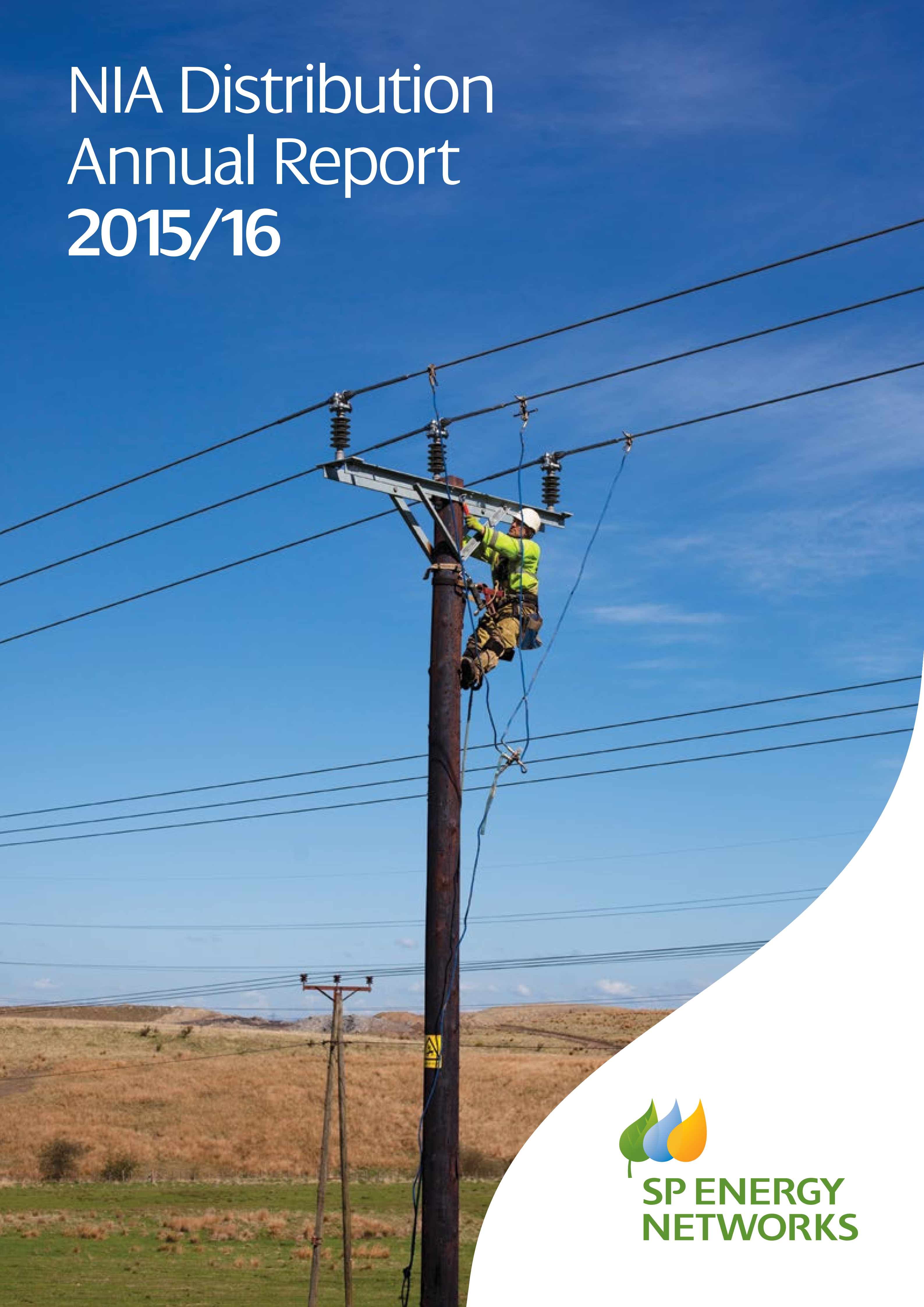
NIA Distribution Annual Report 2015/16



SP ENERGY NETWORKS

Our innovation focus remains firmly centered on our customers and stakeholders, who shape both our Innovation Strategy and innovation project portfolio that could help toward the successful delivery of our RIIO ED1 Business Plan for 2015 (1st April) through to 2023.

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Foreward

Innovation is at the core of SP Energy Networks. We have the ambition and capability to lead the industry by innovating in the best interests of our customers and wider stakeholder to reduce costs and facilitate the transition to a low carbon economy while continuing to improve customer service, security of supply and network performance.

SP Energy Networks (SPEN) is committed to delivering the Distribution Network of the future in our two license areas (SP Distribution plc. and SP Manweb plc.).

This is our first Network Innovation Allowance (NIA) Annual Distribution Report and is an overview of projects registered during the regulatory year 2015/2016.

We were delighted to have the opportunity to co-host, alongside the Energy Networks Association, the Low Carbon Networks & Innovation Conference in Liverpool in 2015, which was the UK's largest smart grid event in the year with over 1,200 delegates from 23 different countries. This major event presented an ideal forum to share learning from our innovation projects with other Distribution Network Operators (DNOs), suppliers and industry participants.

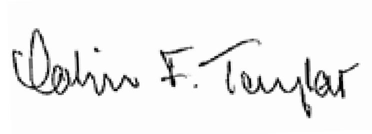
Following our success in the Network Innovation Competition (NIC) 2015, we are preparing a submission in 2016 (Inspire) which will demonstrate an innovative methodology for DNOs to manage their network information in a way that will be required to facilitate the future smartgrid. This will build upon the learning and output from the following SPEN projects:

1. *Flexnets (Flexible Networks LCNF Tier 2 project);*
2. *ARC (Accelerating Renewable Connections LCNF Tier 2 project);*
3. *DINO (NIA SPEN 0009 Data Intelligence for Network Operations project detailed in this report); and*
4. *EVOLUTION (NIC Bid 2015 and NIA SPEN 0010 project detailed in this report)*

In response to our unsuccessful NIC bid for project Evolution, which would have been a commercial project trialling one model of the role of the Distribution System Operator (DSO), we are seeking to develop this concept further through a NIA project which will consider a sustainable model for the provision of network balancing services; this model will seek to be inclusive of Distributed Energy Resources (DERs) providing them with a market to trade ancillary balancing services, in addition we expect this model to provide additional capacity for renewable generation.

The transition from a DNO into a DSO is one of our strategic business goals, as we believe it is the best way to facilitate the future energy requirements of our customers. In order to facilitate this transition we have engaged with key stakeholders to develop a single cohesive vision of what we believe a DSO is and the services that it could provide. We will also work with Government, Industry and UK network operators to develop a roadmap of how we will transition to this model.

Our innovation focus remains firmly centered on our customers and stakeholders, who shape both our Innovation Strategy and innovation project portfolio that could help toward the successful delivery of our RIIO ED1 Business Plan for 2015 (1st April) through to 2023.



Colin Taylor
Director of Engineering Services

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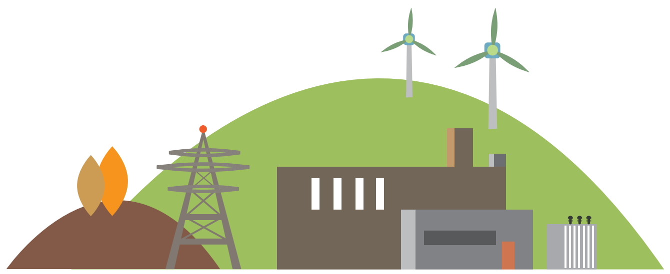


SP ENERGY NETWORKS

Executive Summary

We collaborate with other GB network companies to ensure that all customers benefit

Our first 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 first NIA D Annual Report presents an overview of the projects we have registered during the regulatory year 2015/2016.

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

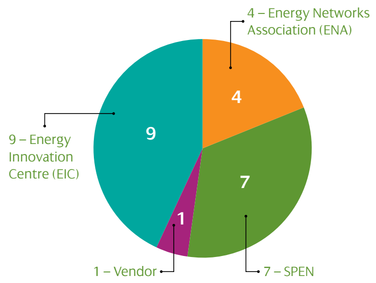
Key Facts

Key Facts at a Glance

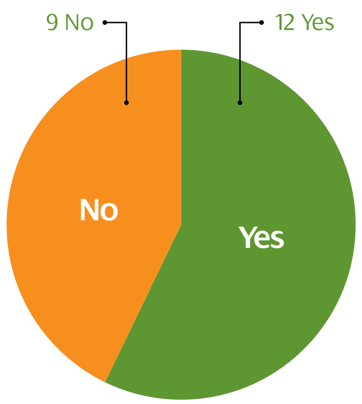
In total, this report details 21 NIA projects that we are involved in, with the objective of applying relevant learning to realise business benefits.

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

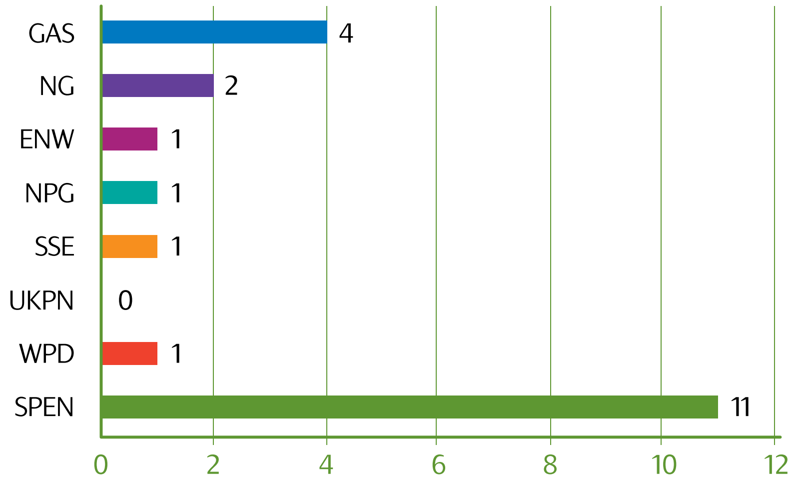
Project Origin



Collaboration



Lead DNO

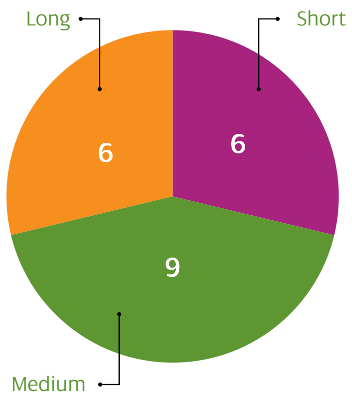


We seek to collaborate where possible in order to leverage our NIA funding.

SP ENERGY NETWORKS

1 Introduction

Estimated Timeframe to Adoption for Project Portfolio



Estimated Timeframe to adoption

Short: Deliver benefits within 12/24 months
Medium: Deliver Benefits 2–4 years
Long: 4 year +

We recognise the need to be innovative in order to get more out of our electricity distribution network and delivering value for money for customers. Consequently, we welcome the introduction of the Network Innovation Allowance (NIA) for Distribution.

Under the previous Innovation Funding Incentive (IFI) mechanism we had a large innovation portfolio (42 projects in 2014/15) which included a balanced mix of projects covering the short, medium and longer term. Going forward, 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 customer benefits.

With the start of the new eight year RIIO ED1 price control period there is an increased emphasis on innovation which is reflected in Ofgems performance based model for setting our price controls under:

RIIO:
Revenue = Incentives + Innovation + Outputs

SPEN is consequently committed to identify innovative performance improvements across all aspects of our business.

Since the start of Distribution Price Control Review 5 (DPCR5) there has been an established Research and Development (R&D) Panel headed up by SPEN's Future Networks Department that has held the responsibility of approving the delivery of projects under Ofgem's innovation stimulus incentives. In ED1 there is increased need to ensure that innovation is embedded into all business function, as such the role of our Innovation Board is to ensure increased participation from all business functions and to allow innovation projects to be completed and integrated into Business as Usual (BaU). Our Think Big, Start Small, Scale Fast approach to innovation enables us to be at the forefront of innovative practice and is embodied in our guiding values. At SPEN 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.

SPEN 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.

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

2 Progress Summary

During the reporting year 1st April 15 to 31st March 16 SPEN registered the following eleven NIA Distribution projects:

Project No.	Project Name	Project Start Date
NIA SPEN 0001	Smart Building Potential Within Heavily Utilised Networks	Apr–15
NIA SPEN 0002	Virtual World Asset Management	Apr–15
NIA SPEN 0003	Enhanced Real-Time Cable Temperature Monitoring	Apr–15
NIA SPEN 0004	Substation Earth Monitor	Apr–15
NIA SPEN 0005	Portable Radiometric Arc Fault Locator	Apr–15
NIA SPEN 0006	Mini Mole	Apr–15
NIA SPEN 0007	SUSCABLE 2	Jul–14
NIA SPEN 0008	APPEAL	Mar–16
NIA SPEN 0009	Data Intelligence for Network Operations (DINO) Phase 1	Sept–15
NIA SPEN 0010	EVOLUTION	Dec–15
NIA SPEN 0011	LV Elbow Joints	Mar–16

NIA Distribution projects, led by other Distribution Network Operators, which SPEN is collaborating on, are tabled opposite.

Project No.	Project Name	Project Start Date
NIA SGN 0035	Beyond Visual Line of Site	Apr–15
NIA WPD 0008	Improvement Statistical Ratings for OHL	Ju–15
NIA NGN 142	Project CONCUR	Mar–16
NIA WWU 0025	Project Futurewave Phase 2	Apr–15
NIA NGGD 0072	Project Futurewave Phase 3	Feb–16
NIA NGET 0135	Reactive Power Exchange Application Capability Transfer (REACT)	Apr–15
NIA ENWL 0003	Review of Engineering Recommendation P2/6	Apr–15
NIA SSEPD 0006	Ultrapole	Apr–15
NIA NPG 0001	Vonaq Utility Pole Strength Measurement	Apr–15
NIA NGET 0154	Work Stream 7	Apr–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 **SPEN's website** (www.spenergynetworks.co.uk/pages/innovation.asp) and on the **ENA Learning Portal** (www.smarternetworks.org). Key learning associated with these projects is summarised in Section 6.

3 NIA Projects Led By SPEN

3.1 NIA SPEN 0001 Smart Building Potential within Heavily Utilised Networks

Networks within City centres are the most economically important to the country, the most heavily utilised and the most expensive to reinforce. To this extent these networks will be at the forefront of issues arising from the much anticipated low carbon technology loads and increased penetration of Distributed Generation. There is an expectation that network operators need to deliver the solutions to these problems not just through traditional means, but through the integration with existing building management systems to help create minimum-cost low carbon energy systems.

Glasgow is Scotland's largest City and is undergoing dramatic change towards sustainable regeneration driven by the City Council. With around 1.5 million square metres of office space in the city centre, managing the peak load demand of this space could have major cost benefits to a DNO through provision of ancillary services to the grid and the potential deferment of costly city centre grid infrastructure upgrades.

The UK and Europe are moving towards a common standard (EN15232) for energy performance classification in buildings — this standard considers both energy efficiency and dynamic load management (i.e. demand side response (DRS)). The challenge is to explore the benefits to DNOs, through the projected widespread adoption of the EN15232 standard within buildings, and understand how the DNO can proactively engage with public and private building stock in Cities, to leverage benefit for all of the City stakeholders.

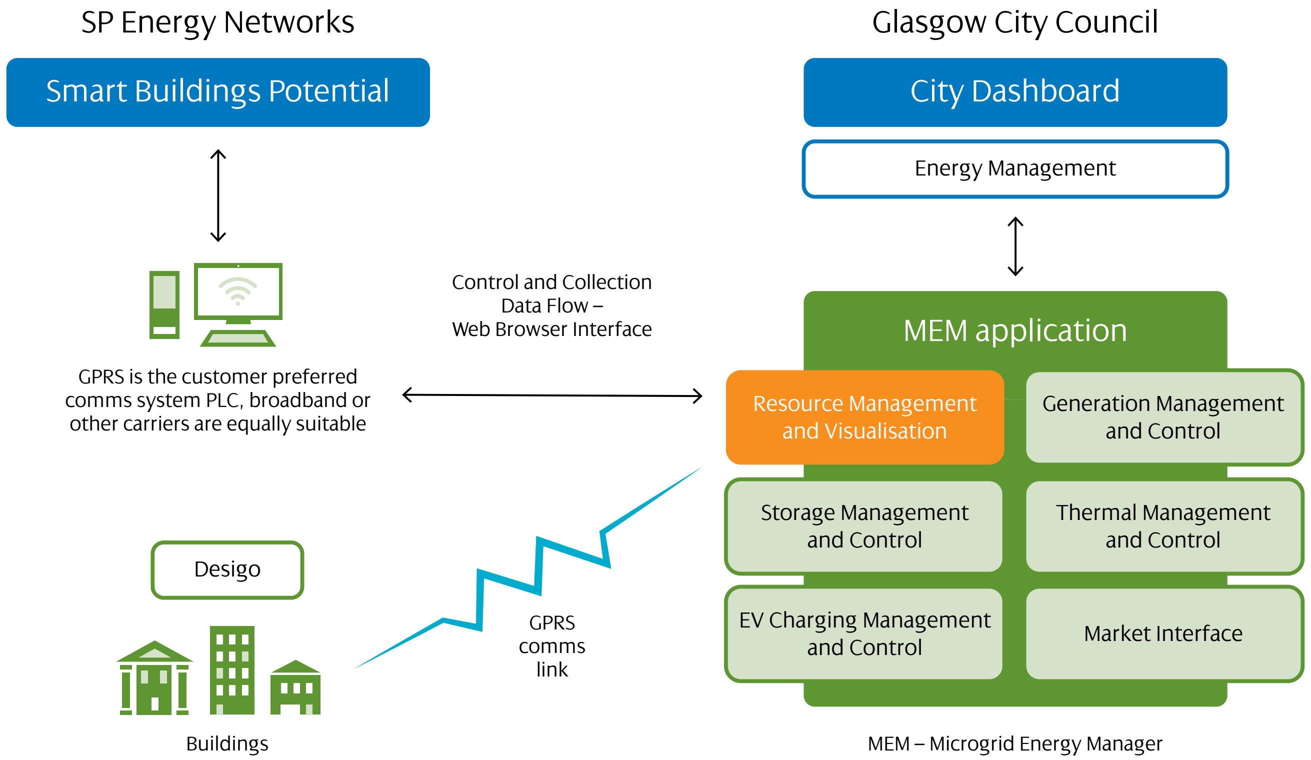
In order to understand the benefit that demand-side response could bring to a DNO, the scope of the project is to:

1a) Model the load on each secondary substation in postcode areas G1 and G2 and quantify the demand contribution made by each commercial building. (Commenced under LCNF Tier 1)

1b) Explore how the introduction of DSR in these buildings could potentially reduce loads during 'overload' periods.

2a) Survey candidate buildings for DSR trial suitability and install DSR equipment including communications in up to 10 buildings. (Complete under LCNF Tier 1)

2b) Carry out a number of trial DSR interventions at varying times of day over the course of a year and analyse results to evaluate capability of the buildings to provide DSR in real world conditions.



Key Outcomes

Key Outcomes will be:

1) Development of a City Centre network model where cost and impact of smart grid interventions can be assessed. Physical DSR interventions will complement the modelling;

2) Gaining experience in the application of DSR measures to City Centre building stock;

3) Achieving measurable results to peak load reduction;

4) Understanding and quantifying the role DSR could play in cost-benefit analysis of future reinforcement;

5) Understanding the resource DSR may represent in terms of ancillary services to the network;

6) Integrating the use and monitoring of DSR into our systems.

The net result for customers will be a potential increase in low carbon technologies that can be deployed on the network, without the need for future costly and potentially disruptive grid infrastructure reinforcements.

3.1.1 NIA SPEN 0001 Project Progress

Implementation of Demand-Side Measures

Demand side measures have been successfully implemented in 10 Glasgow City Council buildings, based on the outcome of EN15232 surveys. Tests have been ongoing throughout the year and it has been demonstrated that demand side measures can reduce overall demand over the period of a working day by over 20% on average.

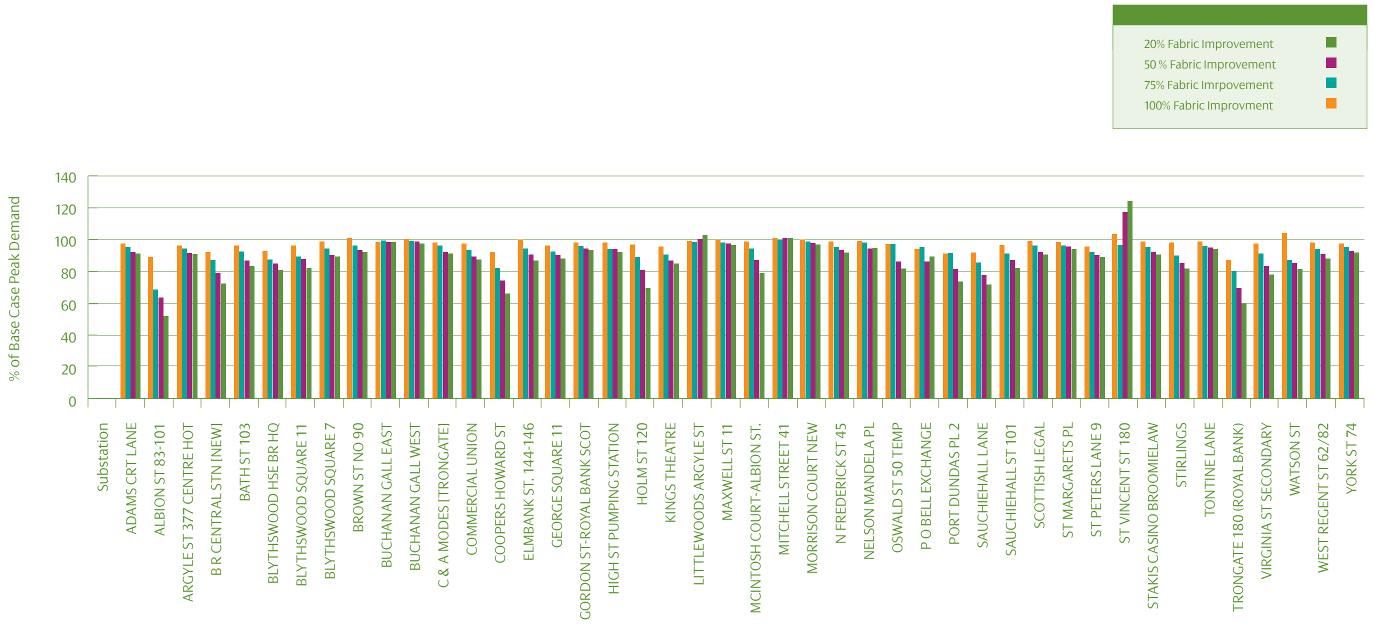
This is against a baseline of the same controllable loads running without demand-side reduction and it is the total reduction of controllable loads in the 10 buildings, not the total load.

The extent of the controllable load within buildings was found to be lower than originally anticipated and the cost of increasing the level of control within buildings and the benefit this could bring to both the building owner/operator and DNO is currently being assessed.

The use of 4G within a city Centre environment was shown to not be as effective as first thought and many suggestions have been provided as to how future deployments of demand-response could be improved.

Network Modelling

Using only building area and use information for the loads connected to city centre LV circuits, and building archetypes developed by Energy Systems Research Unit (ESRU) at the University of Strathclyde, good correlation has been found between the modelled load and that seen in Pi (SPEN's Plant Information system). Modelling several future load growth scenarios taken from SPEN Future Network predictions has shown that the load growth in buildings will have less impact on the network than that of other technologies likely to impact city centre networks – Electric Vehicles (EVs), Photo Voltacs (PV), Combined Heat and Power (CHP), etc. Therefore, the impact of demand-response uniquely in buildings may be lessened.



The model developed by ESRU can be used to model other SPEN networks to understand the likely future load growth. The model requires relatively few inputs to produce a good estimation of current load and likely future loads.

Merging of Modelling and Physical Demand-Side Interventions

The modelling work and physical trials have only recently been completed and the work to tie both work streams together to understand the cost-benefit of using demand-side measures as a smart-grid intervention to avoid potential network peaks is still ongoing.

3.2 NIA SPEN 0002 Virtual World Asset Management

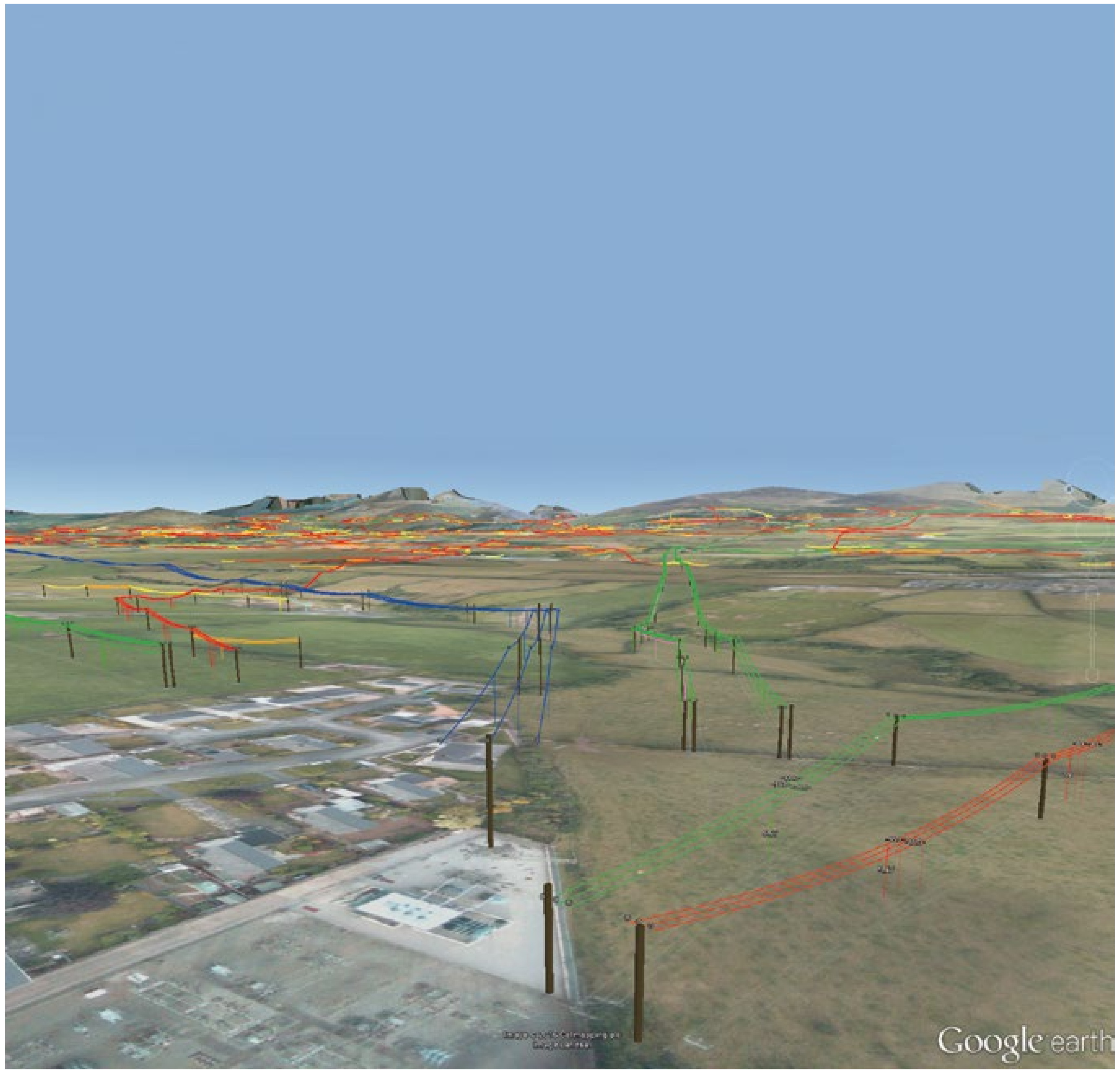
The Distribution Over Head Line (OHL) network is manually inspected on a cyclic basis as part of vegetation and Electricity Safety, Quality and Continuity (ESQCR) management policies. Over the years these manual inspections have served the UK Distribution Network Operators (DNOs) well, however inherent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

Manual Inspection Issues:

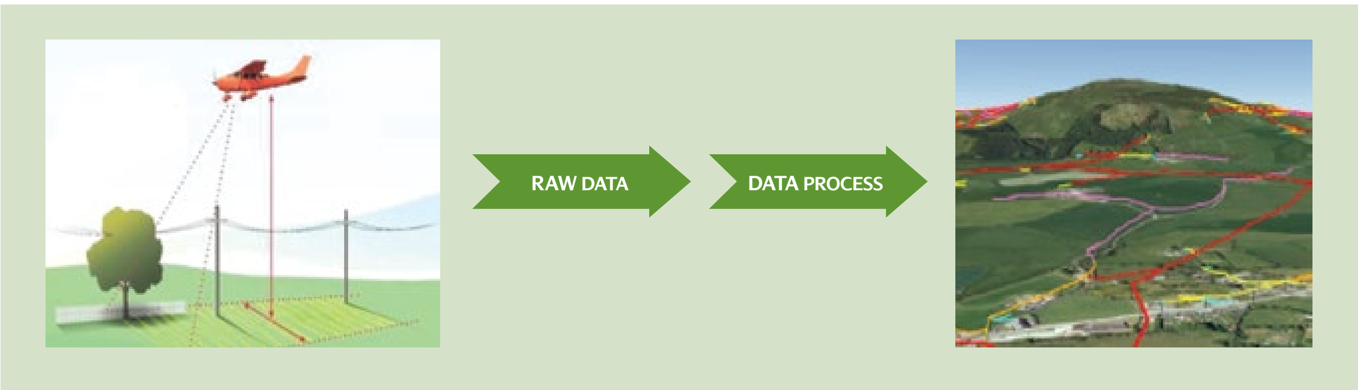
- It goes without saying that Manual Inspections are inherently labour intensive, requiring every km of OHL network to be inspected on foot. As a result they may not provide DNOs with the most financially beneficial and timely solution and the frequency at which they are undertaken is limited
- Whilst 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 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 Management (VWAM), 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. 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.



3.2.1 NIA SPEN 0002 Project Progress

Year one has seen the succesful completion of flights in both the SP Manweb (SPM) and SP Distribution (SPD) license areas. North Wales District in SPM and Dumfries District in SPD were flown between June and August 2015, with the full publication of data completed during September 2015.

Licence Area	District	Area (m²)	Total Distribution OHL (km)	% of Total Distribution OHL
SPM	North Wales	3,787	7,605	18.40%
SPD	Dumfries	6,544	5,605	13.56%
Total		10,330	13,210	31.96%

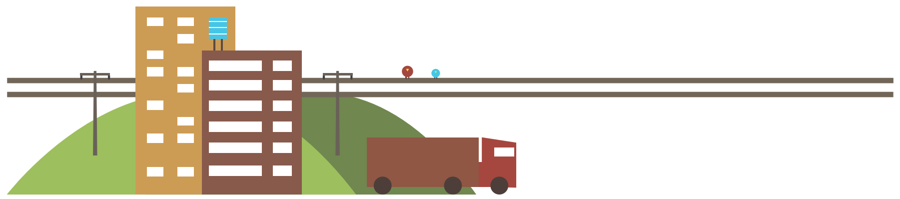
14th June Data Capture Commenced → 31st August Data Capture Complete Data → Full Virtual Model Published of Trial Areas 20th September

Key Outputs From Year 1:

1. Population of an acurate and comprehensive model of the distribution overhead line network; capturing in excess of 95% of all distribution voltages.
2. VWAM proved reliable at detecting and reporting vegetation intrusions and was able via the analytic spreadsheets, to provide in-depth information for each span. The system provided accurate vegetation and structural intrusion data which could either be viewed on the analytic spreadsheets or 3D visualisations.
3. Evaluation of the accuracy of the product at identifying vegetation and structural intrusions, ground clearance and asset location
4. Detailed investigation into the benefits of the solution and how it could be incorprated into business as usual.

Project Changes for Year 2 flight programme base on learning generate to date

- SPENs original plan was to fly the same two geographical areas in both 2015 and 2016, the areas being the Dumfries and North Wales Operational Districts.
- SPEN now intend to undertake an alternative flight programme in 2016 that encompasses OHL network not previously flown and encompassing sections of network from several SPD and SPM Operational Districts.
- The 2016 flight plan has been selected to maximise the development of the VWAM solution in order to accelerate its suitability for UK DNOs to adopt it as BaU. Whilst the flight plan has also been selected to ensure it covers a similar length of OHL as the 2015 programme (13,000–15,000km).



The original intention was to fly the same areas in subsequent years to understand whether an accurate vegetation growth model could be developed. However, based on our findings to date on the project, in conjunction with the findings of the IFI funded ADAS Study (IFI 0625), we do not believe that a vegetation growth model can be achieved from LiDAR data alone, at least not with only two years of evidence.

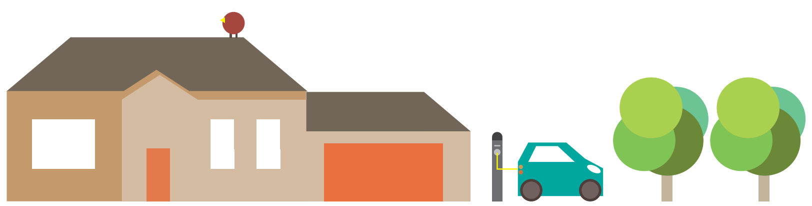
We now believe there will be greater benefit in calibrating the VWAM solution in order to make it ready for BaU adoption for UK DNOs. The VWAM model returned from 2015 is impressive, however a number of iterations were required over the last 12 months to get it to achieve the current level of accuracy. Even still it does have several issues that SPEN has identified and are keen to eliminate over the remainder of this project, such as missing LV Services and Mains, incorrectly identified H-Poles, incorrectly identified road crossings and data matching issues. We want to ensure that the developed solution is capable of providing an accurate model from one flight alone.

To this end we believe that flying a new area of network with a varied OHL infrastructure / geography provides us with the best way forward in 2016 to accelerate the solution for UK DNOs.

3.3 NIA SPEN0003 Enhanced Real-Time Cable Temperature Monitoring

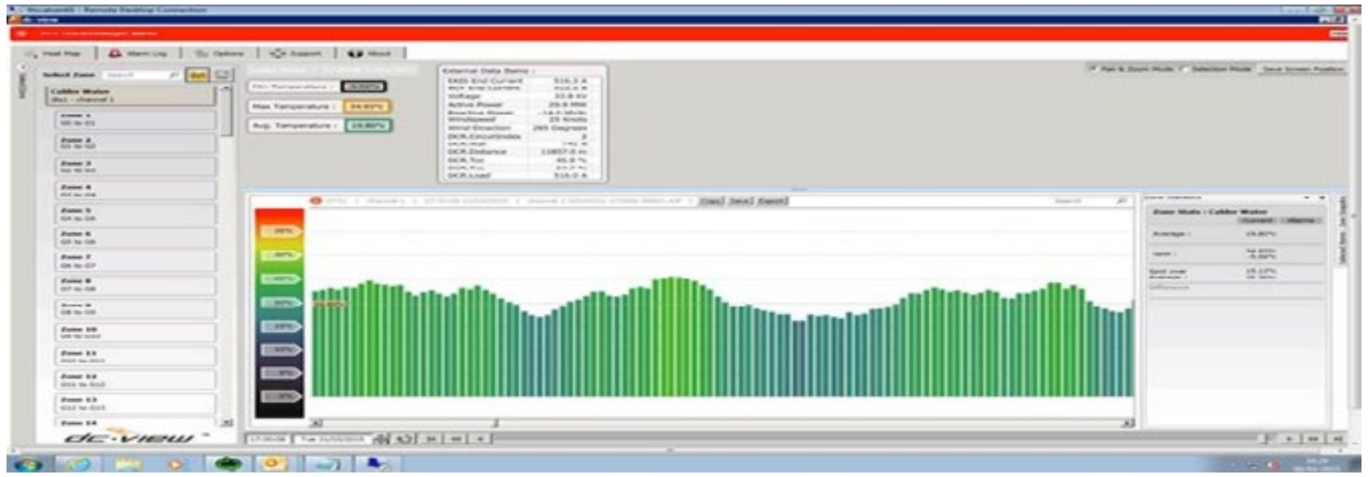
SPEN installed, under the Tier 1 LCN Funding mechanism, distributed temperature sensing (DTS) technology for monitoring the real time temperature of cable circuits connected to different windfarms. It is important to enhance the learning from this trial by carrying out additional analysis on the recorded temperature data when all of the four 33kV cable circuits are energised. This analysis can help to identify the thermal pinch points and their causes along the cable circuits. Learning from data analysis will also inform day to day cable laying activities and the process for estimating network headroom capacity. In order to boost the confidence in the implemented DTS system and dynamic cable rating (DCR) calculations, and fully capture the thermal behaviour of the cable circuits, the cable temperature data for at least a 12 month period covering different weather conditions and season affects, in conjunction with full generation conditions, should be considered.

The main benefit of deploying a real time cable temperature monitoring system can be achieved in an Active Network Management (ANM) application where the outputs of generators are controlled based on the available real time network capacity. Building upon previous learning points from SPEN's ANM trials, the requirements for integrating a DTS system into an ANM architecture will be considered.



The scope of this project will include:

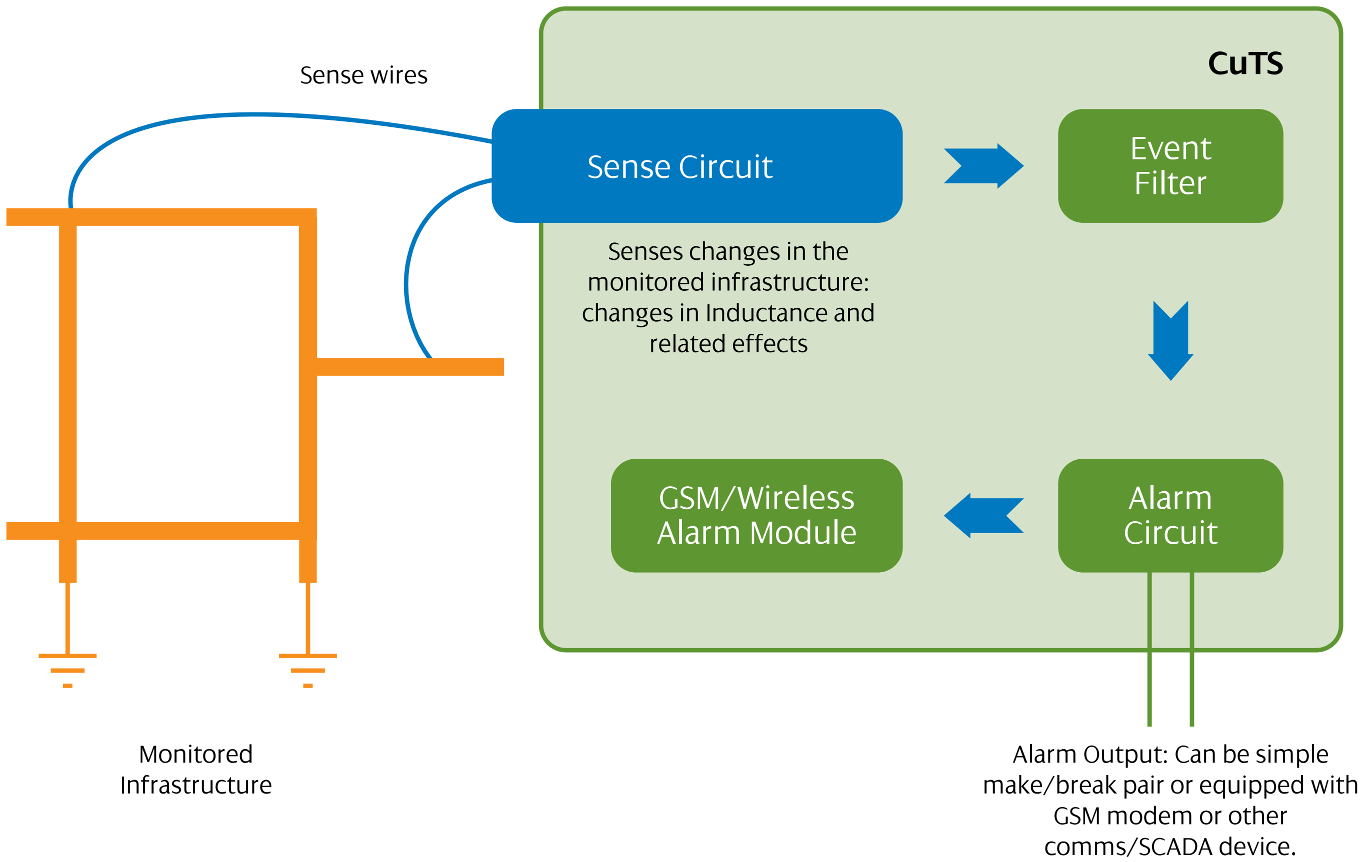
1. Enhancing the cable temperature monitoring system developed in previous SPEN's Tier 1 LCNF project by conducting additional diagnostic tests and validations.
2. Carrying out data analysis of historical cable temperature data for at least 12 month period to Identify temperature hotspots and causes of temperature bottlenecks.
3. Design the architecture of an ANM system informed by real-time cable temperatures.
4. Updating the relevant policy documents and provide recommendation for full business adoption of the DTS system.
5. Dissemination of the outcomes and learning points through workshops with other UK DNOs and conferences as appropriate.



3.3.1 NIA SPEN0003 Project Progress

The project started in April 2015 and is planned to be completed by November 2016. The project's progress has been in line with the project plan and following progress has been made until end of March 2016:

1. Following the commissioning of the remaining windfarm cable circuit, the associated temperature monitoring optical fibre was integrated into the DTS equipment.
2. As the new commissioned power cable circuit is tapered (the first half of the circuit is larger size cable than the second half of the circuit), two thermal models of the entire circuit were constructed and uploaded to the DCR calculation engine.
3. A data validation exercise was carried out in the entire cable temperature monitoring system to ensure all the servers communicate correctly.
4. An independent validation was carried out on the calculated cable temperature. For this exercise WSP | Parsons Brinckerhoff was commissioned to model the thermal behaviour of the cable circuits and compare it with the calculated cable temperature based on DTS measurements.
5. Various data analysis were carried out on the monitored and calculated data including cable temperature, fibre temperature, windfarm export power, and short term permissible loading of the cable.
6. A data analysis tool was also developed to provide various reports on historic DCR data and that can be used by different users within the SPEN business.
7. A generic DCR system specification was drafted based on the learning from the previous Tier 1 LCNF project. This will be used to support the transition into business as usual.
8. The results and outcomes of the project were disseminated at the Low Carbon Network Innovation conference in 2015. A technical paper has been also drafted to be submitted to one of the international conferences as part of our knowledge dissemination activities.
9. Initial discussions with Active Network Management (ANM) suppliers were undertaken to explore the requirements of a system architecture where ANM system operates based on a dynamic cable temperature which potentially could allow the windfarm to increase their output power using the existing network.
10. The results of data analysis showed that a cyclic cable sizing approach may be adopted for calculating the maximum permissible loading of the windfarm cable circuit. In order to explore this further, work has started with University of Southampton to investigate the possibility of adopting a cyclic rating approach for future windfarm cable circuit sizing.



3.4 NIA SPEN 0004 Substation Earth Monitor

The legislative changes to increase regulation of the scrap metal industry and eliminate cash payments for scrap metal have had some success in reducing the number of metal thefts. However, theft of copper earthing systems remains a serious safety risk for engineers, customers and metal thieves as well as an operational performance risk for electrical power networks. While marking technologies help identify cable theft when the thieves or receivers are caught, preventing theft in the first place remains a desirable target. On larger sites, security can be improved by technologies detecting trespass but there are many smaller sites where this approach is cost prohibitive. Such detection does not address the issue of what is happening on site upon such intrusion. The ideal solution is a low-cost method of detecting tampering with the earthing system itself.

SPEN has been working with the manufacturer Cresatech Ltd to further develop a novel method of reliably detecting the cutting and removal of sections of the earthing infrastructure. The CuTS® system monitors for changes in the inductance characteristics of the site earthing network. Sense wires are connected to the earthing system, as shown below. Once connected the unit is simply tuned, either automatically or manually, locally or remotely via the operational software. Normal site variations and events such as faults are filtered out by the on-board filtering logic module, ensuring such occurrences do not trigger false alarms.

3.4.1 NIA SPEN 0004 Project Progress

During the past year Stage 1 was successfully completed with the installation of 25 monitors at substation locations in the Ayrshire and Merseyside Districts. The installed units were subjected to a range of testing scenarios which proved their effectiveness at detecting incidents of copper tampering. However, following a review of the installation cost and performance of the monitors, the decision was made to end the project early before completing stage 2 (integration of monitoring units into SPEN's corporate security system). It was subsequently considered that our stakeholders would not benefit from fully integrating the solution into Business as Usual and that limited further learning would be generated by continuing the project.

Over the past 12 months this project has successfully trialed and evaluated the CuTS substation earth monitor against the following success criteria;

- The successful and reliable detection of copper theft and tampering at key substation locations either through test simulations or actual events.
- Low incidences of mal-operation and spurious alarms.

The trial was unable to fully;

- Quantify the benefits associated with detecting when key earth infrastructure is removed or tampered with.

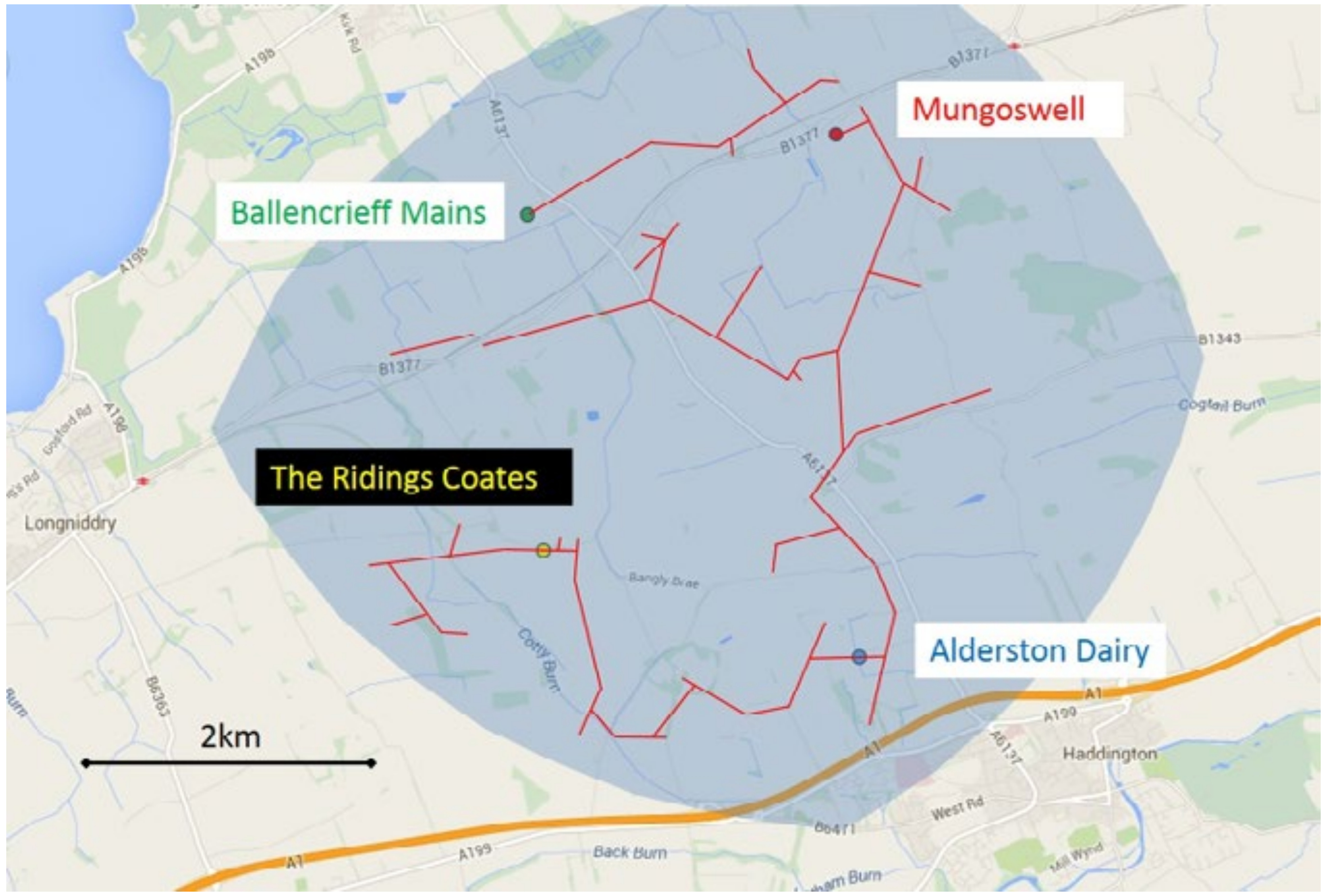
This project successfully supported an SME to bring a simple and effective solution to the market to provide automated remote monitoring of the integrity of earthing infrastructure. Cresatech has successfully gone on to market this product and service in several markets both in Europe and USA.

This project is now closed and a final closedown report will be made available.

3.5 NIA SPEN 0005 Portable Radiometric Arc Fault Locator

Elimpus has developed a trial radiometric arc fault locator (RAFL) system consisting of a network of 4 monitoring stations which can determine the presence of a fault through the reception of the short-duration radio-frequency (rf) energy impulse which is emitted when the arc occurs. The arrival of the rf fault signal is accurately timed by the use of GPS hardware and forwarded to a cloud server through 3G internet technology. The monitoring stations are geographically spaced around the area of interest containing the 11kV OHL circuit. The figure below shows the 4 RAFL monitoring stations which were applied to an 11kV OHL feeder circuit (shown in red) located to the east of Edinburgh. The coverage of the locator, for rf fault signals from the fault site, is shown in blue.

Fault arrival timing data from the system is processed by the cloud server to identify only signals that are received by 2 or more monitoring stations. This information is sent via 3G to a rugged tablet PC – for the use of field engineers – which can graphically display information on the position of the fault.



3.5.1 NIA SPEN 0005 Project Progress

The broad objective of the project was to develop a system to field trial the radiometric arc fault location principle. This objective has been achieved, although a decision was taken early in the project to permanently mount the monitoring stations on 11 kV wooden poles fitted with transformers, allowing the hardware to be powered by 230 Vac rather than using batteries. This decision was made to increase the chances of proving the RAFL principle by allowing a longer monitoring campaign on a feeder circuit that has previously had a higher than average rate of faults.

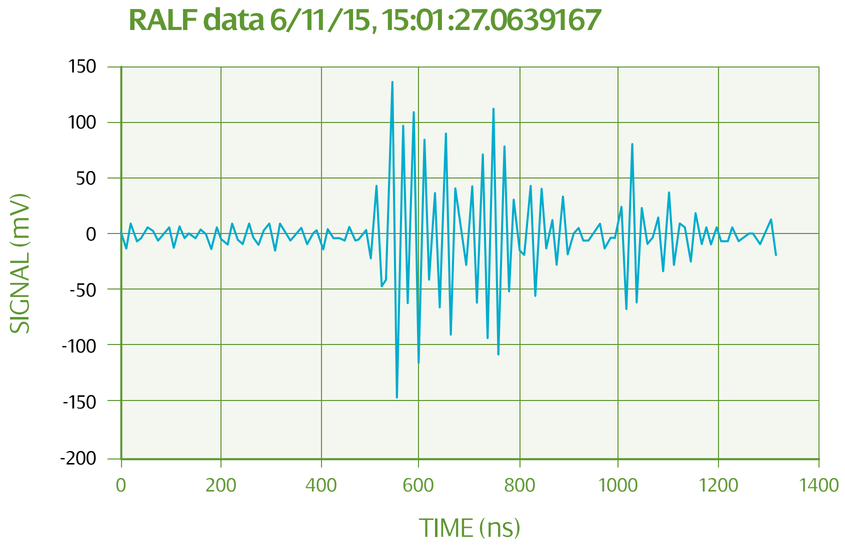
The 4 RAFL monitoring stations were installed in the period between November 2015 and February 2016. Since February 2016, the following observations were made:

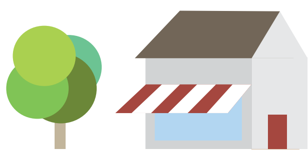
1. All the monitoring stations detected impulsive rf activity and timing data was regularly uploaded to the server.

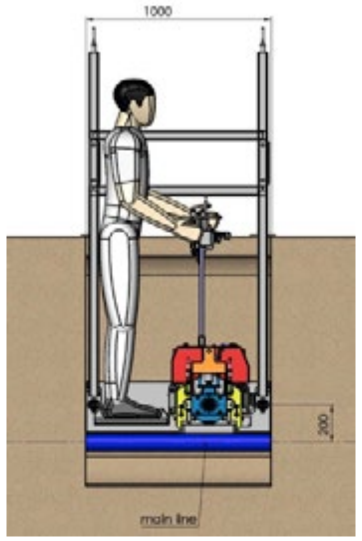
2. The target 11 kV feeder circuit experienced virtually no faults – this is an unexpected result given that the previous experience of this circuit suggested that the incident of faults was higher than average. There have, however, been faults on adjacent circuits.

3. The GPS timing hardware in all the monitoring stations experienced regular drop-outs which prevented fault data being recorded and subsequently located. An extensive series of tests conducted by Elimpus at the factory on similar hardware identified a faulty GPS connector as the likely cause. Replacement connectors will be fitted to the 4 monitoring stations during July 2016.

4. The trial monitoring period will include autumn/winter 2016 to allow the RAFL principle to be proved and further refined.





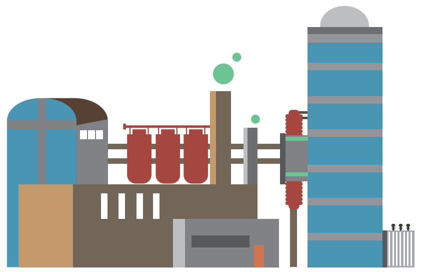


3.6 NIA SPEN 0006 Mini Mole

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.

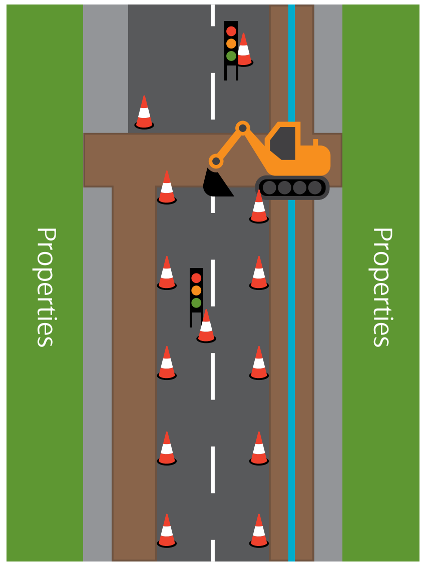
Although the merits of conventional open cut trenching are well known there is an intrinsic risk to home owners and members of the public. To develop an alternative solution to this problem SPEN has been working with R&D partner, Tracto-Technik (TT), to design an innovative trenchless technology system (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 opposite illustrate the open trench work required in order to connect service cables.

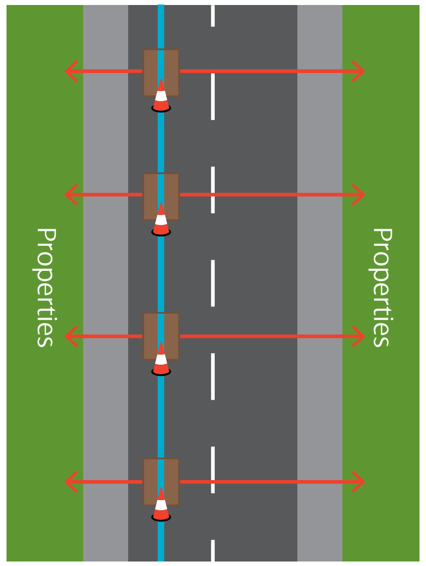


The Mini-Mole has been designed to fit a standard excavation required for jointing LV cables, removing the need to complete costly and time consuming road crossings. The Mini Mole method will greatly reduce the footprint of the work, reducing excavation and reinstatement costs, improving the working 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 Method



Mini Mole Method

The diagram (left) 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.

3.6.1 NIA SPEN 0006 Project Progress

The project team identified that the Mini Mole and all its component parts would offer the greatest operation flexibility if it could all be accommodated on a single vehicle.

The challenge of accommodating the product onto a compact and less than 10 ton vehicle has been met and an operational layout that meets UK health and safety legislation has been designed and agreed. This design has been passed to a vehicle coach builder who will shortly commence production of the design.

3.7 NIA SPEN 0007 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.

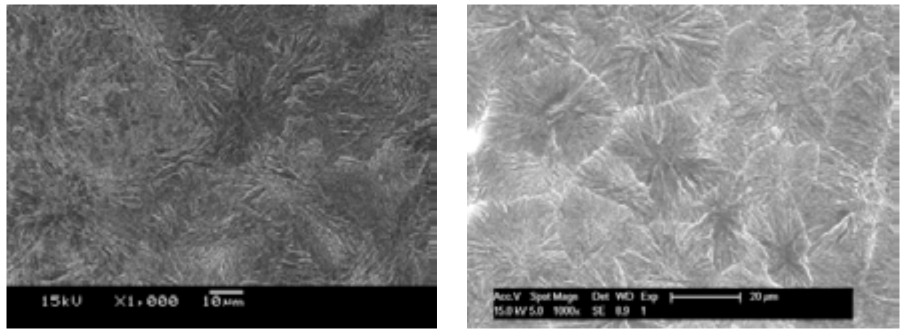
First generation PVC insulation restricted cable ratings to 60 – 70°C, subsequent cross linking (XLPE) to prevent the plastic melting offered a continuous rating at 90°C while the new thermo plastics under consideration offer the prospect of an operating range of 120°C to 150°C. This increased operating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

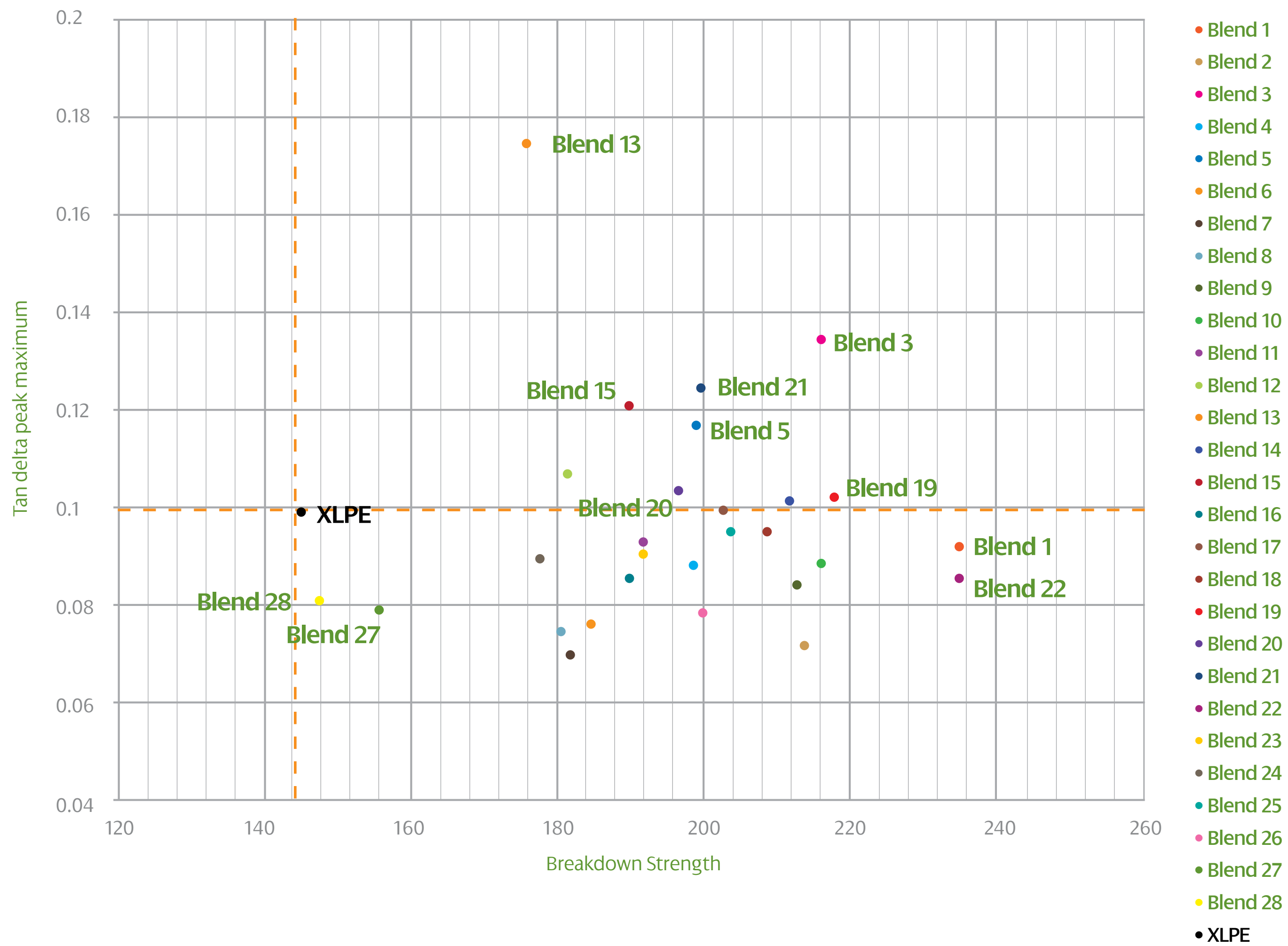
1. Morphology

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

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.

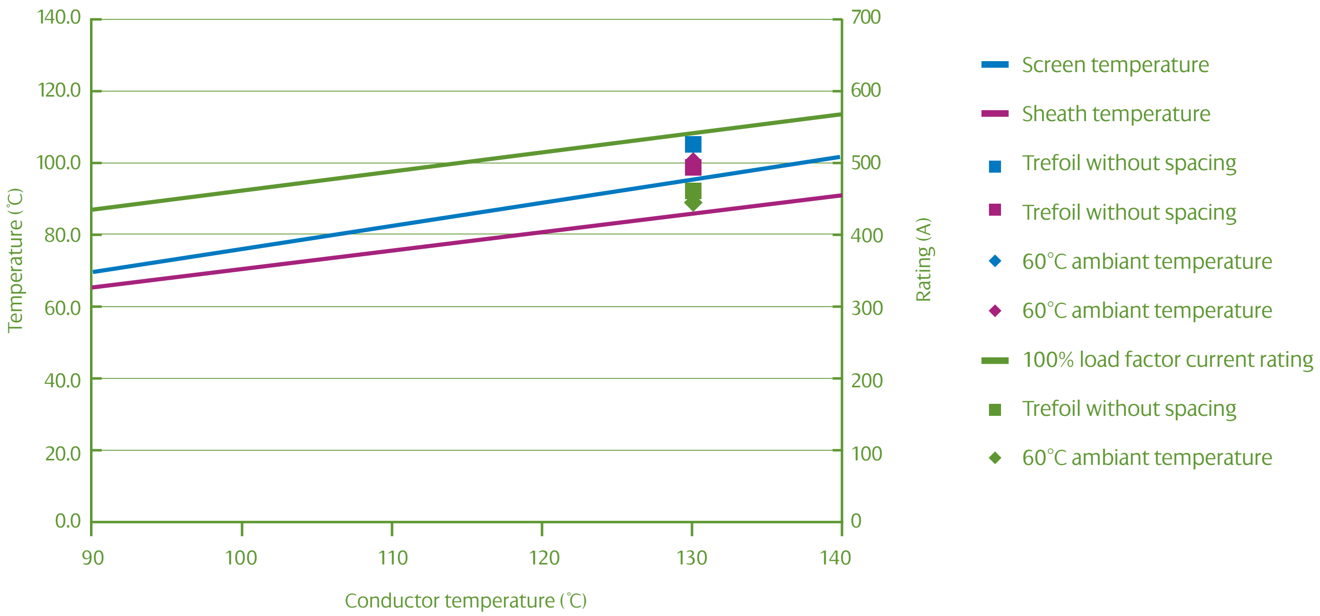


3. Processing

Figure 3 Processability of the blends is good. Rods are extruded on a laboratory scale extruder and pelletised.

4. Cable Ratings

Figure 4 Cable rating calculations for different conductor temperatures, for cables laid in free space. 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.



3.7.1 NIA SPEN 0007 Project Progress

The project began in June 2014 and has made significant advance in the 21 months to March 2016. The original bi-polymer polypropylene blends from SUSCABLE 1 have been superseded with new bi-polymer and tri-polymer blends which have been successfully sourced for multiple suppliers globally. The new blends performance electrically, mechanically and thermally have been mapped and best candidate bi-polymer and tri-polymer blends have been produced and scaled for process trials by the cable manufacturers in advance of cable extrusion trialling. The antioxidant package has been refined to meet thermal stability requirements for processing and operational ageing.

It was decided to use related blends for the manufacture of the new semiconducting screen materials and these have been successfully produced and the compounding up-scaled to meet cable production needs. The cable extrusion trials are expected to start in summer 2016. The MV cable designs have been finalised alongside completion of the cable rating studies. The latter showed the need to put in place higher operating temperature cable sheaths and materials have been selected to meet this requirement enabling further cable deployment opportunities and constraints to be examined. The cable extrusion and cooling process has been modelled and shown that the effective radial cooling rate can be controlled to optimise the performance of the insulation system. This modelling was extended to cover HVAC as well as MVAC cables and both are considered to be manufacturable. Review work has also been completed on the deployment options for both MV and HV cable designs but we expect to revisit this at a workshop to be held in October 2016 to further consider distribution, transmission and offshore network applications. Delays in obtaining the materials from suppliers created some knock-on delays to later tasks but the project plan was reset to accommodate this and good progress is being achieved across the whole project. The cooperation and commitment of the cable companies who are co-funding the project remains high.

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

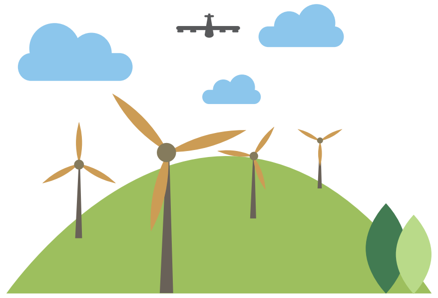
Project APPEAL was registered in March 2016; it is a collaborative project between SPEN, ENW, NPG and SSE and managed by the Energy Innovation Centre (EIC). It is a 2.5 year project looking to assess the performance of environmentally friendly alternatives to creosote for wood pole preservation. It is expected that the outcome of this project will influence UK DNO policies for the replacement of wooden poles.

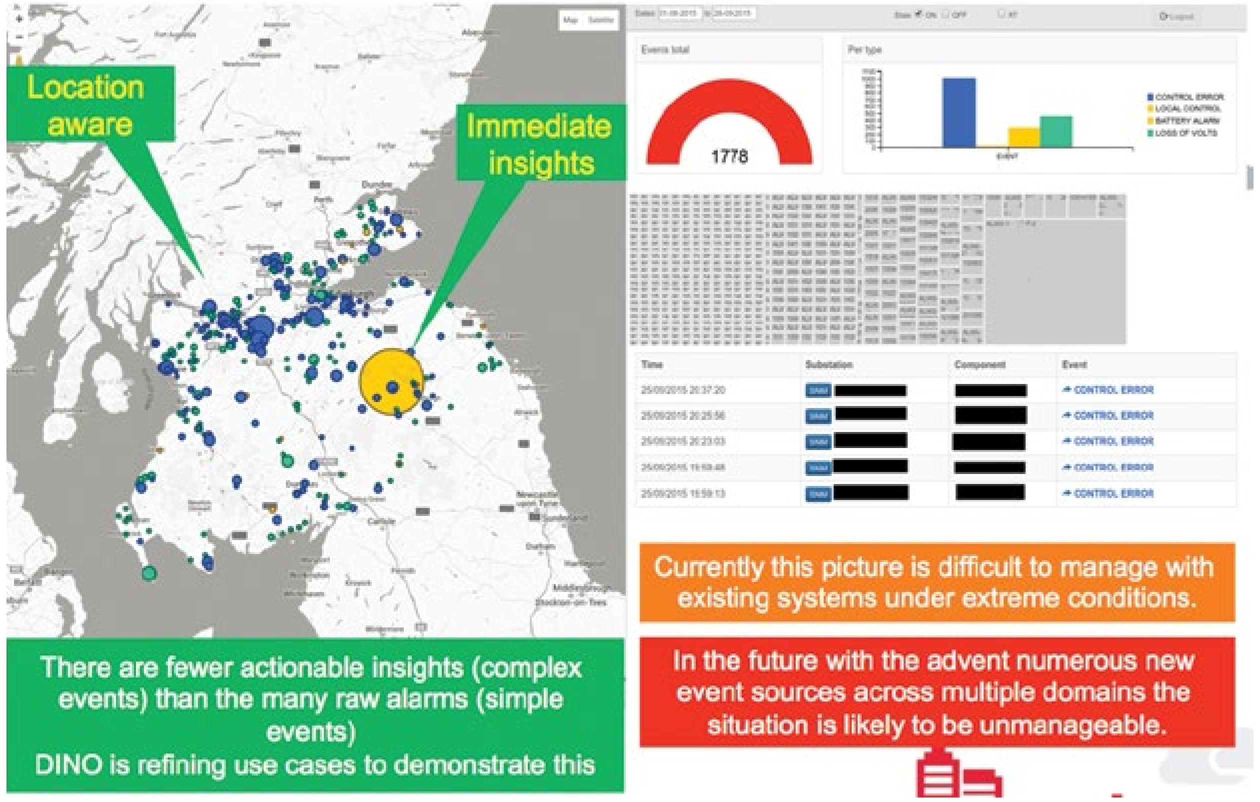
The project consists of three stages with individual objectives:

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.





3.8.1 NIA SPEN 0008 Project Progress

This project was registered in March 2016, as such prior to the end of the 2015/16 period there was no significant progress to report on beyond that Stage 1 had commenced. It is expect by the end of Q2 2016 that Stage 1 will be complete and Stage 2 will commence shortly afterwards.

3.9 NIA SPEN 0009 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

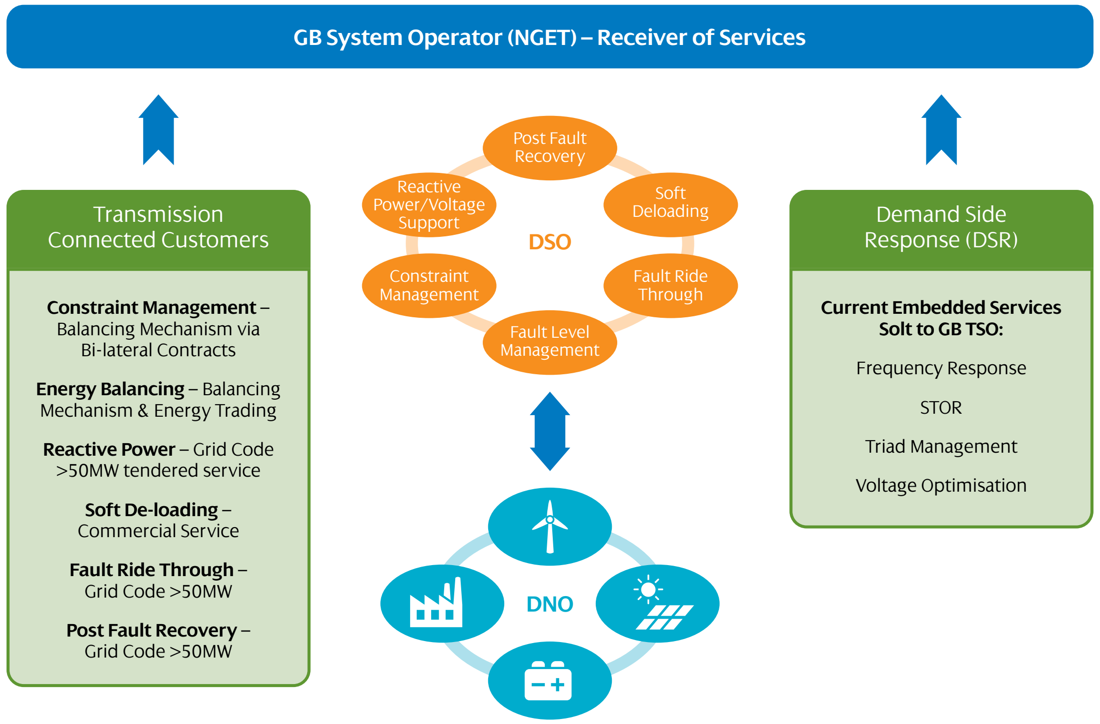
Passing data between multiple systems and ensuring that only one current version of truth exists is an ongoing issue for all DNOs. Without solving this it is hard to understand the full context (network, asset, and communications) that information relates to. As part of the process of identifying the 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.

3.9.1 NIA SPEN 0009 Project Progress

A functioning demonstration system has been developed which shows how:

- An integrated network model with both network and communications connectivity can be created
- Complex Event Processor rules can be used to realise a business use case for improved handling of events
- Actual NCP alarm data could be presented and analysed in this context to give enhanced visibility
- This can be achieved without replacement or major change to existing systems



3.10 NIA SPEN 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 SPEN 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.

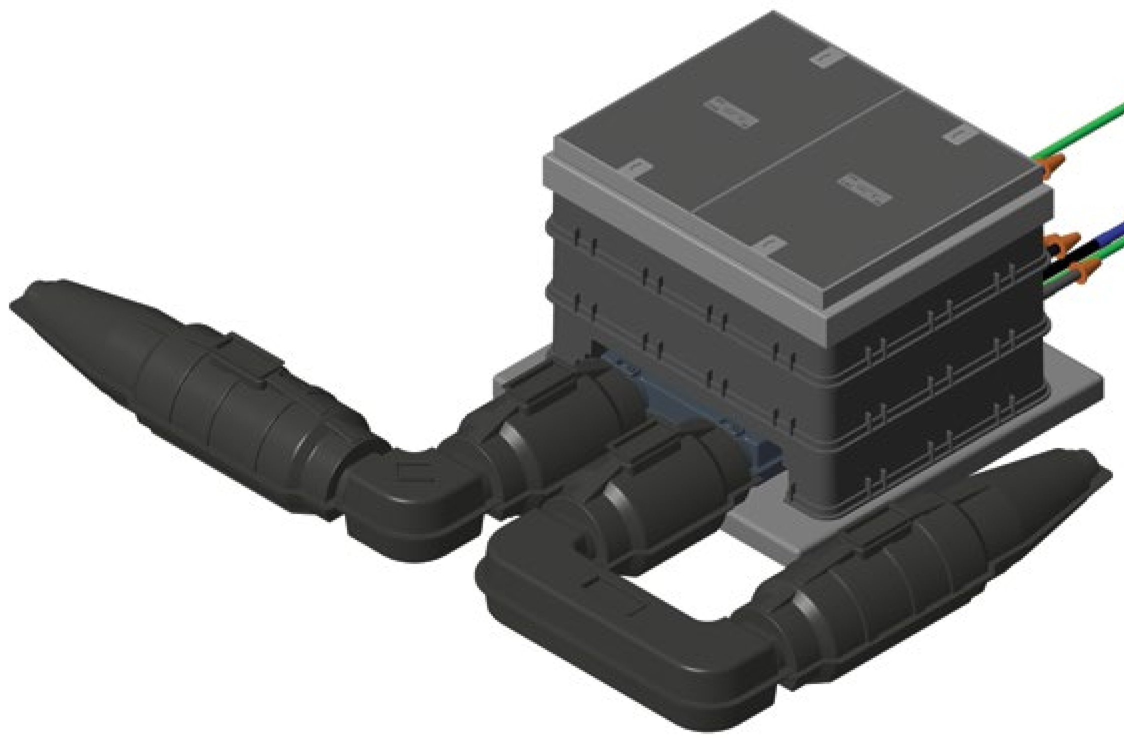
3.10.1 NIA SPEN 0010 Project Progress

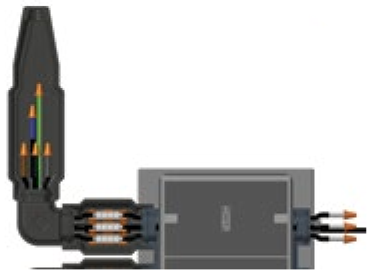
We have spoken informally to a number of other organisations that would also have an interest, also speaking publicly at the LCNI conference in Liverpool last year. Following that we held meetings with Scottish Renewables and other industry bodies to discuss the issue in more detail.

We have now established our dedicated DSO programme and are focusing on progressing it over the next few years. Our first priority has been to establish a DSO steering group involving senior SPEN staff and key stakeholders. The group is now formed and met on the 2nd March 2016. We have also drafted a DSO Vision document. Membership comprises six SPEN board directors, plus representatives from National Grid, Smarter Grid Solutions, Strathclyde University, RES, Elexon and Scottish Government. This group will be responsible for developing our vision of a DSO and for setting the direction of stakeholder engagement within the UK energy sector. The group will instruct the creation of sub-groups to address technical,commercial, market and regulatory challenges identified by the steering group. It has fully agreed terms of reference which was developed in collaboration with members. We expect to make our DSO Vision document publically available in September 2016 and will seek further input from our wider stakeholder groups.

We will be developing a detailed plan for stakeholder engagement; however we believe our key engagement challenges going forward are twofold:

- The technical challenge; can we develop a model that works in practice? Do we have the technology available to support it, e.g. telecommunications?
- The commercial challenge; can we achieve a model that will work in an open market, while delivering best value for customers?





3.11 NIA SPEN 0011 LV Elbow Joints

Renewing and upgrading underground Low Voltage (LV) link-boxes can be a costly and time consuming activity that is also disruptive to customers, businesses and road users alike. Although the current method of modernisation is well established and has been optimised for improved internal efficiency, significant cost are still incurred through the excavation and reinstatement process as this makes up the majority of cost for this type of work. The conventional DNO approach for this activity is for open cut trenching to allow for enough space for the new equipment and cables to be safely installed as per the manufacturer's recommendations. This can include significant additional excavations to allow cables to be installed with the correct bending radius. This additional excavation work can greatly increase the cost for the work, ties up limited resources from front line activities and can cause significant disruption for local business and road users as increase traffic management is often required.

This project aims to deliver a safer, less disruptive and more resource efficient way of upgrading and replacing LV links boxes so as to provide an improved service to our customers.

The use of the innovative LV Elbow joints is seen as a practical and economic method to reduce the excavation footprint of modernisation work which will significant reduce the resources required for this type of work whilst reducing the impact this work can have in local communities.

3.11.1 NIA SPEN 0011 Project Progress

The project registered in March 2016 is expected to last around 2 years with the first joints due to roll of the production line during summer 2016. The joints will be trialed in Edinburgh and Liverpool, with the aim to generate a representative understanding of the potential benefits the LV elbow joints may have, and to facilitate the most cost effective and efficient way to integrate the joints into business as usual.

4 Collaborative NIA Projects Led By Other Network Operators

During the reporting period SPEN has collaborated on ten NIA projects that have been registered by other parties as follows:

Project No.	Project Name	Project Lead
NIA SGN 0035	Beyond Visual Line of Site	SGN
NIA WPD 0008	Improvement Statistical Ratings for OHL	Western Power Distribution
NIA NGN 142	Project CONCUR	Northern Gas Networks
NIA WWU 0025	Project Futurewave Phase 2	Wales and West Utilities
NIA NGGD 0072	Project Futurewave Phase 3	National Grid Gas Distribution
NIA NGET 0135	Reactive Power Exchange Application Capability Transfer (REACT)	National Grid Electricity Transmission
NIA ENWL 0003	Review of Engineering Recommendation P2/6	Electricity North West Limited
NIA SSEPD 0006	Ultrapole	Scottish Hydro Electric Power Distribution
NIA NPG 0001	Vonaq Utility Pole Strength Measurement	Northern Powergrid
NIA NGET 0154	Work Stream 7	National Grid Electricity Transmission

The following sections provide a short overview of each active NIA D project on which SPEN is collaborating.

4.1 NIA SGN 0035 Beyond Visual Line of Site

Electricity distribution networks (steel tower and wooden pole circuits) and gas distribution networks (high pressure gas pipelines) require regular inspection in order to ensure that they remain fit for purpose and comply with HSE regulations. Emerging Unmanned Aerial Vehicle (UAV) technologies (such as small multi-rotor systems) are starting to be deployed, particularly for electricity asset inspections, for the inspection of steel towers in combination with the well proven approach of using manned helicopters. The benefits of such technology used for these types of inspection tasks are that they are relatively cheap to procure, are highly manoeuvrable, but they do have limitations with regards to payload carrying capacity, range, endurance as well as overall flight times. Repeatability of inspection data capture can also be an issue, as well as access to the assets and infrastructure that have been targeted for inspection.

This project is investigating the feasibility (from both a commercial, technical and regulatory perspective) of deploying similar, small Remotely Piloted Aircraft Systems (RPAS) but operating them Beyond Visual Line Of Sight (BVLOS) to augment and complement current asset inspection methods. If this can be achieved, then asset inspection costs have the potential to be substantially reduced, inspection tasks can be automated, such that truly repeatable inspection data can be not only gathered, but also analysed for different types of trend. One such example is degradation trend analysis of a specific asset or across assets of similar types - potentially automatically, using advanced software tools and techniques. If low-cost BVLOS operations can be achieved, then the electricity and gas distribution networks will have an additional asset and infrastructure inspection capability that they can deploy at a lower cost in most cases than current techniques, hence opening up new possibilities for increased frequency of inspection or a broader use of such technology in places where it is not used today for new asset inspection tasks such as inspecting wooden pole circuits from the air in addition to current steel tower circuits, or within the gas sector, inspecting difficult to access gas pumping stations.

4.1.1 NIA SGN 0035 Project Progress

This project has now been completed; the project lead SGN has provided a close down report. As an active partner of the project, we have outlined our new learning on this project under Section 6 of this report.

4.2 NIA WPD 0008 Improvement Statistical Ratings for OHL

Distribution overhead line ratings are based on CEGB research work and further assumptions described in ENA ACE 104 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.

4.2.1 NIA WPD 0008 Project Progress

This is a collaborative project involving all UK DNOs, with WPD acting as the main DNO Project Lead. The project commenced in July 2015 and is scheduled to complete by March 2018. The data recording process started in January 2016 and is currently ongoing. 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.

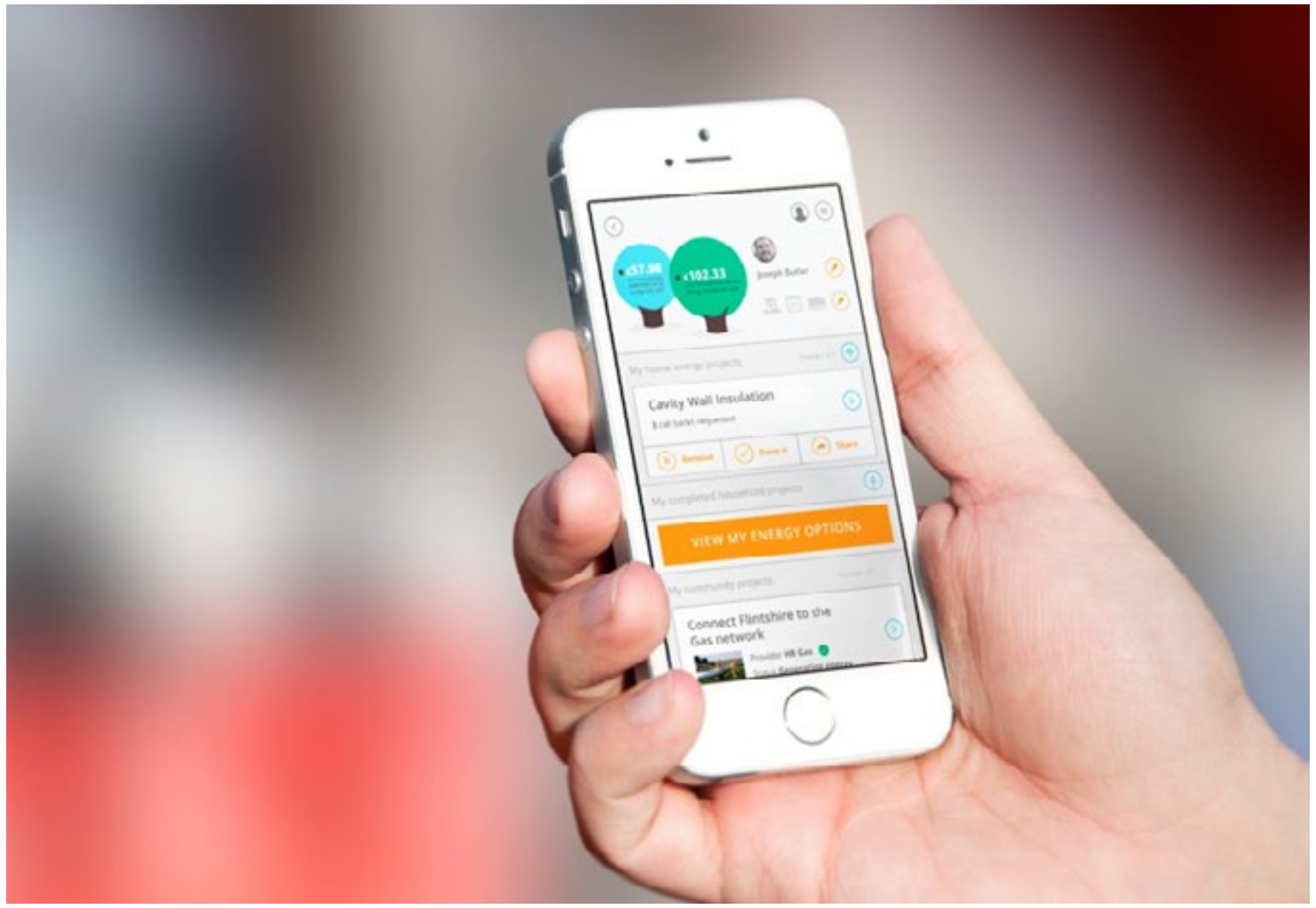
4.3 NIA NGN 142 Project CONCUR

This is an EIC collaboration project between several Licenced Network Operators (LNOs), it explores the potential future of customer service through cross-network collaboration.

- The identified benefits of a collaborative approach to customer being:
- Providing mass access to improved services
- Incorporating and connecting other utility providers
- Instant energy disruption outage alerts before they may even be aware of an issue
- Additional Vulnerable Customer support, allowing customers to adopt special alerts to other stakeholders
- Improved emergency planning coordination during major civil disruptions, floods, extreme weather and technical failures
- Linked to long term network management awareness of faults on network to inform customers before potential issue

4.3.1 NIA NGN 142 Project Progress

This project has been registered as a joint project by Northern Gas Networks, and therefore they will provide a progress summary in their NIA Annual Report 15/16, consequently no project progress has been included in this report. However, we, as an active partner of the project, have outlined our new learning on this project under Section 6.



4.4 NIA WWU 0025 Project Futurewave Phase 2

This is an EIC collaboration project between several LNOs, it builds upon Futurewave Phase 1 (NIA_NGN_090) through the development of a prototype Futurewave digital platform.

The Futurewave digital platform is intended to facilitate the greater uptake of energy solutions by UK customer and communities. It intends to do so by bridging the gap between consumers who want energy solutions, suppliers who want to deliver them and funders who can support them, and all from a single easy to access platform. It intends to do this through three services:

'Source It' will provide energy consumers with clear information on their energy options and connect them with trusted developers and funding sources to help them realise their chosen route(s).

'Build It' will connect energy developers and the industry with each other and relevant projects that have been triggered by consumers. It will also enable them to identify areas of demand and to 'seed' projects where appropriate.

'Fund It' will connect individuals and communities with sources of investment that can fund their energy projects.

Phase 2 specifically looks at the development of the Futurewave concept by defining the parameters of the digital platform and the development of a prototype with supporting commercial rationale. The project concludes with a test programme with prospective users to assess its suitability for moving on to the next phase of the project.

4.4.1 NIA WWU 0025 Project Progress

This project has been completed, with the project lead Wales and West Utilities providing a closedown report that details the successfully delivery of this project that has resulted in the decision by the LNO partners to progress to Phase 3. As an active partner of the project, we have outlined our new learning on this project under Section 6.

THE ENERGY Loop

4.5 NIA NGGD 0072 Project Futurewave Phase 3

As highlighted in the previous section, this is the continuation of the Futurewave EIC collaboration project. As part of the user acquisition strategy, the project has gone through a re-brand from 'Project Futurewave' to 'The Energy Loop'.

Phase 3 seeks to develop and pilot the digital platform with UK communities representative of the core target audience. Over the course of this phase customers in select communities will be able to engage with the platform and start activating otherwise inaccessible energy projects either in communities or as individuals.

Objectives:

- Define and build the minimum viable product required for each trial.
- Validate and determine the viability of the commercial model through live data observed in trials including;
- What penetration are we likely to achieve in year one for 'Source It' and 'Build It' users?
- What rate of completion rate we are likely to achieve?
- What the average project value is?
- What level of 'Fund it' support is required
- Define user acquisition tactics for 'Build it' and 'Source it' users.
- Develop the final product ready for commercial launch.
- Outline the commercial launch plan.

4.5.1 NIA NGGD 0072 Project Progress

This project has been registered as a joint project by National Grid Gas Distribution, and therefore they will provide a progress summary in their NIA Annual Report 15/16 consequently; no project progress has been included in this report. However, we, as an active partner of the project, have outlined our new learning for this project under Section 6.

4.6 NIA NGET 0135 REACT

This is a collaborative research project undertaken by the University of Manchester (UoM) and led by NGET. The project looks to address this issue of managing transmission voltage levels during minimum demand periods. Analysis of this issue has shown that the root cause is related to the significant decline in reactive power relative to active power. Whilst minimum active power demands have fallen by around 15% in the last 5 years, reactive power has declined by 50% in this time. Trends show that this reduction is continuing, broadly, across the country.

The key objectives are to determine:

- The key factors behind the significant decline in reactive power demand and the corresponding increase in the DNO system reactive power gain as observed at the Transmission/DNO interface (i.e., Grid Supply Point). During periods of minimum loading the reactive power demand has reduced from circa 7500 MVAr in 2005 to 2100 MVAr in 2013.
- The key factors behind the significant decline of the reactive to active power ratio (Q/P ratio) during periods of minimum demand. During the last 5 years, there has been a fall of 50% of the reactive power demand followed by a corresponding non-proportional fall of 15% of the active power demand.
- The relationship of all factors affecting the decline in reactive power demand at these interfaces during the same periods.
- The link to the upcoming requirements from the European Demand Connection Code changes expected in Demand Connection Code

4.6.1 NIA NGET 0135 Project Progress

This project is now complete and NGET as project lead have completed a close down report that details the progress and success of the project. However, we, as an active partner of the project, have outlined our new learning on this project under Section 6.

4.7 NIA ENWL 0003 Review of Engineering Recommendation P2/6

Engineering Recommendation P2 has been in place since the 1950s and has played a major role in the development of secure and reliable electricity distribution networks. The recommendation has been reviewed and updated a number of times since its inception, most notably by the introduction of P2/5 in 1978 and P2/6 in 2005.

The most fundamental issue regarding the future evolution of the P2 standard is whether it continues to prescribe economically efficient investments, given the many changes affecting the energy market at present, including the (anticipated) prolific deployment of new and emerging low carbon technologies and the changing role of the customer - demand, generation and prosumer customers. This gives rise to the need for a fundamental review of the baseline philosophy of distribution network operation and design to ensure that the UK Government's energy policy objectives can continue to be met in a cost effective and pragmatic way.

The review is formed of two distinct phases. The objective of Phase 1 is to identify and agree a range of options for a future UK security standard and agree the most appropriate approach that should be taken forward into Phase 2 which is the development and codification of the new standard.

The fundamental review of Engineering Recommendation P2 is being directed by the Distribution Code Review Panel P2 Working Group (DCRP P2 WG) through the Energy Network Association (ENA). The DCRP P2 WG through the ENA engaged a consortium consisting of DNV GL, Imperial College London (ICL) and NERA to carry out phase 1 of the P2 review. The Consortium, supported by DCRP P2 WG members, has identified and assessed high level options for the reform of ER P2/6 through a range of quantitative and qualitative analysis. The high level options considered for reform include:

1. Retaining the present deterministic1 P2/6 standard without revision.
2. Retaining a deterministic planning standard, but with improvement.
3. Implementing a non-deterministic planning standard.
4. Implementing a high-level standard that obliges efficient investment, while retaining some deterministic elements, represents a hybrid of options 2 and 3.
5. Abolition of the planning standard.

4.7.1 NIA ENWL 0003 Project Progress

This is a collaborative project involving all UK DNOs, with Electricity North West (ENW) acting as the main DNO Project Lead. The option review has been completed and stakeholder feedback is being sought prior to selecting the review option to be taken forward in Stage 2 (development and codification of the new standard). This joint project was registered by ENW as the lead DNO and so more details on project progress will be reported in the ENW Annual Report. Consequently; no detailed project progress has been included in this report. However, we, as an active partner of the project, have outlined our new learning for this project under Section 6.

4.8 NIA SSEPD 0006 Ultrapole

Wooden poles are used extensively throughout the utility networks to carry LV and HV overhead networks across open countryside and in rural areas. Current Health & Safety legislation demands that risk assessments are regularly undertaken to assess their health status in terms of the remaining load bearing strength of the pole, which is usually buried to a good depth in soil or tarmac. The pole may extend to several metres in height.

Currently, this assessment requires the use of ladders and climbing equipment to assess the state of the pole close to its main load bearing area (the top one third of its length) and at the root of the pole. This is both time consuming and involves some risk to the operative, either in climbing or digging around the base of the structure.

There are currently several invasive instruments on the market for detecting wood rot, based on both acoustic (hammer in nail, tap and listen) and ultrasonic (slice shadow) technologies. Testing of wood poles by existing methods such as hammer test can be subjective in nature and result in the inappropriate replacement of poles with residual life. As the result of testing is localised to the point of test, abnormalities elsewhere along the length of the pole can go undetected which can result in the failure of the overhead line under adverse weather conditions

This project considers the use of ultrasound which works by detecting changes in wood density which results in an acoustic path impedance variation between different wood densities. This change can be caused by rotted fibres within the pole, or other features such as drilled holes etc. This density change produces a discernible energy reflection at the boundary which can be analysed and visualised in an instrument.

The purpose of the Ultrapole project was to determine whether it is possible to develop a non-intrusive product that ultrasonically determines the condition of a wood pole. The project aims included for a prototype development of an instrument that is easy to use in the field, it would take non-intrusive measurements and should have the ability to operate at ground level, scanning over the entire length of the pole. Such an instrument would prevent the need for digging around the base of the pole disturbing previously good ground conditions, or climbing the pole to make measurements at height.

4.8.1 NIA SSEPD 0006 Project Progress

This project has been registered as a joint project by Scottish Hydro Electric Power Distribution, and therefore they will provide a progress summary in their NIA Annual Report 15/16 consequently; no project progress has been included in this report. However, we, as an active partner of the project, have outlined our new learning on this project under Section 6.

4.9 NIA NPG 0001 Vonaq Utility Pole Strength Measurement

As per NIA SSEPD 0006 Ultrapole:

Wooden poles are used extensively throughout the utility networks to carry LV and HV overhead networks across open countryside and in rural areas. Current Health & Safety legislation demands that risk assessments are regularly undertaken to assess their health status in terms of the remaining load bearing strength of the pole, which is usually buried to a good depth in soil or tarmac. The pole may extend to several metres in height.

Currently, this assessment requires the use of ladders and climbing equipment to assess the state of the pole close to its main load bearing area (the top one third of its length) and at the root of the pole. This is both time consuming and involves some risk to the operative, either in climbing or digging around the base of the structure.

There are currently several invasive instruments on the market for detecting wood rot, based on both acoustic (hammer in nail, tap and listen) and ultrasonic (slice shadow) technologies.

This project differs to Ultrapole by utilising a different type of sensing technology that has already been deployed in an off the shelf solution for the European Telecommunication Industry. The VONAQ product utilises an acoustic sensor head that provides a quantifiable score for telecommunication pole health. This project will look to identify if the VONAQ product can be calibrated to provide the same function for electrical distribution poles. This will require significant field trials given the range of poles and their associated furniture on UK networks.

4.9.1 NIA NPG 0001 Project Progress

This project has been registered as a joint project by Northern Powergrid, and therefore they will provide a progress summary in their NIA Annual Report 15/16 consequently; no project progress has been included in this report. However, we, as an active partner of the project, have outlined our new learning on this project under Section 6.

4.10 NIA NGET 0154 Work Stream 7

The "Distribution System 2030" (DS2030) project, managed under the auspices of the Smart Grid Forum, Work Stream 7, has undertaken detailed analysis into the operation of the GB power system as projected for 2030. Future needs of the Distribution Networks were identified with consideration of both traditional and non-traditional reinforcement with the later referred to as smart solutions. The analysis has been comprehensive with challenge and guidance at each stage from the WS7 stakeholder group.

DS2030 was the first time that the Smart Grid concept had been assessed in a holistic manner, using load flow models that were representative of real UK distribution networks and taking on board the main Smart Grid solution sets.

Detailed Power System Studies have characterised the performance of different network types, from transmission connection point down to LV. Four Base networks were studied: Urban, Rural, Interconnected Manweb, Interconnected London. Two Low Carbon Technology (LCT) uptake scenarios were used, one was demand biased, the other being Distributed Generation biased. Whilst there is inevitable uncertainty surrounding the chosen scenarios they provide a good indication of the type of future challenges to distribution networks.

The conclusions from the work demonstrate that with suitable reinforcement the 2030 power network is expected to be technically viable and capable of serving consumers to the national standards for security and quality that are familiar today.

However, attention must be given to important learning points from the studies if this positive outcome for 2030 is to be attained. Overall, the present power networks operate satisfactorily today, and there is time to address the challenges that may arrive as networks evolve to 2030 - provided there is visibility of emerging issues and a coherent plan is put in place.

Investment will be needed in the networks to respond to the challenges between now and 2030 and a mix of smart and traditional solutions will be necessary.

4.10 NIA NGET 0154 Project Progress

This project has been registered as a joint project by National Grid Electricity Transmission, and therefore they will provide a detailed progress summary in their NIA Annual Report 15/16 consequently; no project progress has been included in this report, other than to say that the project is now complete. However, we, as an active partner of the project, have outlined our new learning on this project under Section 6.

5 NIA Activities Linked to SPEN Innovation Strategy

SPEN Innovation Process

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

Figure 5 SPEN Approach to Innovation Development

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:

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

2. **Evaluation**: We use the priorities of our stakeholders as the main evaluation criteria for new projects. We will ensure that all new projects align with at least one of the areas listed in Figure 5 under Stakeholder Priorities. Operating our network safely, providing value for money and delivering excellent customer service are all implicit requirements in what we do.

3. **Approval:** Our 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.

4. **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.

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

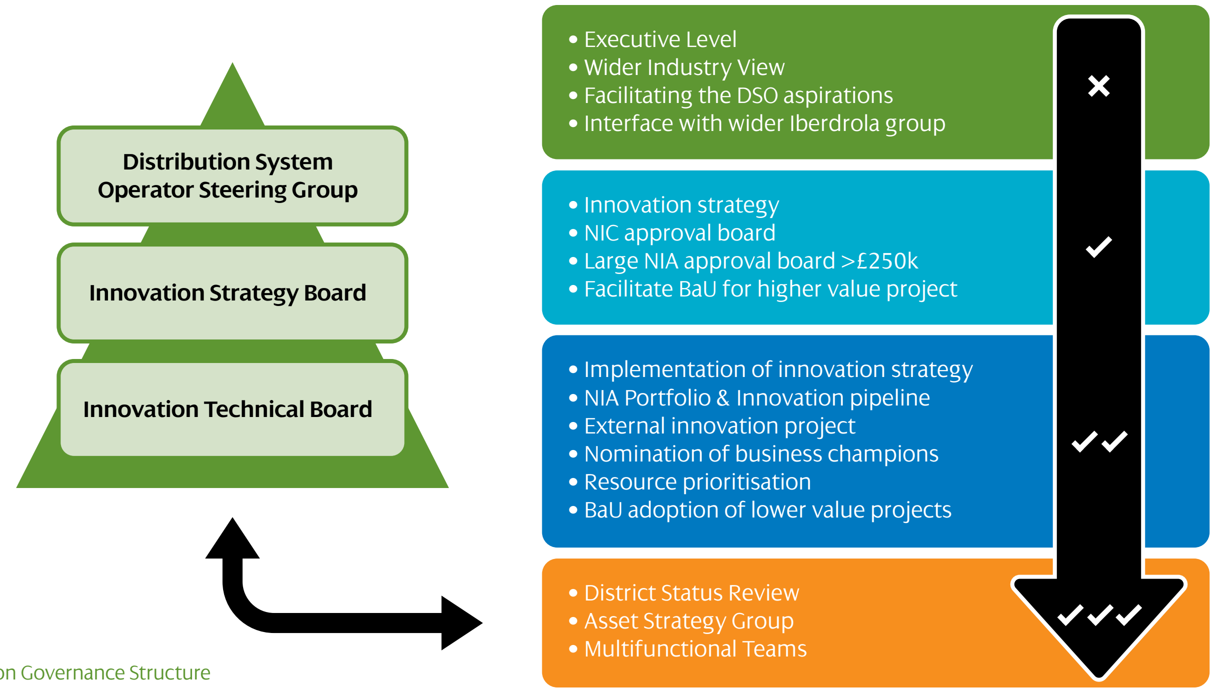


Figure 6 Innovation Governance Structure

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.Our innovation governance structure and project approvals process Figures 6 and 7 respectively, helps to ensure the following:

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

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

A Project must also meet all of the requirements

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

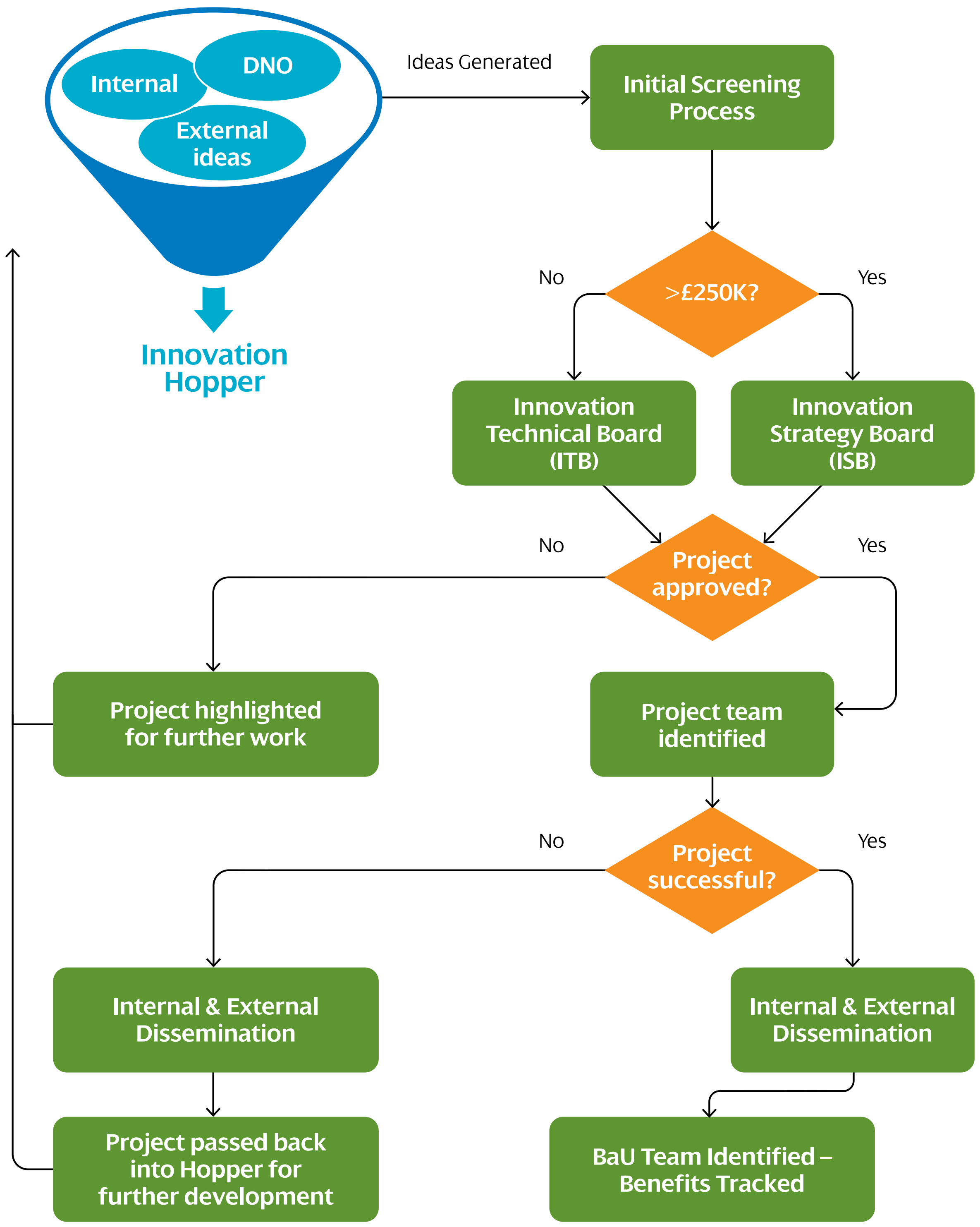


Figure 7: Project Approvals Process

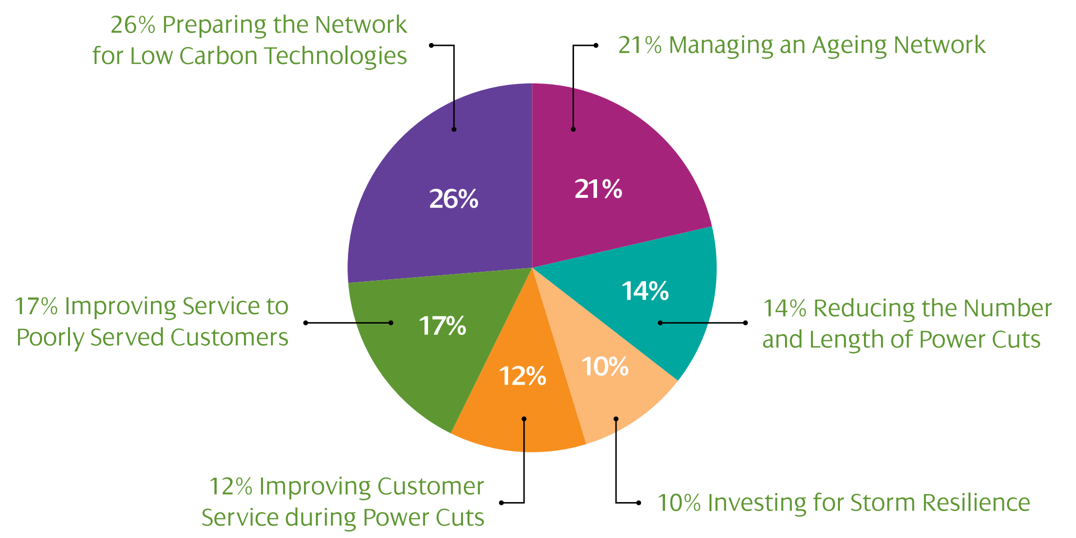
5.2 SPEN NIA Project Mapping with Innovation Strategy

5.2.1 Informed by Our Stakeholders

We are acutely aware that the funding we access through the various innovation mechanisms is sourced from our customers. In developing our innovation strategy 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 six specific priorities:

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

Projects Aligned to Stakeholder Priorities



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

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

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

Project No.	Managing an Ageing Network	Reducing the Number and Length of Power Cuts	Investing for Storm Resilience	Improving Customer Service during Power Cuts	Improving Service to Poorly Served Customers	Preparing the Network for Low Carbon Technologies
NIA SPEN 0001						✓
NIA SPEN 0002	✓	✓	✓	✓	✓	
NIA SPEN 0003						✓
NIA SPEN 0004		✓				
NIA SPEN 0005		✓		✓	✓	
NIA SPEN 0006	✓			✓		
NIA SPEN 0007						✓
NIA SPEN 0008	✓					
NIA SPEN 0009	✓					✓
NIA SPEN 0010	✓					✓
NIA SPEN 0011	✓	✓		✓		
NIA SGN 0035	✓		✓			
NIA WPD 0008						✓
NIA NGN 142				✓	✓	
NIA WWU 0025					✓	✓
NIA NGGD 0072					✓	✓
NIA NGET 0135						✓
NIA ENWL 0003						✓
NIA SSEPD 0006	✓	✓	✓		✓	
NIA NPG 0001	✓	✓	✓		✓	
NIA NGET 0154						✓
	9	6	4	5	7	11

Innovation Projects Mapped to Stakeholder Priorities

6 Areas of Significant New Learning

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

6.1 Project Learning: NIA SPEN 0001 Smart Building Potential Within Heavily Utilised Networks

- Level of controllable loads within buildings – i.e. loads controlled by a Building Management System (BMS) – is significantly lower than anticipated. Therefore, scope for demand reduction through BMS is reduced.
- Demand-side response does work and load can be demonstrated to reduce 'on demand' during periods of peak demand (throughout the day on a city-centre network).
- Communications (4G) very poor in city centre environment – despite ubiquity of 4G signal and masts – and it has proven to be an unreliable medium for demand-response that requires a robust connection for: enactment of demand response; and collection to data to demonstrate to National Grid that demand response realised.
- Volume of data output by buildings to evidence demand-side response needs to be considered carefully as too much data can create large processing overhead that can cloud real behaviour of system.
- In future modelling scenarios, building load growth less than other technologies – EVs, PV, CHP, etc. – therefore these loads may require controlling alongside buildings. The centralised solution developed during this project and the techniques used would be applicable to demand response of other technologies. The interface to each device, however, would differ.

6.2 Project Learning: NIA SPEN 0002 Virtual World Asset Management

- The delivery of an accurate VWAM system that captures >95% of SPENs OHL assets within the pilot areas.
- The ROAMES system can accurately detect uninsulated conductors but struggles to identify and correctly model insulation service wire. A number of solutions will be investigated during year to address these issues, including:
  - Flying the planes at a slightly lower altitude
  - Using multiple sensors with differing wavelengths
  - Improving the asset identification process by utilising additional manual interventions
  - Improved QA process
- It was established that external conditions, tree species and vegetation management policy can have significant impact on growth rates and as such it would be very difficult and ultimately incorrect to base vegetation growth predictions on LIDAR data in isolation.

6.3 Project Learning: NIA SPEN 0003 Enhanced Real-Time Cable Temperature Monitoring

The following learning and knowledge have been generated:

Data analysis on the DCR historic data suggested that there is potentially headroom in the existing cable circuits to export addition wind power. As an example, Figure 8 shows the cable conductor temperature variations versus windfarm output (maximum 32 MW) for a 5 day period when a sustained generation was experienced. The temperature of the cable conductor has reached around 65°C which is below the 78°C permissible temperature i.e. 13°C headroom. Figure 9 shows the results of a simulation for a case where the output of windfarm (loading of the cable) is allowed to increase to the actual installed capacity of the windfarm, 39MW. In this case, the temperature of the cable conductor only for a short period of time and for around 1°C will exceed the permissible temperature.

DCR would be a successful solution when it is deployed in a closed-loop controlled system where the output of a generator is curtailed by an Active Network Management (ANM) system in case the cable conductor is overheated. As discussed and shown in Figure 9, the output of the windfarm can be increased to 39 MW for majority of times, however, ANM system may ensure the cable circuit always operates within permissible temperature and curtail the windfarm output if required.

The initial engagement with ANM suppliers suggested that it would be possible to design a system architecture where ANM system is informed by the real-time DCR system. We have also concluded that in an ANM application, short term permissible loading of the cable should be used as the controlling parameter rather than the dynamic temperature of the cable. In other word, the real-time thermal status of the cable should be translated to a permissible loading of the cable for a given time ahead e.g. next 24 hours

Based on conventional approach the rating of the windfarm cable circuits are calculated in a conservative way assuming a sustained maximum power output of the windfarms. Nonetheless, the loading of a windfarm cable circuit is not continuous as the wind power is intermittent in nature, therefore, a cable circuit may dissipate heat during low power output period and gradually gains heat during high loading periods. Data analysis on a 15 month period data for a windfarm showed:

Only 21% of times windfarm generated more than 90% of its full capacity (see Figure 10).

The windfarm output also does not remain at the maximum level for long consecutive hours. Figure 11 shows the probability when wind generation stays at greater than 90% level for different consecutive hours. The worst case (and also a rare case) is when wind power output stays 88 hours above the 90% maximum output. In the majority of cases, windfarm export stays at the maximum level only temporarily.

The aforementioned analysis suggested that a cyclic rating approach (rather than continuous) may be plausible for wind farm cable sizing. This is now being further investigated with the University of Southampton.

Figure 8 – The wind farm output and the cable conductor temperature variations when the output of windfarm is limited to 32 MW – Dotted line shows the 78°C permissible temperature limit

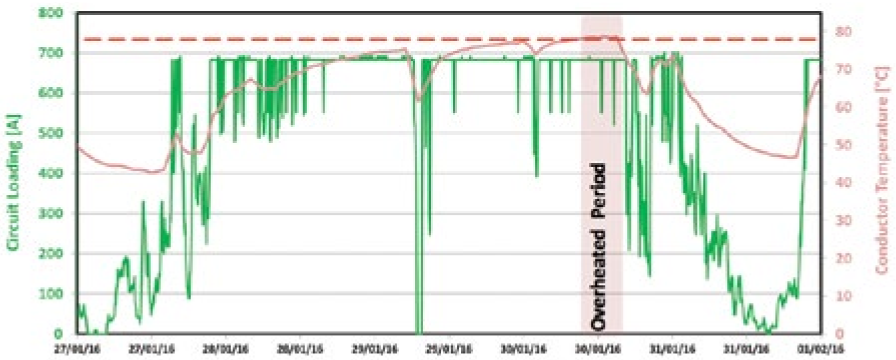


Figure 9 – The wind farm output and the cable conductor temperature variations when the output of windfarm is increased to 39 MW (simulation) – Dotted line shows the permissible temperature limit

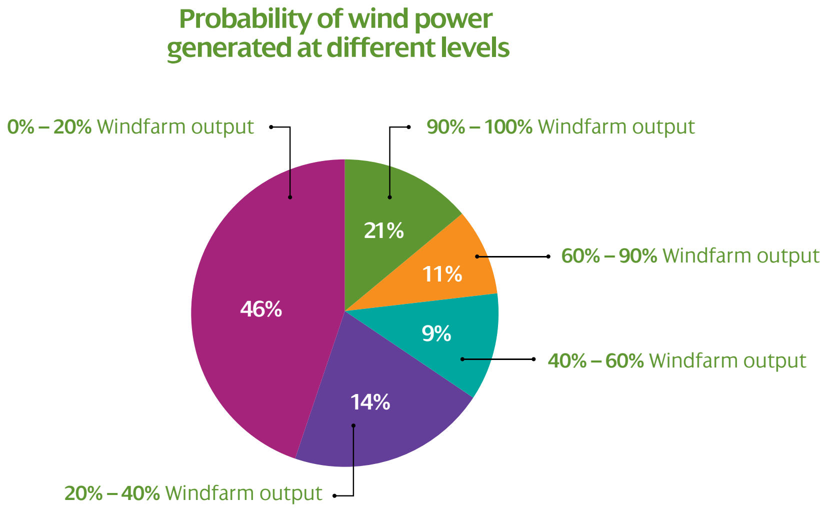


Figure 10 – The probability of the windfarm output being in different level of maximum capacity, a 15 month period has been considered

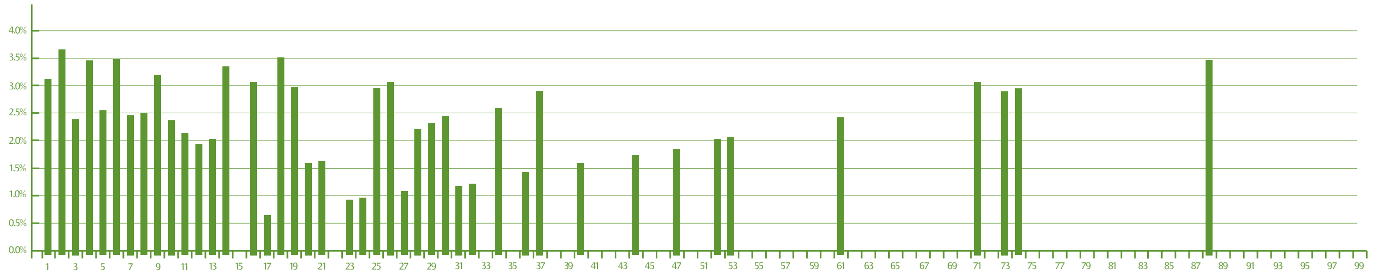


Figure 11 – The probability of the windfarm outputs stays on > 90% of maximum capacity for consecutive hours

6.4 Project Learning: NIA SPEN 0004 Substation Earth Monitor

- This project highlighted that it is possible to monitor substation assets through the use this innovative monitoring system. It also highlighted the changing and variable impact that external economic factors can have on the level of theft and vandalism at substation locations.
- Remote monitoring technologies in general are likely to support multiple business cases, potentially across multiple stakeholders. In the case of this project in addition to security, it has become clear that these include;
  - Safety (for employees and public on-site and further downstream in the network); and
  - Operational efficiency (for example, asset protection, planned maintenance etc.)

6.5 Project Learning: NIA SPEN 0005 Portable Radiometric Arc Fault Locator

- Hardware suitable for the reception and accurate timing of impulsive radio frequency (rf) signals emitted by arcing faults has been successfully developed and demonstrated to work correctly in the field.
- Experience with the operation of a network of rf monitoring stations has shown that impulsive signals are regularly recorded, e.g. several every day.
- The majority of the impulsive signals recorded are related to small scale switching events in the local proximity to each monitoring station, e.g. thermostat operations in nearby buildings. The relatively low amplitudes of this 'background' activity prevent these signals being detected by more than one monitoring station.
- Background activity is easily filtered by the server which looks for time delays between signals which is less than the time of flight between any pair of monitoring stations. There is, therefore, no benefit in the RAFL system being able to distinguish between background activity and genuine fault events, since only the latter will result in the correct time delays to calculate the location of the source of the signals.
- Background activity provides a useful feedback to the RAFL system operator that all the monitoring stations are working correctly.

6.6 Project Learning: NIA SPEN 0006 Mini Mole

The main learning so far is centered 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.

6.7 Project Learning: NIA SPEN 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 will also suit HVDC applications in addition to HVAC, beyond the MVAC cable development being pursued in this project. 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 could be used for HVDC cable development.

6.8 Project Learning: NIA SPEN 0008 APPEAL

As this project only commenced in March 2016 it has not yet generated any significant new learning.

6.9 Project Learning: NIA SPEN 0009 Data Intelligence for Network Operations (DINO) Phase 1

This project has already demonstrated benefits from:

- Visualisation techniques which help identify system discrepancies
- Reduction in the number of events being presented to the end user
- Flexibility in changing and adapting how events are processed

6.10 Project Learning: NIA SPEN 0010 EVOLUTION

As we are in the early stages we are currently in 'listening mode' with our stakeholders. We have some ideas about how the DSO model will be developed, but are focused on what others have to say to help us build a model that works for everyone. In time we will develop our ideas further, using external input, and will then open the discussion up for wider consultation. This will involve formalizing the ideas to a certain extent, communicating the ideas to a wide audience, gathering feedback and reviewing our plans on the basis of that feedback.

6.11 Project Learning: NIA SPEN 0011 LV Elbow Joints

SPEN are currently awaiting the first batch of LV Elbow Joints for trial deployment. Until these trials are undertaken there is no significant new learning to report at this stage.

6.12 Project Learning: NIA SGN 0035 Beyond Visual Line of Site

The full findings of this project can be found in the close down report submitted by SGN along with supporting documents from the project partner.

From SPENs perspective this has been a successful project as it has delivered against its success criteria and has generated significant new learning that has advanced the deployment of UAVs within the UK utilities. The below is a brief summary of the key learning/outcomes of this project.

- **Cross-utility Collaboration** – Through its completion this project has become the largest ever collaborative NIA project undertaken by the UK LNOs. By doing so it has proven that LNOs are capable of identifying overlapping technology needs and extracting maximum value from projects that deliver the requirements of both electrical and gas network operators.
- **Civil Aviation Authority (CAA)** – The attitude and support given to this project by the CAA has generated confidence in the LNOs they will be willing to support the long term adoption of UAV technology to benefit UK networks.
- **Con-Op Specification** – Through utility collaboration and the support of the CAA the project has delivered an initial specification for an UAV capable of flying BVLOS that has been generated through the assessment of the 'Concept of Operation' required by the LNOs. This specification will serve as the foundation of any further work/uptake of this technology.
- **Financial Benefits** – The project has produced an updated forecast of the financial benefits that UAVs flying BVLOS can generate. This will serve as the foundation of any future cost benefit analysis SPEN undertakes to asses further work / uptake with this technology.

UAV Awareness – Through undertaking this project a greater awareness of UAV technology and its performance and limitations has been generated throughout SPEN.

- **Next Steps** – The project has highlighted to SPEN that the capability of UAV technology is developing at an accelerated rate, but it still could be several years before it can be used by LNOs to fly routinely BVLOS. SPEN along with the other UK LNOs now need to decide whether they want to continue to play an leading role in the development of this technology in order to accelerate the BaU adoption, or whether we wait for the technology to naturally mature through other applications.

6.13 Project Learning: NIA WPD 0008 Improvement Statistical Ratings for OHL

This project is still on-going, having entered the 12 month "data acquisition" phase back in January 2016. It is anticipated that the learning produced by the forthcoming data analysis will lead to appropriate revisions of ENA ACE 104/ENA ER P27, resulting in more accurate assessment of overhead line rating and therefore more accurate understanding of performance capability.

6.14 Project Learning: NIA NGN 142 Project Concur

As this project only commenced in March 2016 it has not yet to generate any significant new learning.

6.15 Project Learning: NIA WWU 0025 Project Futurewave Phase 2

The full findings of this project can be found in the close down report submitted by WWU along with supporting documents from the project partner.

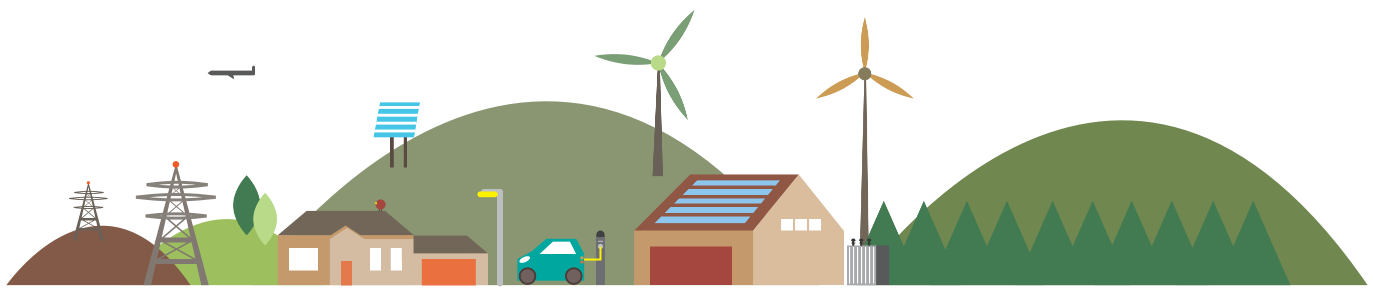
In 2015/16 SPEN along with the other DNOs was invited to join this Gas led NIA project at its second phase. We decided to join the project on the basis that it had the potential to deliver a sustainable approach for LNOs to support customers and communities wishing to make changes to the way they consume energy. Through the development of the prototype digital platform we believe this project has started off on the right path to delivering a solution that will engage customers.

Through our involvement SPEN has learnt about the behaviour of customers and how the platform needs to help to educate them at the touch of a button if it is to succeed. We have also learnt from suppliers of energy saving solutions that ~60% of their time is spent on educating customers. If the digital platform takes this burden off the suppliers the UK could see an increase in the uptake of energy saving solutions.

Whilst there is a long road ahead to get the digital platform assisting customers and communities, SPEN believes that the solution is worth pursuing, and as such we agreed to continue with Phase 3 of the project in February 2016.

6.16 Project Learning: NIA NGGD 0072 Project Futurewave Phase 3

Given that Phase 3 only started a month prior to the end of March 2016; no significant new learning can be reported by SPEN at this time.



6.17 Project Learning: NIA NGET 0135 REACT

The key project learning from this project is contained within the five project reports produced by the University of Manchester that have now been circulated within the business to raise awareness of this issue. The key learning points SPEN has taken from the project are:

- The specific SPEN Grid Supply Points that are demonstrating the decline in reactive power exchanges.
- The key factors behind the change in reactive power exchanges and the extent each is likely to have in the next 2 to 8 years.

6.18 Project Learning: NIA ENWL 0003 Review of Engineering Recommendation P2/6

As part of this project, Imperial College carried out a comprehensive review of network security issues, which has provided us with valuable additional insight. As a result, the project has generated the following learning points for SPEN:

- The existing security of supply standard (Engineering Recommendation P2/6) reflects a traditional design approach to network security. The emerging Smart Grid technologies do not fit neatly into this framework. Consideration should be given to developing a suitable framework for the assessment of both conventional and Smart Grid technologies.
- Some simple changes to the Security of Supply Standard should be able to remove most of the discrepancies previously mentioned, enabling a deterministic approach to be retained (i.e. by introducing some flexibility around the "Supply Class" definitions and by adding some additional tables) with cost benefit analysis (CBA) and other economic assessment techniques.
- The Security of Supply Standard will need to recognise that not all new technologies have exact values e.g. dynamic thermal ratings vary depending on conditions.
- The complexity and topology of some networks can present circumstances that make the use of CBA or other economic assessment more appropriate than a deterministic approach. In these circumstances it needs to be possible to revert to the fundamental principles of network security (i.e. recognising the differences in reliability between cables, overhead lines, transformers and Value of Lost Load) using economic assessment techniques to arrive at the most appropriate solution.
- Based on the work carried out by Imperial College, it does seem that P2/6 compliance requires a higher level of security than would be considered to be "economically efficient" using the "ACE 51" approach directly. This is partly due the inherent limitations of the "Value of Lost Load (VoLL)" approach, which fails to capture all of the societal benefits attributable to network security of supplies, especially for larger load classes.

We will take this learning into consideration as we prepare for the next price review.

6.19 Project Learning: NIA SSEPD 0006 Ultrapole

As the project started from a low technology readiness (TRL) level all testing and prototyping was conducted under laboratory conditions to ensure the proof of principle and concept. From the outputs of the project there has been an increase in understanding regarding the use of ultrasonic to determine the condition of a wood pole. Due to the low TRL on completion of this phase of the project and the demonstration not showing a strong enough indication of the overall pole condition, there is no plans for any further development.

6.20 Project Learning: NIA NPG 0001 Vonaq Utility Pole Strength Measurement

The objective of this project is to develop the pole test solution for telecom poles to work on power line poles and to provide a simple instrument to determine the pole and climbers' safety. Since many variances exist such as; different cable tensions, cable weights, pole sizes and equipment transformers. The system comprises a small hardware probe that is strapped to the pole by the operator and controlled by an android smartphone. The pole mounted probe analyses the frequency response following operator initiated impact, passes this into the patented algorithm and displays the ultimate breaking strength of the pole on the smartphone, indicating a Pass or Fail. This automates the judgement into a consistent measure and allows the user to make a more informed decision.

Data has been collected from over 600 poles during Stage 1 and Stage 2 of the project. All the data has been fundamental to understanding how the electricity poles impacts the prediction of the pole assessment condition made by the CXI device.

The CXI-PT5500 is the actual name of the test device/unit that gets strapped to the pole and calculates the test results.

It was understandable that the differences that there are between the electricity poles and the telecom poles would affect the frequencies of the poles.

What we have learnt from processing the collected data that the most important parameters that affect the pole vibration are related to:

- the masses attached to the pole
- the conductors tensioning
- the conductors configuration
- the different height levels at which conductors/masses may be attached to the pole

This has been a very successful project. It is cross sector – from telecoms to utilities – which has created an opportunity for shared learning across utilities. If the problem faced is solved, Network Operators will lead to less unnecessary pole changes, with cost benefit analysis indicating estimated improvements of 7.5%.

6.21 Project Learning: NIA NGET 0154 Work Stream 7

The headline learning points from DS2030 can be grouped under three headings:

1) Technical Challenges and Solutions,
2) Commercial and Business Challenges,
and 3) Wider Insights, as follows:

6.21.1 Technical Challenges and Solutions

- By 2030, SPEN networks will be required to accommodate both demand growth and the connection of LCTs comprising new demands and generation. Analysis shows that the associated challenges are material in scale, will manifest themselves in geographic 'hotspots', and will be influenced by network type – notably the different characterisation of urban versus rural systems and radial versus interconnected topologies.
- Network technical constraints to be addressed will include thermal overloading, high voltages, low voltages, waveform quality, and generator stability. Importantly, the modelling revealed that generalisations are hard to make, for example these unacceptable conditions may vary seasonally, may be off-set by a combination of demand growth and local generation, or may be exacerbated by the presence of LCTs.
- System studies examined the networks in accordance with system security standards, and checked the technical performance at all intermediate voltages from Low Voltage customers to the transmission connection point (400/132kV). The spread of overload conditions is significant.
- System voltages become non-compliant with statutory limits with issues being identified at different voltages for each characteristic network. Adjustments to voltage control strategies and DNO actions will be needed to maintain all the non-compliant networks within acceptable limits. In most cases existing voltage control strategies were shown to be adequate for the Scenarios and Base Networks considered, although additional voltage regulation will be required for conditions beyond those studied. i.e. LV voltage control, such as an on-load tap changer. Future co-ordination of voltage control will be important going forward to ensure that multiple voltage control systems do not conflict with each other.
- Investment will be needed to address network constraints identified in the simulations to the year 2030. The analysis shows that a mix of smart solutions and traditional reinforcement is likely to provide the best outcomes. Smart solutions (such as demand response, Real Time Thermal Ratings, Active Network Management, and Energy Storage) can be expected to add flexibility, and so help address uncertainty , as they are generally lower cost and faster to implement than traditional solutions. However, the modelling indicates that some smart solutions may have a relatively short 'life' if applied to the general network rather than to address a specific network issue. For example depending upon the rates of growth of demand and generation Demand Side Response applied to the general network could be expected to be effective for approximately four years,

compared with traditional reinforcement that can provide significantly greater capacity and a longer life. A mix of smart and traditional investment types is therefore likely to be advantageous.

- Traditional reinforcement to mitigate the issues identified in the studies up to 2030 are typically more than 10%, and up to 50%, of the existing system capacity at each voltage. The greatest reinforcement needs occur where the loading is already approaching the existing installed capacity. The existing capacity margin was seen to be reduced in all networks, except in areas in which reinforcement was proposed. Despite remaining compliant with the security of supply standard, the areas of network with reduced margin will be less flexible and less able to respond to more onerous outage conditions beyond the requirements of the standards, compared to today's network.
- The studies have shown some smart solutions to be more appropriate to certain network types, highlighting that they must be applied with consideration of the characteristics of the network.
- The DS2030 analysis has included harmonic analysis (waveform distortion) created by the power electronic interfaces that connect many LCT devices. Challenging issues have been identified that will require further examination as they reveal the potential for low order harmonic voltages to breach standards where the existing background harmonics are already close to limits.

Increasingly intelligent protection systems based on existing techniques are expected to be required as the complexity of distribution networks increase and the load and fault flows become more volatile. Transmission protection concepts are likely to be re-designed for application to lower voltage levels.

- Frequency balancing studies have been performed on the entire GB system model. These have shown the high potential and significance of the contribution from DNO connected equipment towards system frequency containment. It is therefore envisaged that DNOs are likely to play an active role in frequency balancing in 2030.
- Consideration has been given to the dynamic behaviour of distributed generators under fault conditions and their interaction with the dynamics of the national power system. This whole-system modelling has revealed the potential for generator instability arising from the relatively slow protection clearance times that are typical in distribution systems.

6.21.2 Commercial and Business Challenges

- Development of solutions such as active network management is an opportunity for evolving the Distribution System Operator (DSO) role. This creates a need for new skills and new tools for forecasting and modelling, and new policies and approaches as the nature of business changes. Although future practices will need to be mindful of business needs, it is likely that this will require more than grafting new skills into current teams and processes; the rising complexities, numbers of interfacing parties, and the pace of change brought about by Community Energy developments, Smart Cities, cross-vector developments, and the Internet of Things can be seen to require some fundamental rethinking. Increased visibility of emerging changes which affect network utilisation will be important, including understanding the geographic penetration of LCT devices, the take-up and characteristics of new consumer devices and energy services, and the emergence and roles of new third parties in the energy sector. In summary, many of these changes can be encapsulated in the shift that is perceived for DNOs as they move from traditional peak demand planning to active management of networks with flexible LCTs and the resulting variable profiles.
- DS2030 has confirmed that demand response is potentially a useful smart intervention. Two issues for further consideration are the business approach to obtaining and deploying this, especially where it is obtained from large numbers of small (domestic and SME) customers, and the obligation for network companies to be able to demonstrate adequacy of their arrangements to the Regulator. Alternative approaches can be explored such as network companies obtaining demand response services from an Aggregator or managing the EV charging profile to reduce peak demand.
- 2.3. There is a need to resolve the potential for conflicting service requirements from demand response if this is called by the GBSO, by Suppliers, or by the Network companies. Care is required to ensure that the market mechanism ensures services that benefit the network are not conflicted commercially. Similarly, smart solutions may offer benefits in regard to improved flexibility and responsiveness to customers, and it is important that this can be captured in investment cost/benefit analysis.
- In comparisons between the Transform Model and the DS2030 study, there was general alignment regarding the overall need for a mix of smart and traditional reinforcements. In addition the DS2030 studies were able to highlight where certain solutions were most applicable or not suitable.

"Our Innovation Strategy uses the priorities identified through our stakeholder engagement process."

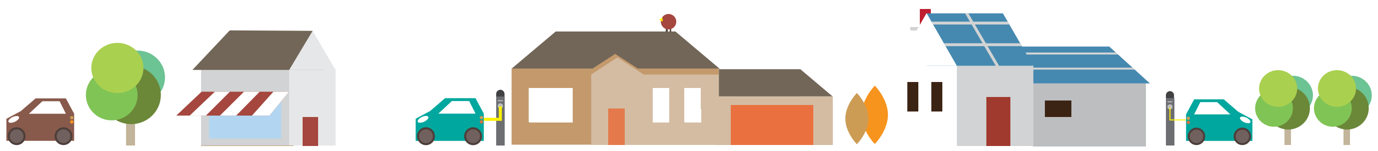
SP ENERGY NETWORKS

6.21.3 Wider Insights

- A review of the detailed findings shows that the 2030 network will be subject to challenges that impact the legacy design concepts of the GB distribution systems. Hence the solutions will require changes to the existing design, planning and operating practice. Examples that can be seen from the studies include:
  - significantly greater 'whole-system' interactions that span transmission, distribution and customers,
  - the importance of scenario approaches to planning,
  - the need for strategies to manage uncertainty,
  - the need to review the fundamentals of long-standing design and operational standards (ER P2/6, security of supply is currently under review),
  - a re-examination of the speed of distribution system protection devices, and,
  - new approaches to the treatment of diversity of demands, generation and storage sources.
- A further high level observation from the project is that changes can be anticipated to the control, communications and data systems with which we are familiar today. Centralised control rooms, point to point communications, and bespoke data protocols and archiving will require review. These matters have been addressed at a conceptual level in the project and point towards the need for architecture and strategic road-maps in these areas, so that as smart network solutions and new commercial arrangements increase in penetration, their ICT systems build towards co-ordinated designs that facilitate agreed data sharing, devolved systems integrated with centralised systems, and robust cyber security and data privacy.

Piecemeal developments and bespoke systems are an entirely suitable approach at an exploratory stage (for example the successful Low Carbon Network Fund projects), but as these smart solutions become Business as Usual, a co-ordinated development path will be needed if stranded assets are to be avoided and seamless services offered to customers and third parties. Application of smart solutions must consider their interaction and interface with the network and the operation and business context in which they will operate. Some aspects of this may require 'investment ahead of need' and an approach developed jointly between ourselves and the Regulator will be helpful.

- The challenges revealed by the DS2030 modelling are not unique to the GB power system. Similar issues have been identified through an international review that formed part of the project. However, generalisations can be problematic as the design philosophies of national systems differ, which can make a material difference especially when conditions approach design limits. Fundamental network design reviews for the GB system will need to be cognisant of developments in international standards, most particularly emerging European network code obligations.
- DS2030 findings include a high level examination of network losses. The DS2030 report discusses how deploying smart solutions such as Real Time Thermal Ratings to raise the utilisation of network assets will inevitably increases losses, whilst others also incur inherent losses due to their operation for example Energy Storage. A question for further consideration is how this should be viewed in 2030 under conditions where it is expected that these losses will be supplied from carbon-free renewable generation, having near-zero marginal cost.
- Finding solutions to the network challenges identified by the modelling is likely to require dialogue between many more parties than has been the case to date. Involving for example, network operators, generators, suppliers, aggregators, energy service providers, equipment manufacturers and vendors and standards bodies. Furthermore the scope of this interaction will extend far beyond traditional power system equipment and will include consumer appliances, home energy management, electric vehicle charging, and in the future cross-vector interactions with the gas, heat, hydrogen and transport sectors. Today's industry governance frameworks require review for this very different mix of stakeholders and the speed of response that will be expected by customers and third parties. It is timely that DECC have instigated the Future Power System Architecture (FPSA) project that is exploring these changes of requirements in further detail.



Innovation is at the core of SP Energy Networks. We have the ambition and capability to lead the industry by innovating in the best interests of our customers and wider stakeholder to reduce costs and facilitate the transition to a low carbon economy while continuing to improve customer service, security of supply and network performance.

At SP Energy Networks we welcome new ideas and collaborations, so if you have an innovative idea or solution that you would like to discuss please contact us via the email address below.

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