

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

In total, this report details 26 NIA projects that we are involved in, with the objective of applying relevant learning to realise business benefits.

Estimated Timeframe to Adoption for Project Portfolio

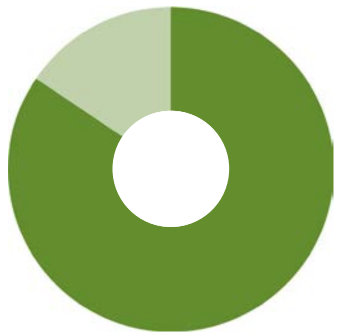


5 - Long

6 - Medium

15 - Short

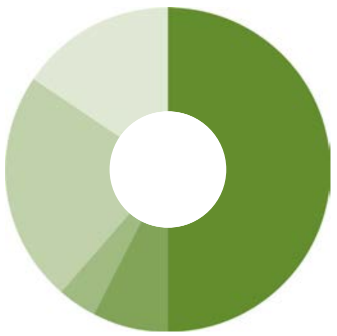
Collaboration



22 - No

4 - Yes

Project Origin



13 - SP Energy Networks

2 - Energy Innovation Centre

1- Energy Networks Association

6 - Vendor

4 - Open Innovation

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 left.

Introduction

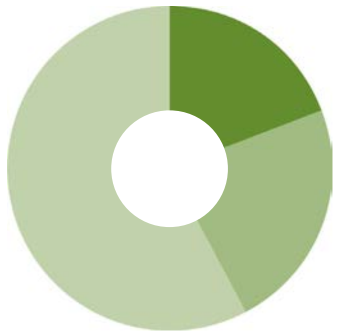
We recognise the need to be innovative in order to get more out of our electricity distribution network and deliver value for money for customers.

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 Strategy 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 Timeframe to Adoption for Project Portfolio

- **15 - Short** (Deliver benefits within 12/24 months)
- **6 - Medium** (Deliver Benefits 2-4 years)
- **5 - Long** (4 year +)

2 | Progress Summary

During the reporting year 1st April 17 to 31st March 18 SP Energy Networks registered the following twelve NIA Distribution projects:

Project No.	Project Name	Project Start Date
NIA SP Energy Networks0020	**Instrument for the identification of Live and Not Live HV and LV cables** http://www.smarternetworks.org/project/nia_SP Energy Networks0020	Aug-17
NIA SP Energy Networks0021	**Endbox G38 Level Detection** http://www.smarternetworks.org/project/nia_SP Energy Networks0021	Feb-18
NIA SP Energy Networks0022	**Weather Normalised Demand Analytics (WANDA)** http://www.smarternetworks.org/project/nia_SP Energy Networks0022	Aug-17
NIA SP Energy Networks0023	**Connected Worker Phase 1 - Field Data Automated Capture** http://www.smarternetworks.org/project/nia_SP Energy Networks0023	Oct-17
NIA SP Energy Networks0024	**Endbox G38 Level Detection Phase 2** http://www.smarternetworks.org/project/nia_SP Energy Networks0024	Oct-17
NIA SP Energy Networks0025	**Low Cost Fault Current Measurement of Wooden Poles** http://www.smarternetworks.org/project/nia_SP Energy Networks0025	Nov-17
NIA SP Energy Networks0026	**Linkbox Monitoring using Narrow Band IoT** http://www.smarternetworks.org/project/nia_SP Energy Networks_0026	Nov-17
NIA SP Energy Networks0027	**Transition to LVDC Networks Phase 1** http://www.smarternetworks.org/project/nia_SP Energy Networks_0028	Oct-17
NIA SP Energy Networks0028	**Transition to low voltage DC distribution networks – Phase 1** http://www.smarternetworks.org/project/nia_SP Energy Networks_0028	Oct-17
NIA SP Energy Networks0029	**Secondary Telecommunications Phase 3 – Trial of Hybrid Telecoms** http://www.smarternetworks.org/project/nia_SP Energy Networks_0029	Nov-17
NIA SP Energy Networks0030	**Zebedee Sectionaliser Device** http://www.smarternetworks.org/project/nia_SP Energy Networks_030	Mar-18
NIA SP Energy Networks1801 (Phase 1)	**Distributed Ledger Technology-enabled Distribution System Operation** http://www.smarternetworks.org/project/nia_SP Energy Networks_1801	Mar-18

Active NIA Distribution projects, led by other Distribution Network Operators, which SP Energy Networks is collaborating on, are tabled below.

Project No.	Project Name	Project Start Date
NIA WPD 0008	**Improvement Statistical Ratings for Distribution Overhead Lines** http://www.smarternetworks.org/project/nia_wpd_008	Jul-15

The following sections provide a short overview of each active NIA D 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 (http://www.SP Energy Networksergynetworks.co.uk/pages/innovation.asp) and on the ENA Smarter Networks Portal (http://www.smarternetworks.org). Key learning associated with these projects is summarised in Section 6.

3 | NIA Projects Led By SP Energy Networks

3.1 | NIA SP Energy Networks0002 Virtual World Asset Management

The Distribution Over Head Line (OHL) network is manually inspected on a cyclic basis as part of vegetation and Electricity Safety, Quality and Continuity (ESQCR) management policies. Over the years these manual inspections have served the UK Distribution Network Operators (DNOs) well, however inherent to these inspections are a number of issues that it would be advantageous for DNOs to eradicate.

Manual Inspection Issues:

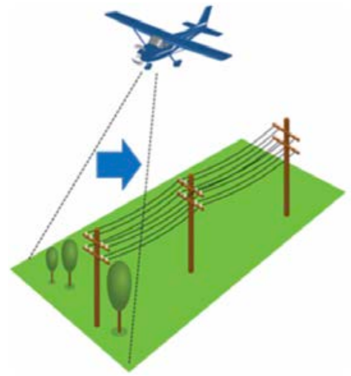
- It goes without saying that Manual Inspections are inherently labour intensive, requiring every km of OHL network to be inspected on foot. As a result they may not provide DNOs with the most financially beneficial and timely solution and the frequency at which they are undertaken is limited.
- Whilst inspectors are fully trained and competent, there is always an underlying risk that the severity of certain asset conditions are missed or misinterpreted as a result of the inspector's position and perspective relative to the OHL. As a result, for certain network issues manual inspections may not be the optimal solution for identifying and quantifying the severity issues such as vegetation intrusions to the OHL.
- With present inspection programmes there is a missed opportunity to gather further information about the OHL assets for the benefit of other DNO work programmes, however as it stands this is prohibited due to the additional cost incurred by the lengthier manually capture of information.

In summary, given time the quality of the data recorded from manual inspections is likely to improve marginally, however it is very unlikely their cost will decrease, restricting their frequency and scope.

The high level Scope of this project is to deliver the UKs first Virtual World Asset Managment (VWAM) system, quantify its accuracy, performance, capabilities and the impact it has on several DNO work programmes, provide evidence and guidance to support the decision to adopt VWAM as Business as Usual.

VWAM utilises Light Detecting and Ranging Technology (LiDAR) to produce a 3D model of the overhead line network. LiDAR is a surveying method that measures distance to a target by illuminating that target with a pulsed laser light, and measuring the reflected pulses with a sensor. Differences in laser return times and wavelengths can then be used to make accurate digital representations of the target and surrounding environment.

The network is captured using a fixed wing aircraft which blanket covers the distribution network. The raw LiDAR data collected is processed using a patented algorithm to produce a detailed analytic spreadsheet and 3D visualisation.

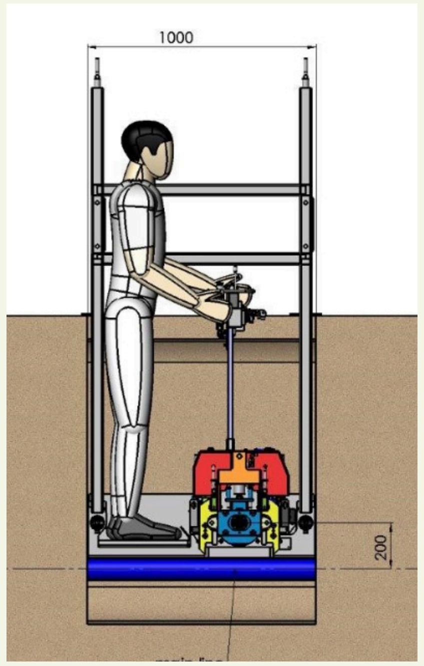


3.1.1 | NIA SP Energy Networks0002 Project Progress

This project has delivered the UKs first VWAM system, quantified its accuracy, performance, capabilities and the impact it has on several DNO work programmes, provided evidence and guidance to support the decision to adopt VWAM as Business as Usual.

This project is now complete a closed down report will be made available on the ENA Smarter Networks Portal.

3.2 | NIA SP Energy Networks0006 Mini Mole

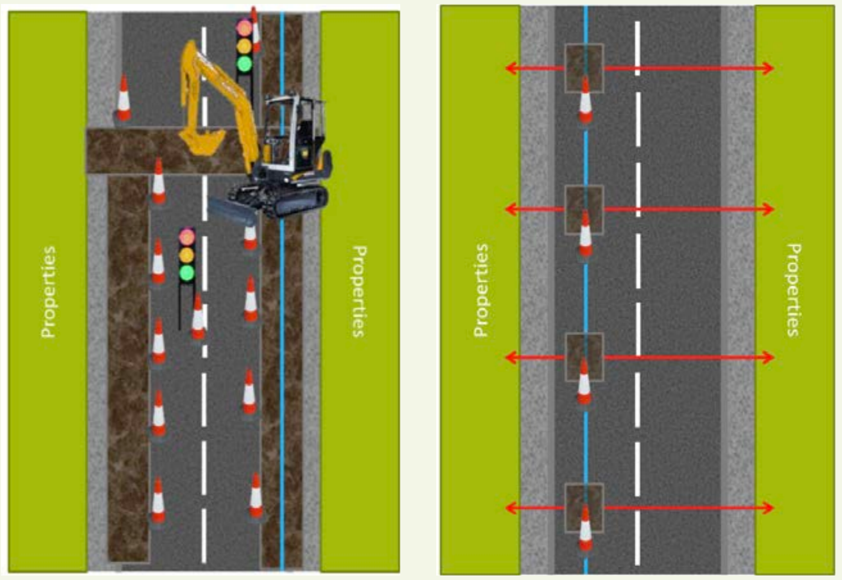


Renewing and upgrading underground LV cables and service connections can be a costly and time consuming activity. The standard unit cost for this activity does not take into consideration different circumstances which can significantly increase costs and inconvenience to customers; such as increase excavation and reinstatements resulting from ornate or decorative paving. These types of excavations can be significantly more expensive and time consuming, removing limited resources from front line activities, and reducing efficiencies.

Although the merits of conventional open cut trenching are well known there is an intrinsic risk to home owners and members of the public. To develop an alternative solution to this problem SP Energy Networks has been working with R&D partner, Tracto-Technik (TT), to design an innovative trenchless technology system (Mini-Mole) which could be used as viable alternative to traditional open cut trenching method current utilised for LV cable applications. The R&D phase, completed during IFI Keyhole Trenchless Technologies, will be manufactured into a full scale working prototype and extensively trialled to establish the benefit of the technique over conventional excavation methods for a variety of typical jobs.

The pictures below illustrate the open trench work required in order to connect service cables.

The Mini-Mole has been designed to fit a standard excavation required for jointing LV cables, removing the need to complete costly and time consuming road crossings. The Mini Mole method will greatly reduce the footprint of the work, reducing excavation and reinstatement costs, improving the working environment and lead to a reduction on standard traffic management costs. In addition, a reduction of exposure to manual handling risk using this innovative Mini Mole Trenchless Technology is anticipated.



This new method of inserting new/renewing existing services will help to prevent costly re-instatement of footways, which during excavation/reinstatement can render the footpath off limits to some pedestrians, as well as restricting access and egress from properties.

Traditional MethodMini Mole Method

The above diagram outlines the potential difference between the traditional method with road crossing and traffic management vs. the Mini Mole method with no open excavation road crossings and limited excavation requirements.

3.2.1 | NIA SP Energy Networks0006 Project Progress

The first prototype has now been constructed and was delivered in time to be exhibited at the Low Carbon Networks & Innovation (LCNI) conference in November 2017.




Training for safe and correct use of the equipment has been planned to take place in June 2018, with real jobs programmed for live trials of the equipment throughout the remainder of 2018.

3.3 | NIA SP Energy Networks0007 SUSCABLE 2

SUSCABLE 2 project is the second phase of a project for the development of a new design of high operating temperature power cable. The objective of SUSCABLE 1 was to develop new power cable material technologies with reduced whole-life environmental impact, increased power system efficiency with enhanced sustainability (increased peak-load thermal tolerance) and increased security of supply in urban and environmentally sensitive areas. The outcome of SUSCABLE 1 was new polymer blends with high thermal stability materials with enhanced electrical performance, reduced production costs and improved environmental performance.

The project aims to deliver a 35kV cable based on the new materials and also put in place the design for a 400kV cable based on the experience built up in making the 35kV cable.

First generation PVC insulation restricted cable ratings to 60 - 70°C, subsequent cross linking (XLPE) to prevent the plastic melting offered a continuous rating at 90°C while the new thermo plastics under consideration offer the prospect of an operating range of 120°C to 150°C. This increased operating head room will lead to improved cable performance.

The objectives of the project are as follows:

- Design, develop and test a MV polypropylene (PP) blend cable, preferably 35kV, utilising existing cable accessory technologies that are compatible (or readily made compatible) with up to 150°C conductor emergency rating and 120°C continuous operating temperature
- Refine the PP blend materials to achieve the MV cable design, processing and cable production processes. The development efforts will also be used to specify material enhancements for EHV cable applications up to 400kV.
- Undertake cable manufacturing and testing with structured development to generate experience that will be of value in 400kV design, manufacture and testing.
- Undertake MV cable deployment and operational studies to define the best operating mode and value proposition for Network operators and other MV cable users including economics of deployment with incorporation of risk factors and environmental benefits assessment.
- Review material thermal properties, cable thermal performance and cable ratings to meet current international standards and develop an action plan to address any identified performance gaps

1. Morphology

Specific polymer morphology is targetted:

- Target morphology orphology is spherulites with merged boundaries
- Polymer blends with no evidence of phase separation

Evidence of more prominent spherulite boundaries with charging evidenced in the scanning electron microscope indicates a poor boundary condition which will have low electric strength. Phase separation and distinct spherulitic boundaries are an early indication of samples that will show poor electrical performance.

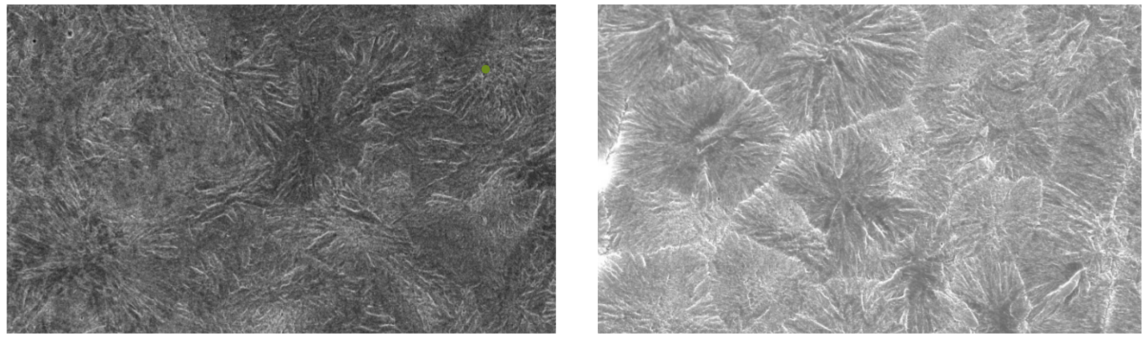


Figure 1 Electron micrographs showing A. a good blend, with no defined boarders between spherulites and no evidence of phase separation, B. a poor blend with sharp boundaries between spherulites and evidence of charging (brighter patches)

2. Performance of blends

Specific polymer morphology is targetted:

- Target morphology orphology is spherulites with merged boundaries
- Polymer blends with no evidence of phase separation

Evidence of more prominent spherulite boundaries with charging evidenced in the scanning electron microscope indicates a poor boundary condition which will have low electric strength. Phase separation and distinct spherulitic boundaries are an early indication of samples that will show poor electrical performance.

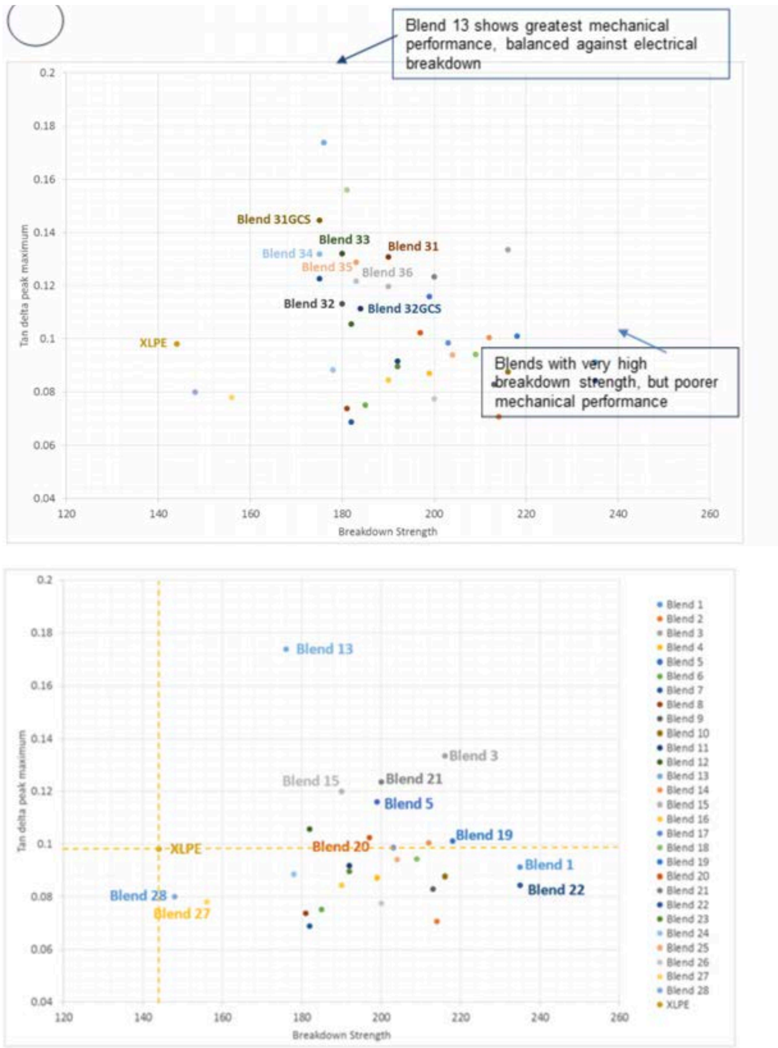


Figure 2 Plot of breakdown strength vs tan delta peak maximum for all blends and XLPE. Dashed lines show the minimum position for both parameters, as achieved by XLPE. Candidate blends for upscaling selected from those towards the top right of the figure.

3. Cable Manufacture and Performance

Specific polymer morphology is targetted:

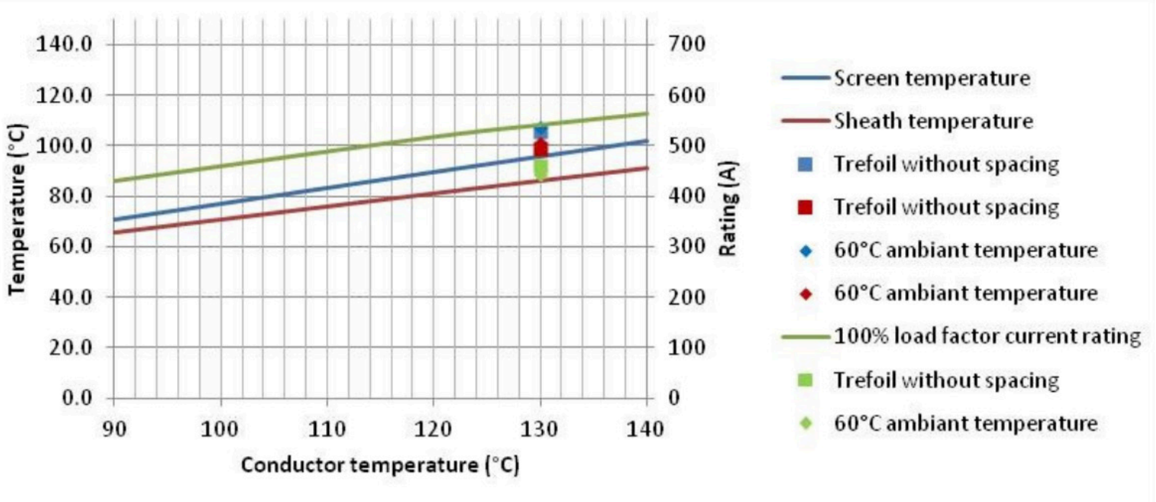
- Target morphology orphology is spherulites with merged boundaries
- Polymer blends with no evidence of phase separation

Evidence of more prominent spherulite boundaries with charging evidenced in the scanning electron microscope indicates a poor boundary condition which will have low electric strength. Phase separation and distinct spherulitic boundaries are an early indication of samples that will show poor electrical performance.

Figure 3 Picture showing the pelletised blend granules which are translucent with the corresponding extruded MV cable. The aluminium conductor has an adjacent black inner semiconducting screen and there is an outer screen bounding the insulation layer – this layer appears dark grey because the cross section acts as a black reflector.

4. Cable ratings

Cable rating calculations for different conductor temperatures, for cables laid in free space have been undertaken. Calculations are based on thermal conductivity data for the blends. Data suggests that at conductor temperature of 140°C (cable rating 564A at 100% load), the sheath temperature is approaching 100°C.



3.3.1 | NIA SP Energy Networks0007 Project Progress

The project began in June 2014 and has made significant advance in the 33 months to March 2017 with both cable maker partners succeeding in making the first MV cables from the new bi-polymer and tri-polymer blends which have been successfully formulated using materials sourced from multiple suppliers globally. The mapping of the new blends performance electrically, mechanically and thermally enabled the best candidates to be selected and volume scaled to tonnage level in advance of processing trials and cable manufacture by the cable manufacturers. New semiconductive screen compounds were also produced which have excellent compatibility with the new insulation materials.

Cable manufacturing revealed that while cable making was possible with the new materials, the melt flow behaviour could not support commercial high volume cable manufacture due to feed rate constraints affected by melt phase viscosity limitations. Further modifications were made to the blend formulations in Figure 4 to overcome this constraint and 11 new quaternary blends were produced and on evaluation a number of these satisfied the melt viscosity requirements and that are being evaluated with aone was selected for volume upscaling to enable a second prototype cable to be produced and tested. This new cable is due to be manufactured and tested in 2018. one to go into further cable manufacturing.

The cable extrusion trials started in October 2016 and were continued with the new quaternary blends are expected to continue into 2018 with associated assessment of short term performance before longer term testing begins. An example of the first MV cable produced to meet a common European standard design is shown in Figure 4 along with the polymer blend material used to produce it which was produced at 1 to 2 tonne level. The MV cable has satisfied the short term tests undertaken to date but it is planned that the long term tests should be undertaken on cable produced from the selected quaternary blend that will more closely match the materials which will satisfy commercial production rates.

The triple head extrusion equipment used to produce the cable is shown in Figure 4.

Figure 4 Picture showing the triple head extruder used in General Cable Silec's cable manufacturing of the MV Suscable core. The cable core then passes through a water bath cooling zone 80m in length with no crosslinking stage.

Thermal modelling of underground deployed cable showed the need for higher operating temperature cable sheaths and materials have been selected to meet this requirement. This modelling was extended to cover HVAC as well as MVAC cables and both are considered to be manufacturable. Work was completed on the deployment options for both MV and HV cable designs.

Delays in obtaining the materials from suppliers created some knock-on delays to later tasks including extrusion trialling and cable making but the project plan was reset to accommodate this. However, it is likely that the project timescale would need to be extended to enable the new cable to be long term tested. The cooperation and commitment of the cable companies who are co-funding the project remains high and they are seeking to complete cable testing in 2018.

In the early part of 2018 a new patent application was filed detailing multi-component polymer blends for power cable applications.

3.4 | NIA SP Energy Networks0008 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). It is a 2.5 year project looking 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:

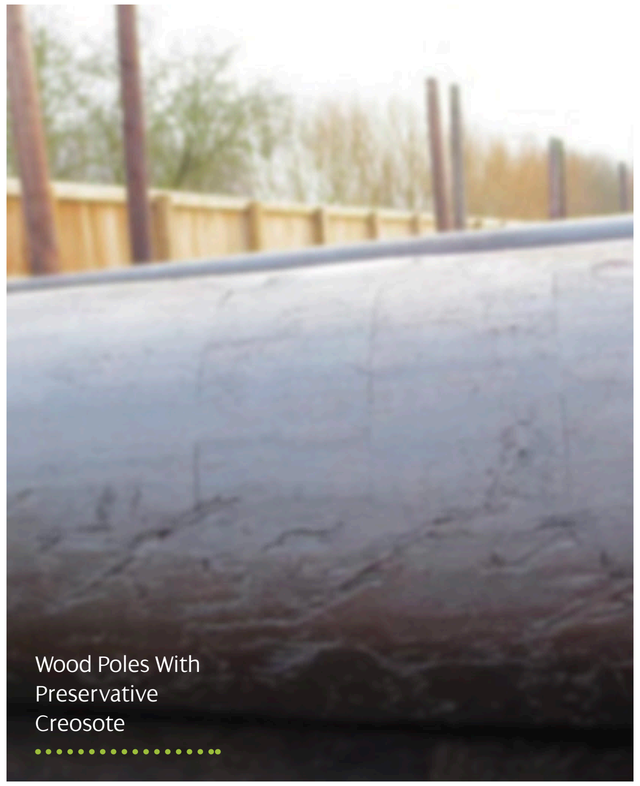
Stage 1 – Literature Review: This stage will provide a comprehensive review of candidate replacements for creosote, enabling the DNO partners to select the solutions to take forward for testing.

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 of the elements to 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.

3.4.1 | NIA SP Energy Networks0008 Project Progress

The project started in August 2016 with Stage 1 the 'Literature Review' now being completed. Potential candidates to replace creosote as presentative on wood poles were identified. The proposed Stage 2 accelerated trial has been upgraded from a pole section (timber round) trial to a Scots pine timber stake trial. This represents an upgrade as the trial will now conform more closely to standard EN preservative protocols specifically designed to assess the protective effectiveness of treated timber in ground contact. The container-chamber for the trial has been constructed with all the necessary water and electricity supply. The rainfall apparatus is fully installed and tested. All stake samples collected for the trial are installed in the soil bed as planned. Therefore, the trial stage has been successfully initiated in October 2017. Regular checks take place in a monthly basis to ensure the trial goes as planned and to check decay progress. In addition, the inclusion of alternative product samples was decided and particularly these of pollywood.



Wood Poles With Preservative Creosote

3.5 | NIA SP Energy Networks0009 Data Intelligence for Network Operations (DINO) Phase 1

This NIA project "DINO" seeks to research the two levels of "large volume data management" problems which DNOs will experience as they move towards a "Smart Grid". The two problems which will be addressed are:

1. The Issue of Too Much Data

DNO Network Management Centres (NMCs) are presently inundated with data from the network. Hence, there is a need to turn large volumes of data into useful information suitable for supporting operational decisions.

This is a big problem area and in order to focus it is proposed to take a use case led approach. This approach will allow a narrow route to be taken through a large problem. Hence, in this initial Phase of the DINO project the Parties will look at the use case of handling alarms from Network Controllable Points (NCP), which represents a real "too much data" problem experienced today.

2. The Issue of Data Exchange/Discovery

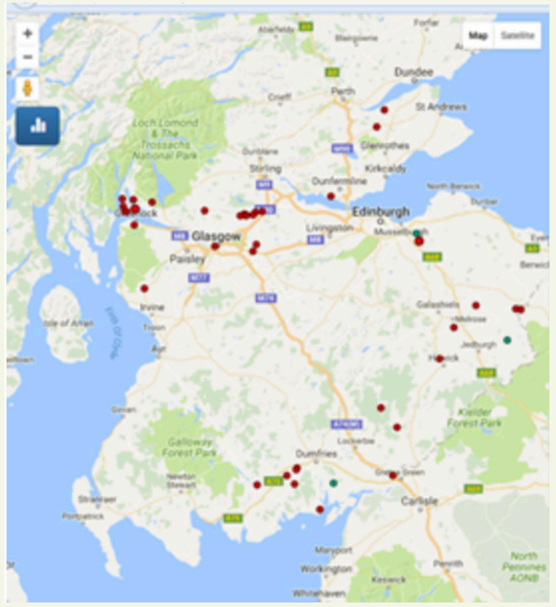
Passing data between multiple systems and ensuring that only one current version of truth exists is an ongoing issue for all DNOs. Without solving this it is hard to understand the full context (network, asset, and communications) that information relates to. As part of the process of identifying the solution for the business use cases identified in (1) we will also investigate the potential future data infrastructure required for DNOs as they build out their smart grid infrastructure.

Although base technology exists to address these problems, the best methodology to do so is unproven. This project is research based as it evaluates different ways of managing, analysing and visualising data.

3.5.1 | NIA SP Energy Networks0009 Project Progress

The project was concluded towards the end of 2017 with the publication in September of the final close down report and dissemination of the results over the following months. The project was extended by 6 months during 2017 to allow further input from the business and further scenarios to be developed. These additional use cases demonstrated the value of lower volume but higher priority alarms. This led to the creation of a detailed use case list of scenarios which would benefit from this type of analysis in future.

Learnings from the project were successfully transferred into SP Energy Networks's procurement process of an enterprise IT and data integration system.

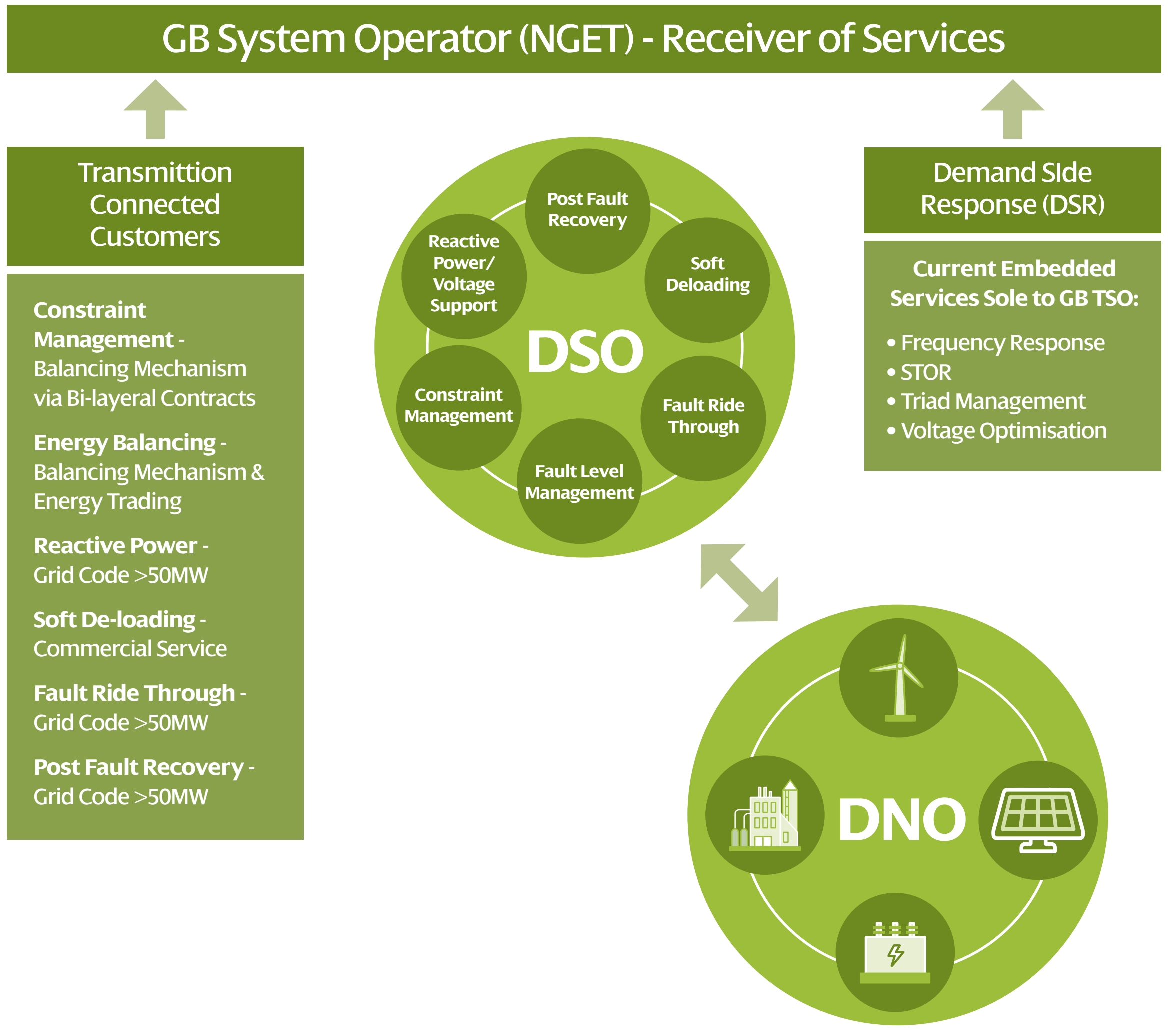


3.6 | NIA SP Energy Networks 0010 EVOLUTION

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 generation 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.



3.6.1 | NIA SP Energy Networks0010 Project Progress

EVOLUTION has been taking on the strategic role in facilitating effective engagements within and outside of the DSO sector. Over the past 12 months, the project successfully supported by identifying the right resources and expertise in the sector, stakeholder engagements and initial feasibility studies as part of the FUSION proposal under the 2017 Network Innovation Competition (NIC). The FUSION proposal was approved with funding condition, demonstrating the value of the NIA regime in flagship innovation project development.

3.7 | NIA SP Energy Networks0012 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/low carbon technologies (DG/LCTs) have connected to the distribution network. This system will overcome current business challenges due to limited numbers of experts and the labour-intensive time needed to carry out some power quality monitoring-related tasks at present.

SINE Post will demonstrate the automation of previously time consuming and labour-intensive tasks often undertaken by valuable experts. This will give design engineers, asset managers, control room staff and field staff within SP Energy Networks timely access to processed information, allowing them to make informed decisions more quickly. Ultimately, this will deliver performance benefits to SP Energy Networks's 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.

3.7.1 | NIA SP Energy Networks0012 Project Progress

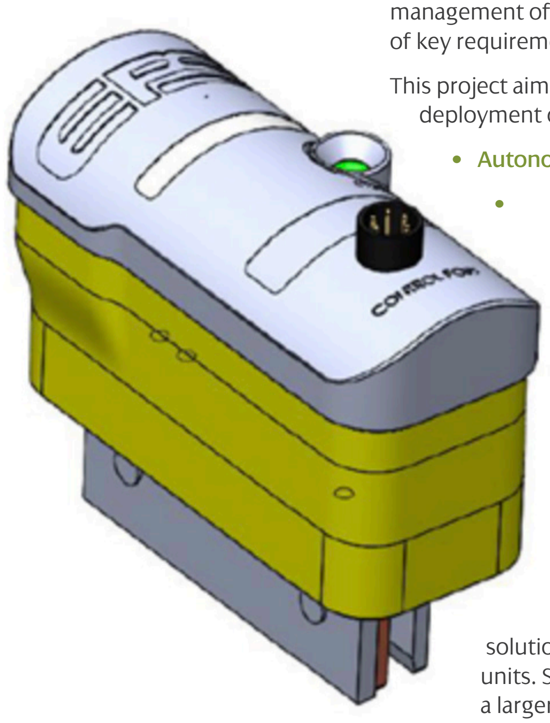
The last 12 months have been SP Energy Networkst developing the architecture to allow the integration of data from Power Quality Monitors (PQMs) into SP Energy Networks corporate system to autonomously generate fault location reports. The progress with this task has been slower than hoped as it has been aligned with the delivery of SP Energy Networkss Smart Data Integration Fabric (SDIF) programme. This alignment ensures that SINE Post is forward compatible with SP Energy Networkss future IT systems and greatly simplifies the transfer of data between corporate systems. The solution has also been modified to allow more field data devices to supply fault impedance data into the fault location application, it is now expected that fault impedance from Pole Mounted Reclosers and Protection Relays can be accommodated into the solution.

The proposed SINE Post functionality and architecture has been provisionally approved allowing for construction to commence in 2018/19.

3.8 | NIA SP Energy Networks0013 Interoperable LV Automation

Meshed LV networks are common place within SP Energy Networks (predominantly SP MANWEB), whilst these network provide greater utilisation of network assets and a more secure supply for customers they do have some associated issues:

- Meshed LV networks require greater discipline and control to ensure the running arrangements are kept within the design and operational parameters
- They typically operate at higher fault level than radial networks due to interconnection of multiple secondary transformers
- HV automation schemes are reliant on the control of LV interconnections, the present approach to achieve this is through potentially costly network reconfigurations and subsequent control measures to ensure that the new running arrangements are maintained



LV Automation has the potential to provide a solution for the long term management of meshed networks, however, in order to do so there are a number of key requirements that need to be developed.

This project aims to develop and trial a prototype LV automation device for deployment on meshed networks. The device will be designed to:

- Autonomously and remotely un-mesh and re-mesh the network
- Provide customer service improvements through fault re-closing (designed for higher network fault level)
- Interoperate with existing and emerging fault location solutions
- Interoperate with HV automation schemes
- Provide real time visibility of the LV network configuration
- Fit all types of LV boards
- Keep deployment costs to a minimum with a targeted price per LV circuit board way of <£2,000

This is Stage 1 of an intended two stage NIA project, the first stage is to design, develop and trial a prototype LV automation solution. Stage 1 of the project only considers a limited field trial of 3 units. Should it be a success then Stage 2 will look to deploy the units on a larger scale.

3.8.1 | NIA SP Energy Networks0013 Project Progress

As of the end of 2017/18 the Stage 1 'Proof of Concept' project is on track for completion in early 2018/19 with successful Phases 1 through to 4. A decision is being made on the value of undertaking Phase 5 prior to commencing the Stage 2 'Pilot' project. The project partner has successfully demonstrated and tested the functionality of the LV automation solution and its operating characteristics, with external testing verifying the results. It is expected that SP Energy Networks will progress to register the Stage 2 project in 2018, subject to internal approval.

3.9 | NIA SP Energy Networks0014 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.

3.9.1 | NIA SP Energy Networks0014 Project Progress

Phase 1 of the AFLM project has investigated available solutions to address fault level challenges through modelling, measurement, mitigation and management techniques. A high-level concept for AFLM has been developed and a number of case studies have been investigated.

The project is tasked with demonstrating an innovative solution to Fault Level Management, and it is with this in mind and the positive Cost Benefit Analysis (CBA) that we are focusing on a solution bringing Active Network and automation concepts to the fault level management challenge within Phase 2. The AFLM concept is still being refined and the functional design for the solution and testing specification are being developed. The AFLM prototype will be tested over the coming months.

Having fully explored the implementation and operational characteristics of such a solution the project will establish the control philosophy and interface requirements that will provide the foundation for an AFLM network trial of in Phase 3.

3.10 | NIA SP Energy Networks0015 Real Time Fault Level Monitoring (RTFLM) – Stage 1

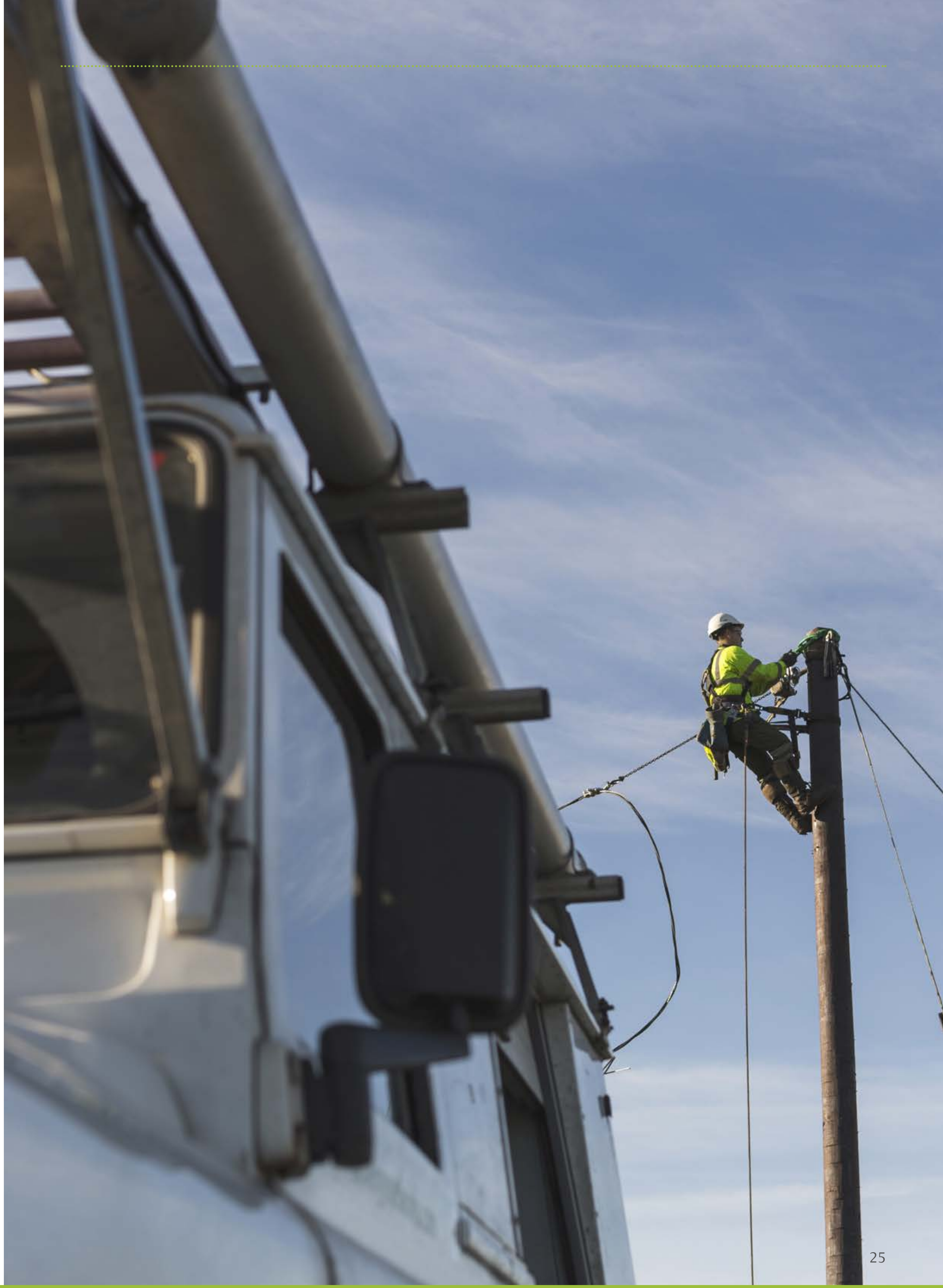
This project aims to develop and trial a novel Real Time Fault Level Monitoring (RTFLM) solution. The solution being developed to:

- 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".

3.10.1 | NIA SP Energy Networks0015 Project Progress

Major progress has been made on this project during the last 12 months. Several tests have been undertaken using the first prototype RTFLM at LV and 11kV see left hand photograph below. These tests highlighted the need to make some small adjustments to the RTFLMs design and functionality. Most importantly the tests highlighted that the RTFLM was capable of producing stable and consistent fault level measurements which corroborated with corresponding fault level studies. This confidence has enabled SP Energy Networks and Outram Research Ltd to push ahead with the construction of two fully assembled RTFLM units capable of being deployed for extended network trials at LV, 11kV and 33kV. With trials planned for Q3 2018.

The right hand photograph below shows one of the fully assembled RTFLMs in a 19" cabinet ready for delivery to SP Energy Networks for extended trial. The unit comes complete with an integral health check system and remote communication that will enable the device to run unsupervised for a prolonged period of time at a minimal risk.



3.11 | NIA SP Energy Networks0016 Network Constraint Early Warning Systems (NCEWS)

The management of LV network access requirements for future UK customer's dynamic LCT energy behaviours is the key theme of Smart Grid research. This project will assist in this process by building on the understanding of the 'Distributed Sensor Network' (DSN) data that the mandated role out of SMETS2 Smart Meters (SM) will bring to the DNO. The aim of this project is to understand how SM's can be utilized as network sensors for recognition of network constraint in LV networks. It is considered that this early warning of network constraint understanding can,

- Help plan more effectively and timely traditional general network reinforcement required for increased LCT penetration
- Help manage new Connection quotations requirements, design risk and time to quote
- Be used to trigger potential future Smart Grid interventions (dynamic or permanent) currently being explored in other Innovation research projects.

The core aim of this research project is to investigate the initial integration of the SM data and develop adaptive and scalable methodologies for future data analytical system and modelling requirements. This will be done initially using low volume 'Static' planning limit data derived from voltage and consumption profiles along with SM maximum demand.

Plan more effectively and timely

Manage new Connection quotations

Trigger potential future Smart Grid interventions

Specifically the projects will provide,

1. A first step visibility of previously unseen LV network behaviour from SM 'Profile Limit' data availability

2. Improvement in existing asset management LV connectivity models through investigation and specification of Data Analytical transformation requirements

3. Guidance on adaptive data monitoring systems that can react to system risk to provide increasingly granular levels of LV network behaviour visibility

4. Minimize overall SM data requirements through this adaptive monitoring capability

5. Define future data analytical requirements for integration of increasingly dynamic network profile data

This initial investigation of SM data in the understanding of LV network constraint will be delivered while capability and availability of Smart Meter Data is still being realized; but within the background environment where heavy expectation is being placed on the DNO's by Ofgem on the use of this data for eventual DSO and Smart Grid intervention working. Methodology will consist of,

Establishment at Proof of Concept level the data analytical improvement techniques required within vectorised GIS asset management and connectivity systems

Utilize a Data Science research associate partly funded by Innovate UK through their Knowledge Transfer Partnership (KTP) scheme to carry out low TRL research after direct application of available and test SM Data

3.11.1 | NIA SP Energy Networks0016 Project Progress

Extremely good progress has been made on this project which saw the completion of module 1 which was a Proof of Concept (PoC) data analytical LV network node and edge modelling platform. This analytical methodology and asset GIS data transformation IT system has already generated significant interest in the wider business. Due to its initial success and identified capability it is also being proposed as:

A business as usual implementation in 2019

The modelling methodology for a NCEWS2 project focussed on verification and improvement of existing network connectivity. This will enable scenarios such as network constraint management of distributed Electric Vehicle (EV).

Module 2 has seen the successful recruitment in October 2017 of a PhD Data Scientist researcher. This was funded in conjunction with the Knowledge Transfer Partnership and employed through Heriot-Watt university. Unfortunately, due to the delay in obtaining SMETS2 Smart Meter (SM) data, especially Voltage profile data, the project has had to adjust the research priorities. Focus was therefore placed upon using data science techniques for data improvement of the currently available network asset data in GIS. This will utilise the underlying capability of the modelling platform to understand archetype LV circuit make up and use pattern analysis algorithms to backfill missing asset information. This will be based on the principle that all circuits are designed using DNO design rules for distribution over a given length, load and number of connected customers. It is hoped this work will lead to better global impedance and rating understanding that will feed into the constraint analysis work once the energy use data is available from smart meters.

3.12 | NIA SP Energy Networks0017 Secondary Communications Phase 2 – Consultancy Engagement

Every DNO in the UK uses a communications network. All of these networks face similar issues and opportunities to future-proof their networks. The learning which will come of this project will help shape what direction all other DNOs will take, as it will provide an analysis of the potential options, along with an analysis of protocol conversion for legacy system integration.

This is Phase two of a research and development project, looking to investigate a future-proofed communications network for secondary automation on the distribution network. It will determine a number of external influencing factors which will affect the requirements for the communications network.

The project will analyse various aspects of the requirements of the future network of the Smart grid, and its comparison to what is required for Secondary automation; it will look at the communications requirements, protocols and their backward compatibility, and various telemetry systems. Additionally, it will identify the scope and parameters of the future trials, which will be carried out as part of a future phase.

3.12.1 | NIA SP Energy Networks0017 Project Progress

The following project activities were undertaken:

- **Analysis and review of both readily available and future looking telecommunication solutions:**
  - Private network: VHF and UHF Point to Multipoint Digital Radio (P2MP-DR) and Private LTE (frequency to be selected; 450 MHz band is being proposed by EUTC).
  - Public network: 2G/3G/4G based.
- **Comparative analysis of telecommunication solutions.**
  - Proposal developed for Laboratory tests (e.g. PNDC). 3 MHz wideband low-power LTE communications between a central Control station and a small number of fixed outstations within a 300m radius.
  - Test sites Selection: Identified potential Trial site locations that best suits the objective of the project and that is representative enough to make the most of the different technologies. Desktop planning would be done beforehand.
  - In-depth study of the different solutions:
- **RTU requirements analysis (interfaces, throughput, traffic). Referenced to existing RTUs within Iberdrola.**
- **Architecture: Radio network planning.**
- **Spectrum feasibility study and further license management.**
- **Draft cost analysis.**
- **Backwards compatibility.**
- **Scalability for Smart Grid expansion.**
- **Cybersecurity.**

This project is now complete.

3.13 | NIA SP Energy Networks0018 Technical Review of Non-Conventional Statcom Applications

In this project, a review of current Statcom technologies will be carried out, with a strategy for taking them from a one off installation to a business as usual reinforcement option. This will involve investigating whether Statcoms can be deemed a cost effective alternative to conventional reinforcement for addressing voltage constraints on the network, particularly for the 11kV network.

One of the main areas of potential new learning is the determination of whether Statcoms are a cost-effective way to address network constraints- more than just for voltage level issues. This NIA project will provide evidence to identify the innovative opportunities from an engineering, investment planning and commercial model perspective. These are areas which have not been explored in depth regarding Statcoms, and so the technical specifications and learnings from this project will allow other licensees to adopt them more widely and quickly into a business as usual application.

3.13.1 | NIA SP Energy Networks0018 Project Progress

A Statcom sizing study has been developed looking into the installation of Statcoms on four areas of the Scottish Power Distribution (SPD) network that are, or are expect to be, experiencing voltage issues due to network load changes and continuing connection of distributed generation.

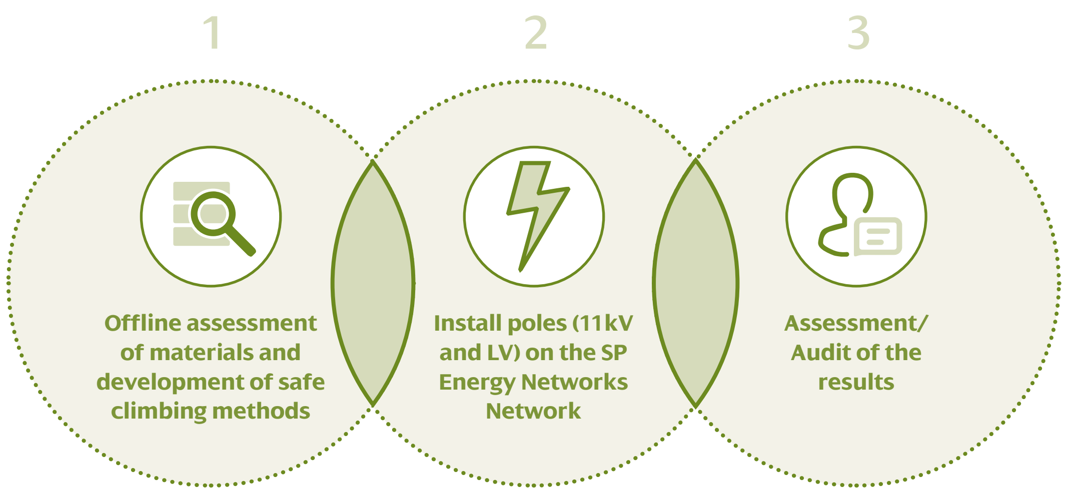
The findings of these studies will be used as input into a needs case for each area. This will assess whether a Statcom installation is a cost effective alternative to traditional upgrades.

3.14 | NIA SP Energy Networks0019 Operational Assessment of Composite Poles

Distribution Network Operators (DNOs) throughout the UK use the preservative Creosote to protect the wooden poles that are used for overhead line construction at all voltages from LV through to 132kV with over 25,000 new poles erected each year. Creosote is a harmful chemical. If it comes in to contact with the skin it can cause burns and it has carcinogenic properties. The use of Creosote comes under review every 5 years and there is already a ban in certain circumstances. Industry experts expect that the use of Creosote shall be allowed until 2023 but before this ban is enforced DNOs have to begin investigating alternatives and have a plan already in place if the ban goes ahead.

This project aims to investigate the feasibility of an alternative to wood poles. It will examine the use of composite poles for a network application involving both 11kV and LV applications, ensuring that best practice can be adopted whilst trialling and developing the different innovative working, design and climbing techniques required.

The project will have 3 stages:



3.14.1 | NIA SP Energy Networks0019 Project Progress

Stage 2

The trial was postponed due to a specific concern about the staying arrangement and the termination at the top of the pole to secure the stay. It was declared by the supplier that the "pole top wrap" for terminating the stay on a typical 11kV configuration could cause a crushing of the hollow composite pole. This is not the case with existing wood poles that are solid and not hollow.

The trial was therefore reduced in scope on the day of the installation but there was a second concern raised about the drilling accuracy and the steel inserts that must be used with the composite pole when inserting bolts through the pole. A satisfactory accuracy could not be achieved using conventional drilling practices and the installation was suSP Energy Networksded.

Stage 3

There were a number of conclusions and learning outcomes from the trial. The two main areas that were identified were;

1. The existing stay terminations are not compatible with composite poles
2. The existing drilling practices are not compatible with composite poles.

The first point has been declared to the ENA Overhead Line Assessment Panel and they have agreed to commission a UK wide, ENA led, project to fully assess all the mechanical stresses and forces applied to overhead line structures and develop a construction specification for composite poles.

The second point has been assessed internally within SP Energy Networks and clear guidance will be issued in advance of any future installation of composite poles that states the drilling technique and equipment required. This second point is dependent on the conclusion of the ENA led project to fully understand the final agreed industry principles when constructing overhead lines on composite poles.

3.15 | NIA SP Energy Networks0020 Instrument for the identification of Live and Not Live HV and LV cables

It is vital when performing maintenance on cables that live cables close by are not interfered with, thus the need for a technology to detect them.

When carrying out maintenance on distribution cables, especially underground, there can be a large number of cables within a small region. With this project the safety of the workforce of the DNO should be drastically improved. Whilst those working in situations where live and not live cables are fully trained professionals, the underlying risk of working on the wrong cable is always present, hence the need for a new way of approaching these situations. It should be known at this time that this project will not eradicate the need and/or use of the tried and tested approach of cable spiking.

This project aims to utilize technologies which only in recent years have become available for use in environments such as those faced by the workforce in situations like this. In its development phase this project will trial a number of solutions, including but not limited to magnetic coupling using differential hall sensors and inductive coupling, and the measurement of the radio-frequency (RF) leakage levels.

At this time the prototype will be thoroughly tested to ensure that it is fit for purpose and able to meet the objectives of this project – to detect live or not live cable and thus determine whether or not the cable is running at HV or LV.

3.15.1 | NIA SP Energy Networks0020 Project Progress

A prototype device has been created for the purpose of determining whether a cable is running live or not live, and whether at HV or LV voltages. This device is currently being used to gather data for algorithm training and validation. This data will be used to ensure that each type of cable can have its state correctly identified, and that the device outputs can be relied upon.

Once this data gathering has been carried out, we will be distributing prototype devices to inform staff training and enable testing to gather further data, and to ensure the device can meet the business needs.

HV/LV Device being tested at the Power Networks Demonstration Centre

3.16 | NIA SP Energy Networks0021 Endbox G38 Level Detection

Ensuring that the volume of insulating medium does not drop below the critical limits is paramount to ensuring the safe and continuous operation of assets on the SP Energy Networks network.

In order to ensure the correct working order of assets, in the case transformers, the exposed live conductors for each phase entering the transformer are contained within what is known as an endbox. To avoid catastrophic incidents occurring, these conductors are surrounded in an insulating medium – in this instance G38, which is a very viscous tar like insulator. As per the case in most scenarios, there are boundaries surrounding the extreme limits of this substance that must be retained within the endbox at all times – which in certain cases has not been the case, and accidents have followed.

In order to prevent similar scenarios in the future, a project has been undertaken to develop a detection device/method to measure the volume of G38 within the end box. The main method for detected the G38 volume is by the use of an ultrasound device. In this first initial phase of works, the main aim is to determine the optimum ultrasound transmitters and receivers, and through this work also determine the optimum frequency or frequency range which is to be used in this case. Following this stage of the project, a document will be drafted.

Following the initial findings, testing will be undertaken by a professional in a variety of differing types of substations as a series of substation inspections, and this will lead to the creation of a policy document. The document will only be written once widespread testing has been undertaken and satisfactory results achieved. Following the completion of this project, a framework will be provided to other licensees to make use of ultrasound apparatus in the detection of G38 levels within endboxes.

3.16.1 | NIA SP Energy Networks0021 Project Progress

The G38 project has been completed and the outputs of this stage have been taken forward into the Stage 2 project. This will lead to a full rollout of the monitoring solution across our distribution network. A closedown report will be generated for this and made available on the ENA Portal.

G38 Units with signs of leakage

3.17 | NIA SP Energy Networks0022 Weather Normalised Demand Analytics (WANDA)

Forecasts of electrical load are used by network operators to determine the volume, type and location of investments.

Load forecasts are based upon the power flows through substations and are adjusted for the embedded generation on the network. Currently, there is no regular adjustment made for the effect of weather upon demand in the local area served by each individual substation. This means that it is extremely difficult to separate out the effect of weather upon demand and the effect of other customer behaviour upon demand (e.g. energy efficiency measures, increases in the number of electric cars being charged, the closure of industrial premises, etc.)

This results in additional uncertainty when making investment decisions leading to under or over investment in individual network areas and therefore suboptimal outcomes for customers. Additionally, it leads to inconsistent regulatory reporting. An example would be a mild winter causing demand to drop and the load index metrics becoming artificially low for that year.

Weather patterns and customer behaviour are two key drivers in electricity demand. By undertaking this project, it will be possible to better understand how these have changed historically within a given licence area and will provide invaluable insights into future demand scenarios. It will also highlight their relative significance and current trends. This will allow asset managers to develop better and more targeted investment strategies. Furthermore, accurate demand models will provide more realistic data for investment risk and cost-benefit analysis and subsequently lead to better returns for customers.

A comprehensive understanding of the effect of weather upon demand is a key enabler for the transition to a DSO model.

The objectives of the collaboration are:

Analyse historical demand data and calibration of normalisation models.

Evaluation of the weather normalised demand model.

Completion of uncertainty analysis against historical data.

Analysis of demand trends – weather related vs customer behaviour.

Creation of summary report and data files.

Delivery of final presentation or paper at industry event/conference.

The study shall include all SPD primary substations across the central belt of Scotland covering both the west and east coast. The wide geographical area is to provide a broad range of input conditions for the machine learning algorithms to ensure applicability across the GB area.

The project shall be a desktop exercise using historic SCADA, generation and discretised weather data. Where available, the project shall use 10 years of hourly data. Each primary substation will be allocated a geographic polygon which represents the service area for the substation.

This data will be used to build and evaluate models which disaggregate electrical demand into load driven by weather conditions and load driven by other customer behaviour. Analysis of the underlying trends will be undertaken.

The output from the project will then be used in network planning and the completion of regulatory reports.

An advanced numerical weather prediction model will be used to simulate hourly weather conditions.

The location-specific weather data will be weighted by population density and aggregated across the areas served by each of SP Energy Network's primary substations.

This will be used to calibrate a weather normalised demand model.

An embedded generation module will be implemented within the demand function in order to reduce generation-related uncertainties.

The demand model will be trained against recorded data for the period of analysis using advanced machine learning algorithms.

A comparison of the demand model results vs historical data will provide a level of confidence in the predictions.

The results will then be used to infer weather vs customer-behaviour trends over the period of analysis and predict future demand scenarios.

3.17.1 | NIA SP Energy Networks0022 Project Progress

All research phases of the project are now complete. The close down report for the project is currently being compiled.

Learnings from the intermediate stages of the project were presented at:

- 4th Asset Management Forum (Amsterdam, December 2017)

The findings from the close down report will be presented at LCNI 2018 (Telford, October 2018)

3.18 | NIA SP Energy Networks0023 Connected Worker Phase 1 - Field Data Automated Capture

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

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 (ERSI) to include both installed and decommissioned assets.

3.18.1 | NIA SP Energy Networks0023 Project Progress

Initial workshops have been held with the project partner ESRI to define the project deliverables and project delivery roadmap.

3.19 | NIA SP Energy Networks0024 Endbox G38 Level Detection Phase 2

Upon proving that the technology for this 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 be further validated, which is a vital step in preparation for integration into Business as Usual (BaU). This trial will involve testing this approach on a representative sample of switchgear across both licence areas, SP Distribution (SPD) and SP Manweb (SPM). Furthermore, within this trial, the methodology for the determination and classification of the status of endboxes will be developed. This should enable the objective of determining a method to classify the criticality of the endboxes, depending on the G38 levels within and whether the exposed conductors are fully covered and insulated.

3.19.1 | NIA SP Energy Networks0024 Project Progress

We are currently looking at how this testing can be rolled out across all G38 equipment in our distribution networks. It has been determined that this will be an internal process, and the testing will be integrated as a part of normal district operation. The pathway to achieving this is to be determined.

3.20 | NIA SP Energy Networks0025 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 becomes 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 than 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.

3.20.1 | NIA SP Energy Networks0025 Project Progress

Stage 1	Stage 1	Stage 2
Explored the device concept using a small electrochemical cell that integrates low-level leakage current and provides a visual 'fault' indication when the total current that has passed through the cell exceeds ~ 24 mA.hr. This was successfully demonstrated at the end of Stage 1.	Successfully completed on time and within budget, Stage 2 is underway and planned for completion in November 2018.	Is to develop a 'looks-like, works-like' design, manufacturing a small number of devices for test and evaluation. Device concepts were shared with the DNOs early in stage 2 and a concept agreed upon for detailing. The detailed design of the device is now complete and will be subject to testing.

3.21 | NIA SP Energy Networks0026 Linkbox Monitoring using Narrow Band IoT

Link boxes are an integral part of the electricity network, providing network protection and isolation in fault scenarios. They help to restore supply to customers quickly, and enable increased flexibility in heavily loaded areas of the LV network.

At present inspectors inspect these link boxes every 3 years to ensure the lids are accessible, secure and level. Furthermore, intrusive inspections take place at a range of frequencies every 1 to 3 years depending upon criticality. These inspections, however, are labour intensive as the currently rely on manual techniques, therefore the need for a new way of testing has arisen This project will aim to investigate the feasibility of making use of Narrow Band (NB) Internet of Things (IoT) communications and low cost sensors to automatically gather good quality data easily and cheaply from the link boxes. This new technology means that it is now possible to deploy monitoring and control solutions in areas where it was not previously possible due to insufficient cellular coverage, insufficient battery technologies and an uneconomical cost.

3.21.1 | NIA SP Energy Networks0026 Project Progress

A device for monitoring the state of linkboxes has been developed with Vodafone. This measures the linkbox temperature at two points, the ambient temperature, water flooding level, and has an accelerometer for tamper detection. This device uses Vodafone's narrow-band IoT communications, and links to their Remote Monitoring and Control Services Platform to display this data. We are currently in the process of rolling 100 of these devices out across our Merseyside District for testing.

The sensor and communications device on a link box lid

3.22 | NIA SP Energy Networks0028 Transition to low voltage DC distribution networks – Phase 1

It is well documented that a shift towards a low carbon society will have a huge impact on the way electricity is generated and consumed across the distribution network. Particularly the uptake of Low Carbon Technologies (LCTs) such as electric vehicles (EVs), photovoltaics and heat pumps is reducing the capacity within the LV networks and creating the requirement for costly and time consuming network reinforcement.

These aforementioned LCTs for the most part consume and generate DC power, whilst being connected to the AC distribution network, which in turn created the need for converters between DC and AC devices, thus increasing network demand, customer losses and equipment costs. The proposal to resolve this issue is a conversion of the current AC distribution network, to a DC network to release additional capacity with the infrastructure currently in place.

In theory, an LVDC distribution network could support longer LV feeders and reduce the number of secondary substations required to supply an area. This is due to improvements in transfer capacity caused by improved circuit voltage drop and increased cable thermal capacity. However, there exists a number of technical and commercial challenges which need to be addressed prior to LVDC being implemented by UK DNOs as a business as usual approach to combat the challenges of LCTs.

In the first instance, a detailed review of the LVDC network requirements from a UK DNO standpoint will be undertaken and thus will determine the optimal scope for the second phase of this project.

3.22.1 | NIA SP Energy Networks0028 Project Progress

A summary of project progress to date is as follows:

- The University of Strathclyde and WSP have been commissioned for delivery of different aspects of the project
- The University of Strathclyde has conducted a literature review on international experience in applications of utility scale LV DC networks. The initial report of this literature review is now under review by WSP and SP Energy Networks
- WSP has progressed steady state studies demonstrating the additional power transfer capacity over distance that can be achieved by converting the exiting AC cables for DC operation. Automated script within DigSILENT have been developed to evaluate the network capacity uplift for different cable specifications
- The Power Network Demonstration Centre (PNDC) is also working with the University of Strathclyde to prepare the technical specifications for testing the capability of AC cables under DC operation
- The project's aims and objectives have been disseminated internally to relevant experts within SP Energy Networks. The specifications of the existing AC cables and those being procured for future installation were collected for considerations in the desktop studies

3.23 | NIA SP Energy Networks0029 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 address these. 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 SP Energy Networks, UKPN and WPD) has concluded that a single technology solution (which can cost effectively satisfy all of the technical and commercial criteria) is unlikely to be suitable. It is likely that a hybrid approach to the solution will be most cost effective and will 'future proof' the solution to the greatest extent possible. Similarly, arguments around the pros and cons of self-build vs third party solutions are not straightforward and the optimum is probably an intelligent combination of both.

3.23.1 | NIA SP Energy Networks0029 Project Progress

The initial project kick-off meeting has taken place.

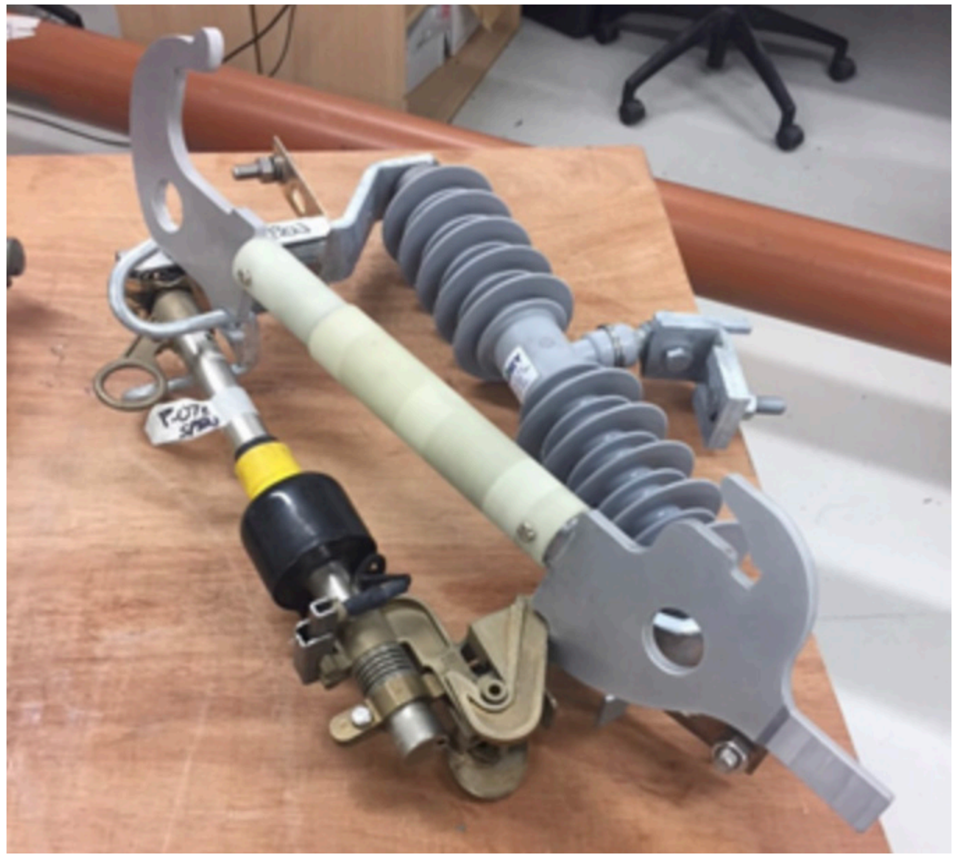
3.24 | NIA SP Energy Networks0030 Zebedee Sectionaliser Device

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.

3.24.1 | NIA SP Energy Networks0030 Project Progress

The Zebedee device is being developed by Reece Innovation. A prototype has been developed and will be tested both at the PNDC and on our electrical network prior to further development work being carried out.



The Prototype Zebedee device

3.25 | NIA SP Energy Networks180 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.

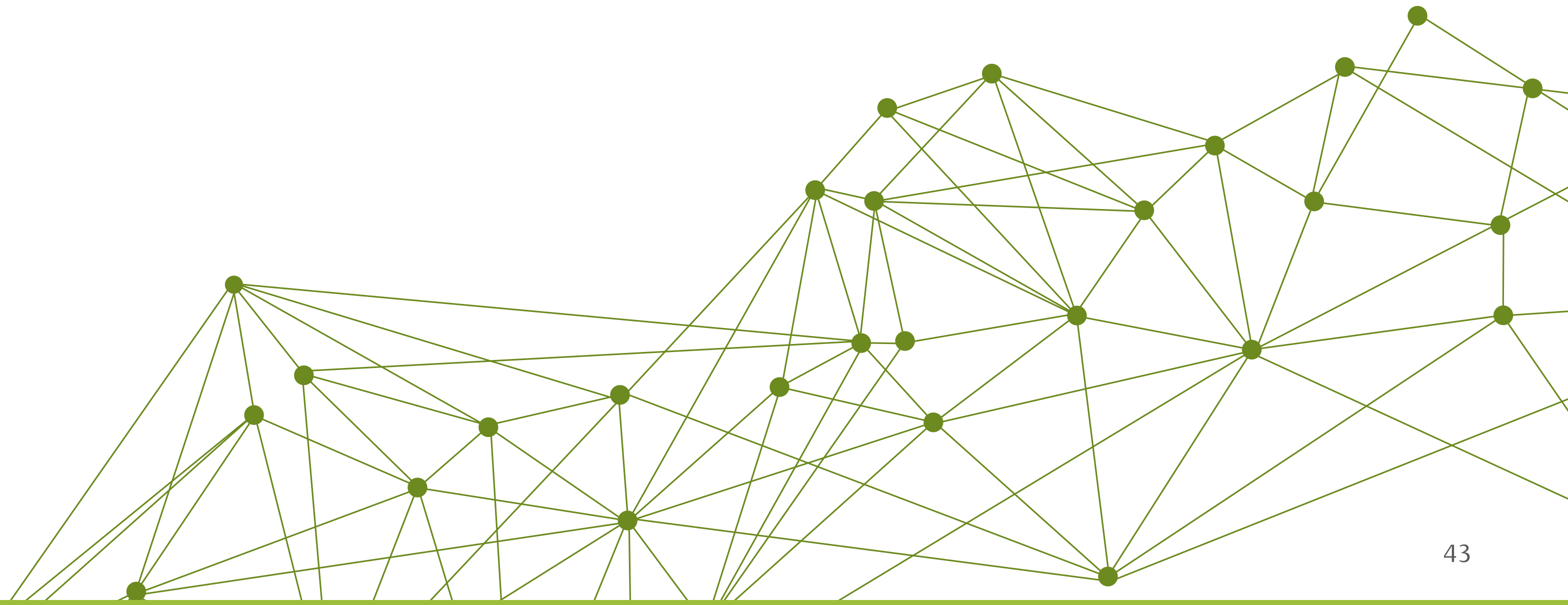
DLT based smart contracts include rules for information exchange, contract formation and value transfer among multiple entities, based on a shared ledger which is easily validated. They could reduce the cost of establishing mutual trust between multiple DER owners and network operators who have agreed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

This 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 a software simulation environment, engaging with stakeholders in the supporting networks to raise the common level of understanding.

3.25.1 | NIA SP Energy Networks0030 Project Progress

This project is only at the contractual stage so there is no project progress to repeat as yet.



4 | Collaborative NIA Projects Led By Other Network Operators

During the reporting period SP Energy Networks has collaborated on the following NIA project that has been registered by another party:

Project No.	Project Name	Project Lead
NIA WPD 0008	Improvement Statistical Ratings for OHL	Western Power Distribution

The following section provides a short overview of each active NIA D project on which SP Energy Networks is collaborating.

4.1 | NIA WPD 0008 Improvement Statistical Ratings for OHL

Distribution overhead line ratings are based on CEGB research work and further assumptions described in ENA ACE104 and ENA ER P27 published nearly 30 years ago. Recent work testing these assumptions have found some of them to be erroneous, with the result that existing distribution line ratings are now considered out of date. This means that load-related decisions to replace or reinforce lines are currently based on inaccurate ratings. DNOs, therefore, need a cost-effective, up-to-date and robust methodology for calculating and optimizing overhead line ratings.

A previous DNO collaborative project under the Innovation Funding Incentive established an overhead line test rig to monitor weather conditions and temperatures of different conductors at various current levels. Under this current project, the test rig will be operated continuously for 24 months, recording conductor temperatures and weather conditions. The data will be analysed and appropriate revisions of ENA ACE 104/ENA ER P27 will be made and a more sophisticated overhead line assessment software tool will be developed.

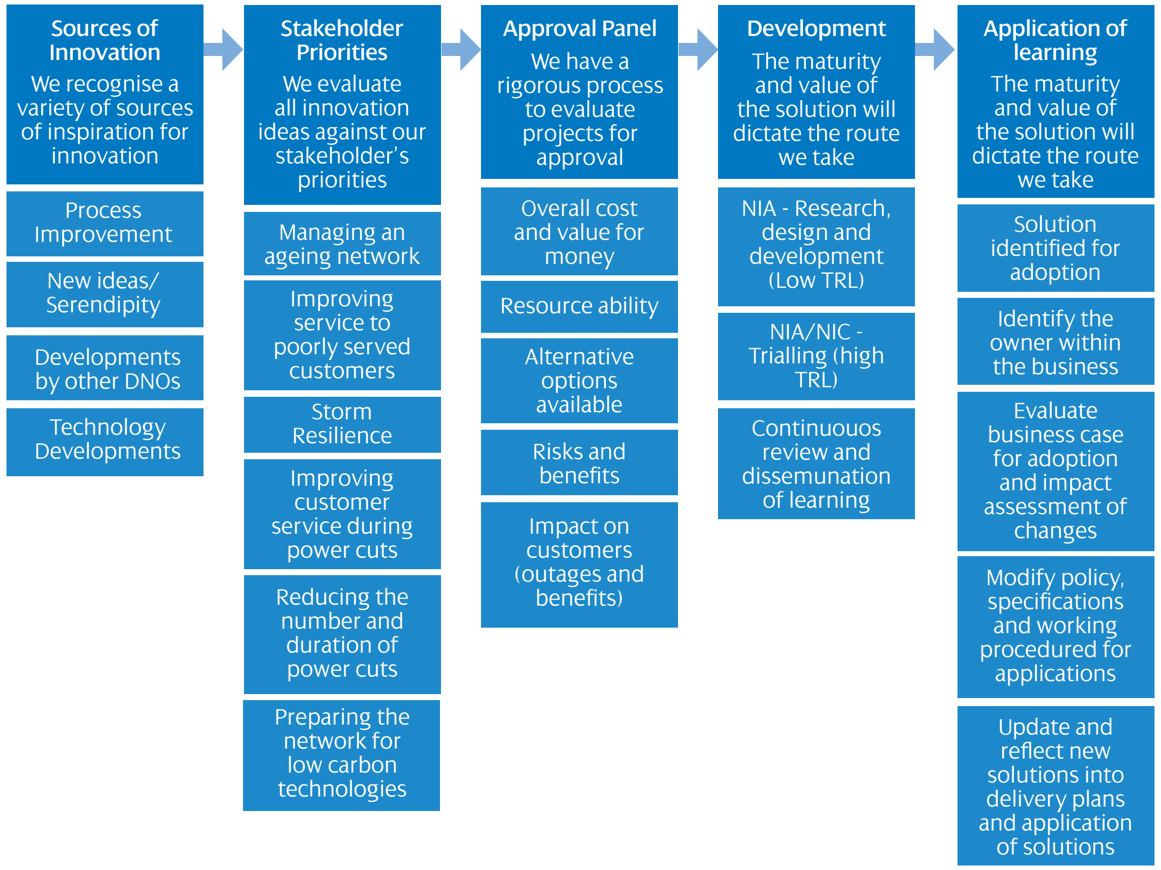
4.1.1 | NIA WPD 0008 Project Progress

This is a collaborative project involving all UK DNOs, with WPD acting as the main DNO Project Lead. This joint project was registered by WPD as the lead DNO and so more details on project progress will be reported in the WPD Annual Report.

5 | NIA Activities Linked to SP Energy Networks Innovation Strategy

5.1 | From Inspiration to Solution

Our approach to innovation development (From Inspiration to Solution) is summarised in Figure 5 below which contains five steps:



The five key steps of our innovation process are:

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.

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 6 under Stakeholder Priorities. Operating our network safely, providing value for money and delivering excellent customer service are all implicit requirements in what we do.

Approval: Our R&D Approvals Panel 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.

Development and Delivery: A project manager and project team identified for each project to deliver the day-to-day project activities. Business champions are nominated to facilitate the integration of proposed, existing and completed project into BaU. Projects are monitored through their lifecycle 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.

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.

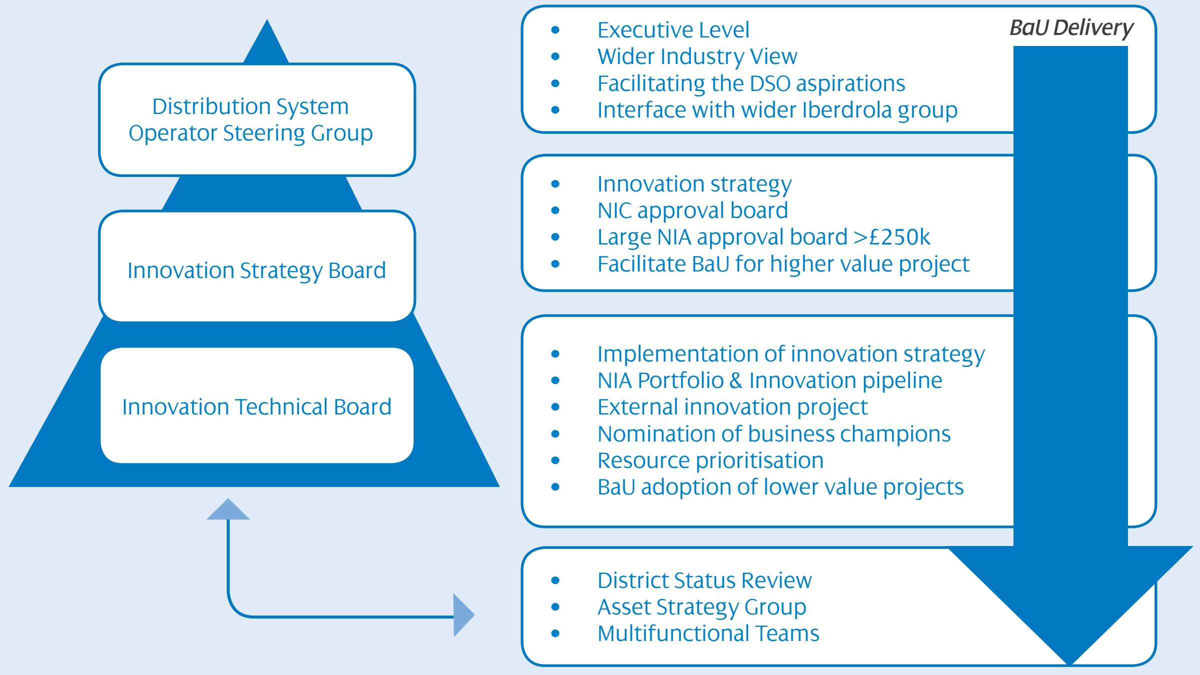


Figure 6 Innovation Governance Structure

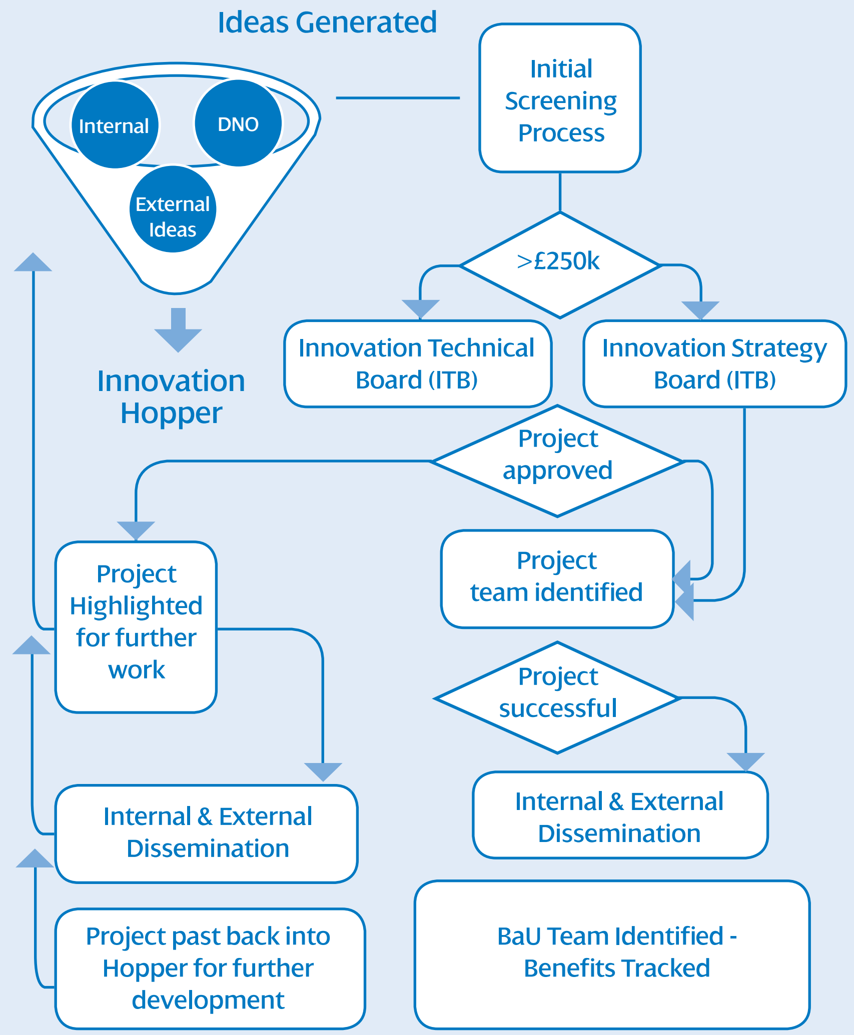
Our innovation governance structure and project approvals process Figures 5 and 6 respectively, helps to ensure the following:

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



5.2 | SP Energy Networks NIA Project Mapping with Innovation Strategy

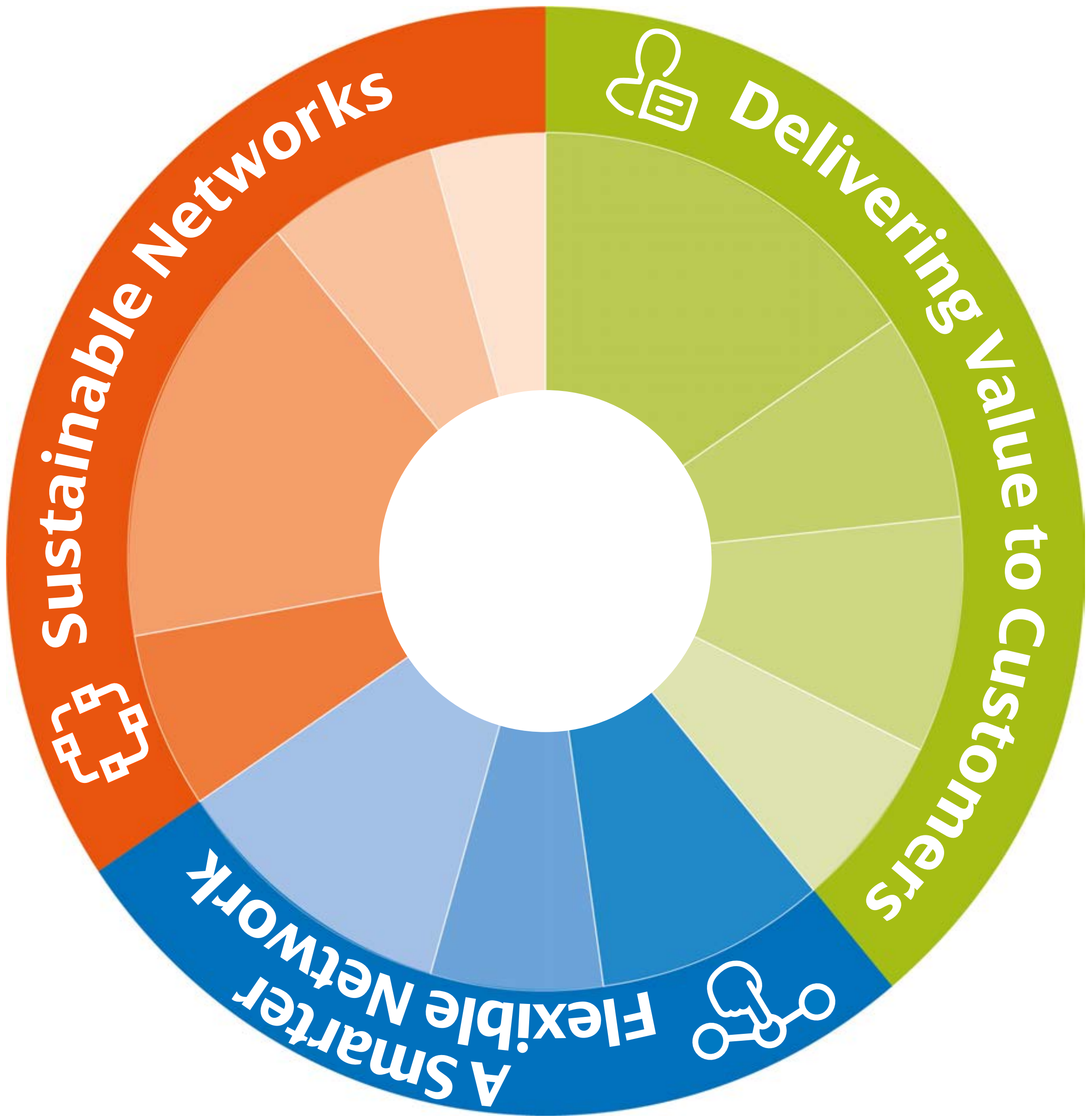
We are acutely aware that the funding we access through the various innovation mechanisms is sourced from our customers. In developing our Electricity Distribution Network Innovation Strategy 2018 we have not only ensured that our innovation activity is focused on areas which customers most value, but 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:

- **Delivering Value to Customers**
  - Managing an Ageing Networks
  - 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

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



40% - Delivering Value to Customers
- 16% - Managing an Ageing Network
- 8% - Maximising the benefit of data
- 9% - Network Control & Management
- 7% - Reducing the number and length of power cuts

27% - A Smarter Flexible Network
- 9% - Managing an Ageing Network
- 7% - Network, Flexibility and Communications
- 11% - Preparing the network for Low Carbon Technologies (LCT)

35% - Delivering Value to Customers
- 7% - Minimising the Environmental Impact of Assets and Activities
- 17% - Modernisation of Work Practices and Business Systems
- 7% - Our People - Skills and Resources
- 4% - Socially Responsible Member of the Local Communities We Serve

5.2 | SP Energy Networks NIA Project Mapping with Innovation Strategy

No.	Project	Delivering Value to Customers: Managing an Ageing Network	Delivering Value to Customers: Maximising the Benefit of Data	Delivering Value to Customers: Network Control & Management	Delivering Value to Customers: Reducing the Number and Length of Power Cuts	A Smarter Flexible Network: Faster, Easier, Accurate Connections	A Smarter Flexible Network: Network Flexibility and Communications	A Smarter Flexible Network: Preparing the network for Low Carbon Technologies (LCT)	Sustainable Networks: Minimising the Environmental Impact of Assets and Activities	Sustainable Networks: Modernisation of Work Practices and Business Systems	Sustainable Networks: Our People - Skills and Resources	Sustainable Networks: Socially Responsible Member of the Local Communities We Serve
01	NIA_SP Energy Networks 0002 Virtual World Asset Management	✓	✓		✓	✓			✓	✓	✓	✓
02	NIA_SP Energy Networks 0006 Mini-mole	✓				✓		✓	✓	✓		
03	NIA_SP Energy Networks 0007 SUSCABLE 2							✓	✓			
04	NIA_SP Energy Networks 0008 APPEAL	✓							✓			✓
05	NIA_SP Energy Networks 0009 DINO		✓									
06	NIA_SP Energy Networks 0010 EVOLUTION			✓			✓	✓				
07	NIA_SP Energy Networks_0012 SINE Post	✓	✓	✓	✓	✓		✓		✓		
08	NIA_SP Energy Networks_0013 Interoperable LV Automation	✓		✓	✓		✓					
09	NIA_SP Energy Networks_0014 Active Fault Level Management	✓				✓	✓	✓		✓		
10	NIA_SP Energy Networks_0015 Real Time Fault Level Monitoring	✓				✓	✓	✓		✓		
11	NIA_SP Energy Networks_0016 NCEWS		✓			✓		✓		✓		
12	NIA_SP Energy Networks_0017 Secondary Communication Ph			✓								
13	NIA_SP Energy Networks_0018 STATCOM			✓								
14	NIA_SP Energy Networks_0019 Operational Assessment of Wood Poles	✓							✓			✓
15	NIA_SP Energy Networks 0020 Instrument for the identification of Live and Not Live HV and LV cables									✓	✓	
16	NIA_SP Energy Networks 0021 Endbox G38 Level Detection	✓								✓		
17	NIA_SP Energy Networks 0022 Weather Normalised Demand Analytics (WANDA)					✓	✓	✓				
18	NIA_SP Energy Networks 0023 Connected Worker Phase 1 - Field Data Automated Capture		✓							✓	✓	
19	NIA_SP Energy Networks 0024 Endbox G38 Level Detection Phase 2	✓								✓		
20	NIA_SP Energy Networks 0025 Low Cost Fault Current Measurement of Wooden Poles	✓			✓					✓	✓	✓
21	NIA_SP Energy Networks 0026 Linkbox Monitoring using Narrow Band IoT	✓	✓		✓					✓		
22	NIA_SP Energy Networks_0028 Transition to low voltage DC distribution networks – Phase 1	✓				✓	✓	✓	✓	✓	✓	
23	NIA_SP Energy Networks_0029 Secondary Telecommunications Phase 3 - Trial of Hybrid Telecoms			✓								
24	NIA_SP Energy Networks_0030 Zebedee Sectionaliser Device				✓							
25	NIA_SP Energy Networks_1801 Distributed Ledger Technology-enabled Distribution System Operation (Phase 1)		✓	✓						✓	✓	
26	NIA_WPD 0008 Improvement Statistical Ratings for OHL	✓		✓				✓		✓		

6 | Areas of Significant New Learning

The following identifies area of learning on a project by project basis:

6.1 | Project Learning: NIA SP Energy Networks 0002 Virtual World Asset Management

A number of key leaning points have been established through this project which will be used for future innovation projects and BaU solutions. These include;

- Large volumes of data can be difficult to manage and can result in an uneven workload. It is therefore important to ensure that processes are in place to ensure best use of data, minimising the requirement where possible of manual interventions
- The development of a vegetation growth rates algorithm is unlikely to be achieved without significant levels of annual flight data including the inclusion of additional data sets such as tree species, cutting history, soil type and location aspect
- Early in our analysis we identified the importance of being able to match the LiDAR and GIS data, in doing so we have highlighted the need for unique asset identifiers for each overhead line span
- The technology solutions can quickly outpace innovation projects therefore it is essential to ensure that a flexible approach can be taken to maximise the benefits of innovative trials for the benefit of UK consumers

As regards, BaU integration, the engagement with all relevant business functions during the project has enabled the project to be integrated into several working practices either as a solution or as a tool for assistance in areas such as;

- Vegetation management
- Defect clearance
- Low Ground Clearance programmes
- Desk top quotes
- Control centre fault management

Key areas of development have been highlighted which it is believed would enhance the solution for UK DNOs.

These include;

- Automatic chimney attachment identification for LV Services
- The detection of OHL jumpers
- Pole top equipment including, fuse carriers, transformers, switches
- Pole identification and danger plate notices
- Poles with third party equipment
- Pole top rot
- PLS CADD alternative

6.2 | Project Learning: NIA SP Energy Networks 0006 Mini Mole

The main learning so far is centred around the significant variance between German H&S legislation / requirements and those of the UK. In order to prepare the product for UK trials, a concerted effort has had to be made by all the project parties to identify and overcome the differences to ensure UK compliance. For example in Germany there is no requirement for the products emergency stop function to include a supervisor circuit that ensures it is fail safe, whereas in the UK this is a requirement, and as such has had to be built into the design.

As detailed in the progress section, there has also been significant new learning generated from the challenge of accommodating the solution without exceeding duty weight of standard production vehicles. As the training and live trials have not yet commenced we cannot report any learning from operating the technology at this stage.

6.3 | Project Learning: NIA SP Energy Networks 0007 SUSCABLE 2

The prospects look very good for achieving the original objectives, and more, as further electrical and dielectric assessment of the materials and their ease of processing have shown the materials to be suitable for wide ranging MV and HV applications. This includes HVDC applications, in addition to HVAC, as the materials as sourced have higher purity than existing polyethylenes used to make conventional crosslinked polyethylene (XLPE) cables.

The new blends also avoid the use of crosslinking peroxide chemicals that further contaminate the insulation system in XLPE and which also impose the need for degassing to remove volatiles – both are avoided completely with the new polymer blends and this also requires lower cable manufacturing investment and reduces manufacturing risks particularly for HVAC and DC cables in the future.

It is noted that the second objective of producing a MVAC cable core to support HVAC cable development is also being achieved and this same core would also be used for HVDC cable development. A parallel development of the two HV cable technologies is the next step based on the multi-component polymer blend technology that has been filed as a patent by the research partners.

6.4 | Project Learning: NIA SP Energy Networks 0008 APPEAL

This project has so far provided the following learning to the DNOs:

1. DNO managers have been given a clear understanding and knowledge of the number of pre-treatment preservative types that are presently available for the pre-treatment of OHL wood poles.

2. DNO managers have been given an insight into the present state of research concerning the development of alternative and more environmentally acceptable types of timber preservation/modification which may have implications for the continuing future use of wood poles for electricity networks.

3. DNOs are gaining useful knowledge regarding the organisation and specific in puts required for the conduct of cost-saving accelerated tests designed to provide predictive results for real field applications

6.5 | Project Learning: NIA SP Energy Networks 0009 Data Intelligence for Network Operations (DINO) Phase 1

This project has demonstrated benefits from:

- Integrated Network Modelling using a 'standard' data format like CIM. This will be a key requirement for cross business DSO level future data analytic and integration requirements
- Business use case value needs to be carefully evaluated through overall understanding of data analytical and data integration requirements. This is simplified by investment in enterprise level business IT data Integration fabric
- Case by case Complex Event Processing rules can be defined for individual business use cases within a suitable enterprise system
- Data quality management is key to maximising value for the individual business use case

6.6 | Project Learning: NIA SP Energy Networks 0010 EVOLUTION

EVOLUTION has been working as the right vehicle to collect information and synergy across the industry at the national level and liaised with Northern Power Grid, Bath University and Citizen Advices Bureau to ensure that innovation efforts and customer's investment would not be duplicated.

6.7 | Project Learning: NIA SP Energy Networks 0012 SINE Post

A major issue SP Energy Networks have has had to overcome in developing the architecture for SINE Post is aligning it with pre-existing hardware that does not support the desired protocols / security requirements. As a result of this additional complexity has had to be built into the solution to support the inclusion of these devices. Through this activity SP Energy Networks has generated a clearer understanding of the requirements for all future field data devices we want to integrate into SINE Post or any of our corporate systems.

6.8 | Project Learning: NIA SP Energy Networks 0013 Interoperable LV Automation

The project has identified the viable operating range of the LV automation solution and the range of functionality it can adopt. This new learning will be fundamental to the assessment as to whether the project continues to Stage 2.

6.9 | Project Learning: NIA SP Energy Networks 0014 Active Fault Level Management (AFLM)

Phase 1 of the project has delivered an understanding of the tools, methods and solutions that are readily available to address high fault levels on distribution networks. A headroom analysis has been performed on various case study networks. This analysis has identified areas that are suitable for trialling management as a mitigation solution to address high fault levels.

Phase 1 has recommended a number of alternative solutions which can be applied to manage or mitigate fault level. These have been assessed both qualitatively and quantitatively through cost benefit analysis. One of the key conclusions is that an Active Network Management solution could be used alongside other mitigation solutions (such as network reconfiguration, control of demand and generation, and disabling of auto reclose functionalities) to solve fault level issues in real time.

6.10 | Project Learning: NIA SP Energy Networks 0015 Real Time Fault Level Monitoring (RTFLM) – Stage 1

- The RTFLM has proven to be capable of producing stable and consistent results that corroborate with fault level studies
- The RTFLM has proven to work at LV and 11kV using the proposed 'synthetic disturbances'
- The transportation and manual handling approach for substation work has influenced the final construction of the prototype RTFLMs

6.11 | Project Learning: NIA SP Energy Networks 0016 Network Constraint Early Warning Systems (NCEWS)

The project has helped clarify the functionality required and potential benefits from Data Analytics for future LV network constraint management:

Module 1

- LV GIS asset data transformation into Data Analytical node and edge model data
- Nodal data attachment – Derivation of 'SAVED' nodes for investigation into Summarizing, Aggregating, Visualizing, Enquiring and Deriving individual property SM 'sensor' data
- Data analytical representation of network connectivity and overall complexity
- Existing business connectivity improvement requirements
- API integration with existing enterprise systems like GIS for live model updating
- Data gathering and export capability into further business visualisation and analysis tools - Including web-based GIS visualisation platform and DigSilent

Module 2

- Network complexity analysis – Network complexity levels derived from understanding of number of linking points (configurable network nodes) and breech joints (non-configurable network nodes)
- GIS asset data improvement - Data science analysis of customer distributed location (distance from source to every customer) and existing business connectivity. To backfill missing data for global impedance (XSA & Material) and rating (impedance and cable type) map
- Introduction of Data Science research into the DNO

6.12 | Project Learning: NIA SP Energy Networks 0017 Secondary Communications Phase 2 – Consultancy Engagement

This learning from this project has informed the required scope for Phase 3. Different options, both presently available and future looking, have been considered:

• Private network:

- VHF/UHF P2MP-DR.
- Private LTE: e.g. based on 450-470 MHz Band (3GPP B31).

• Public (commercial) networks: cellular 2G/3G/4G.

• Hybrid solution based on public and private network

Technologies should be considered complementary to one another; some of them can be more suitable than others in certain scenarios. In order to choose the best technology, analysis must be done in terms of:

- Global Automation service requirements: Critical and Less Critical Data.
- Throughput.
- Application Level Performance: Latency and Packet loss rate.
- Scalability needs.
- MNO's public cellular footprint information that should be confirmed with on-site survey (Directive antennas to be installed if necessary).

• Radio planning for deploying a radio based- private infrastructure: P2MP-DR and LTE:

- Identifying repeater site candidates (either owned or third-party's).
- Spectrum License management.

In order to go through the above mentioned analysis it is necessary to perform both laboratory and on-field tests:

• Laboratory tests in order to:

- Explore technology limits.
- Confirm network design criteria.
- Perform technical and economic analysis.

• On-field tests in order to:

- Check automation service performance.
- Expectations confirmation.

6.13 | Project Learning: NIA SP Energy Networks 0018 Technical Review of Non-Conventional Statcom Applications

A Statcom sizing study has been developed containing the following sections: -

1 Introduction
2 Voltage Supply Policy
3 Study Methodology
4 Simulation Results (N-0)
5 Contingency events (N-1) simulation results
6 Statcom sizing and placement

6.14 Project Learning: NIA SP Energy Networks 0019 Operational Assessment of Composite Poles

It has been identified that the composite poles can only be accessed via a mobile working platform and cannot be climbed using spikes or ladders. This impacts Stage 2 of the project (installation of poles (11kV and LV) on the SP Energy Networks Network) where we will have to restrict the trial locations to areas only accessible with a mobile working platform. There were two further conclusions and learning outcomes from the trial;

1. The existing stay terminations are not compatible with composite poles
2. The existing drilling practices are not compatible with composite poles.

The first point has been declared to the ENA Overhead Line Assessment Panel and they have agreed to commission a UK wide, ENA led, project to fully assess all the mechanical stresses and forces applied to overhead line structures and develop a construction specification for composite poles.

The second point has been assessed internally within SP Energy Networks and clear guidance will be issued in advance of any future installation of composite poles that states the drilling technique and equipment required. This second point is dependent on the conclusion of the ENA led project to fully understand the final agreed industry principles when constructing overhead lines on composite poles.

6.15 | Project Learning: NIA SP Energy Networks0020 Instrument for the identification of Live and Not Live HV and LV cables

Through this project, we have determined that the Voltage and Live/Not live state of a cable can be determined through analysis of the electrical field generated from the capacitance between the conductors and sheathing of a cable. This electric field will vary depending on number of cores in a cable, cable insulation and sheathing type, the voltage along the cable and the loading on the cable. As a result, knowing the type of cable being analysed, the other parameters can be determined – that is, the device will indicate whether the cable is Live, Not Live, or Live without Load (or Current Energised), and whether it is running at HV or LV.

One important lesson learned through the development of this device is that a large amount of data is required to ensure that the device can operate with a sufficient level of confidence; to train the algorithms, a large amount of data for all possible cable types is required. As such, it is important to ensure that there is sufficient time given to data gathering and testing to allow the device to provide an accurate response.

6.16 | Project Learning: NIA SP Energy Networks0021 Endbox G38 Level Detection

The main learning from this project has been that it is possible to detect the level of G38 compound in an endbox through the use of an ultrasound device. The use of a two-way transducer will allow a pulse to be sent through the endbox at one side, and the signal reflected from the other side can be detected and displayed. This graph will update in real time, so any changes in this signal can be identified. The change between Air and G38 compound has a large difference in signal attenuation. This level can then be marked and dated, and an assessment of whether this is safe or unsafe can be made.

6.17 | Project Learning: NIA SP Energy Networks0022 Weather Normalised Demand Analytics (WANDA)

The project demonstrated that the weather has a strong influence on electricity demand at a local level and that there is a large degree of local variability that cannot be quantified by a system level correcting. It investigated the historical trends in customer behaviour at individual substations by correcting the varying annual peak demand to account for the effect of variable weather conditions.

Key findings of the project are as follows:

- Weather is masking underlying demand trends
- There is a clear relationship between demand and multiple weather variables including effective temperature, global horizontal irradiance and the cooling power of the wind.
- The effect of weather conditions at local substations will be different due to a combination of customer sensitivity to weather and local climate effects.
- The variability of weather driven demand at a local level is significant.

Understanding demand at this level of granularity is a key enabler for DSO and microgrids. It provides tools to improve the targeting of investment, provides earlier warning of shifts in demand and provides a platform to run scenarios upon.

Future work will expand the presented analysis to entire SP Energy Networks's distribution network in order to determine long term trends, identify patterns and create forecasts.

6.18 | Project Learning: NIA SP Energy Networks0023 Connected Worker Phase 1 - Field Data Automated Capture

The project has just started and consequently there is not learning to report at this stage.

6.19 | Project Learning: NIA SP Energy Networks0024 Endbox G38 Level Detection Phase 2

To date, there are no significant new learnings from this project beyond that of the phase 1 project. It is expected that the main lessons from this project will relate to the integration of G38 testing into the company's business as usual, as well as the training requirements to ensure that staff can carry out the ultrasound testing effectively.

6.20 | Project Learning: NIA SP Energy Networks0025 Low Cost Fault Current Measurement of Wooden Poles

Project learning has developed at both network and device levels, and the interaction between them. At network level, there will always be a small residual leakage current flowing down the wooden pole even when the insulator is in good condition because the resistance between the HV line and ground is large but not infinite. This has been confirmed on a wooden pole in the local area using a multi-meter under dry conditions and the indicator is being designed with this in mind to ignore leakage currents below a given threshold (100uA) to avoid false positives. With regard to device level learning, factors that could potentially lead to false positives include robustness of the chemical system, the effects of UV and temperature. Initial theoretical chemistry work has been carried out on the reaction dynamics to ensure the size of the two electrodes are correctly scaled to each other given the relative abundance of chemical species reacting at each electrode and the addition of chemical modifiers has been investigated to improve stability over temperature although this work is not yet finished.

Lifetime testing will be commencing shortly on the 'looks-like, works-like' prototype to mitigate these risks and to provide further learning. In Stage 3, once the looks-like works-like device has been lab tested and its operation characterised (in Stage 2), we expect to move to real wooden test poles at a DNO test sites. This should generate further learning about the device's suitability for field use and determine if the current threshold before chemical reaction occurs (currently set at 100uA) is sufficiently high.

6.21 | Project Learning: NIA SP Energy Networks0026 Linkbox Monitoring using Narrow Band IoT

The Device which is to be used in this project will use Vodafone's narrow-band IoT communications network, which enables low-power communications, and can provide better communications for buried assets, or assets which may not typically be able to receive communications. Preliminary testing has shown that this communications method will be suitable for the linkbox monitoring, but this is to be tested in the widespread trial once it starts. This communication method could be applied to other sensors in linkboxes, and to other situations where long-life communications are required.

6.22 | Project Learning: NIA SP Energy Networks0028 Transition to low voltage DC distribution networks – Phase 1

The learning of the project is now under review and it will be disseminated in the next NIA annual report update.

6.23 | Project Learning: NIA SP Energy Networks0029 Secondary Telecommunications Phase 3 - Trial of Hybrid Telecoms

The project has just started and consequently there is not learning to report at this stage.

6.24 | Project Learning: NIA SP Energy Networks0030 Zebedee Sectionaliser Device

The Zebedee device will allow a sectionaliser to be temporarily bypassed in order to facilitate the smart fuse to be changed. These devices will be designed for very short-term use, and as such will not be used for more than a short period of time.

6.25 | Project Learning: NIA SP Energy Networks1801 Distributed Ledger Technology-enabled Distribution System Operation (Phase 1)

This project has just commenced as so there is no learning to report at this stage.

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