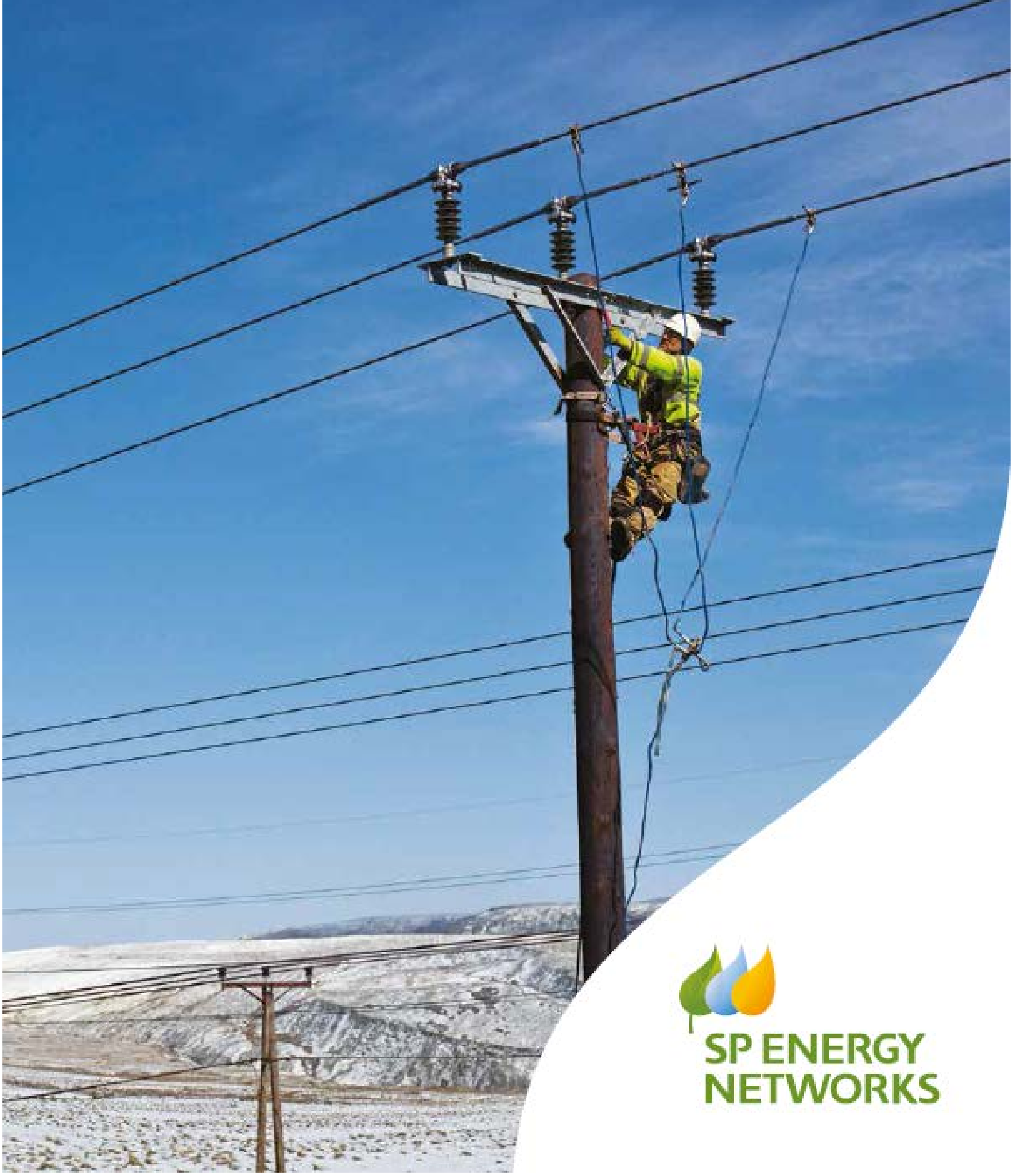
NIA Annual Report

2016/17

For SP Distribution plc. and SP Manweb plc.



SP ENERGY NETWORKS

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Foreword

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.) and is leading the industry across a number of areas with our wide and varied innovation portfolio. We have a continued drive, ambition and capability to be at the forefront of innovation in the best interests of our customers and wider stakeholders.

We have a major focus on network flexibility and commercial innovation as outlined in our recently published 'Distribution System Operator Vision which provides a clear message of our desire to transition towards becoming a Distribution system operator (DSO). In support of this vision we are actively engaged with the ENA Open Networks project which is a major energy industry initiative that will transform the way our energy networks work, underpinning the delivery of the smart grid. The changes it will make will give the UK's households, businesses and communities the ability to take advantage of a new range of energy technologies and services, including renewable generation, battery storage and electric vehicles, to take control of their energy and lower their costs.

This is our second Network Innovation Allowance (NIA) Annual Distribution Report and is an overview of the projects we have initialised during the regulatory year 2016/2017 and an update on those projects reported during 2015/2016 that are still active.

In response to Ofgem's 2017 Network Innovation Competition (NIC), SPEN invited third parties, for the first time, to submit applications. These applications were requested to address the key challenges that our network faces now, or will face in the future. This resulted in a healthy response with a range of innovation ideas being presented. As a consequence of this third party challenge SPEN is currently developing two NIC projects submissions:

1. LV Engine which aims to add flexibility to LV networks by informing the design and selection of intelligent secondary transformers to enable the cost effective uptake of low carbon technologies (LCTs) ; and
2. FUSION which will implement the Universal Smart Energy Framework (USEF) across North East Fife as a new open access market place for flexibility.

We were delighted that SP Energy Networks was the main sponsor for CIRED 2017. This is the leading forum where the Electricity Distribution Community meets and this year it was held in June at the Scottish Exhibition and Conference Centre (SECC) in Glasgow. We presented on a number of our projects and showcased how innovation is delivering customer service improvements and greater efficiency. We also communicated our vision for the evolution to a DSO.

Our innovation focus remains firmly centred on our customers and stakeholders, who shape both our Innovation Strategy and innovation project portfolio that could help towards the successful delivery of our RIIO ED1 Business Plan for 2015 (1st April) through to 2023. Given the challenges and opportunities facing our energy system this emphasises the need for a stable regulatory framework to fund effective and efficient innovation activities through ED2.

Similarly to our third party challenge for innovation ideas under NIC, SPEN welcomes third parties to submit innovative ideas for potential NIA projects.

Colin Taylor**, Director of Engineering Services**

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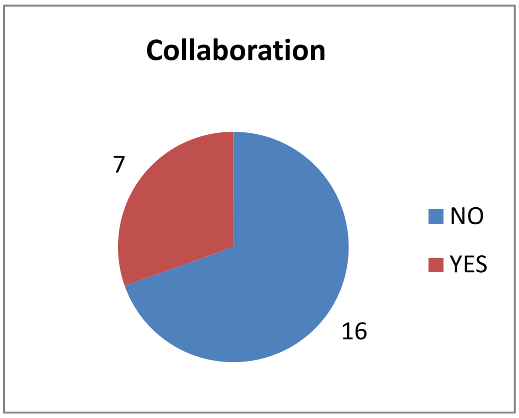
Executive Summary

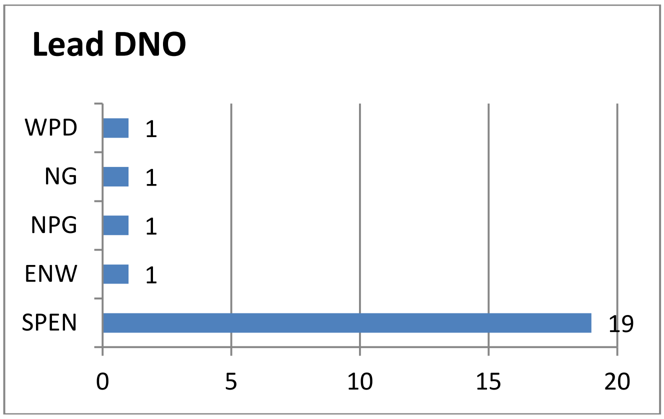
This Network Innovation Allowance Annual Distribution (NIA D) Report has been compiled in accordance with Ofgem's Electricity Network Innovation Allowance Governance Document which sets out the regulation, governance and administration of the Electricity NIA. This second NIA D Annual Report presents an overview of the projects we have initialised during the regulatory year 2016/2017 and an update on those projects reported during 2015/2016 which are still active.

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

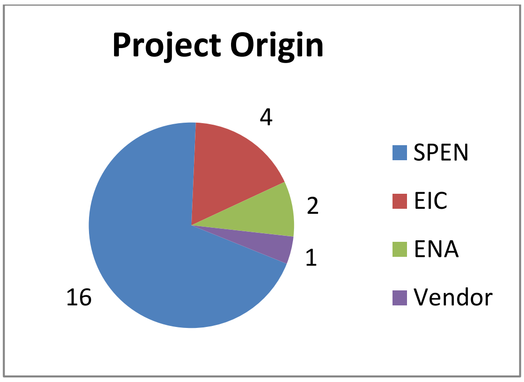
Key Facts at a Glance

In total, this report details 23 NIA projects that we are involved in, with the objective of applying relevant learning to realise business benefits.





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



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, as illustrated above.

1 Introduction

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

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

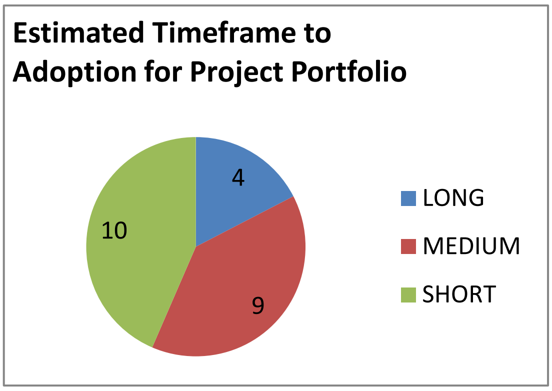
SPEN is committed to identify innovative performance improvements across all aspects of our business.

In ED1 there is increased need to ensure that innovation is embedded into all business function, as such the role of our Innovation Strategy Board is to ensure increased participation from all business functions and to allow innovation projects to be completed and integrated into Business as Usual (BaU). Our Think Big, Start Small, Scale Fast approach to innovation enables us to be at the forefront of innovative practice and is embodied in our guiding values. At 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.

Estimated Timeframe to adoption

Short:	Deliver benefits within 12/24 months
Medium:	Deliver Benefits 2-4 years
Long:	4 year +
N/A:	Research Project



2 Progress Summary

During the reporting year 1st April 16 to 31st March 17 SPEN registered the following eight NIA Distribution projects:

Project No.	Project Name	Project Start Date
NIA SPEN0012	**SINE Post** http://www.smarternetworks.org/Project.aspx?ProjectID=2048	**Jan-17**
NIA SPEN0013	**Interoperable LV Automation** http://www.smarternetworks.org/Project.aspx?ProjectID=1968	**Sep-16**
NIA SPEN0014	**Active Fault Level Management (AFLM)** http://www.smarternetworks.org/Project.aspx?ProjectID=2052	**Feb-17**
NIA SPEN0015	**Real Time Fault Level Monitoring (RTFLM) – Stage 1** http://www.smarternetworks.org/Project.aspx?ProjectID=2038	**Jan-17**
NIA SPEN0016	**Network Constraint Early Warning Systems (NCEWS)** http://www.smarternetworks.org/Project.aspx?ProjectID=2039	**Feb-17**
NIA SPEN0017	**Secondary Communications Phase 2 – Consultancy Engagement** http://www.smarternetworks.org/Project.aspx?ProjectID=2033	**Jan-17**
NIA SPEN0018	**Technical Review of Non-conventional Statcom Applications** http://www.smarternetworks.org/Project.aspx?ProjectID=2043	**Feb-17**
NIA SPEN0019	**Operational Assessment of Composite Poles** http://www.smarternetworks.org/Project.aspx?ProjectID=2057	**Feb-17**

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

Project No.	Project Name	Project Start Date
NIA WPD 0008	**Improvement Statistical Ratings for OHL** http://www.smarternetworks.org/Project.aspx?ProjectID=1735	**Jul-15**
NIA NGN 142	**Project CONCUR** http://www.smarternetworks.org/NIA_PEA_PDF/NIA_NGN_142_3113.pdf	**Mar-16**
NIA WWU 0025	**Project Futurewave Phase 2** http://www.smarternetworks.org/Project.aspx?ProjectID=1736	**Apr-15**
NIA NGGD 0072	**Project Futurewave Phase 3** http://www.smarternetworks.org/NIA_PEA_PDF/NIA_NGGD0072_2028.pdf	**Feb-16**
NIA NGET 0135	**Reactive Power Exchange Application Capability Transfer (REACT)** http://www.smarternetworks.org/Project.aspx?ProjectID=1861	**Apr-15**
NIA ENWL 0003	**Review of Engineering Recommendation P2/6** http://www.smarternetworks.org/Project.aspx?ProjectID=1723	**Apr-15**
NIA SSEPD 0006	**Ultrapole** http://www.smarternetworks.org/Project.aspx?ProjectID=1667	**Apr-15**
NIA NPG 0001	**Vonaq Utility Pole Strength Measurement** http://www.smarternetworks.org/Project.aspx?ProjectID=1687	**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 (http://www.spenergynetworks.co.uk/pages/innovation.asp) and on the ENA Learning Portal (http://www.smarternetworks.org). Key learning associated with these projects is summarised in Section 6.

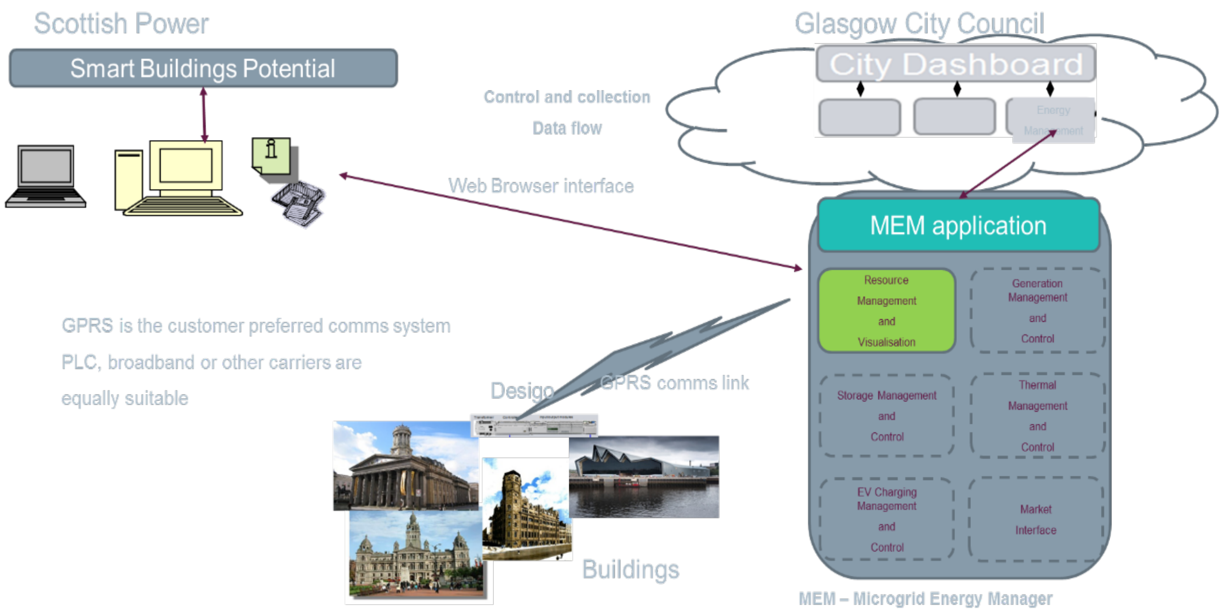
3 NIA Projects Led By SPEN

3.1 NIA SPEN0001 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 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 SPEN0001 Project Progress

Physical DSR Implementation

DSR was implemented in 10 buildings and found to be successful in 6. Poor comms (4G) resulted in issues being masked and data being lost. From the DSR trials, the following overall observations were made:

- The level of load under Building Management System (BMS) control varies considerably across building archetypes, affecting the load available for DSR;
- The average load reduction possible varies according to factors such as building type, season, time of day and time of week; and
- The average load reduction possible was around 20% of the total BMS-controlled load, illustrated in Figure 1 below.

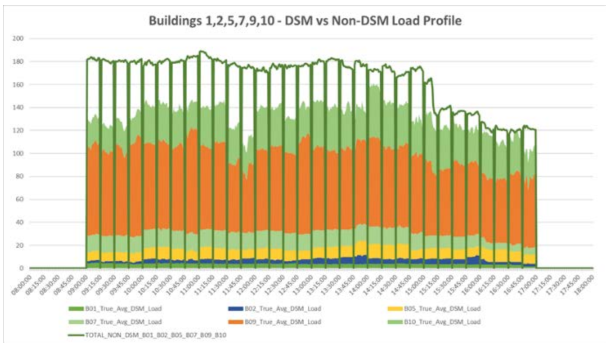


Figure 1 Load Reduction Seen In Trial Buildings

Note that the maximum building demand was calculated to be 893kW (for Buildings 1,2,5,7,9,10) and the total load available for demand reduction was 280kW, which equates to a theoretical maximum reduction of 31%. Therefore, the average demand reduction of 20% of load controlled by the BMS across the period of a year seen in live trials, equates to about a 7% reduction overall.

Network Modelling

A number of different scenarios were modelled, which looked at possible load growth outcomes for the network from increased deployment of a range of technologies. The following observations were made:

- The impact of a number of low-carbon technologies on the network load profile varied considerably with some (heat pumps) reducing network peaks in the short-to-medium term and others (Electric Vehicles) significantly increasing peak loads anticipated;
- The impact of increased cooling load in the future is likely to present the greatest challenge to city-centre networks; and
- Increased penetration of heat pumps is unlikely to adversely affect network until penetration > 60%.

Whilst the impact of cooling should be closely monitored, if we look at the annual load profile of an existing city centre feeder – illustrated in Figure 2 below – the winter load is still the most critical. Therefore, until such time as cooling presents a significant load to the network, winter – January in particular – will continue to be the peak loading period for a city centre network.

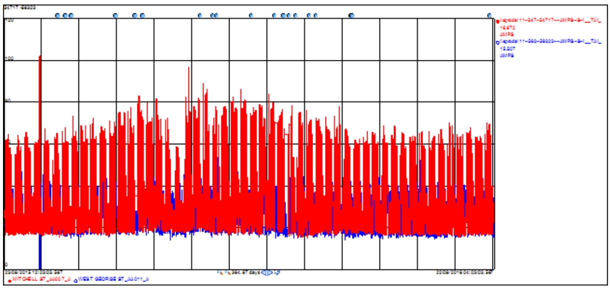


Figure 2 Annual Load Profile of City Centre Feeder

Business Case

From the business case, the following observations were made:

- DSR is unlikely to be cost-effective as a standalone implementation that supports the network only – it must be done in conjunction with other, established load control mechanisms (Short Term Operating Reserve (STOR), etc.) and tariff benefits.
- As the level of DSR required increases, the cost of installing the equipment approaches that of traditional network reinforcement
- Increasing the amount of load controlled by the BMS will improve the cost-effectiveness of DSR
- As the price of DSR equipment drops, the business case to install it become more compelling with paybacks of less than 5 years achievable in some circumstances
- If DSR is procured by the DNO as a service, with the cost of DSR implementation borne by the building operator or an aggregator, it becomes considerably more cost-effective and could rival the cost of traditional reinforcement.

- DSR could play a significant role for a future Distribution System Operator (DSO), allowing localised control of loads
- If incentives are targeted correctly, business case of STOR can be improved which in turn will encourage more building owners to install DSR capability within their buildings.

3.2 NIA SPEN0002 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:

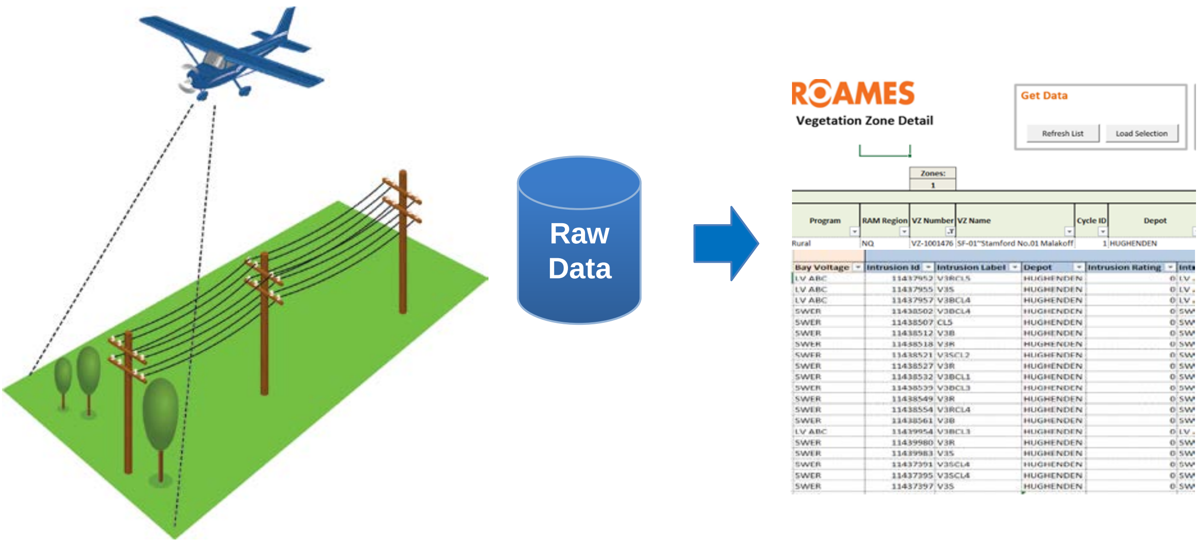
- It goes without saying that Manual Inspections are inherently labour intensive, requiring every km of OHL network to be inspected on foot. As a result they may not provide DNOs with the most financially beneficial and timely solution and the frequency at which they are undertaken is limited.
- Whilst 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 VWAM system, quantify its accuracy, performance, capabilities and the impact it has on several DNO work programmes, provide evidence and guidance to support the decision to adopt VWAM as Business as Usual.

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

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



3.2.1 NIA SPEN0002 Project Progress

Year 2 of this innovative project has seen the succesful completion of flights in both the SP Manweb (SPM) and SP Distribution (SPD) license areas. 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 during Year 1 (2015), and in conjunction with the findings of an earlier IFI funded ADAS Study (IFI 0625), we concluded that a vegetation growth model could not be achieved from LiDAR data alone, at least not with only two years of evidence. The VWAM model returned from Year 1 data capture was impressive; however a number of iterations were required to achieve the current level of accuracy. SPEN also identified improvement areas over the remainder of the project, such as missing LV Services and Mains, incorrectly identified H-Poles, incorrectly identified road crossings and data matching issues.

Due to Year 1 outcomes a variation to the project was submitted to Ofgem, to gather data from alternative network areas, primarily as a response to the business desire to develop a solution capable of providing an accurate model from one flight. This decision enabled both SPEN and our collaborative partners to improve the asset detection capabilities and implement an enhanced QA process; whilst also ensuring that a larger number of internal resources where able to benefit and input into the project.

Key modifications to the project for year 2 data capture:

- Flying the planes at a slightly lower altitude
- Using multiple sensors with differing wavelengths
- Improving the asset identification process by utilising additional manual interventions and improved QA process
- Flying new areas of network covering multiple regional operational bases

These changes resulted in both improved quality of data returned and increased levels of network captured; with significant improvements witnessed for the LV voltage service connections when compared to Year 1. The nominal reductions in accuracy for higher voltages have been attributed to variations within SPEN's GIS data.

	33kV	11kV	LV Main	LV Service
2015 Data Capture	100.02%	100.45%	97.93%	26.31%
2016 Data Capture	98.8%	99.8%	94.1%	41.3%

Business Case

The project has identified a number of hard and soft benefits which provide a robust business case for BaU adoption for network inspections using LiDAR.

Potential benefits identified include:

- Reduction in faults cause by 'Growing of Falling Trees' through the use of improved auditing and targeted vegetation management.

- Reduction in inspection costs through the collection of automatic ground clearance information.
- Audit of Vegetation Management and improved proximity information leading to improved network safety performance.
- Improved network visibility leading to greater ability to plan, prioritise and audit ESQCR work load, including low ground clearance, pole lean, sag and vegetation / structure intrusions.
- Improve understanding of network location aiding network design
- Improved customer service.
- Improved location information leading to greater understanding of potential wayleave issues.
- Improved information for ETR 132 reporting and auditing.

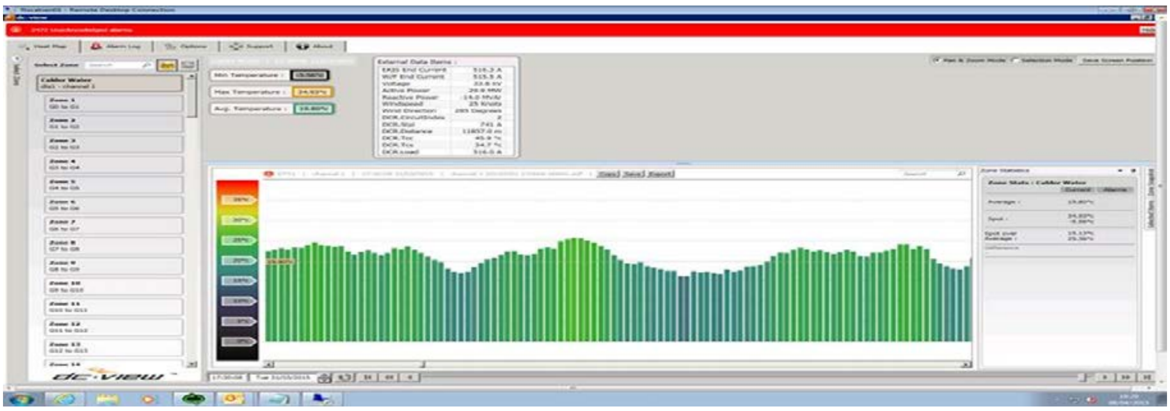
3.3 NIA SPEN0003 Enhanced Real-Time Cable Temperature Monitoring

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

A 12 month period of DCR data was collected and analysed to enhance the confidence in the DCR system and also demonstrating the seasonal cable temperature variations. Figure 3 shows the cable conductor and fibre temperature variations of Calder Water for a 12 month period. The calculated conductor temperature recorded in this period is below 60°C in majority of time. As the maximum permissible temperature of the cable circuits are 78°C, there would be a 18°C temperature headroom available for additional wind power generation.

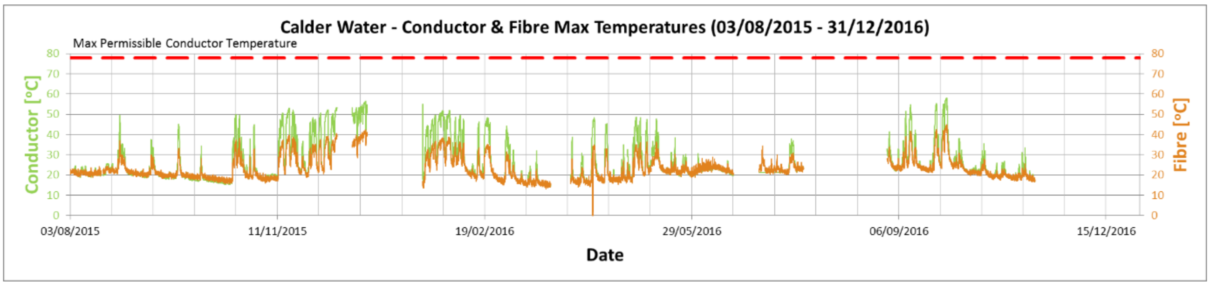


Figure 3 – Variation of the cable conductor and fibre temperature

Following the data analysis on the DCR data, we recognised that there might be an opportunity to size the cable circuits based on a cyclic rating approach. In this regard, University of Southampton (UoS) was commissioned to investigate the feasibility of cyclic rating consideration for wind farm cable circuits. Some of the outcomes of these studies:

a. A cyclic loading profile shown in Figure 4 was considered a fit-for-purpose profile for wind farm cyclic rating. The parameters of this load profile was calculated based on data analysis on the 2 years historic windfarm generation.

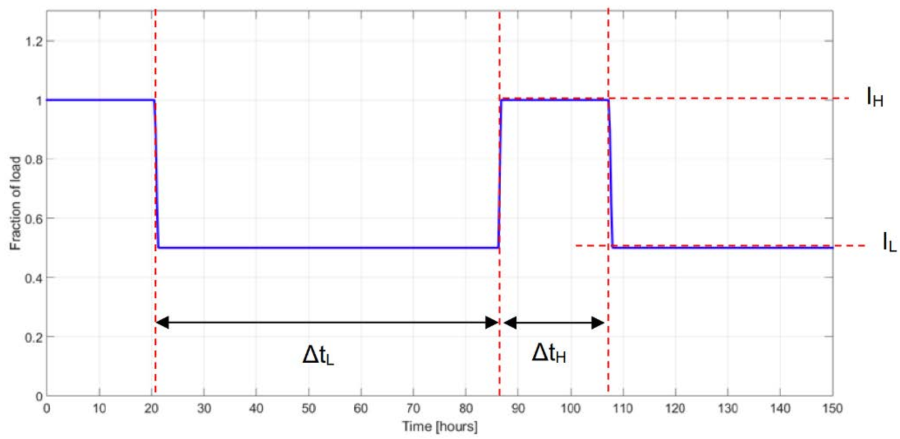


Figure 4 Cyclic load profile considered for wind farm outputs

A cyclic cable rating for renewables (CRR) tool was developed to convert historical loadings or wind farm outputs into representative cyclic load profiles for use alongside a business-as-usual cyclic rating tool, such as Cable Rater (CRATER) and CYMCAP. Figure 5 shows the dashboard of the cyclic calculator tool.

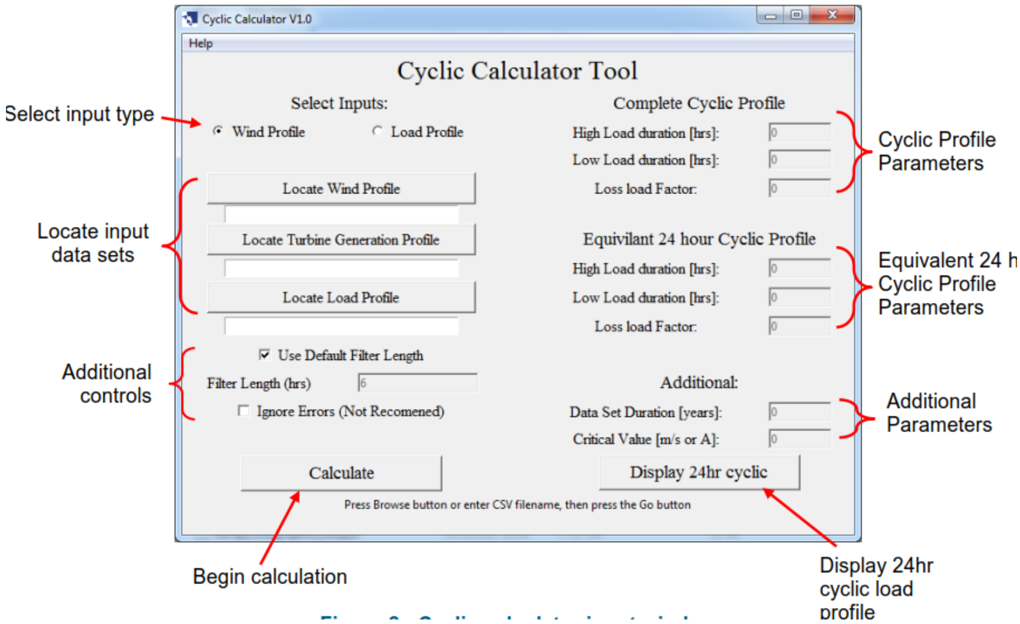


Figure 5 Cyclic Calculator Tool Dashboard

Figure 6 illustrates an example of conversation which can be carried out by the cyclic load profile tool.

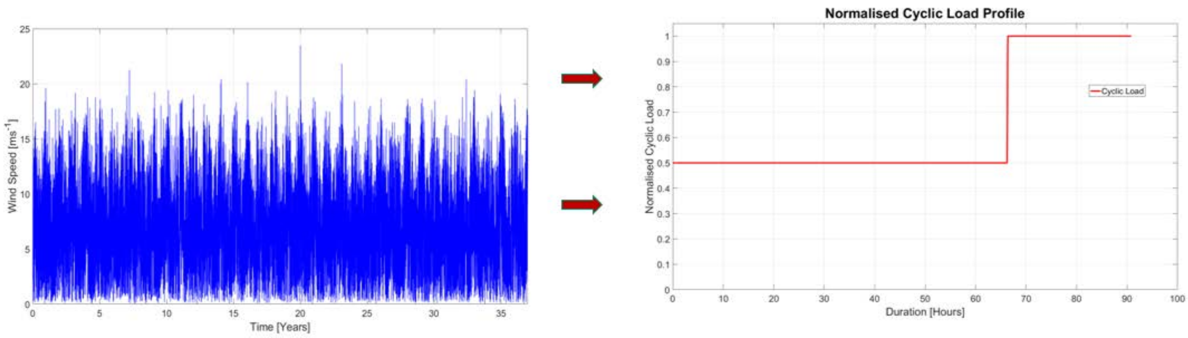


Figure 6 An example of the conversation by the cyclic load profile tool

A conservative cyclic rating was calculated for different cable sizes based on the onshore wind regimes samples in North and South Scotland. These cyclic ratings was compared with the continuous cable ratings given in our internal Asset Rating policy document which is a reference document as part of the BaU connection planning practices to size of the cable circuits. The results are shown in Table 1. We have disseminated internally that there is an opportunity to update our Asset Rating policy document to include Table 1 and size the windfarm cable circuits based on the calculated cyclic ratings.

Table 1 – Wind farm cyclic rating compared with the BaU continuous rating

Cable	Continuous		TDHVL Wind Farm Cyclic	
	Laid Direct	Ducted	Laid Direct	Ducted
150 mm^2 Al	296	282	335	327
150 mm^2 Cu	378	350	425	403
240 mm^2 Cu	488	436	546	498
240 mm^2 Al	385	350	432	411
400 mm^2 Al	495	446	567	523
500 mm^2 Cu	693	597	779	681
630 mm^2 Cu	772	660	861	744

The project has now been completed and a project close-down report will be produced which will include the work carried out, project outcomes and lessons learnt.

In order to facilitate the integration of DCR into business as usual a technical specification of the DCR system was developed, reviewed and is now a live document within SPEN.

We have also prepared a draft of policy document which provides guidance about the network conditions where DCR should be considered as a solution for monitoring the thermal rating of the cable circuits. DCR is not a retrofitted solution and the installation of micro-ducts at the time of cable installation is essential. Therefore, we have recommended in our proposed policy document that the consideration should be given to install micro-ducts as a minimum for those circuits which may benefit of DCR solution in the future.

We have conducted extensive internal dissemination with SPEN planning and operation teams to share the knowledge and findings of the project and also discuss the BaU requirements and adoption of DCR solution.

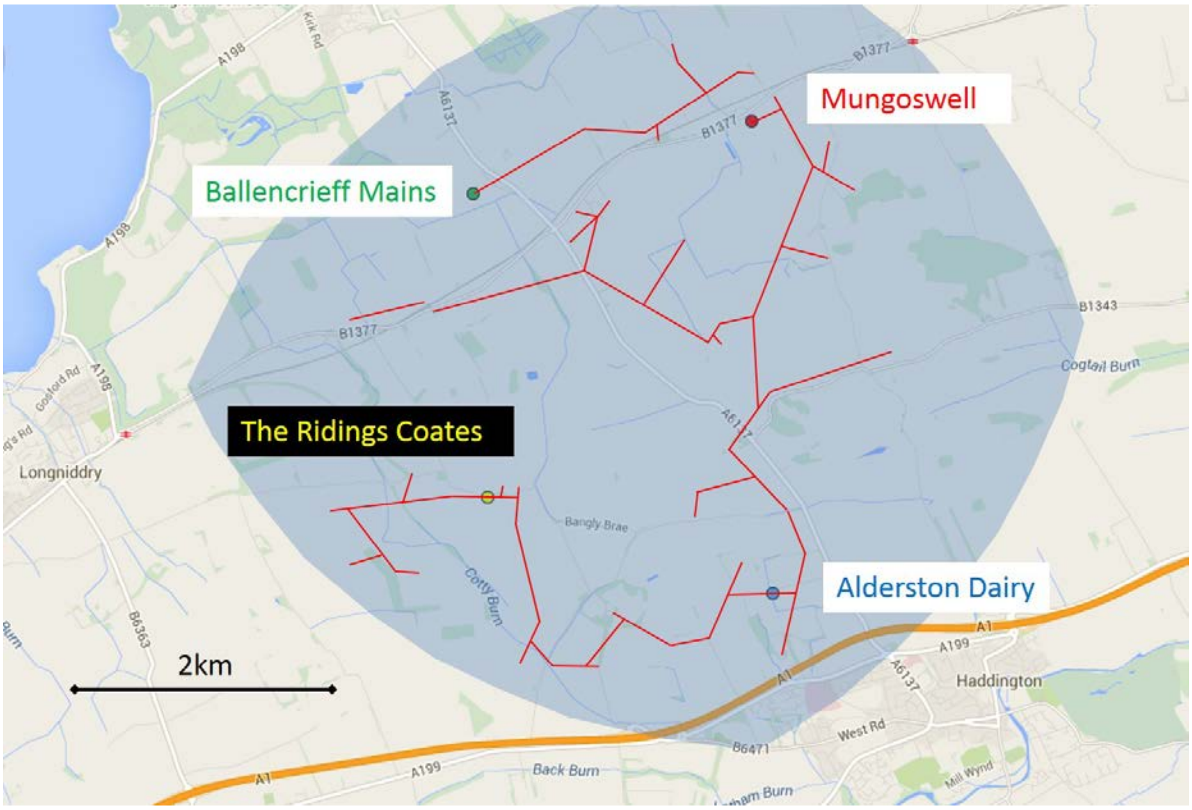
Information and data from our DCR system were shared with the University of Manchester in order for further research to be carried out. Subsequently, two MSc dissertations were produced, namely the "*Modelling and Control of Battery Energy Storage Systems and Cable Temperature for Windfarms Application*" and the "*Optimization of Energy Storage Systems for Wind Farms under Cable Temperature Monitoring*" theses.

3.4 NIA SPEN0005 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 location of faults using the radiometric approach relies on accurate timing of the arrival of the fault induced arcing signal at several receiving points which are geographically dispersed around the OHL network. When an arcing fault occurs, the radiated signal travels outwards from the fault at the speed of light. By calculating the differences in the arrival times from the receiving stations, the position of the fault point can be calculated mathematically, using a similar system used for lightning location systems.

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.



RAFL Trial Location

3.4.1 NIA SPEN0005 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.

View Inside The RAFL Cabinet **RAFL Cabinet In Situ At Ballencrief Mains Site**

Propagation Tests

During an OHL fault, the insulation of the HV conductor is compromised resulting in the rapid development of an unwanted current path, either to the ground, or between the phases, due to arcing. The initial breakdown of the insulation leads to an extremely rapid rise in current – i.e. within a timescale of < 1us - that is sufficient to generate radio-frequency (rf) radiation.

A knowledge of the magnitude of the rf signal radiated from the fault site is needed to estimate over what distance the arc may be reliably detected. Consequently, a test was set up using an 11 kV normally-open-point, pole-mounted Air break Switch dis-connector (ABSW), which was operated to generate arc induced rf radiation. The radiated signal was measured from a vehicle equipped with a roof-mounted 1.5m monopole antenna connected to a 300 MHz bandwidth oscilloscope. With the vehicle adjacent to the pole (11 m distant), the operation of the ABSW produced a signal as shown in Figure 7; and Figure 8 shows the same effect at a distance of 162 m.

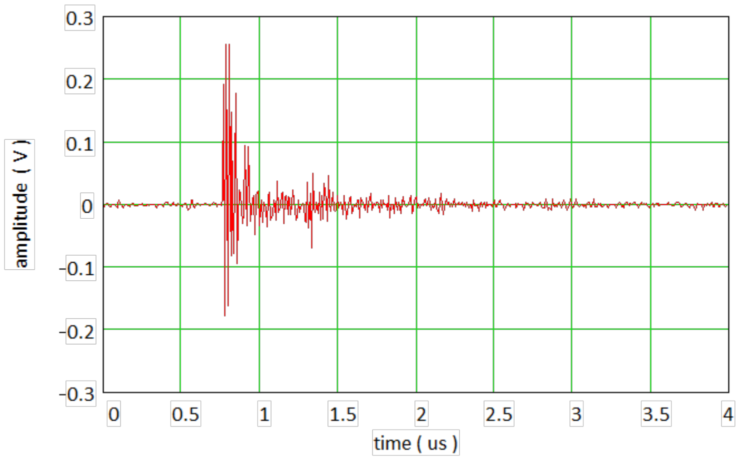


Figure 7 11m Test

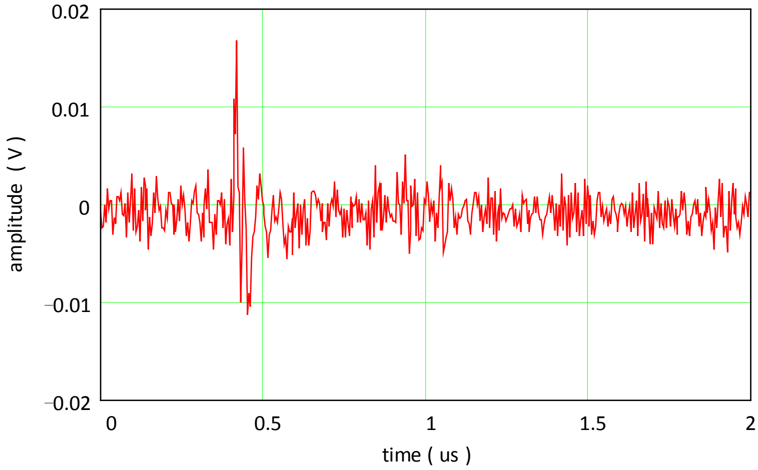


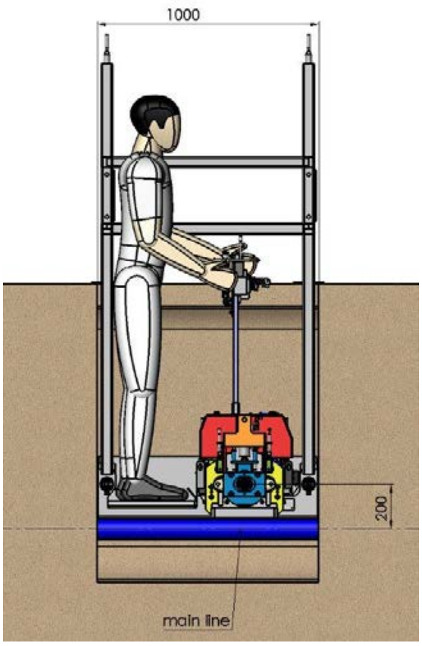
Figure 8 162m Test

It can be seen that the act of closing the air break switch (ABSW) produces an impulsive 'spike' in the signal measured by the oscilloscope. The impulsive spike signals were similar, but not identical, for repeated operation of the ABSW; there was no discernible difference between opening or closing operations.

Although the propagation distance during the test was very small – in the range between 162m and 668m - the voltage change which caused the arc was at least an order of magnitude smaller than would be expected during a genuine arc fault. Consequently, it is hypothesised that genuine arcing faults will radiate signals that can be detected at distances of several km.

3.5 NIA SPEN0006 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.

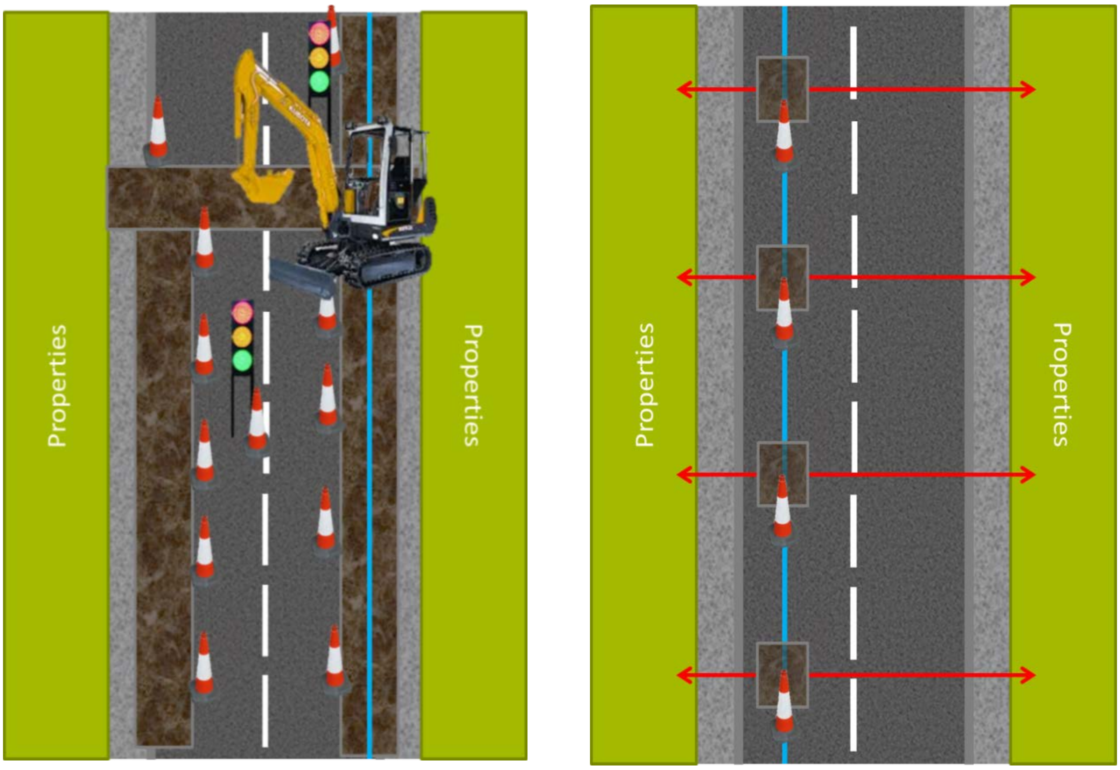


Although the merits of conventional open cut trenching are well known there is an intrinsic risk to home owners and members of the public. To develop an alternative solution to this problem SPEN has been working with R&D partner, Tracto-Technik (TT), to design an innovative trenchless technology system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

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

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



Traditional Method **Mini Mole Method**

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

3.5.1 NIA SPEN0006 Project Progress

The project duration has been extend by 18 months due to delays in the construction of the first prototype unit, several months were spent on attempting to bring the size and weight down sufficiently so that it could be mounted on a trailer. Unfortunately this was not possible and the prototype had to be redesigned to fit onto a flatbed truck.

The first prototype has now been constructed with delivery due in the summer, with training for safe and correct use of the equipment planned to take place in July, with real jobs programmed for live trials of the equipment throughout the remainder of 2017.

3.6 NIA SPEN0007 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

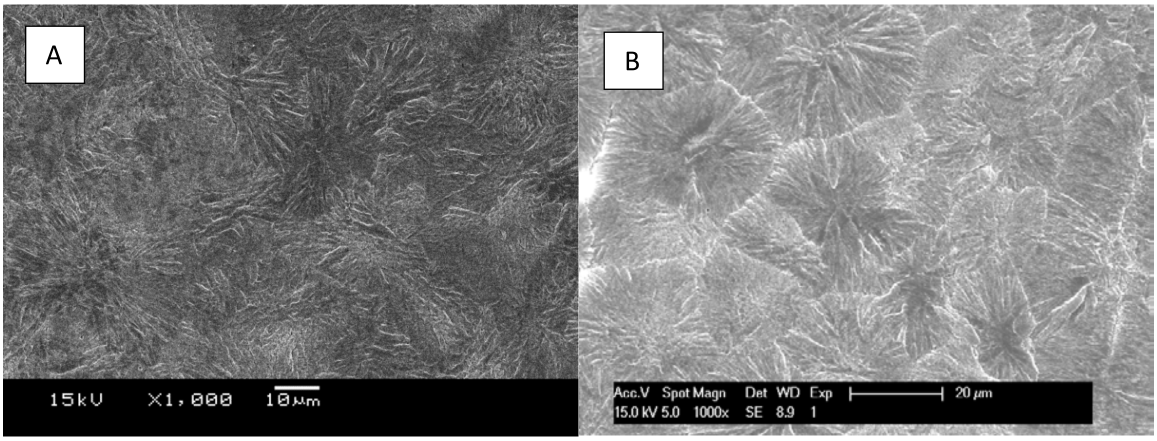


Figure 9 Electron micrographs showing A. a good blend, with no defined boarders between spherulites and no evidence of phase separation, B. a poor blend with sharp boundaries between spherulites and evidence of charging (brighter patches)

2. Performance of blends

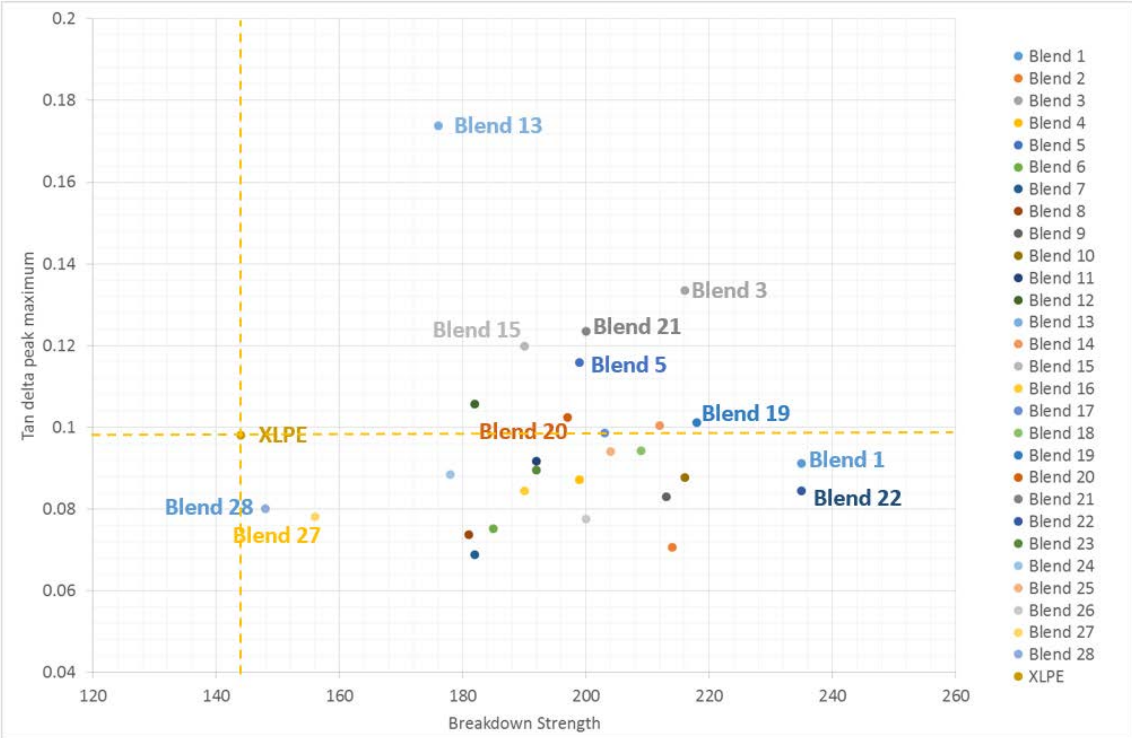


Figure 10 Plot of breakdown strength vs tan delta peak maximum for all blends and XLPE. Dashed lines show the minimum position for both parameters, as achieved by XLPE. Candidate blends for upscaling selected from those towards the top right of the figure.

3. Cable Manufacture and Performance

Figure 11 Picture showing the pelletised blend granules which are translucent with the corresponding extruded MV cable. The aluminium conductor has an adjacent black inner semiconducting screen and there is an outer screen bounding the insulation layer – this layer appears dark grey because the cross section acts as a black reflector.

4. Cable ratings

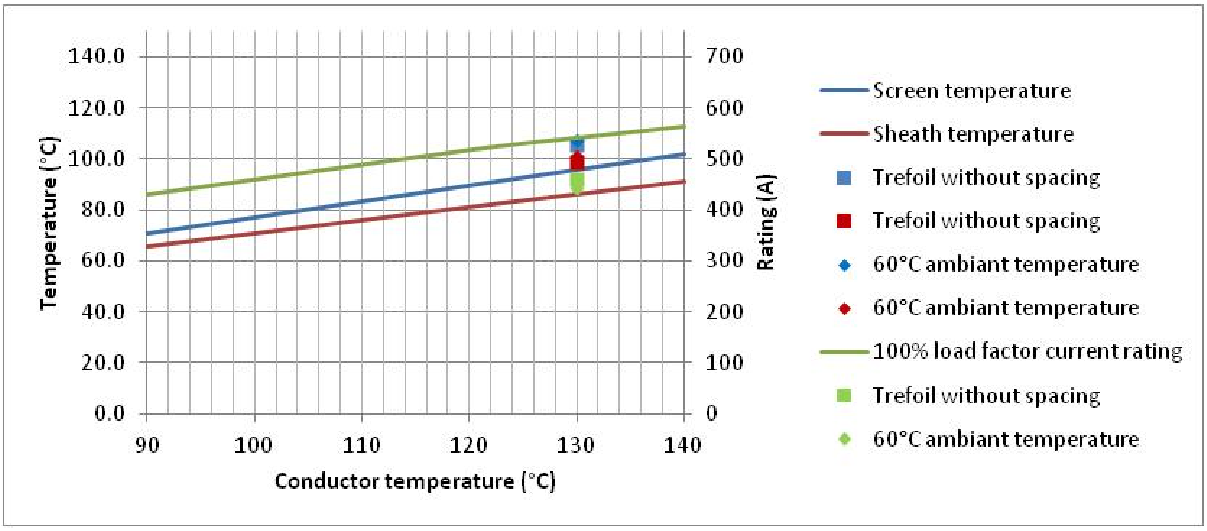


Figure 12 Cable rating calculations for different conductor temperatures, for cables laid in free space. Calculations are based on thermal conductivity data for the blends. Data suggests that at conductor temperature of 140°C (cable rating 564A at 100% load), the sheath temperature is approaching 100°C.

3.6.1 NIA SPEN0007 Project Progress

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

Cable manufacturing revealed that while cable making was possible with the new materials, the melt flow behaviour could not support commercial high volume cable manufacture due to feed rate constraints affected by melt phase viscosity limitations. Further modifications were made to the blend formulations in Figure 10 to overcome this constraint and 11 new quaternary blends were produced that are being evaluated with a view to selecting one to go into further cable manufacturing.

The cable extrusion trials started in October 2016 and are expected to continue into 2017 with associated assessment of short term performance before longer term testing begins. An example of the first MV cable produced to meet a common European standard design is shown in Figure 11 along with the polymer blend material used to produce it which was produced at 1 to 2 tonne level. The MV cable has satisfied the short term tests undertaken to date but it is planned that the long term tests should be undertaken on cable produced from a quaternary blend that will more closely match the materials will satisfy commercial production rates.

Thermal modelling of underground deployed cable showed the need for higher operating temperature cable sheaths and materials have been selected to meet this requirement. This modelling was extended to cover HVAC as well as MVAC cables and both are considered to be manufacturable. Review work was completed on the deployment options for both MV and HV cable designs and this was reinforced by an early dissemination workshop that was held in November 2016 in Glasgow and hosted by SPEN and the Offshore Renewable Energy Catapult to further consider distribution, transmission and offshore network applications. Delays in obtaining the materials from suppliers created some knock-on delays to later tasks including extrusion trialling and cable making but the project plan was reset to accommodate this. However, it is likely that the project timescale would need to be extended to enable the new cable to be long term tested. The cooperation and commitment of the cable companies who are co-funding the project remains high and they have engaged cable testing rigorously.

3.7 NIA SPEN0008 Environmentally Acceptable Wood Pole Pre-treatment Alternatives to Creosote (APPEAL)

Project APPEAL was registered in March 2016; it is a collaborative project between 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.

Wood Poles With Preservative Creosote

3.7.1 NIA SPEN0008 Project Progress

The project started in August 2016 with Stage 1 the 'Literature Review' now being completed.

The literature review was designed to identify a selection of environmentally acceptable preservative alternatives to creosote that would provide treated poles with a service life of at least 40 years with or without the application of supplementary pole protection products.

The project was paused after Stage 1 due to a change in the scope of the project and contractual changes to remove ENWL from the project and replace with UKPN.

The scope change of the project was to increase the accelerated testing by another two years to give four years of testing which would replicate 40 years of service life. This change was considered more appropriate for giving the DNOs a definitive answer on the identified preservatives suitability.

3.8 NIA SPEN0009 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

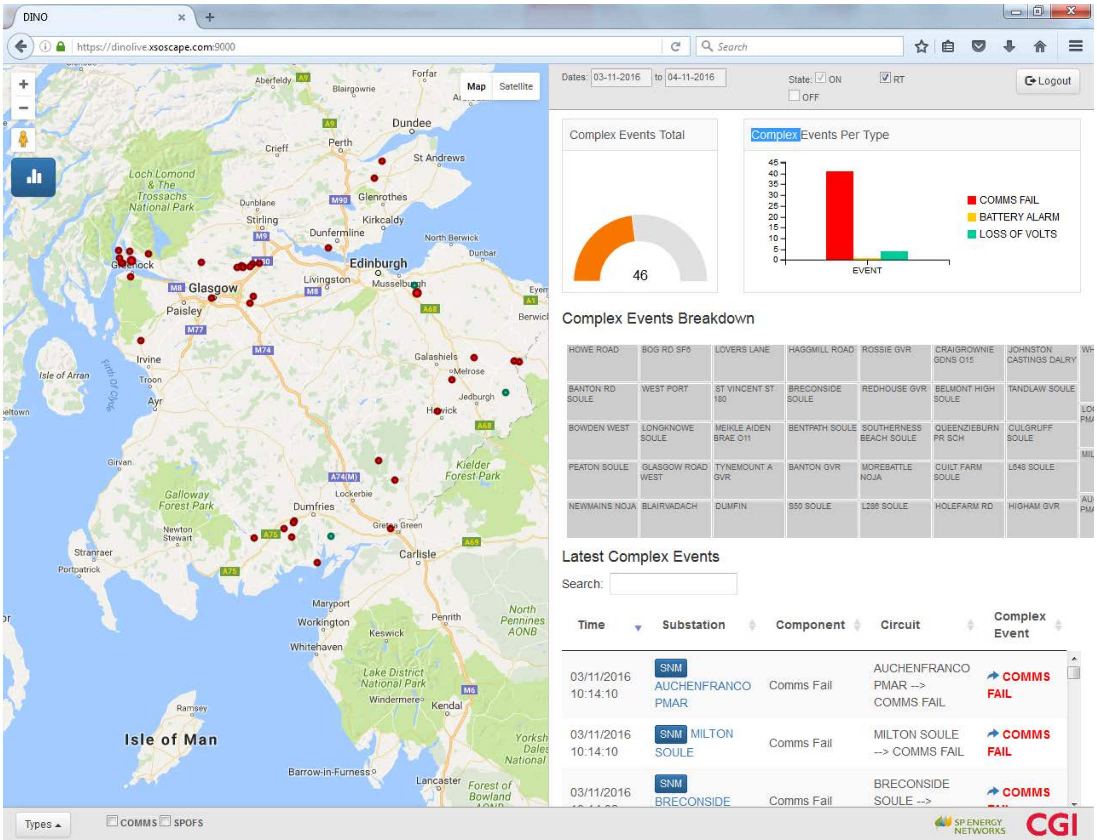
Passing data between multiple systems and ensuring that only one current version of truth exists is an ongoing issue for all DNOs. Without solving this it is hard to understand the full context (network, asset, and communications) that information relates to. As part of the process of identifying the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

3.8.1 NIA SPEN0009 Project Progress

A demonstration system using live SPEN network data has been developed and evaluated within the SPEN business. This allowed the business to identify the potential alternative use cases for the approach identified in this research project. The findings will be used to assist in our next steps in infrastructure procurement to support data management and in the next stages of our data innovation. The demonstration system showed that:

- An integrated network model with both network and communications connectivity can be maintained
- Complex Event Processor rules can be used to realise a business use case for improved handling of events and that these rules can be quickly enhanced to support other business requirements without rebuilding the platform
- Actual NCP alarm data has been presented and analysed in this context to give enhanced visibility
- This can be achieved without replacement or major change to existing systems


DINO
https://dinolive.xsoscape.com:9000
Map
Satellite
Dates: 03-11-2016 to 04-11-2016
State: ON OFF
RT
Logout
Complex Events Total
46
Complex Events Per Type
COMMS FAIL
BATTERY ALARM
LOSS OF VOLTS
EVENT
Complex Events Breakdown
HOWE ROAD
BOG RD SF6
LOVERS LANE
HAGGMILL ROAD
ROSSIE GVR
CRAIGROWNIE GDNS O15
JOHNSTON CASTINGS DALRY
BANTON RD SOULE
WEST PORT
ST VINCENT ST 180
BRECONSIDE SOULE
REDHOUSE GVR
BELMONT HIGH SOULE
TANDLAW SOULE
BOWDEN WEST
LONGNOWE SOULE
MEIKLE AIDEN BRAE O11
BENTPATH SOULE
SOUTHERNESS BEACH SOULE
QUEENZIEBURN PR SCH
CULGRUFF SOULE
PEATON SOULE
GLASGOW ROAD WEST
TYNEMOUNT A GVR
BANTON GVR
MOREBATTLE NOJA
CUILT FARM SOULE
L648 SOULE
NEWMAINS NOJA
BLAIRVADACH
DUMFIN
S50 SOULE
L286 SOULE
HOLEFARM RD
HIGHAM GVR
Latest Complex Events
Search:
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Component
Circuit
Complex Event
03/11/2016 10:14:10
SNM AUCHENFRANCO PMAR
Comms Fail
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SNM MILTON SOULE
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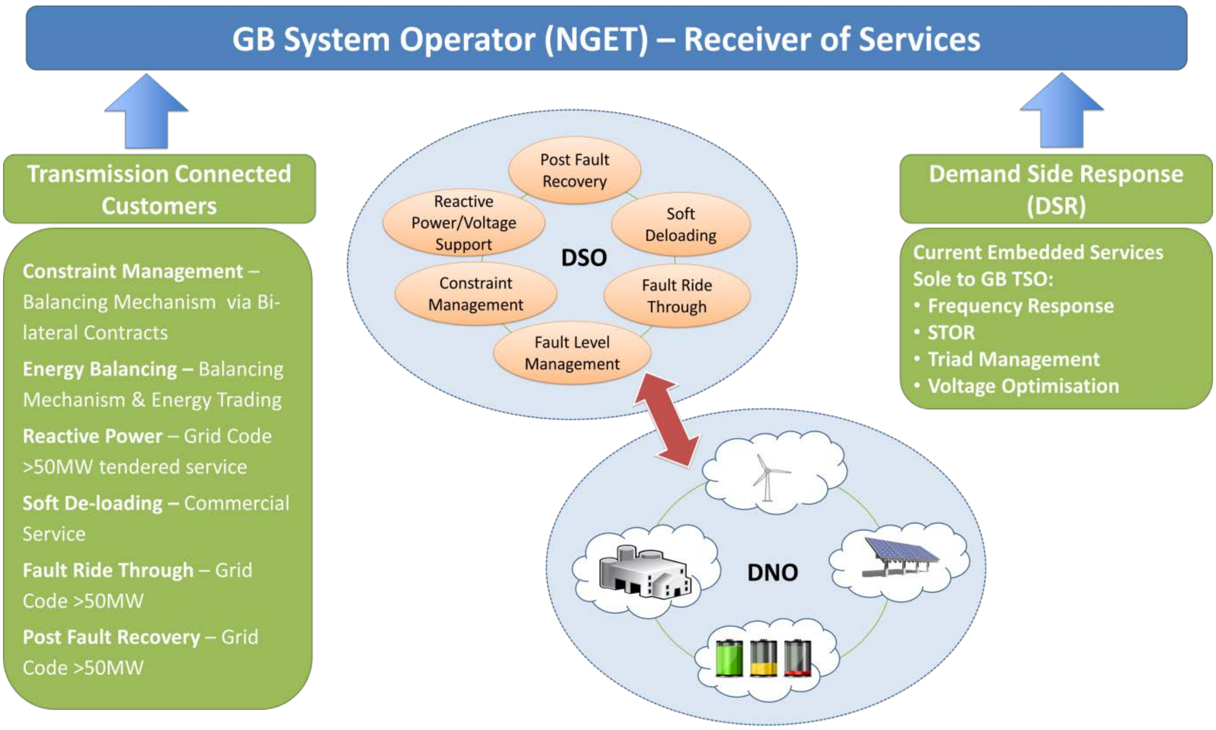
Types
COMMS
SPOFS
SP ENERGY NETWORKS
CGI

3.9 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.



3.9.1 NIA SPEN0010 Project Progress

The past 12 months has seen an acceleration of the industry as a whole towards better defining the needs and requirements for the future DSO. With this in mind SPEN created a DSO steering group bringing together leading industry figures representing key stakeholders. This group enable SPEN to publish the industry's first Vision Document in October 2016.

This landmark document provided a clear message of SPEN desire to transition towards becoming a DSO and has enable SPEN and the wider industry to accelerate the process. Since its publication the Energy Networks Association (ENA) has launch The Open Networks Project. This is as a major initiative SPEN is proud to be a part of that is in the process of re-defining how our energy networks will operate in the future as we head into a new smart era. The changes it will make will give the UK's households, businesses and communities the ability to take advantage of a new range of energy technologies and services to take control of their energy and lower their costs, including renewable generation, battery storage and electric vehicles.

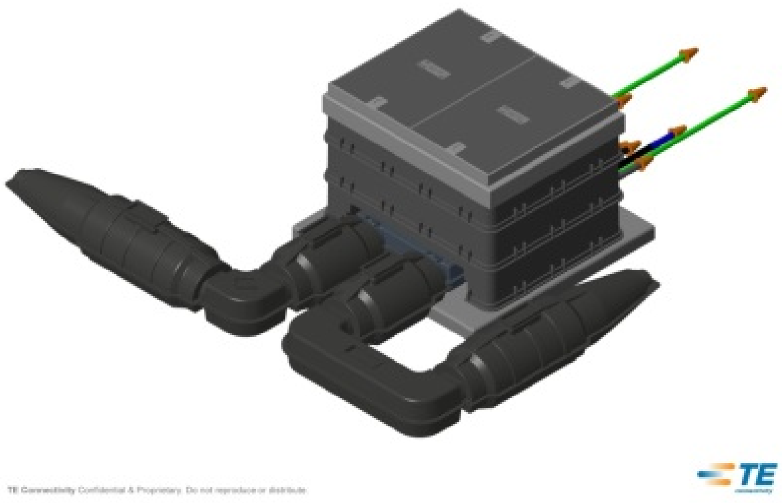
The Project brings together the leading minds in the UK energy industry, including all of the UK's electricity network operators, including National Grid, respected academics, NGOs, the Department of Business, Energy and Industrial Strategy and the energy regulator Ofgem.

SPEN will review the project at the end of Work Package 1 and ascertain if the project still ensures the best value for UK customers when considered alongside the Open Networks project.

3.10 NIA SPEN0011 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.

3.10.1 NIA SPEN0011 Project Progress

This project has been closed due to manufacture and installation problems identified with precast LV link boxes. This caused significant delays to the design and manufacturing process and the decision has been made to close the project early to ensure that resources can be better utilised.

3.11 NIA SPEN0012 SINE Post

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

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

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

SINE Post has the following objectives:

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

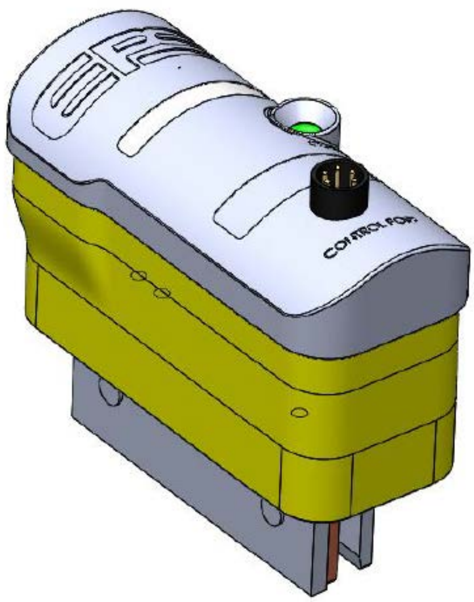
3.11.1 NIA SPEN0012 Project Progress

The first few months of the project have been spent undertaking a thorough mapping of the business requirements for the proposed solution. This piece of work will serve as the foundation for the developing the required architecture. It is expected that construction of the system will take place in the latter part of 2017.

3.12 NIA SPEN0013 Interoperable LV Automation

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

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



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

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

- Autonomously and remotely un-mesh and re-mesh the network
- Provide customer service improvements through fault re-closing (designed for higher network fault level)
- Interoperate with existing and emerging fault location solutions
- Interoperate with HV automation schemes
- Provide real time visibility of the LV network configuration
- Fit all types of LV boards

- Keep deployment costs to a minimum with a targeted price per LV circuit board way of <£2,000

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

3.12.1 NIA SPEN0013 Project Progress

The project was registered in September 2016, it is currently on-going and to date phases 1 & 2 have been successfully completed.

3.13 NIA SPEN0014 Active Fault Level Management (AFLM)

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

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

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

- **Model**: where power system modelling is used to support Fault Level Management, either as:
  - An operational means of FLM;
  - An input to FLM; or
  - for FLM.
- **Monitor**: where fault-level measurement methods either:
  - Enable the verification of network modelling methods and assumptions; or
  - Facilitate the online measurement of fault level for operational management purposes.
- **Mitigate**: where various techniques for fault current limitation are taken in real-time through physical fault current limitation or via protection actions.
- **Manage**: where control systems provide preventative avoidance of fault level infeed exceedance through control of demand and renewable generation to reduce fault level and create network headroom.

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

3.13.1 NIA SPEN0014 Project Progress

The project was formally kicked off in February 2017 with Smarter Grid Solutions appointed as the project partner. During the first two months of the project significant effort has been made to document potential alternatives for enhanced management of fault levels. A number of viable options have been identified and various workshops have been held with system designers, planners and operational staff to confirm applicability of solutions to both radial and interconnected networks. A number of locations have been identified both in the SP Manweb and SP Distribution areas for detailed fault level headroom release assessments to be undertaken. The studies are currently being undertaken and will inform the future cost-benefit analysis stage of the project.

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

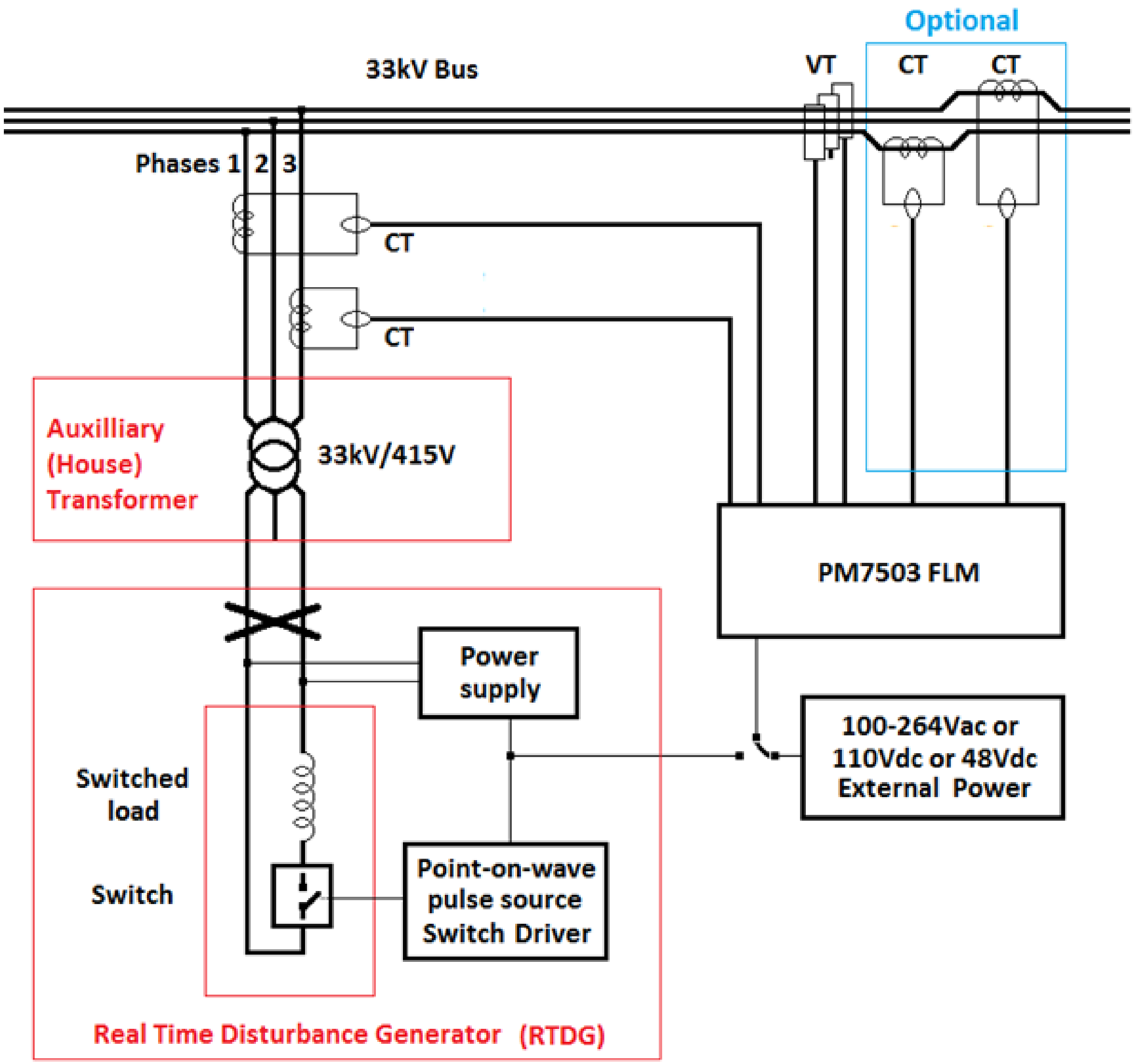
This project aims to develop and trial a novel Real Time Fault Level Monitoring (RTFLM) solution. The solution being developed to:

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

3.14.1 NIA SPEN0015 Project Progress

This project was registered in March 2017 and prototype development is on-going. The prototype version of the Real Time Fault Level Monitor (RT-FLM) has been tested at LV (nominal 400V) to examine the predicted versus actual fault current, motor contribution, and to see whether a change in source impedance can be assessed correctly.

The prototype system comprises all of the switching circuitry expected to be present in the final systems, but it has a higher inductance value for the switched load (to reduce the load current), and is lacking the temperature sensing instrumentation which will be used to monitor temperature around the system for the higher currents involved at the higher target voltages. The disturbance control and Fault Level monitoring are carried out by a PM7503 Panel Mount Fault Level Monitor.



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The tests were conducted on a domestic three phase switchboard, so Fault Level is very low, and although the voltage disturbances imposed on the network could be scaled down close to those ultimately expected to apply at HV, the currents involved were so small that the shapes of the disturbances through the (high current) switches were not entirely representative.

3.15 NIA SPEN0016 Network Constraint Early Warning Systems (NCEWS)

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

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

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

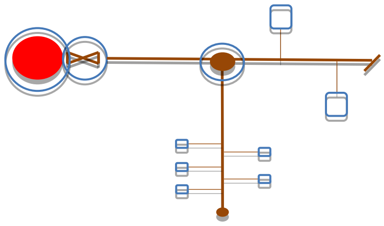
Specifically the projects will provide,

1. A first step visibility of previously unseen LV network behaviour from SM 'Profile Limit' data availability
2. Improvement in existing asset management LV connectivity models through investigation and specification of Data Analytical transformation requirements
3. Guidance on adaptive data monitoring systems that can react to system risk to provide increasingly granular levels of LV network behaviour visibility
4. Minimize overall SM data requirements through this adaptive monitoring capability
5. Define future data analytical requirements for integration of increasingly dynamic network profile data

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

- Establishment at Proof of Concept level the data analytical improvement techniques required within vectorised GIS asset management and connectivity systems
- Utilize a Data Science research associate partly funded by Innovate UK through their Knowledge Transfer Partnership (KTP) scheme to carry out low TRL research after direct application of available and test SM Data

3.15.1 NIA SPEN0016 Project Progress



The project has only been running for one month and we are currently still in the process of recruiting the KTP data scientist research associate. Good initial progress has been seen though on the formulation of the Proof of Concept data analytical platform to do the SM integration research on.

We have clarified how to turn our 'connected' vectorised asset management system into a data analytical node and line model. Key nodes will then be classified as SAVED nodes for investigation into Summarizing, Aggregating, Visualizing, Enquiring and Deriving the individual property SM 'sensor' data. This property level network sensor data will be installed as layer files of SM data per MPAN linked via the property Ordnance Survey UPRN. Methodologies have already been developed to gather the data at the key SAVED nodes with the ability to look down the network at all the individual multiple sensor data items available for network analysis. This will allow flexibility for a wide variety of different requirements to be researched. Key focus will be on visualization and access to the summarized data for network designers with the ability to use widget functionality to pick preformed configuration views and 'point and click' on SAVED nodes to deliver dashboard presentation of the full or summarized downstream individual sensor data.

3.16 NIA SPEN0017 Secondary Communications Phase 2 - Consultancy Engagement

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

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

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

3.16.1 NIA SPEN0017 Project Progress

The following project progress has been made:

- Analysis and review of both readily available and future looking telecommunication solutions:
    - Private network: VHF and UHF Point to Multipoint Digital Radio (P2MP-DR) and Private LTE (frequency to be selected; 450 MHz band is being proposed by EUTC).
    - Public network: 2G/3G/4G based.

- Comparative analysis of telecommunication solutions.
    - Proposal developed for Laboratory tests (e.g. PNDC). 3 MHz wideband low-power LTE communications between a central Control station and a small number of fixed outstations within a 300m radius.
    - Test sites Selection: Identified potential Trial site locations that best suits the objective of the project and that is representative enough to make the most of the different technologies. Desktop planning would be done beforehand.
    - In-depth study of the different solutions:
        - RTU requirements analysis (interfaces, throughput, traffic). Referenced to existing RTUs within Iberdrola.
        - Architecture: Radio network planning.
        - Spectrum feasibility study and further license management.
        - Draft cost analysis.
        - Backwards compatibility.
        - Scalability for Smart Grid expansion.
        - Cybersecurity.

3.17 NIA SPEN0018 Technical Review of Non-Conventional Statcom Applications

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

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

3.17.1 NIA SPEN0018 Project Progress

A Statcom Application Guide has been developed for use by network licensees. The contents of the application guide are listed in the project learning section.

We have commenced trialling the application guide by applying it to a number of real potential applications on the network.

3.18 NIA SPEN0019 Operational Assessment of Composite Poles

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

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

The project will have 3 stages:

- Stage 1: Offline assessment of materials and development of safe climbing methods
- Stage 2: Install poles (11kV and LV) on the SPEN Network
- Stage 3: Assessment/Audit of the results

3.18.1 NIA SPEN0019 Project Progress

Stage 1

The safe working techniques are currently being assessed. During this assessment, it has been identified that the composite poles can only be accessed via a mobile working platform and cannot be climbed using spikes or ladders. Further assessment is ongoing. This impacts Stage 2, where we will have to restrict the trial locations to areas only accessible with a mobile working platform.

Stage 2

The trial is planned for the end of May 2017

Stage 3

Planned for June 2017

4 Collaborative NIA Projects Led By Other Network Operators

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

Project No.	Project Name	Project Lead
NIA WPD 0008	Improvement Statistical Ratings for OHL	Western Power Distribution
NIA NGGD 0072	Project Futurewave Phase 3	National Grid Gas Distribution
NIA ENWL 0003	Review of Engineering Recommendation P2/6	Electricity North West Limited
NIA NPG 0001	Vonaq Utility Pole Strength Measurement	Northern Powergrid

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

4.1 NIA WPD 0008 Improvement Statistical Ratings for OHL

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

4.1.1 NIA WPD 0008 Project Progress

This is a collaborative project involving all UK DNOs, with WPD acting as the main DNO Project Lead. 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.

4.2 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'.

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.

4.2.1 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 16/17 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.

This Phase 03 was completed in March 2017 and it has been agreed to continue on to Phase 04 – 'Evolving the community engagement approach'. Please Phase 03 findings in section 6.20.

4.3 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:

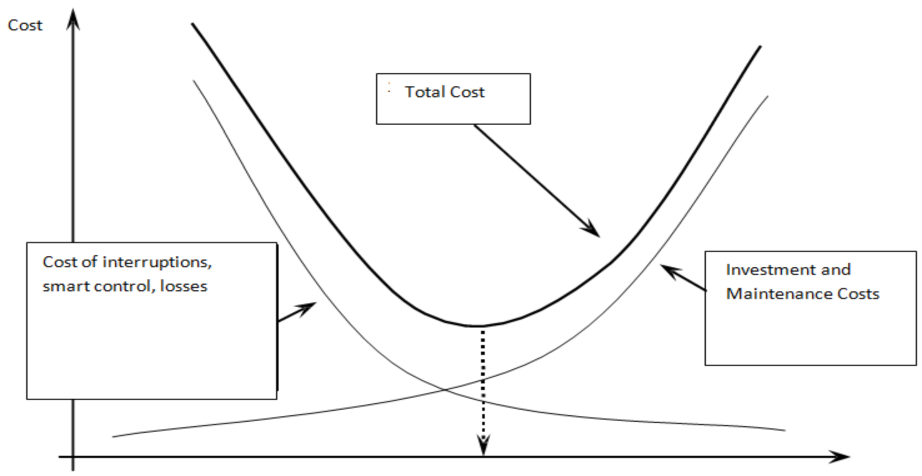
1. Retaining the present deterministic1 P2/6 standard without revision.

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.



4.3.1 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.

4.4 NIA NPG 0001 Vonaq Utility Pole Strength Measurement

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.

4.4.1 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 16/17 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.

5 NIA Activities Linked to SPEN Innovation Strategy

5.1 From Inspiration to Solution

Our approach to innovation development (From Inspiration to Solution) is summarised in Figure 13 below which contains five steps:

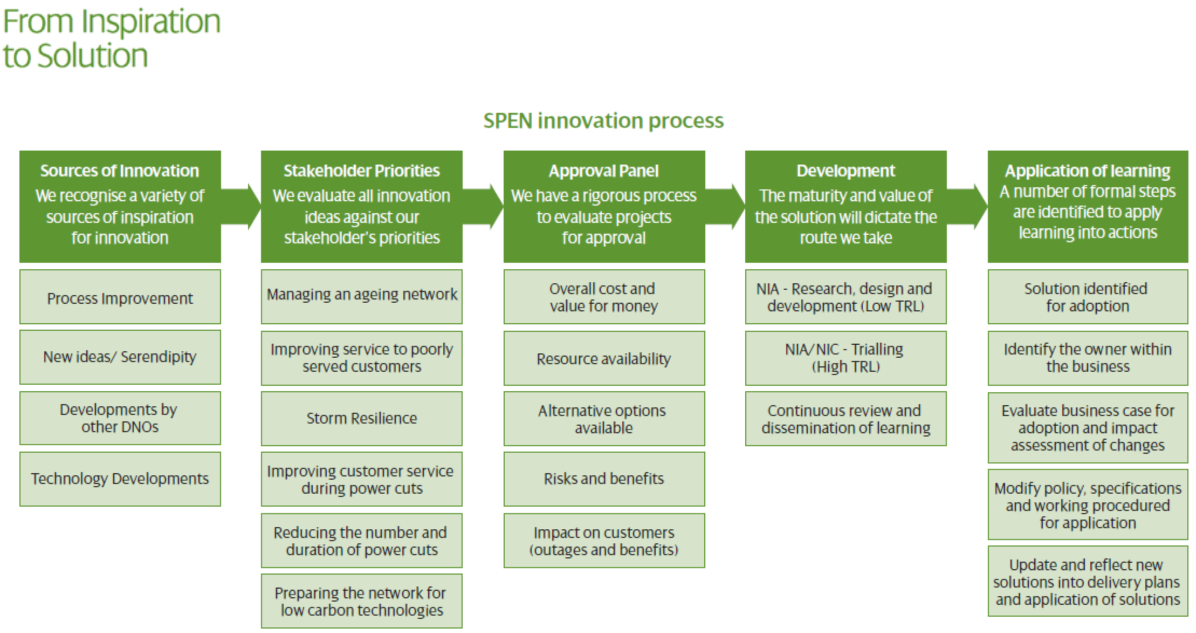


Figure 13 SPEN Approach to Innovation Development

The five key steps of our innovation process are:

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

2. **Evaluation**: We use the priorities of our stakeholders as the main evaluation criteria for new projects. We will ensure that all new projects align with at least one of the areas listed in Figure 13 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.

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

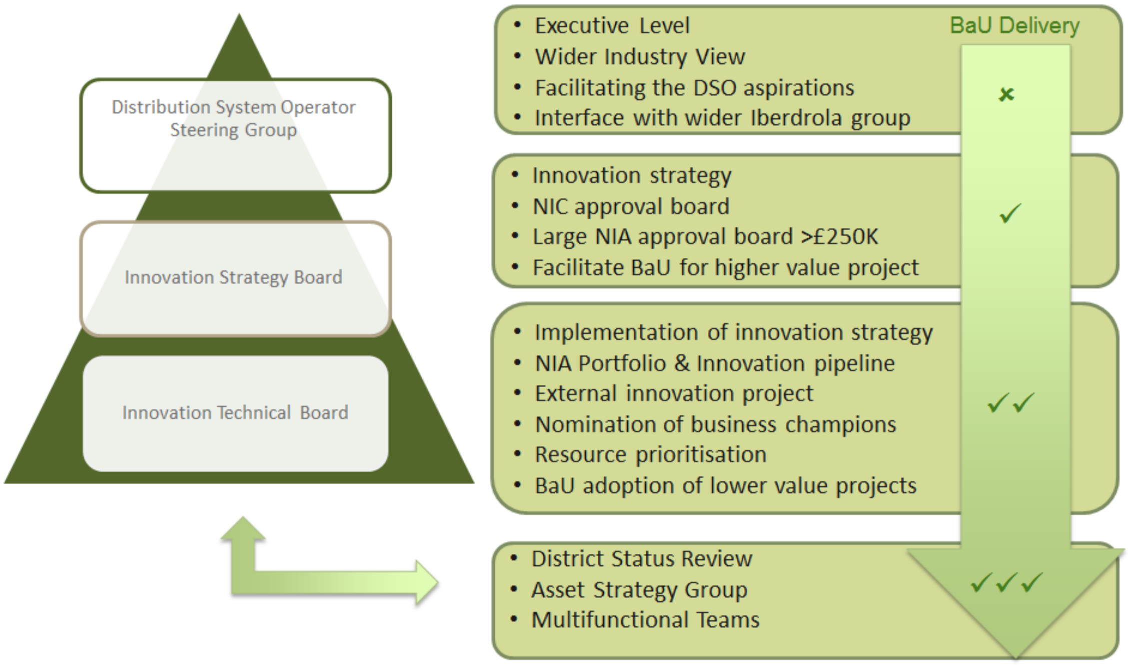


Figure 14 Innovation Governance Structure

Our innovation governance structure and project approvals process Figures 14 and 15 respectively, helps to ensure the following:

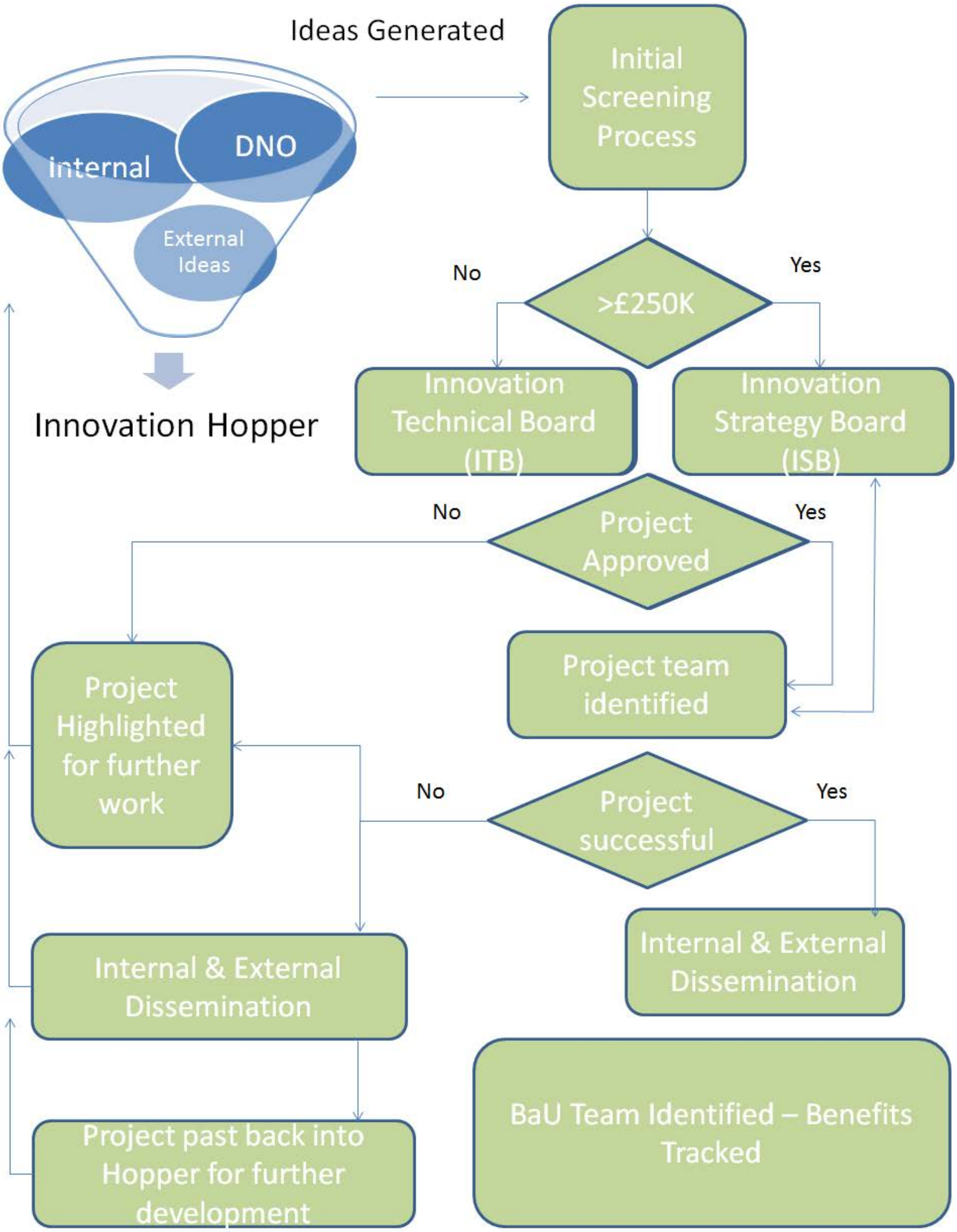
Projects involve the Research, Development, or Demonstration of at least one of the following:

- 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 15 Project Approvals Process

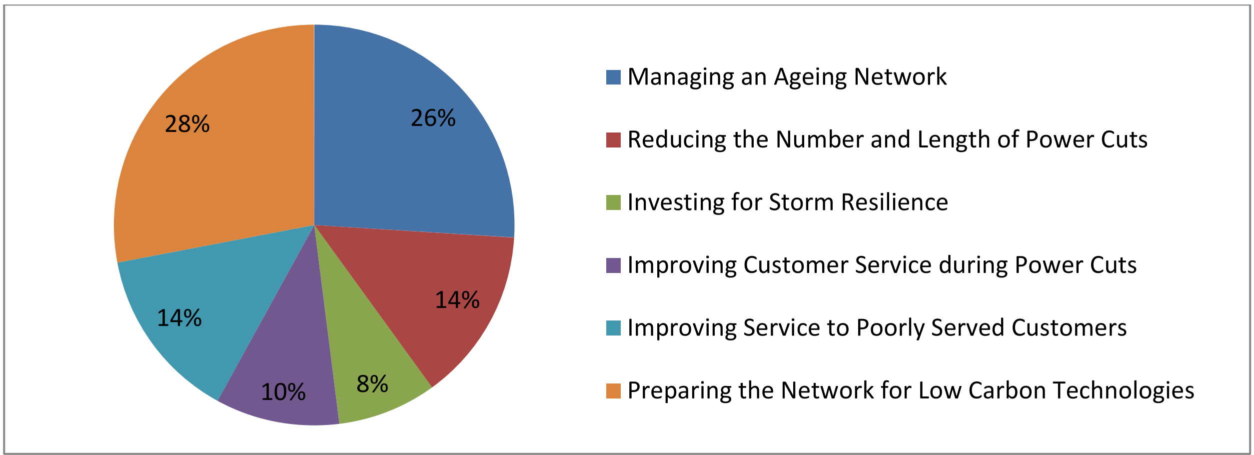


5.2 SPEN NIA Project Mapping with Innovation Strategy

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



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.

Innovation Projects Mapped to Stakeholder Priorities

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 0005		✓		✓	✓	
NIA SPEN 0006	✓			✓		
NIA SPEN 0007						✓
NIA SPEN 0008	✓					
NIA SPEN 0009	✓					✓
NIA SPEN 0010	✓					✓
NIA SPEN 0011	✓	✓		✓		
NIA SPEN 0012	✓	✓	✓	✓	✓	✓
NIA SPEN 0013	✓	✓			✓	✓
NIA SPEN 0014						✓
NIA SPEN 0015	✓					
NIA SPEN 0016	✓					✓
NIA SPEN 0017		✓	✓		✓	✓
NIA SPEN 0018	✓					✓
NIA SPEN 0019	✓					
NIA WPD 0008						✓
NIA NGGD 0072					✓	✓
NIA ENWL 0003						✓
NIA NPG 0001	✓	✓	✓		✓	

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
	13	7	4	5	7	14

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

A summary of the key learning points from Year 2 are as follows;

- Population of an acurate and comprehensive model of the distribution overhead line network; significantly increase capture of LV services wires when compared to Year 1.
- VWAM proved highly 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.
- Improved QA process resulting in improved network reporting and accuracy
- Positive business case to adopt VWAM as BaU
- Development of a training programme and identification of super users across the business

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

A summary of the lessons learnt are as follows:

Consideration of the cyclic rating for the wind farm cable circuits can potentially unlock 10% of the cable capacity for additional wind power output. This figure can increase to 20% unlocked capacity if a closed-loop DCR system is deployed.

A central DCR calculation engine owned and managed by SPEN may be considered. A central calculation engine will give the opportunity to SPEN to assess i) thermal behaviour of a wider range of cable circuits such as transmission and distribution cable circuits, ii) further enhancements or modifications can be carried out internally without relying on external suppliers, who may not flexible to changes and only provide a "black box", iii) for future DCR systems, SPEN may need to procure only the DTS system which will allow participation of more suppliers in the competitive tendering.

In general, it should be more advantageous thermally to place the highly loaded cables on the outer sides of the flat formation. However, care needs to be taken not to cause unnecessary crossings of the cables on their way to their respective wind farm.

For the transition to BaU, several key barriers were identified, such as the need for clearly defined ownership of the various aspects of the system, the lack of confidence in novel technologies, the need for defining and securing O&M contracts and the need to resolve commercial aspects, for example cost allocation and recovery.

It is envisaged that DCR systems associated with wind farms could be complemented by an energy storage system that would be controlled according to cable temperature. A further research and trial need to be carried to demonstrate the benefits.

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

It has been concluded that all project objectives as outlined in the project registration document have been successfully completed.

The project successfully developed, installed and tested a working RAFL system and was able, through testing, to provide evidence of the ability to detect and report arc fault incidence over an extended area. Recorded data demonstrates that the system is responsive to impulsive type rf signals, and propagation tests indicate that location should be possible over a range of several km. A summary of the outcomes from the project are listed below and a copy of the closedown report can be made available on request.

1. The hardware was suited to the purpose of detecting impulsive radio frequency emissions from power system arcing, as evidenced from the switching tests performed, and the generally low level of extraneous impulsive noise arising from other sources (e.g. buildings emissions, cattle fences, etc.) experienced during the trial.

2. Despite initial issues with the performance of the GPS disciplined oscillator timing equipment, the measurement hardware proved to be reliable.
3. Uploading the recorded data to the server via 3G proved to work well, additionally allowing remote control of the hardware. In general, the reliability of local 3G base stations was lower than expected, where data upload would abruptly stop for periods between several hours to several days. It is anticipated that regularly re-establishing the 3G connection would alleviate some of these issues.
4. The inability to move the recording units was a disadvantage, given that no faults were experienced by the system during the monitoring period.

The RALF system installed consisted of four recording units permanently mounted to wooden poles supporting transformers. The circuit was chosen due to its historical poor performance, although during the trail no faults were recorded. Despite the lack of fault data, the trial has been very successful and the following learning points have been achieved:

1. The hardware was suited to the purpose of detecting impulsive radio frequency emissions from power system arcing, as evidenced from the switching tests performed, and the generally low level of extraneous impulsive noise arising from other sources (e.g. buildings emissions, cattle fences, etc.) experienced during the trial.
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3. Uploading the recorded data to the server via 3G proved to work well, additionally allowing remote control of the hardware. In general, the reliability of local 3G base stations was lower than expected, where data upload would abruptly stop for periods between several hours to several days. It is anticipated that regularly re-establishing the 3G connection would alleviate some of these issues.
4. The inability to move the recording units was a disadvantage, given that no faults were experienced by the system during the monitoring period.

6.5 Project Learning: NIA SPEN 0006 Mini Mole

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

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

6.6 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 to be suitable for wide ranging MV and HV applications. This includes HVDC applications, in addition to HVAC, as the materials as sourced have higher purity than existing polyethylenes used to make conventional crosslinked polyethylene (XLPE) cables.

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

It is noted that the second objective of producing a MVAC cable core to support HVAC cable development is also being achieved and this same core would also be used for HVDC cable development.

6.7 Project Learning: NIA SPEN 0008 APPEAL

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

1. DNO managers have been given a clear understanding and knowledge of the number of pre-treatment preservative types that are presently available for the pre-treatment of OHL wood poles.
2. DNO managers have been given an insight into the present state of research concerning the development of alternative and more environmentally acceptable types of timber preservation/modification which may have implications for the continuing future use of wood poles for electricity networks.
3. DNOs are gaining useful knowledge regarding the organisation and specific inputs required for the conduct of cost-saving accelerated tests designed to provide predictive results for real field applications

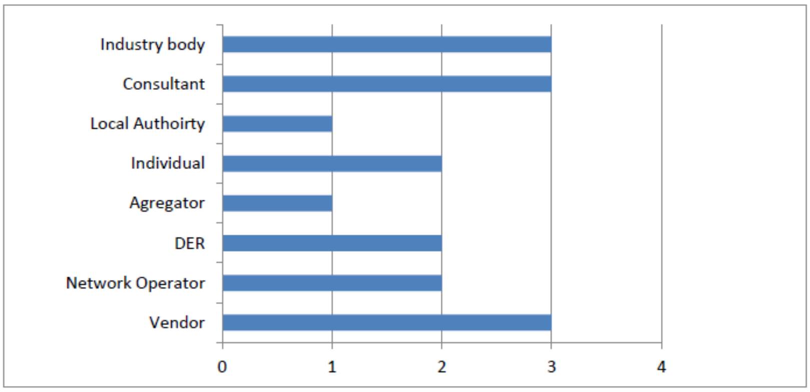
6.8 Project Learning: NIA SPEN 0009 Data Intelligence for Network Operations (DINO) Phase 1

This project has demonstrated benefits from:

- Flexibility in re-use of data platform to process other events/use cases allowing much more dynamic approach to operational analysis
- Improved visibility of communications infrastructure
- An approach for data management and quality in a DNO

6.9 Project Learning: NIA SPEN 0010 EVOLUTION

A key outcome of the project was the development of the SPEN DSO Vision document which was released for consultation during October 2016. A wide spectrum of stakeholders responded to the consultation from a broad section of industries, all commenting positively and constructively with the aim of moving the DSO debate forward. The Vision Document was seen as an important step in the transformation of the UK energy market and the leadership shown was widely welcomed and commended. In total 17 official responses were received from 8 different sectors.



SPEN would like to thank all who have responded constructively to our DSO Vision Document and Consultation Questions; the outcome of which will help shape the wider UK industry debate going forward and will enable SPEN to develop a comprehensive Route-Map to adoption. Key learning from this process has also enable SPEN to take a leading role in the wider industry debate.

6.10 Project Learning: NIA SPEN 0011 LV Elbow Joints

This project has been closed due to manufacture and installation problems identified with precast LV Link boxes. This caused significant delays to the design and manufacturing process and the decision has been made to close the project early to ensure that resources can be better utilise.

Limited learning was established during the project.

6.11 Project Learning: NIA SPEN 0012 SINE Post

As of March 2017 this project is only 3 months old, so far there has not been any significant learning. The mapping of the Business requirements has however identified a few areas where the project deliverables can be slightly modified to add greater value, but in the main this process has reaffirmed the business need for this solution and the approach planned.

6.12 Project Learning: NIA SPEN 0013 Interoperable LV Automation

Phase 2 ‘concept design in 3D CAD and design calculations’ identified the need to increase the speed of measuring the current in the circuit. Therefore code has been rewritten to make use of the processors 2 cores. Off-loading the background tasks to the slower core thus freeing up capacity for the measurement system

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

Since the project was only formally kicked off on 21st February it has not yet generated any significant new learning.

6.14 Project Learning: NIA SPEN 0015 Real Time Fault Level Monitoring (RTFLM) – Stage 1

Although conducted at low and very low fault levels, the tests have shown that the RT-FLM system with inductive switching is inherently accurate to typical sensor tolerances, given good quality disturbances, can include downstream motor contribution and detect changes in source impedance. Result noise is very sensitive to noise on the phase voltages, and may be a determining factor in the choice of disturbance pulse magnitude and frequency/repetition rate.

It was also found that higher currents gave better results, on this low voltage prototype, so it can be concluded that as the voltage level increases the current magnitude will correspondingly increase so increasing the accuracy of fault level measurement .

6.15 Project Learning: NIA SPEN 0016 Network Constraint Early Warning Systems (NCEWS)

As this project only formally kicked off on 13th March it has not yet generated any significant new learning.

6.16 Project Learning: NIA SPEN 0017 Secondary Communications Phase 2 – Consultancy Engagement

Different options, both presently available and future looking, have been considered:

- Private network:
  - VHF/UHF P2MP-DR.
  - Private LTE: e.g. based on 450-470 MHz Band (3GPP B31).
- Public (commercial) networks: cellular 2G/3G/4G.
- Hybrid solution based on public and private network

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

- Global Automation service requirements: Critical and Less Critical Data.
- Throughput.
- Application Level Performance: Latency and Packet loss rate.
- Scalability needs.
- MNO's public cellular footprint information that should be confirmed with on-site survey (Directive antennas to be installed if necessary).
- Radio planning for deploying a radio based- private infrastructure: P2MP-DR and LTE:
  - Identifying repeater site candidates (either owned or third-party's).
  - Spectrum License management.

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

- Laboratory tests in order to:
  - Explore technology limits.
  - Confirm network design criteria.
  - Perform technical and economic analysis.
- On-field tests in order to:
  - Check automation service performance.
  - Expectations confirmation.

6.17 Project Learning: NIA SPEN 0018 Technical Review of Non-Conventional Statcom Applications

A Statcom Application Guide has been developed containing the following sections: -

1 Introduction

2 Network Voltage Control

2.1 Statcoms in Context

2.1.1 Transformers

2.1.2 Capacitors and Reactors

2.1.3 Synchronous Condensers

2.1.4 Static VAR Compensators

2.1.5 Statcoms

3 Statcom Overview

3.1 Statcoms Electrical First Principals

3.2 Basic Control of Statcom Output

3.3 Short Time Overload

3.3.1 Hybrid Statcoms

4 Statcom Technology

4.1 Basic System Components

4.2 Transformers

6.18 Project Learning: NIA SPEN 0019 Operational Assessment of Composite Poles

It has been identified that the composite poles can only be accessed via a mobile working platform and cannot be climbed using spikes or ladders. This impacts Stage 2 of the project (installation of poles (11kV and LV) on the SPEN Network) where we will have to restrict the trial locations to areas only accessible with a mobile working platform. The majority of the project has still to be completed and is planned for May/June 2017.

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

This project is on-going, with the emphasis now shifting from “data acquisition” towards “data analysis”. 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.

6.20 Project Learning: NIA NGGD 0072 Project Futurewave Phase 3

The four major findings over the last 12 months aligned with the project success criteria:

1. Verified the long-term sustainability of community engagement initiatives for networks through demonstration of the ability to generate revenue which can be reinvested back into the business and the communities it serves.
2. It is possible to engage previously unengaged customers to participate in energy efficiency schemes and measures.
3. Cost effective user engagement can be achieved by using trusted messengers and familiar messaging channels to deliver the message.
4. Understanding of how users want to engage with energy efficiency.

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

The work conducted to date (i.e. Phase 1) has demonstrated that there is a strong economic case for the reform of Engineering Recommendation P2. This recommendation has been forwarded to the Distribution Code Review Panel to consider the timing and scope of the Phase 2 work. The recommendations forms can be categorized into three sets of reforms:

1. More explicit guidance on the inclusion of Distributed Energy Resources (DERs) in the assessment of security of supply

2. A change in the minimum level of security of supply

3. Additional consideration of HV network automation and mitigation of High Impact Low Probability (HILP) events.

There are a number of factors that still require further consideration including; timing of investments, the assessment of ‘efficient expenditure’ and the price impacts for customers, before this work can be taken forward in earnest. The proposed Phase two work programme is therefore separated into two parts. Part one will consider incremental changes to the existing standard that can be implemented in the short term (i.e. before the end of ED1). Part two will consider more material changes that can be implemented in the medium term (i.e. in preparation for ED2).

6.22 Project Learning: NIA NPG 0001 Vonaq Utility Pole Strength

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 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:

- Masses attached to the pole- It was shown that under estimation of the mass weight resulted in a lower Strength Assessment (SA) result, this was the case for low masses, <10kg and heavier masses >10kg
- Conductors tensioning - The main effect of the conductors on the pole is to apply a downward force known as down pull. Knowledge of the effect of conductor down pull allowed tuning improvements to be made to the Finite Element Model, FEM
- Pole Geometry- Another aspect learnt when dealing with a pole is the tapering. In the previous version of the algorithm—the calculated linear taper was overestimated or underestimated, depending on the particular pole considered. In order to overcome this

problem, a control has been introduced in the FEM model, i.e. that the tip diameter has always to be inside the standard recommended values. This control allows the algorithm to take into account the actual tapering of the pole, so avoiding any mistake.