Transmission

NIA Annual Report

2021 – 2022

SP ENERGY NETWORKS

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Foreword

SP Energy Networks is committed to maintaining an electricity transmission network that can help deliver the Net Zero future that is critical not only to our business, but more importantly to society and our planet.

SP Energy Networks (SPEN) owns and operates three regulated electricity network businesses in the UK: SP Transmission plc (SPT), SP Distribution plc (SPD) and SP Manweb plc (SPM). Our transmission (SPT) and distribution (SPD) network in Scotland covers an area of almost 23,000km² in central and southern Scotland.

Our transmission network covers the electricity corridor between Scotland and England, responsible for connecting and transferring large volume of offshore wind, targeted at 50GW before 2030 at national level. Over the past years, SP Transmission has led the way with its innovation activities, developing new technologies and solutions to address the challenges of the energy system transition.

This Network Innovation Allowance (NIA) Annual Transmission Report is our first NIA report under RIIO-T2 regime. It provides an overview of NIA innovation projects which cover our SP Transmission network that were initiated, worked on and completed during the regulatory year 2021-22.

Despite the ongoing challenges post the global pandemic, we've been able to continue to keep our business running and the power flowing to our customers and communities – ensuring we provide value for money, a safe and secure electricity supply, and that we support our most vulnerable customers. Last year saw the COP26 climate conference come to our home city of Glasgow, bringing world leaders together to agree on actions to tackle climate change. As a principal partner alongside our Scottish Power Group colleagues, we were proud to showcase our innovation portfolio at the event, highlighting the critical role we are playing in enabling a Net Zero future.

Our NIA projects play a significant role in preparing our larger-scale projects and initiatives and are a crucial part of our innovation portfolio. During the reporting period, we were given the green light from Ofgem and Innovate UK on all nine of our projects under the new Strategic Innovation Fund (Discovery phase) – which was a result of our learning from existing NIA projects.

Collaboration with our stakeholders such as with other TOs, SMEs and academic partners is an important part of what we do too. We're proud to have been able to progress projects on key topics as a result of those efforts. Throughout the reporting year we have continued to deliver innovation projects with high standards under each of the four strategic themes set out in our T2 Innovation Strategy: Network Modernisation, Security & Stability, Digitalisation & Power Networks, and Network Flexibility. We are delighted to share with our customers the good progress made Examples can be found from the progress on System Health Map, a project supporting our energy digitalisation by integrating data from multiple asset monitoring systems into one platform.

We are at a pivotal point in our industry as we become ever-more reliant on electricity for our modern lifestyles, and innovation is key to us keeping up with that increased demand on our network. We are extremely proud of what we've achieved in this latest reporting year and are already looking forward to what's next as we start to deliver on our ambitious business plan. We are consolidating and looking forward to realising more significant learnings that will benefit our customers during the RIIO-T2 and beyond.

If you have an idea you would like to discuss with my innovation team or if you'd like more information on a particular project featured in this report, please get in touch via innovate@spenergynetworks.co.uk.

Graham Campbell

Director of Processes and Technology

SP Energy Networks

Contents Page

Foreword.......... 3
Executive Summary.......... 6

1 | Introduction.......... 9

2 | Progress Summary.......... 10

2.1 | NIA SPEN 0038 System Health Map.......... 10

2.1.1 | NIA SPEN 0038 Project Progress.......... 12

2.2 | NIA SPEN 0044 400kV Dynamic Cable Rating Retrofit Project Utilising RPMA Communications Technology.......... 12

2.2.1 | NIA SPEN 0044 Project Progress.......... 13

2.3 | NIA SPEN 0051 All Terrain Low Ground Pressure Access Vehicle with 34m Boom.......... 13

2.3.1 | NIA SPEN 0051 Project Progress.......... 14

2.4 | NIA SPEN 0053 Project Synthesis – Effective Regional Inertia Monitoring and Automatic Control with a Whole System Approach.......... 14

2.4.1 | NIA SPEN 0053 Project Progress.......... 15

2.5 | NIA SPEN 0054 Transmission OHL Crossing Protection Stage 1.......... 15

2.5.1 | NIA SPEN 0054 Project Progress.......... 16

2.6 | NIA SPEN 0057 Project Conan.......... 17

2.6.1 | NIA SPEN 0057 Project Progress.......... 18

2.7 | NIA SPEN 0059 Landslide Protection Asset.......... 19

2.7.1 | NIA SPEN 0059 Project Progress.......... 20

2.8 | NIA SPEN 0062 DynaLoad – Dynamic Loading of Transformer Insulation.......... 23

2.8.1 | NIA SPEN 0062 Project Progress.......... 24

2.9 | NIA SPEN 0064 Cyber Security for Active and Flexible Energy Networks (Cyber SAFEN).......... 25

2.9.1 | NIA SPEN 0064 Project Progress.......... 25

3 | NIA Activities Linked to SP Transmission Innovation Strategy.......... 27

3.1 | SP Transmission Innovation Strategy.......... 27

3.2 | ENA Innovation Strategy.......... 28

3.3 | Culture of Innovation.......... 29

4 | Areas of Significant New Learning.......... 31

4.1 | Project Learning: NIA SPEN 0038 System Health Map.......... 31

4.2 | Project Learning: NIA SPEN 0044 400kV Dynamic Cable Rating Retrofit Project Utilising RPMA Communications Technology.......... 32

4.3 | Project Learning: NIA SPEN 0051 All Terrain Low Ground Pressure Access Vehicle with 34m Boom.......... 34

4.5 | Project Learning: NIA 0054 Transmission OHL Crossing Protection Stage 1.......... 34

4.6 | **Project Learning: NIA SPEN 0057 Project Conan**.......... 35

4.7 | **Project Learning: NIA SPEN 0059 Landslide Protection Asset**.......... 35

4.8 | **Project Learning: NIA SPEN 0062** DynaLoad – Dynamic Loading of Transformer Insulation.......... 35

4.9 | **Project Learning:** NIA SPEN 0064 Cyber Security for Active and Flexible Energy Networks (Cyber SAFEN).......... 35

Contact Us.......... 37

SP ENERGY NETWORKS

Executive Summary

This Annual Transmission 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 NIA Annual Report presents an overview of the projects we have initialised during the regulatory year 2021/2022 and provides an update on those projects reported during 2020/2021 which are still active.

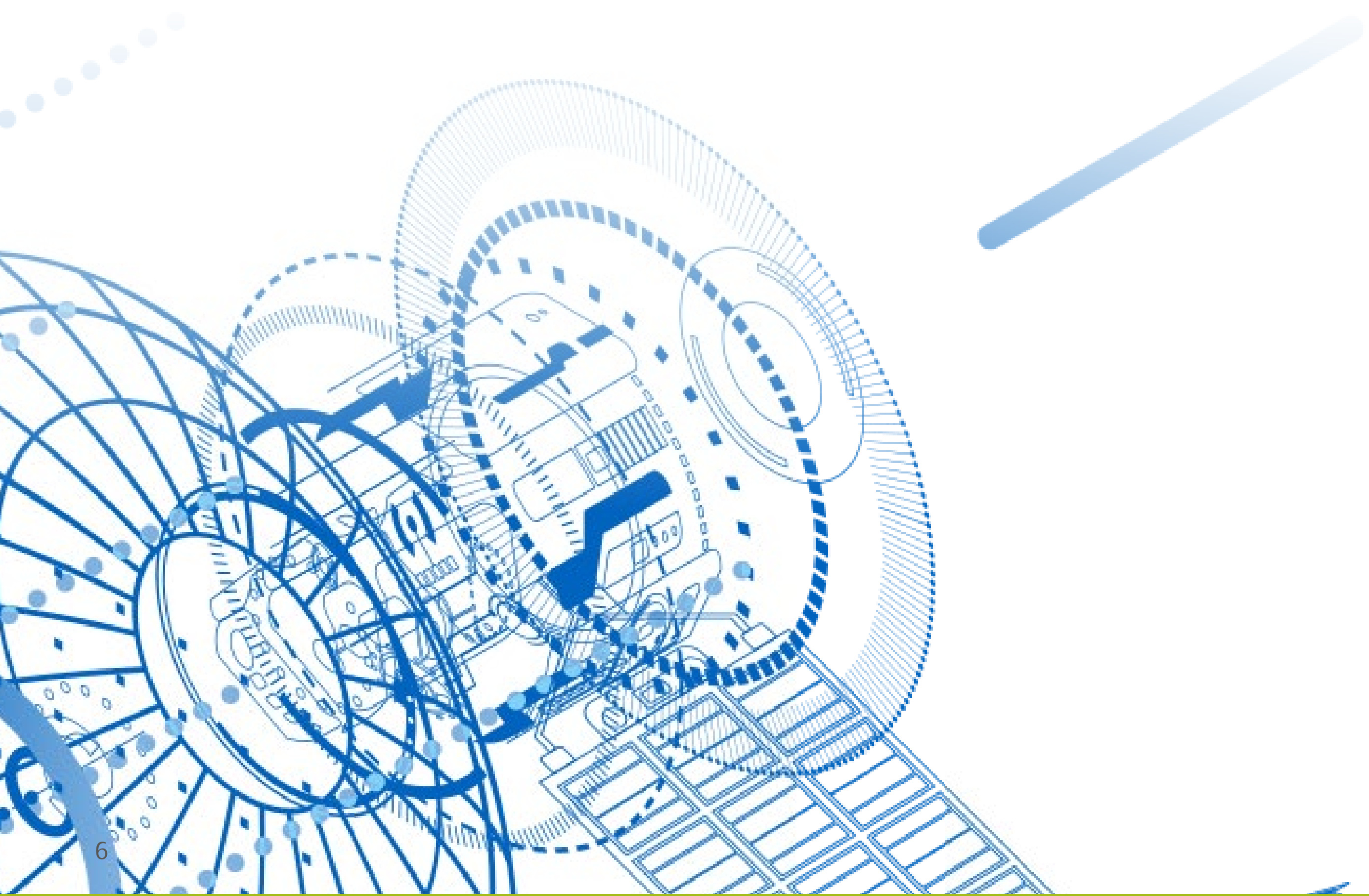
The progress of each project aligns with the following key objectives:

- Innovation meeting the needs of stakeholders;
- Innovation opportunities are identified in a timely manner, which will benefit these stakeholders;
- Innovation is managed in an efficient and proactive manner;
- A balanced portfolio of innovation is pursued which includes commercial, process and technology innovation; and
- The outcome of innovation activity is adopted by the wider business to ensure that customers benefit at the earliest opportunity whilst minimising the risk to the integrity of the network.

Our NIA innovation project portfolio will continue to be shaped by on-going stakeholder engagement, both internal and external, with a view to maintaining a balanced portfolio that will address not just the near/medium term transmission issues, during the current price control period (RIIO-T2), but also those anticipated beyond.

In addition to funding smaller projects, we will continue to utilise NIA Transmission funding, where appropriate, to prepare for future Strategic Innovation Funding (SIF) submissions.

In addition, we will aim to maximise knowledge transfer with other licensees and facilitate useful outcomes into Business as Usual (BaU) at the earliest opportunity.



SP ENERGY NETWORKS

1 | Introduction

SP Transmission has obligations to meet the Special Condition 3H (The Network Innovation Allowance) of the Electricity Transmission Licence, which was introduced as one of the key innovation proposals for the RIIO-T2 (Revenue = Incentives + Innovation + Outputs, 2021-2026) model for price control. The purpose of the NIA is to encourage Network Licensees to innovate to address issues associated with the development of their networks.

NIA is to provide a consistent level of funding to Network Licensees to allow them to carry out smaller innovative projects which meet the criteria set out in the NIA Governance Document

From that point of view, NIA plays an important and integrated role in uplifting the technology readiness levels (TRL), preparing for flagship demonstrations at national level and knowledge sharing.

It is acknowledged that the transmission network will experience unprecedented change in response to realising the low carbon ambitions for the UK. In order to meet the associated challenges, innovative techniques, technologies and processes will be required to develop the transmission network. This is recognised by the fact that Innovation is a key element of the RIIO-T2 model for price controls with the introduction of the NIA.

This report presents SP Transmission's NIA activities during the reporting year and summarises progress made against objectives and highlights areas of significant new learning.

Developments in our transmission network over recent years have fundamentally been driven by an ongoing process of stakeholder engagement. SP Transmission has identified a number of key themes as a result of our ongoing stakeholder engagement which are the principal drivers behind our innovation strategy.

In 2018, the strategy was reviewed to align with RIIO-T2 aspirations. Following extensive engagement with all key stakeholder groups, the resulting feedback significantly influenced the current Transmission Innovation Strategy, which was released in December 2019. For further details please see Annex 6: Innovation Strategy in our RIIO-T2 Business Plan.

https://www.spenergynetworks.co.uk/pages/our_riio_t2_business_plan.aspx

This Transmission Innovation strategy represents a step-change in ambition and approach commensurate with the significant challenges and opportunities that RIIO-T2 represents.

SP Transmission recognised that consideration needed to be given to not only the RIIO-T2 period and stakeholder's immediate needs, but also how we address the longer-term issues which the transmission 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 immediate challenges to be faced over the next decade. This is considered in detail in our Transmission Innovation Strategy.

2 | Progress Summary

During the reporting year 1st April 21 to 31st March 22 SP Transmission registered the following NIA projects:

- NIA SPEN 0062 DynaLoad – Dynamic loading of transformer insulation
https://smarter.energynetworks.org/projects/nia_spen_0062/
- NIA SPEN 0064 Cyber Security for Active and Flexible Energy Networks (Cyber-SAFEN)
https://smarter.energynetworks.org/projects/nia_spen_0064/

The following sections provide a short overview of each active NIA project and a summary of the progress from the reporting year. Further details on SP Energy Networks Innovation activities can be found on our website (**www.spenergynetworks.co.uk/pages/innovation.asp**) and on the ENA Learning Portal (**www.smarter.energynetworks.org**). Key learning associated with these projects is summarised in Section 4.

2.1 | NIA SPEN 0038 System Health Map

SP Transmission is developing a 'System Health Map' which collates multiple existing separate data sources from the Transmission Network into one centralised platform. This platform uses trending and analytics to allow early intervention and an overall improvement in asset management.

Many of the online monitoring datasets have no mechanism to collate the data gathered or to support engineers in processing or analysing this data. Many of these datasets solely rely on manpower to import, analyse and generate outputs from the raw data.

As a result, there are three key growing issues which make the current business practices for network data management impractical:

1. **The volume of data** – Monitoring equipment is increasingly being installed throughout the network to identify potential problems. This data includes

- Power Quality Data: The large increase in low carbon technologies (LCTs) in recent years has significantly increased the requirement for power quality data in order to maintain compliance with standards. As the number of LCTs continues to grow, this increases the volume of data, making it increasingly difficult to regularly and meaningfully assess the data extracted from assets and possibly allow non-compliant network conditions to continue undetected.
- Condition Monitoring Data: With an aging and developing asset population more emphasis is being made on delivery of lifetime extension and the safe and efficient operation of these assets. This has led to an increase in the delivery of asset condition monitoring equipment producing a large and diverse data set with increased need to automate the collection, collation and analysis of this data.

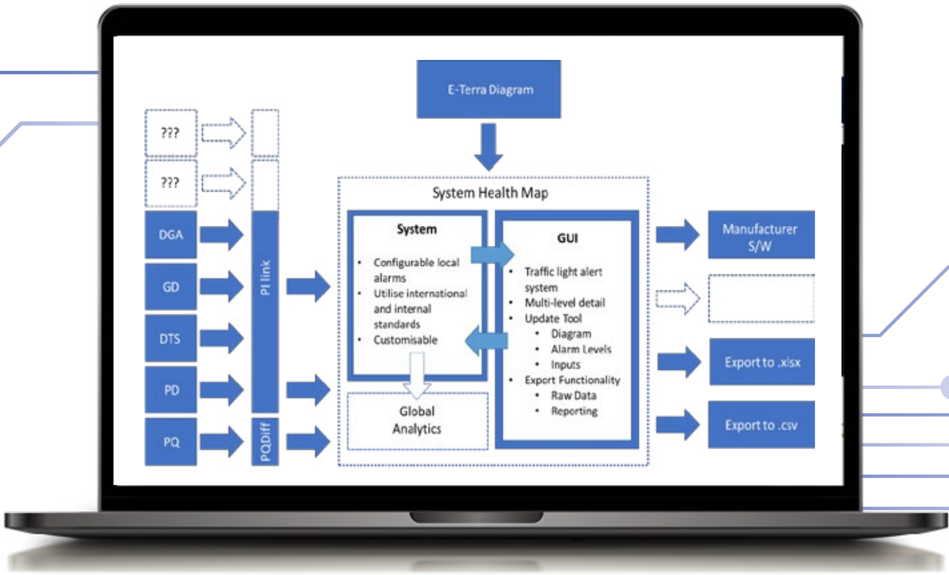
2. **The diversity of data** – The variation in the incoming data is extraordinary with the complexity of managing different sample rates, formats, supplier software and user interfaces being compounded by the fact that different disciplines have installed monitoring equipment to address different issues. The data also requires expertise to build analytics and understand outcomes.

3. **The diversity in user interfaces** – As each supplier presents their bespoke hardware and software to address a specific issue, this leads to a number of issues. Firstly, the number of interfaces becomes unmanageable when looking to capture a system view, meaning technical staff will need to use each software package individually and build up a system picture manually. Secondly, the different software packages provide different levels of access; this ranges from full data access to web-based platforms which allow 'read only' access. The overall impact of these issues is that critical assets are not being monitored effectively, and undetected faults are causing unnecessary asset damage, network congestion and network outages. This results in an ongoing preventable cost to the customer. Furthermore, these events cause unnecessary cost to the consumer in constraint costs.

This platform will be able to extract data from pre-defined sources (such as PI Historian) and display this on a graphical interface. This interface will include a system diagram with indicative system conditions (Traffic Light) and the ability to plot and export data.

The five use cases which have been defined for Phase 1 are:

1. Power Quality (PQ) including harmonics, voltage flicker, and voltage imbalance;
2. GIS Gas Density (GD) SF6;
3. Dissolved Gas Analysis (DGA);
4. Partial Discharge (PD); and
5. Distributed Temperature Sensing (DTS).



System Health Map Platform

System Health Map – Prototype Heat Map

2.1.1 | NIA SPEN 0038 Project Progress

Project progress against the project objectives is as follows:

1. Development of a requirements specification to identify the full system requirements which will determine the successful delivery criteria.

   Requirements Specification – A supplier specification was drawn up identifying the full requirements that the System Health Map platform must contain, and a Functional Design Specification has been drawn up.

2. To configure a general data analytics platform for hosting and using real-time transmission data in the above use cases in line with the technical specification.

   The supplier demonstrated a functional prototype with working example of each use case and the exporting functionality determined in the Requirements Specification and Factory Acceptance Testing has been undertaken.

3. Take sample data sets for each use case to validate a real-time output and alarms.

   Site Acceptance Testing (Transmission Operations Replay room installation) has been carried out.

4. To roll-out the platform for the full dataset into all available SPT sites.

   Formal integration to corporate databases and servers is still to be undertaken.

5. Reporting on demonstrated change in practice due to integrated data and visualisation with a key outcome being improved decision making.

   Reporting and wider business workshop and dissemination along with expansion of analytics into automatic business reports, asset prognostics and further datasets is still to be undertaken.

2.2 | NIA SPEN 0044 400kV Dynamic Cable Rating Retrofit Project Utilising RPMA Communications Technology

As the penetration of LCT increase in the UK greater circuit loading will be experienced on the transmission network. Under certain loading scenarios the power flow on transmission circuits may need to be constrained, which can result in multi-million-pound constraint payments. Rather than undertaking costly network reinforcement schemes, with long lead times and environmental impacts, one option is to operate the network using dynamic ratings.

Sensor Unit

One such circuit where the declared capacity is likely to cause future constraint issues is the Torness to Thornton Bridge (Crystal Rig) 400kV circuit. In order to defer or avoid network reinforcement one potential option to increase circuit capacity is to operate and plan the carrying capacity of the cable circuits based on their real-time thermal behaviour.

An optical fibre laid alongside a power cable can be used to determine real-time thermal behaviour. Installing a fibre optic temperature sensing circuit at the same time as laying a power cable is relatively cost effective; however, excavating an existing circuit is required, then the costs escalate. The problem to be addressed, therefore, is finding a cost effective retrofit dynamic capacity rating (DCR) solution with supporting communications technology that can be deployed easily.

Telemetry Post

To ensure that the measured data is securely transmitted, Random Phase Multiple Access (RPMA) wireless communications technology is proposed. While RPMA technology has not been used by SP Energy Networks before it does provide significant advantages for ultra-rural, isolated, hard-to-reach or targeted meter locations. Utilising globally available unlicensed spectrum in the 2.4GHz band, RPMA's properties of robust interference tolerance, wide geographic coverage, high network capacity, and low power support, allow devices to be connected more efficiently than ever before.

The project will investigate the feasibility of using the RPMA wireless technology coupled with point sensors and integrated with a DCR scheme to provide a cost effective retrofit dynamic rating solution to evaluate real-time thermal behaviour of strategic cable circuits.

The key business benefit is the potential to determine additional headroom capacity on a cable circuit which could eliminate or defer network reinforcement, and avoid the various costs and risks during the associated outages, and extend the lifetime of network assets.

2.2.1 | NIA SPEN 0044 Project Progress

The objective of this project is to investigate the feasibility of using the RPMA wireless technology coupled with point sensors and integrated with a DCR scheme to provide a cost effective retrofit dynamic rating solution to evaluate real-time thermal behaviour of strategic cable circuits.

Seven sensor units, each with two PT100 sensors for redundancy, have been engineered and deployed. Five units have been deployed on the cable jacket and two in cables tunnels for the 400kV Torness/Crystal Rig circuit.

End-to-end telemetry has been established and field data was initially received from six of the seven telemetry posts. This field data (temperature values for the cable jacket) has now been integrated with a DCR scheme and is now being used to determine dynamic cable rating values to evaluate the real-time thermal behaviour of the cable circuit.

There were subsequent reliability issues that impacted the availability of the telemetry posts. Site inspections were undertaken to rectify the situation and telemetry units and associated batteries were replaced. However, it wasn't possible to bring all telemetry posts back into service and this is the subject of further investigation.

Validation of the cable dynamic rating results is on-going.

Field Telemetry Unit

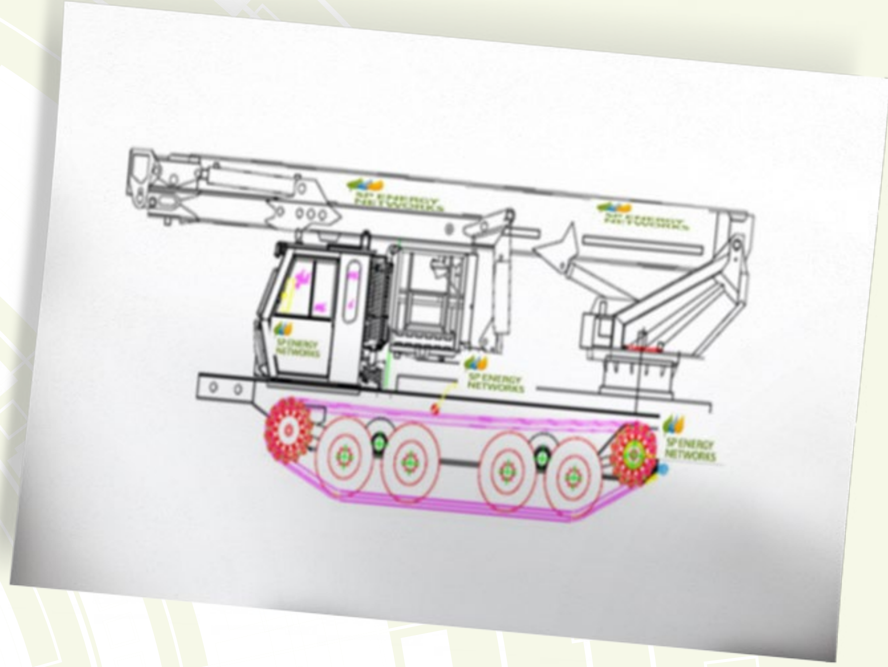
2.3 | NIA SPEN 0051 All Terrain Low Ground Pressure Access Vehicle with 34m Boom

Many of SP Transmission's power lines pass through very remote and inaccessible locations, particularly in the upland areas. In the event of an unplanned outage on these circuits (caused by a failure, environmental incident, 3rd party damage etc) they can cause major disruption to customers and the subsequent repairs can be both time consuming, technically challenging and expensive. Accessing conductors mid-span or accessing on a damaged structure can be particularly challenging.

This project aims to develop a high capacity high reach access platform (Hybrid MEWP) mounted on a high performance all terrain tracked vehicle that will vastly improve response to faults and repairs.

Key specifications for the vehicle are as follows:

- High-capacity basket (over 250kg);
- Long/high reach (34m);
- 8 to 10 months to manufacture from approval agreement;
- The vehicle should be transportable by low-loader without the need for police notification;
- Ideally under 3m wide/25T gross weight;
- Ground bearing pressure of less that 5psi (pounds per square inch);
- Smooth track bars to allow passage over tarmac and farm roads; and
- Fully CE marked, tested and certified.



Hybrid MEWP

2.3.1 | NIA SPEN 0051 Project Progress

The MEWP has been specified to meet the following project objectives:

- Increase efficiency on outage times on faults and repairs reducing network financial constraints and down time, including deployment of the emergency restoration system;
- Greatly reduce risk during work at heights;
- Commitment to stakeholders in fast repairs and response time on OHL windfarm connection routes;
- Grantor commitment using advanced technology to eliminate/reduce land damage;
- Environmental commitment to reducing stone road requirements and wagons required to bring the stone in; and
- Reduction in muscular skeletal injury to work force by allowing two men to work from a very generous 250KG basket on repairs needing heavy equipment such as a press head.

After lengthy shut down delays at the factory due to Covid, Brexit issues and delay issues with getting parts from abroad, we are optimistic that the MEWP will be ready to be used on the network in October 22. This will offer an opportunity to assess the vehicle in the field with respect to the aforementioned objectives.

2.5 | NIA SPEN 0054 Transmission OHL Crossing Protection Stage 1

DW7 Pole 18

During the reconductoring of transmission overhead lines there can be issues when the transmission line crosses a section of distribution overhead line. Action must be taken to ensure that the transmission overhead line cannot drop and make contact with the distribution line and therefore become re-energised. The result of such an event could cause serious harm to the operatives who are working on the isolated line. This is, currently, avoided by undergrounding the section of distribution line, but this can be very expensive once costs such as outages, excavation and reinstatement are factored in.

This project will consider a system to prevent contact with the distribution overhead line by covering it from above. This will be a system installed using live line methods, and will initially be used to protect 132kV systems. A feasibility study has been carried out, and this project will develop a detailed design for the system.

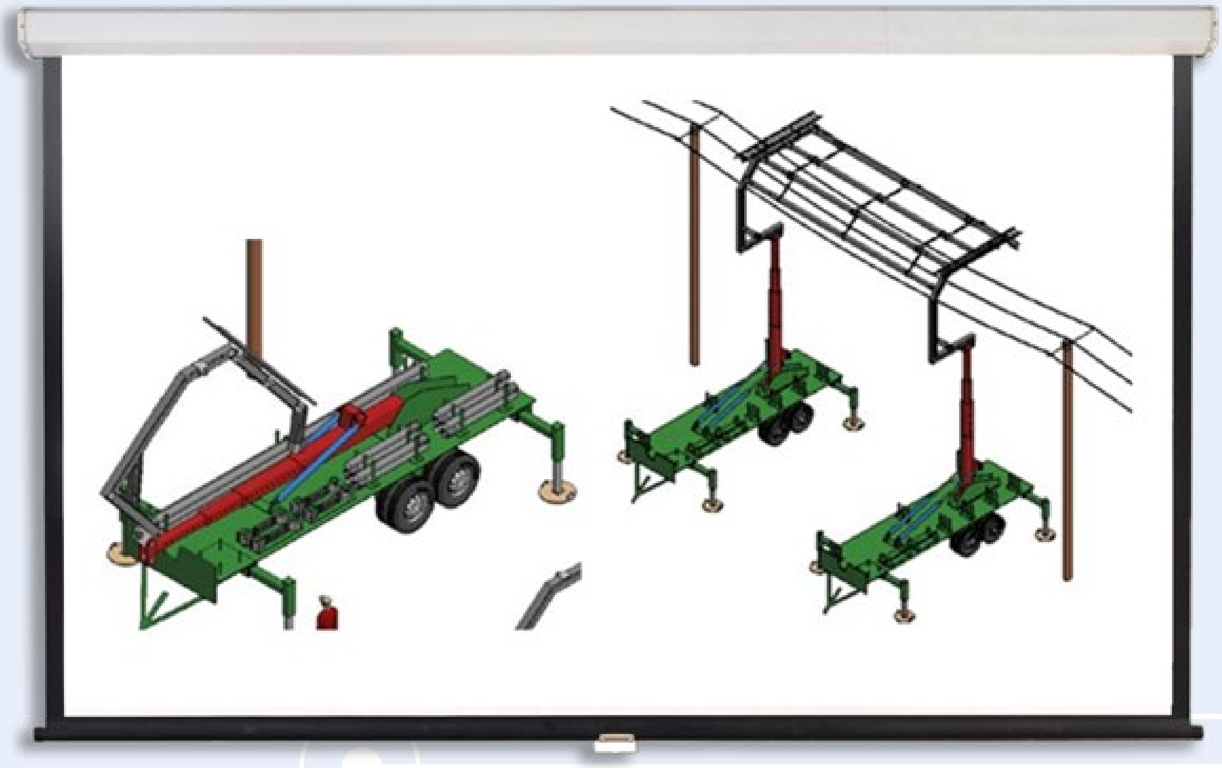
The scope includes the design of the protection system which will be designed to allow a large proportion of distribution crossings to be protected on the current planned reconductoring projects. This project will cover only the design to allow assessment against the requirements of the transmission business, and to ensure that it can be applied to a sufficient number of these crossings to make its use cost effective.

2.5.1 | NIA SPEN 0054 Project Progress

The objective of this project is to develop a technical design of a system to cover distribution overhead lines while transmission reconductoring is being carried out overhead, with an assessment of how this meets the needs of the business, and what number of crossings this can be applied to.

SP Energy Networks appointed RED Engineering (RED) to take over the concept design and further develop it after REECE Innovation, who had been awarded the project through a competition, withdrew. RED carried out a quick analysis with specialist software to gain clarity on load cases from cable failure. RED has assessed the current concept against load cases and identified significantly higher loading. In addition, lateral loading was not considered in the concept and RED raised concerns that the top section cannot be manufactured as intended and that the system is not deployable.

RED had completed an initial design which was then reviewed by SP Energy Network's team; however, it was not accepted as the direction of the design was not going to work. Machine/vehicle-based solution has been ruled out and current design focus is on pole mounted system which avoids the cost of mobilising vehicle to mount the unit on. The project team is currently developing a new concept which will be presented for review by the end of 2022.

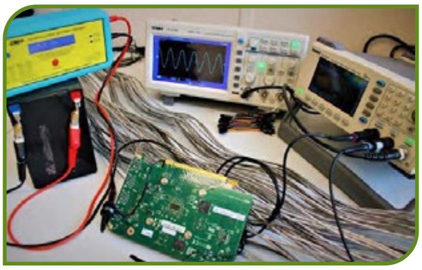


Current OHL protection mechanical bridging system concept by RED Engineering

To the left: Masts in horizontal position
To the right: General arrangement of fully erected system

2.6 | NIA SPEN 0057 Project Conan

This project will look to develop a replacement device (Conan) for the Cormon overhead line conductor conditioning monitoring device.



The aim is that the condition measurement accuracy, reliability, number of points measured and processing capabilities will be far better than currently possible.

The majority of overhead line conductors in the UK are of Aluminium Conductor Steel Reinforced (ACSR) conductors with the rest, predominantly All-Aluminium Alloy Conductor (AAAC) type. Once ACSR conductors are proven to be in poor condition, a replacement with an equivalent AAAC is usually specified.

To ensure accurate and efficient condition-based replacement, rather than based on age, it is essential to utilise the best science and technology available to obtain reliable conductor condition data.

Devices that are currently used for non-destructive testing, have significant limitations, either with obsolete and inefficient, unreliable technology or lacking in ability to predict end-of-life before it arises.

This project will look to develop the first device which reliably and efficiently provides non-destructive conductor assessment information suitable for predictive condition-based intervention. It will also develop concepts or methods for measurement of AAAC condition and develop the first body of scientific information to provide a reliable basis for interpreting the condition of ACSR or AAAC results, upon which to make consistent, traceable condition-based decisions.

The main outputs from the project will be:

- New device with the capability to accurately and efficiently assess conductor conditions, ready for commercialisation;
- New scientific method for making conductor replacement decisions, which will be supported by documentation; and
- Device that is compatible with the working prototype of AAAC detector head.

Main benefits will be:

- Reduction in costs associated with network downtime;
- Greater visibility of conductor condition;
- Greater understanding of conductor condition;
- Reduced network downtime;
- More efficient condition surveying, with less disruption to local community; and
- Safely extending asset life/reducing asset risk of failure through more effective assessment.

It is planned that the unit will be deployable either manually or by drone. The final unit is expected to be 5-10kg which is well within the payload of readily available and inexpensive drones.

2.6.1 | NIA SPEN 0057 Project Progress

Project Conan was registered in March 2021 and the initial kick-off stakeholder meeting was held in May 2021. Initial tasks have included setting up contractual agreements with the Supplier; Energyline Science and Technology (EST) and the Energy Innovation Centre (EIC), which is acting as the Project Manager.

EST have now started their programme of works. The technical specification was developed and finalised in August 2021, as well as early concepts for the prototype. Following feedback from the steering group, which highlighted the need for a robust single-body design, a final concept was selected in September 2021.

The detailed electrical and mechanical design of the Conan prototype, and summary report was completed in February 2022, following feedback from SP Energy Networks. Manufacture and assembly of mechanical components, and the acquisition of necessary electronics began in February and was ongoing as of March 2022.

Bench testing of the electronics was started in March 2022, which aimed to prove capability of the design to detect changes in galvanising thickness of steel wires, loss from ACSR and All AAAC.

The overarching objective of the project is to deliver a working prototype Conan device with a working AAAC detector head. The project is delivered in a staged manner with each stage having measurable objectives which can be used to benchmark progress. In the reporting period stages 1 & 2 of the project were completed.

The first objectives of Stage 1 involved delivery of the breadboard design for the AAAC detector head. On commencement of the work, it was realised that further equipment was needed for testing, which was only available in Stage 2. This deliverable has since been completed and included as part of the detailed electrical design. The measure of success of this will be confirmed in Stage 4 – Performance & Practical testing.

The second objective in stage 1 was to deliver a functional design specification and concept design for the Conan unit. This was achieved with EST providing functional design requirements and a technical specification for the project.

The key objective of stage 2 was to finalise the detailed electrical and mechanical design for Conan and for AAAC detector head. This objective has been met and the design is captured within a detailed design summary report which includes description of the design methodology and detailed description, including dimensions and weights, of all components within the devices.

2.7 | NIA SPEN 0059 Landslide Protection Asset

A landslide in the vicinity of overhead transmission assets can result in costly repairs and put network integrity at risk. This landslide protection project will enhance our knowledge of areas of the Transmission network potentially vulnerable to landslides and prove that mitigation measures can be deployed safely through a trial on a selected pylon.

Debris flow impact to Tower YW102

Background

On the evening of 04 August 2019, widespread debris flows occurred on the slopes of the Loch Katrine catchment following an intense rainfall event. One of these debris' flows impacted and damaged pylon 102, part of the YW 275kV overhead line that runs north-west to south-east along the western bank of Loch Katrine.

As a result of the damage and remedial works at pylon YW102, SP Energy Networks have commissioned Mott MacDonald to undertake a trial landslide risk assessment study to identify other pylons that may be at risk from landslides and debris flows.

The YW route, which runs between Windyhill substation in the north of Glasgow and Dalmally in Argyll, was selected as a trial route for the assessment. The route comprises a total of 230 towers (YW001 to YW229) along a 76.4km length.

The objective of the project is to:

- Develop a Red, Amber and Green (RAG) database of assets which are vulnerable to impact from landslides.
- To prove that installing mitigation measures can be done safely to a selected pylon.

To realise these objectives the project will be undertaken in the following two stages:

1. Development of a risk rating assessment methodology and GIS modelling work to develop a RAG database identifying assets which are at high risk
2. Trial deployment of a steel netting or mesh system at a selected pylon identified as high risk.

The project is expected to realise the following benefits:

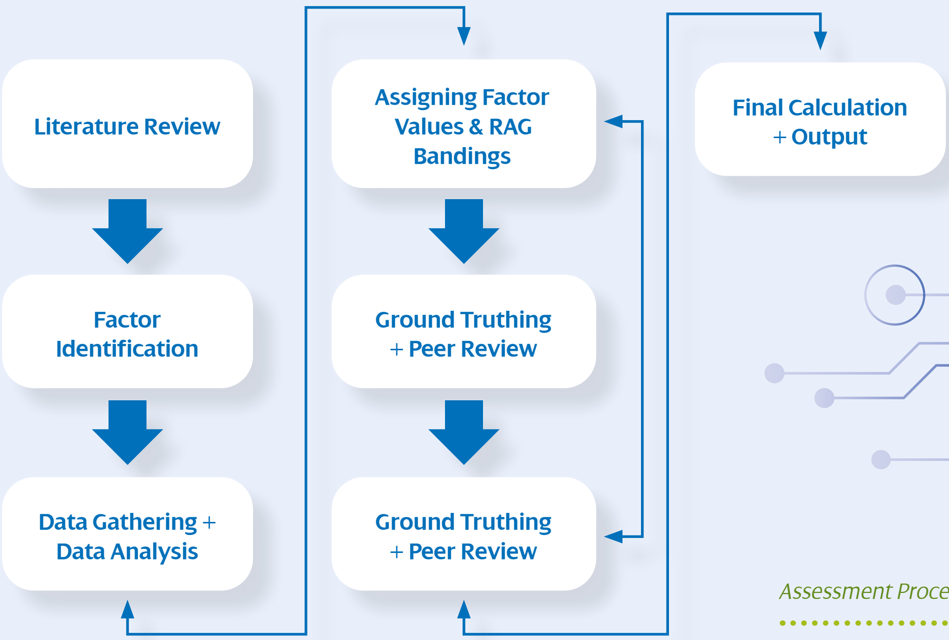
- Improved knowledge of network vulnerabilities;
- Improved network resilience;
- Preventing risk of future events;
- Lower repair costs; and
- Improved safety to staff & public.

2.7.1 | NIA SPEN 0059 Project Progress

The objectives of this project are to develop a RAG database of pylons on the YW route which are highly vulnerable to impact from landslides. This will enable SP Energy Networks to assess the pylons most at risk of being impacted from landslides, apply appropriate mitigation measures and prove that these measures can be done safely to a selected 'high risk' pylon.

The risk assessment phase of the project is in the final stages. The assessment considers the potential susceptibility of the slope above a tower to failure and the potential consequence of failure to present a risk rating.

The workflow diagram shown below describes the process followed.



Assessment Process Map

Literature Review

Mott MacDonald have produced an assessment methodology based on a literature review of existing landslide risk assessment studies.

Factor Identification

Landslide susceptibility is the likelihood of a landslide occurring in an area depending on local terrain conditions. There are a number of factors which can contribute to the likelihood of a landslide which were considered in the assessment.

Exposure (Consequence of Failure)

A landslide exposure value represents the relative value of a receptor that is exposed to potential landslides, i.e., assets on or at the base of a slope are ranked according to importance.

Risk

Risk = Susceptibility x Exposure

Risk is a function of susceptibility multiplied by the exposure.

Data Gathering

Datasets of an appropriate scale / level of detail, and available for the entire length of the route, were selected to build the site model based on the factors identified. Both purchased and freely available data have been used.

Data Analysis

The source data layers were imported into the workspace to create a site model. Further factor data layers were created to complete the model, by both manual digitisation and the use of GIS tools.

The risk area (combined catchment and buffer) for pylon YW102, with debris flow scar visible

Ground Truthing

A ground truthing exercise was undertaken between the 28 February and 11 March 2022. Selected pylons along the YW route were visited, with pylons of all risk levels included.

Final Calculation

The final calculation is subject to peer review.

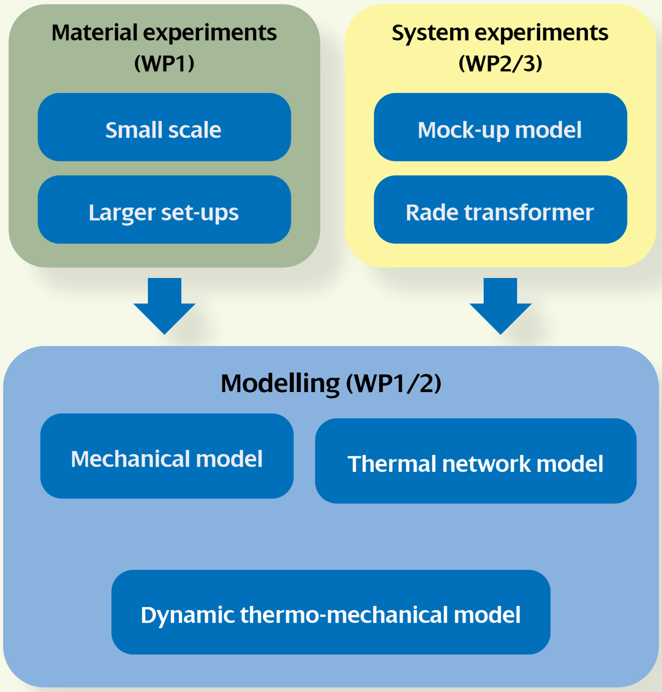
Next Steps

The next stage of the project will be the agreement of pylon specific site visits and selection of sites for trial landslide protection measures.

Interim calculation results for the northern end of the YW route (before ground truthing and final results) showing Red, Amber, Green risk rating for each pylon risk area

2.8 | NIA SPEN 0062 DynaLoad – Dynamic Loading of Transformer Insulation

The main objective of the DynaLoad project is "To characterise the long-term mechanical endurance of transformer insulation under heavy dynamic loading conditions". The diagram below shows how the work packages are linked, and in which order the different tasks will be performed. To reach the main objective, DynaLoad aims to develop a dynamic thermo-mechanical model for describing the clamping pressure of a transformer under rapid dynamic loading.



Objectives

The project aims to characterise the long-term mechanical endurance of transformer insulation under heavy dynamic loading conditions. To realise this objective, the following actaivities are to be undertaken.

- Arrange a workshop on available information on materials and dynamic thermo-mechanical modelling of transformer windings;
- Report on winding clamping designs;
- Investigate clamping pressure and temperature variations in an instrumented transformer in service under relevant load cycling;
- Investigate dynamic thermal and thermo-mechanical computer models for windings in transformers;
- Characterise the mechanical deformation of relevant insulation materials as a result of frequent and rapid thermal and mechanical stress cycles under different moisture conditions in small scale model experiments; and
- Characterise relevant materials using dynamic mechanical (DMA) and thermo-mechanical (TMA) analytical instrument on small material samples.

2.8.1 | NIA SPEN 0062 Project Progress

The objective of this project is to characterise the long-term mechanical endurance of transformer insulation under heavy dynamic loading conditions.

During the reporting period the following progress was made against the project scope:

Arrange a workshop on available information on materials and dynamic thermomechanical modelling of transformer windings

A workshop was arranged in November 2021, the workshop was divided into two days, plus a short 1-hour meeting held on February 2nd. The first day, the partners presented their work on transformers and transformer insulation, relevant for this project. The second day, SINTEF Energy Research presented updates/proposals that served as a basis for discussing the work to be performed in DynaLoad. February 2nd, the plans for a PhD were discussed and the formal steering committee meeting took place.

Report on winding clamping designs

A literature survey on the mechanical behaviour of pressboard used in clamping arrangements is in progress and the learning outputs will be disseminated in September 2022.

Investigate clamping pressure and temperature variations in an instrumented transformer in service under relevant load cycling.

Sensors have been installed in a transformer, currently working through small technical adjustments to ensure the sensors are working correctly. A meeting to plan the required experiments with this transformer will be held after the summer.

Investigate dynamic thermal and thermo-mechanical computer models for windings in transformers.

This work package has not started yet.

Characterise the mechanical deformation of relevant insulation materials as a result of frequent and rapid thermal and mechanical stress cycles under different moisture conditions in small scale model experiments.

Test equipment is ordered, and sensors are being considered. The design of different set-ups is underway. Initial experiments are expected to start in Autumn 2022.

Characterise relevant materials using dynamic mechanical (DMA) and thermomechanical (TMA) analytical instrument on small material samples

Experiments have been performed and a report detailing the learning outcomes is in production. This will be delivered in August 2022.

2.9 | NIA SPEN 0064 Cyber Security for Active and Flexible Energy Networks (Cyber-SAFEN)

To meet the current environmental challenges, the energy industry must digitalise their energy systems in order to meeting the requirements for "de-carbonisation and decentralisation". Customers benefit from the digitalisation of the network through increased reliability, sustainability, and functionality. Projects such as SP Energy Networks FITNESS Project show the viability of the digital substations and reduction in costs. The digital network has increasingly become a highly attractive target for cyber-attackers aimed at disrupting operations.

To meet the Government's aim for the digital transformation to underpin energy markets and optimise physical networks, a secure digital infrastructure needs to be built. Electricity systems urgently require a strong and integrated Cyber Defence system to protect our assets. Cyber defence to date has focused on detection but no integrated response solution exists for the operational network.

Cyber-SAFEN aims to build and demonstrate an Integrated Cyber Defence (ICD) platform for the first time in the UK energy industry.

Cyber-SAFEN will harness advanced artificial intelligence and machine learning technologies to build a dual defence system against advanced cyber threats. The scope of the dual cyber defence system is:

- To build an automatic cyber Intrusion Detection and Protection System (IDPS) to protect the electricity network against known or advanced cyber-attacks, and
- Then to develop AI based cyber Intrusion Response System (IRS) for the electricity networks protection and control system against malicious control action for the infected substations.

National Institute of Standards and Technology (NIST) Cybersecurity Framework

2.9.1 | NIA SPEN 0064 Project Progress

Cyber-SAFEN will research and develop a Cyber Intrusion Response/defence System (IRS) platform to provide essential cyber security functions to protect control systems, such as PAC, WAMS and SCADA, in the electricity networks.

The objectives of the project are as follows:

- Quantify the cost benefit and enabling capability to the GB energy networks;
- Identify the core technologies and applications;
- Engage with the supply chain and identify suitable vendors;
- Determine the data sources required for the response capability;
- Develop combined cyber defence solution; and
- Laboratory based trail of the solution.

We have identified research and licence holder partners for the project and prepared the scope of works. Contract finalisation is being undertaken and project kick off with then follow. The first stage of the project will quantify the cost benefit and enabling capability to the GB energy networks. We will also Identify the core technologies and applications and engage with the supply chain to identify suitable vendors. Following on from this we will identify the required data sources and develop the combined cyber defence solution resulting in a laboratory-based trial.

The benefits to customers and the network will come from:

- Reduced risk of outages and damage caused by cyber attacks;
- Enabler for increased digitalisation and automation across the network; and
- Ensuring a secure and resilient platform on which to rollout further applications.

SP ENERGY NETWORKS

3 | NIA Activities Linked to SP Transmission Innovation Strategy

3.1 | SP Transmission Innovation Strategy

SP Transmission's Innovation Strategy drives the direction and development of all innovation projects and initiatives and has been strongly influenced by the views of a wide range of external stakeholders and collaborators.

The SP Transmission Innovation Strategy was released in 2011 as part of the RIIO-T1 Business Plan submission, and has provided the consistent, coherent, and coordinated platform upon which all SP Transmission T1 innovation has been founded. This strategy has been reviewed annually, remaining robust despite the accelerating transformation of the energy landscape. It received an update by exception in 2014, and in Q3 2018 work began on the further development of this strategy to align with RIIO-T2 commitments. Following extensive engagement with all key stakeholder groups their feedback significantly influenced the latest Strategy, which was released in December 2019. This strategy represents a step-change in ambition and approach commensurate with the significant challenges and opportunities that RIIO-T2 represents. The six key transitional challenges identified are:

1. Improving the sustainability of our network and business processes and empowering our consumers;
2. Whole System Approach: overcoming boundary restrictions between electricity and gas transmission owners (TOs) and distribution network operators (DNOs), transport and telecommunications sector with increased customer engagement;
3. Integrating new technologies and enabling digitalisation, standardisation and cyber security;
4. Challenges related to black start;
5. Maintaining system security and stability: in light of reduced grid services, lower system strength, and increased grid dynamics and interactions; and
6. Evolution of our transmission network and associated uncertainties: including new requirements for reinforcement and the replacement, operation and maintenance of aging assets.

Crucial to the step-change in our Innovation approach, has been greater emphasis upon enabling a Whole System approach, empowering consumers, addressing consumer vulnerability and achieving sustainability through innovation.

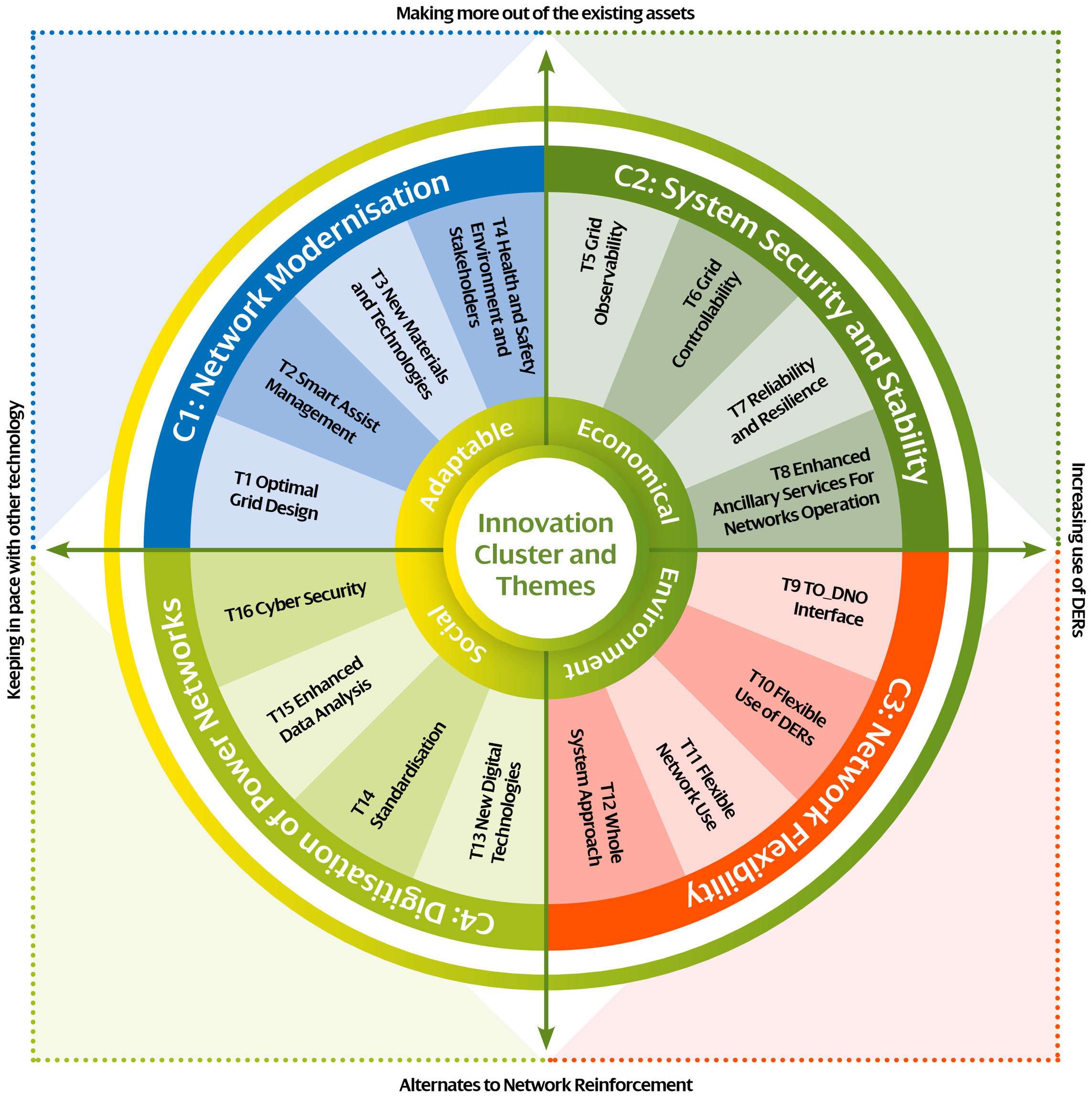
These advancements are supported by equally important step-changes in SP Transmission's innovation process and culture, together with a more robust strategies for translating innovation into BaU and collaborating with third parties.

Benchmarking against other innovative organisations led us to select the ENTSO-E Research and Innovation framework to structure the current strategy, leading to a shift from a project-based approach towards a cluster-based approach, creating groups of innovations to solve key system transition challenges in a holistic, interconnected way.

These clusters cover:

- **Cluster 1:** Network Modernisation (Themes 1-4)
- **Cluster 2:** Security and System Stability (Themes 5-8)
- **Cluster 3:** Network Flexibility (Themes 9-12)
- **Cluster 4:** Digitalisation of Power Networks (Themes 13-16)

Energy System Transition Challenges for the Future Transmission Network



3.2 | ENA Innovation Strategy

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

https://www.spenergynetworks.co.uk/userfiles/file/Electricity_Network_Innovation_Strategy.pdf

With regards to the ENA Innovation Strategy, we are looking to ensure that our existing and new projects can contribute directly to the five focus areas in the near-term:

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

3.3 | Culture of Innovation

Our culture of innovation initiative, DRIVE, has continued to focus on embedding an innovation culture across SP Energy Networks. This has led to an increase in ideas suggested by colleagues on strategic business challenges and an increase in the delivery of solutions that are benefiting our customers and embedding innovation in business-as-usual activities.

With the lifting of COVID restrictions last year, the importance of creating an innovation culture has become even more critical as working from home and hybrid arrangements are more widely adapted across the business.

A core component of DRIVE has been the continued support of the innovation platform, iHUB, which is used to generate ideas from all areas of the business on strategic challenges. To date this has helped deliver 11 innovation challenges on strategic themes to the wider business, resulting in the generation of over 300 ideas and engaged with over 1,300 colleagues.

One such project generated from the iHUB platform is the use of the Platipus anchor system which was proposed and implemented by one of our Innovation Champions. This project alone has significantly reduced cost through material savings, and additionally is used as a contingency plan that in the event of needing to reinstate a transmission line, it can be used to help reinstate the line faster, safer, and cheaper than the previously used process.

DRIVE has also delivered multiple ideation workshops this year, with the goal of promoting innovation and providing colleagues with the required skillset to develop ideas into feasible innovation solutions. The workshops have had a large uptake, allowing colleagues to collaborate with other departments and teams on developing their ideas.

SP ENERGY NETWORKS

4 | Areas of Significant New Learning

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

4.1 | Project Learning: NIA SPEN 0038 System Health Map

The project is now undergoing integration with SP Energy Networks IT systems. Once integrated this project has the potential for new learning in the following areas:

- New understanding and improved awareness of network behaviour - for example, through analysis of harmonic heat mapping;
- Improved understanding of asset degradation forecasting; and
- Understanding of the requirements of the implementation of a general data analytics platform in a networks business.

Some examples of the dashboard process and visuals – showing home page, the system health map and substation summary portals with condition RAG statuses.

The Interactive Reporting Suite

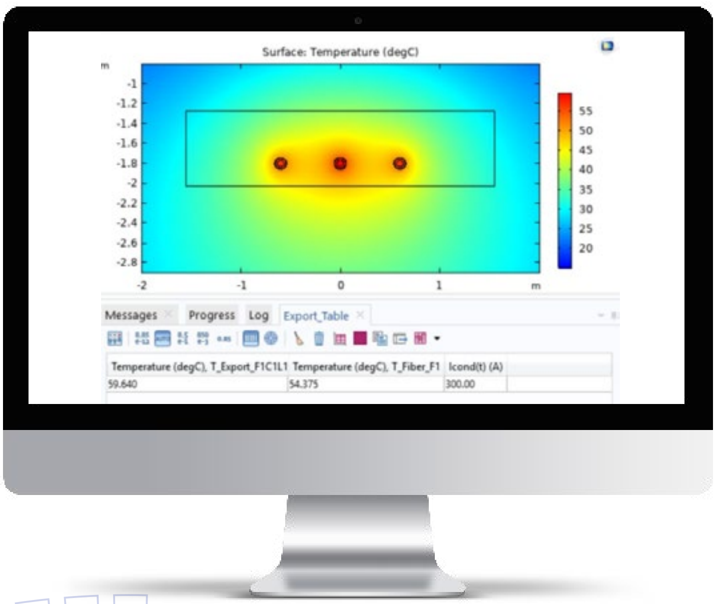
4.2 | Project Learning: NIA SPEN 0044 400kV Dynamic Cable Rating Retrofit Project Utilising RPMA Communications Technology

The RPMA telecoms technology has not proven as reliable as anticipated. To date there has been three site visits to replace telemetry units and batteries at different locations and full availability of all seven sensor units has not been realised. Consequently, having redundancy within the sensor units (there are two Pt100 sensors per unit) and monitoring at several locations (seven for this particular project) has proven essential to ensuring that dynamic ratings continue to be calculated from the NKT real time thermal rating software. Having remote third party access to the telecoms server would have been advantageous to trouble shoot and eliminate/reduce the need for site visits.

From our power cable monitoring experience, the more fluctuating traces above are typical patterns in case that the power cables are surrounded by air (cable tunnels) and the peaks come from ambient daily fluctuations. The more continuous readings are from direct buried sections, where there is no ambient temperature change on the daily basis but long-term changes due to the seasons.

The loading on the cable circuit was highly variable and relatively lightly loaded which makes analysis of the results difficult. In an effort to calculate the steady-state temperature an averaged real-time value was used. For the time period analysed this was assumed to be about 300A with a power cable surface temperature of about 25° C.

Undertaking a steady state ampacity calculation with 300A under summer conditions (15°C ambient temperature and 1.1 Km/W soil thermal resistivity), a power cable surface temperature of 54°C was observed, not 25°C. As the temperatures being observed are lower than those anticipated a sustained highly loaded period is required to allow effective analysis.



4.3 | NIA SPEN 0051 All Terrain Low Ground Pressure Access Vehicle with 34m Boom

Once we have access to the new vehicle there will be project learning arising from its operational deployment.

Currently, there is no vehicle with these unique capabilities in the UK electricity industry. Going forward, the vehicle has the potential to be rolled out across the industry.

4.5 | Project Learning: NIA 0054 Transmission OHL Crossing Protection Stage 1

The system being developed will be able to be used initially where 132kV lines cross lower distribution lines. If the system can prove cost effective, it will then be manufactured and trialled.

Learning so far:

- **Design –** Focus on a vehicle mounted system costing £250K minimum per unit. Estimated that SP Energy Networks would need 4-8 units to cover required area, so anticipated cost will be high and may not be accepted by the business.
- **Additional costs –** There will be training costs for internal staff and/or contractors to factor in, as well as storage, maintenance, LOLER inspections, live working inspections and annual refresher training.
- **Deployment –** Unclear who are the staff that will work and deploy this system? Will be tied up for months on end when the reconductoring season is ongoing.
- **Ownership of the system –** To be discussed and agreed (do SP Energy Networks own? Supplier?). These would need stored indoors and maintained by external contractors which is why SP Energy Networks tend to hire equipment.
- **Usage –** The units would be sitting idle for six months of the year so unless we own them, it is expected that a contractor would lease them to us (like a MEWP) and expect the day charge would reflect they are not used for 6 months of the year. Also, we would then not have exclusive use.
- The units cannot be used in shared partnership with other TOs / DNOs; however, the system can be designed in collaboration with them. This isn't a favoured solution, and it will not help reduce cost.

4.6 | Project Learning: NIA SPEN 0057 Project Conan

The project is at an early stage, however it is envisaged that the learnings and results from the developmental work within Project Conan will provide an understanding of the capabilities and limitations of electromagnetic based sensing techniques on detecting corrosion in both Aluminium Conductor Steel Reinforced (ACSR) and aluminium based conductors.

The project will also deliver learnings through the development of a new traceable, evidence-based methodology/information upon which conductor condition replacement decisions are to be made.

As part of this project, the supplier will utilise the learnings from disassembling, renewing, and servicing existing Cormon equipment to further accelerate the development of the new device, Conan.

4.7 | Project Learning: NIA SPEN 0059 Landslide Protection Asset

The project is largely complete with the findings of the assessment being discussed to understand the implications to the transmission network and recommendations for future work.

The assessment is considered to have allowed for the identification of pylon locations at higher risk of impact by landslides along the YW route. Considering the linear nature and significant scale of the route, the GIS based method of assessment is considered to be a particularly efficient first step in both identification of high risk locations and to allow for the discounting of lower risk locations. This approach therefore allows for focus of future studies and potential mitigation at pylons likely to be at the greatest risk.

The ground truthing exercise undertaken at a number of pylon locations has allowed for both calibration of the GIS model to improve its accuracy, and positive confirmation that the GIS assessment has accurately calculated the quantitative risk levels at the pylon locations, by comparison with the observed / visual (qualitative) risk levels.

4.8 | Project Learning: NIA SPEN 0062 Dynaload – Dynamic Loading of Transformer Insulation

As we are at the early stages of the research, learning is limited to knowledge gained from literature reviews and sharing of information between the research partners. Key learnings from the project will consequently be shared in subsequent annual report.

4.9 | Project Learning: NIA SPEN 0064 Cyber Security for Active and Flexible Energy Networks (Cyber-SAFEN)

The project is at an early stage but as it progresses we would expect to identify new ways to implement a combined cyber defence platform that could be utilised by Energy network operators. The opportunity for demonstrating the cyber-SAFEN solution in the laboratory setup would be used for training and dissemination throughout SP Energy Networks and other interested parties.

SP ENERGY NETWORKS

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