SP ENERGY NETWORKS

TRANSMISSION

NIA Annual Report 2018 – 2019

Enquiry please contact

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Foreword

SP Energy Networks (SPEN) is committed to delivering the Transmission Grid of the future through our licensed business SP Transmission (SPT).

This is our sixth Network Innovation Allowance (NIA) Annual Transmission Report and is an overview of on-going Transmission related projects being undertaken, and those initiated, during the regulatory year 2018/2019.

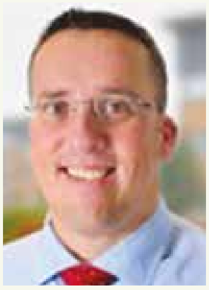
Our NIA projects continue to play a key role informing the development and delivery of our Network Innovation Competition (NIC) projects and we recognise the importance of wider stakeholder engagement and knowledge sharing for the wider benefit of the industry.

Our focus is on the successful delivery of our NIC projects, transitioning them into business as usual and realising their value for the benefit of our customers.

As a Scottish Transmission System Owner (TSO), SP Transmission invests significant efforts to safeguard our system resilience and supply reliability. Partnering and collaboration is a critical part of our innovation strategy and we believe that our projects are greatly enhanced by incorporating wider experience, knowledge and skill sets. We are delighted to be supporting National Grid Electricity System Operator with their NIA project on the feasibility of Black Start from Distributed Resources, which in turn led to an international ground-breaking 2018 NIC project on Distributed Restoration. SP Energy Networks is delighted to participate in this important and timely initiative by leading, testing designing and trialing work packages that could ultimately lead to significant benefits for electricity customers in the UK.

In 2019 we launched our Year of Innovation, a great initiative addressing the most fundamental element of innovation- People! This will set the foundations of a three year campaign to strengthen our culture of innovation and get more people actively engaged in innovation across the business.

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



Colin Taylor
Director
Processes and Technology

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Executive Summary

Our sixth Network Innovation Allowance (NIA) 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 sixth NIA Annual Statement presents an overview of the projects we have initialised during the regulatory year 2018/2019 and an update on those projects reported during 2017/2018 which are still active.

The progress of each project aligns with the five innovation objectives set out in our Transmission Innovation Statement:

- 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 pursed 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-T1), but also those anticipated as longer term requirements (beyond 2021).

In addition to funding smaller projects, we will continue to utilise NIA Transmission funding, where appropriate, to prepare for future Network Innovation Competition (NIC) submissions.

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


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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-T1 (Revenue = Incentives + Innovation + Outputs, 2013-2021) 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 for two purposes:

- To fund smaller projects which meet the criteria set out in this Governance Document; and
- To fund the preparation of submissions to the Network Innovation Competition (NIC) which meet the criteria set out in the NIC 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 new RIIO - T1 model for price controls with the introduction of the NIA.

This report presents SPT's NIA activities during the sixth year of its introduction, 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. SPT has identified a number of key themes as a result of our ongoing stakeholder engagement which are the principal drivers behind our innovation strategy.

Following a comprehensive stakeholder mapping activity, which formed part of our Transmission Innovation Strategy published in 2011 (and subsequently reviewed in 2014) the key outputs from subsequent stakeholder engagement to date have been:

- Communicating with stakeholders to understand their needs and expectations more effectively;
- The connection of customers (demand and generation) onto the network to deliver sustainable low carbon energy through fair, clear and accessible processes;
- Maintain security of supplies and maximise long term value for end-users through improved network availability and reliability processes; and
- Minimise the environmental impact of our operations.

SPT recognise that consideration needs to be given to not only the RIIO-T1 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 consideration is detailed within the report along with details of how our NIA activities link to SPT's innovation strategy.

2 | Progress Summary

During the reporting year 1st April 18 to 31st March 19 SP Transmission registered the following NIA project:

- NIA SPEN 0035 Transient Recovery Voltage Investigation
  www.smarternetworks.org/project/nia_spen_0035
- NIA SPEN1802 SIARA - System Integrity and Restorative Actions
  www.smarternetworks.org/project/nia_spen_1802

The following sections provide a short overview of each active NIA project and summarises the progress that SPT has made on them. 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.smarternetworks.org). Key learning associated with these projects is summarised in Section 5.

2.1 | NIA 1504 Managing Uncertainty in Future Load Related Investment

Uncertainty in relation to future demand and wind and PV generation output is already becoming a matter of concern in electricity network planning. Expected uptake of heat pumps, electric vehicles and other low-carbon technologies (LCT) will further increase uncertainty.

This project will develop and demonstrate (in prototype form) methods to use simulation techniques to examine a large range of 'scenarios' of future demand and generation development and output. This will be done by sampling from suitable statistical models of these and other external factors such as time-of-day and weather. The sampling approach will be designed to give a coherent picture of future network use, considering both traditional load and generation, and the uptake and behaviour of new technologies. The resulting scenarios will then be simulated and analysed individually to evaluate network performance metrics such as of power flows, constraint violations and reliability statistics. This large-scale sampling and analysis approach will result in a statistically representative database of network operating states and external conditions.

Methods to statistically interpret and interrogate this database will then be developed to identify the nature, location and factors underlying the most likely constraint violations and performance degradations, and to identify priority locations and trigger points (in terms of load growth, LCT uptake, etc.) for the deployment of interventions to solve anticipated problems.

The project analysis will focus on one grid supply point in the ScottishPower Transmission area.

2.1.1 | NIA SPT 1504 Project Progress

The project is now in its final reporting stage, with technical work (other than finalization of case studies) being complete. A prototype modelling, simulation and analysis environment has been developed which allows the adequacy of distribution networks (and subsequently transmission networks at the transmission/distribution boundary) to be evaluated under uncertain future conditions in terms both of the deployment of renewable generation and other low-carbon technologies, and also the day-to-day behaviour of these resources.

This evaluation is achieved by describing future scenarios of uptake and deployment to represent long-term uncertainty of deployment, while using statistical models to represent short-term uncertainty of behaviour. These models are sampled to create a large number of operational scenarios of hour-to-hour network behaviour, which may be focused on particular times of concern, such as winter evenings (for load constrained cases) or summer daytime (for cases with significant PV uptake). These scenarios are programmatically simulated, and results collated and summarized to assess the adequacy or otherwise of the network, and to characterize the condition under which any inadequacy is experienced. The overall approach is shown in Figure 1:

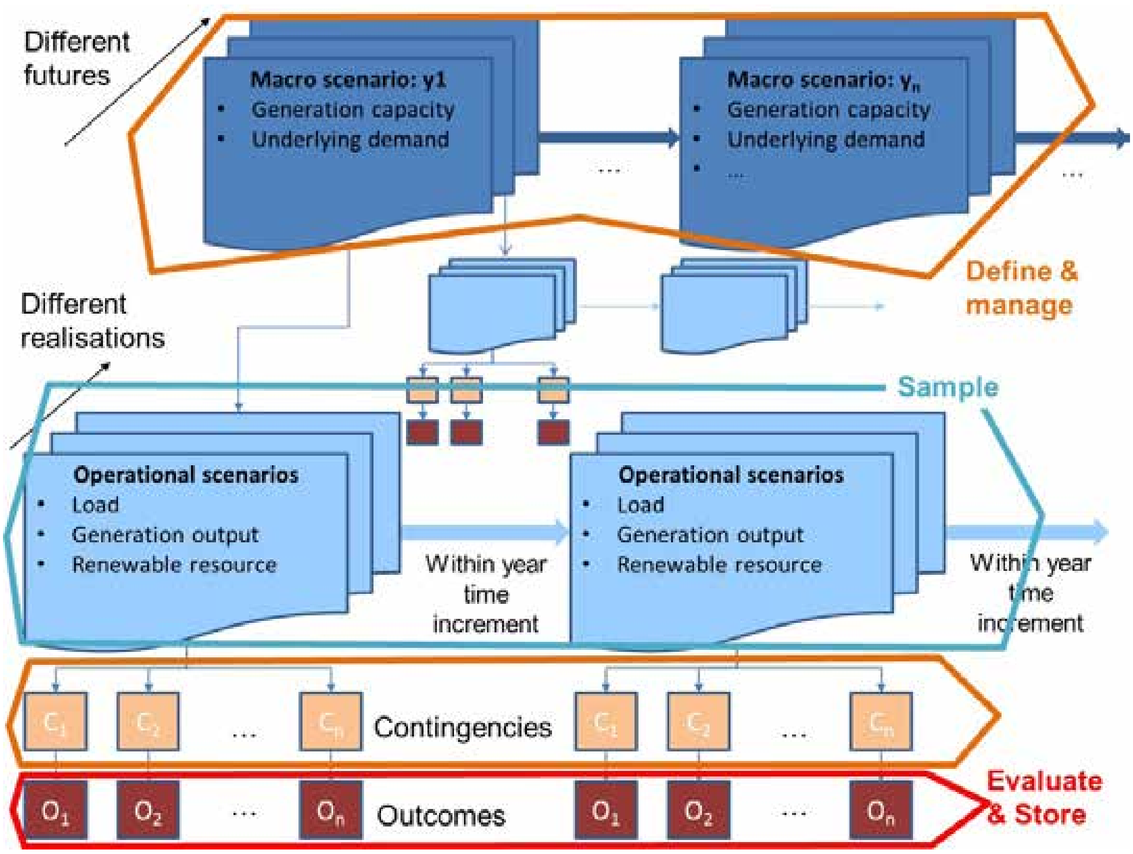


Figure 1 Overall Approach to Managing Uncertainty in Future Load Related Investment

In Figure 1, long-term uncertainties (LCT deployment, changes in underlying demand, etc) represented by "macro scenarios", each of which describes a coherent possible future situation, and may represent different future years. Shorter-term uncertainties are represented (as noted above) by operational scenarios, each of which describes a possible daily combination of load and generator behaviour. To these are added contingencies (which may be complex to model protection and control systems) to give an overall set of cases to be simulated, analysed and summarized.

Models of innovative interventions demonstrated in DNO-led innovation projects (such as dynamic equipment ratings and intelligent network reconfiguration) have also been integrated, and can be applied to networks which experience constraint violations in order to assess their suitability to improve network adequacy. Selective reanalysis of specific operational scenarios has been built into the simulation environment to permit efficient evaluation of the applicability of these techniques in relieving observed problems.

The simulation environment has also been extended, and its interfaces adapted to permit analysis of adequacy at the transmission/distribution boundary. This has involved the addition of further simulation methods (e.g. fault level and voltage step) and corresponding visualization and summarization tools.

2.2 | NIA 1505 Trial of Open Innovation in Utilities Sector

The Open Innovation (OI) model is being developed to bring together the company challenges and the innovators. It has been shown that the most innovative and game-changing ideas can come from outside the sector. In addition, it can be time and resource challenging to develop and deliver suitable projects within the business.

Scottish Enterprise awarded SP Energy Networks with funding to promote contracts with Scottish SME's by the implementation of Open Innovation. SP Energy Networks works together with Subsea 7, Weir and Doosan Babcock to share the advances done in Open Innovation inside each during the duration of the programme.

The Open Innovation programme aims to evolve the concept of innovation in the companies working on this programme. Innovation usually means focus on inside research and development to develop new technologies or processes to create new products to improve the current market or to open new markets for the company.

Open innovation changes this paradigm, involving the acquisition, licensing and use of technologies developed outside the company to solve the challenges, as well as the spin-off of technologies developed inside the company that are not used or may have applications in a different industry.

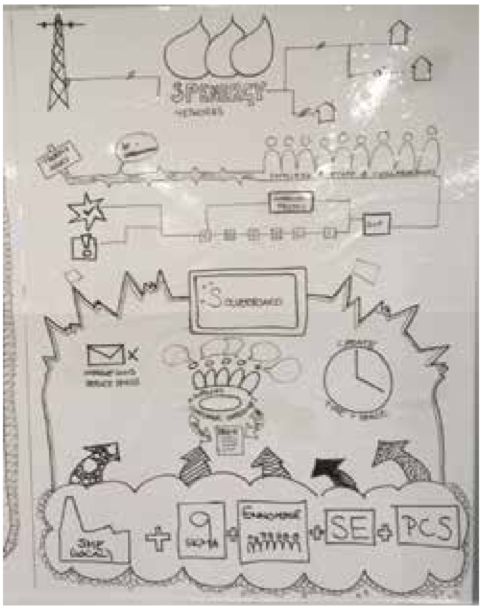
Open Innovation programmes aims to increase the number of SMEs working together with SP Energy Networks to expand and spread the talent.

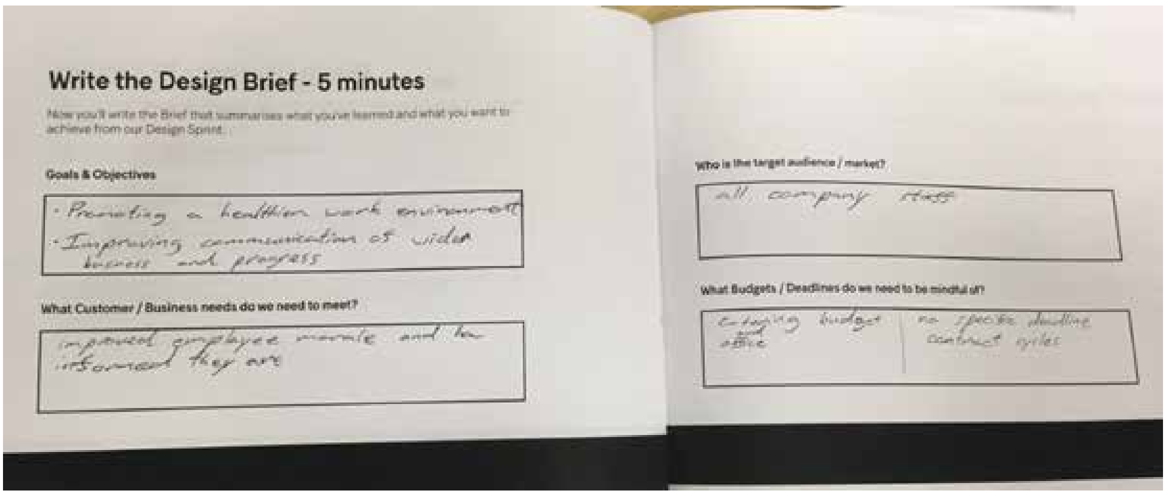
2.2.1 | NIA SPT 1505 Project Progress

At the start of 2019, SPEN launched the Year of Innovation initiative; this has developed a number of initiatives from the Open Innovation project and is rolling them out to the business more widely.

One of these initiatives is to introduce an innovation platform to enable the discussion of challenges and ideas. This will empower staff within the business to start innovation projects, and to encourage them to share the issues and challenges they face. This will help to increase the number of innovation projects that are initiated and carried through, and improve our ability to deliver benefits into the business.

In association with this, we have worked to recruit over 90 "Innovation Champions" across the business to assist in running Lunch and Learn events, and to assist in gathering challenges and ideas. These champions will also assist in future stages of innovation projects, ensuring that resources within the business can be leveraged more effectively and quickly.





In addition to these developments, we have also continued to develop projects which have come from Open Innovation challenges. An example of this is the CALISTA project, which has developed from a cable fault location challenge, and is now an NIA project in our distribution portfolio.

Another project we are developing is a system for improving safety during the reconductoring process for transmission overhead lines (OHL). This will be a system to prevent transmission conductors from coming into contact with distribution OHL assets where these assets cross one another. This project has been developed through Open Innovation, and is currently being reviewed after feasibility work with Reece Innovation.

2.3 | NIA 1507 Modelling of Static and Dynamic Loads

The ultimate goal of this project is to improve the understanding of behaviour of load centres and evaluate the existing load models used in the system studies performed by SPEN.

It is expected that by achieving this, the accuracy/effectiveness of network planning and operation tools will be improved by:

- gaining a better understanding of load behaviour
- improving understanding of existing load models
- creating new methods for the estimation of load model parameters
- demonstrating a methodology for estimation of load model parameters using different load models
- assessing the interaction between different load types and the main grid.

Accurate load models can support improved decision making when considering the required system expansion. It is expected that the exploitation of the existing assets can be improved, potentially deferring network reinforcement and influencing fundamental network design principles. Last but not least, a detailed understanding of demand behaviour is a prerequisite for integration of system operation actions at distribution and transmission levels.

In order for the project to deliver these benefits, the investigators from The University of Manchester are proposing an approach for the estimation of the unknown load parameters of generic aggregated load models based on measurements recorded from the distribution/transmission system. This approach would first be demonstrated using detailed simulated studies in DIgSILENT PowerFactory. It is assumed that the research will also include processing of laboratory data records, which will be used to validate the quality of conclusions obtained through simulation studies.

2.3.1 | NIA SPT 1507 Project Progress

The work planned for this project has been done according to the project plan.

At this project stage, an assessment of the classification for load modelling techniques resulted in the following block diagram:

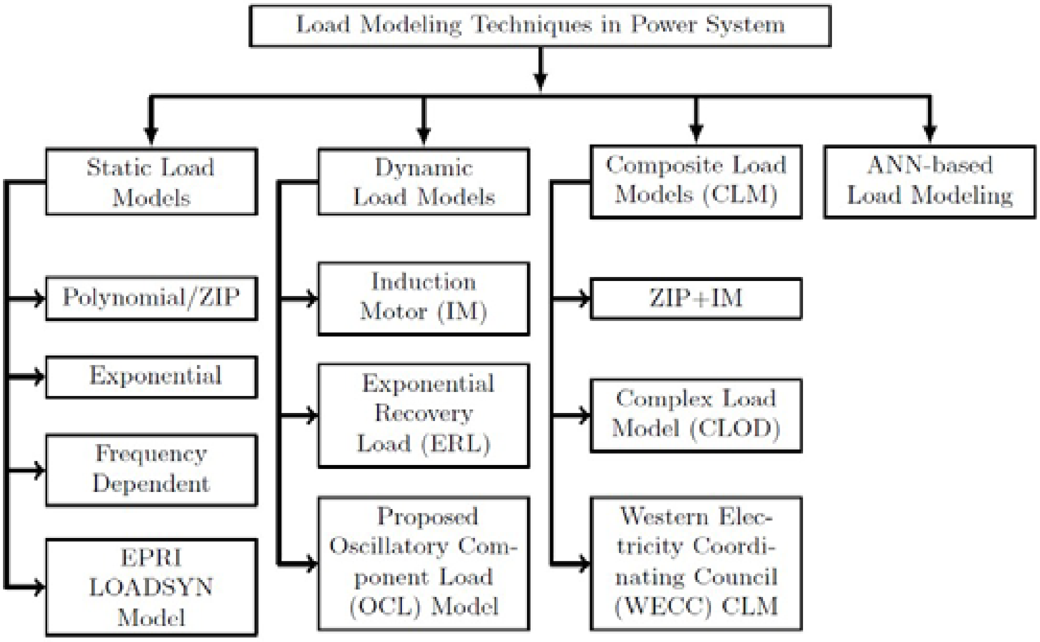


Figure 2: Load Modelling Techniques

Furthermore, by assessing the existing calibration techniques suitable for load modelling, the following block diagram is created:

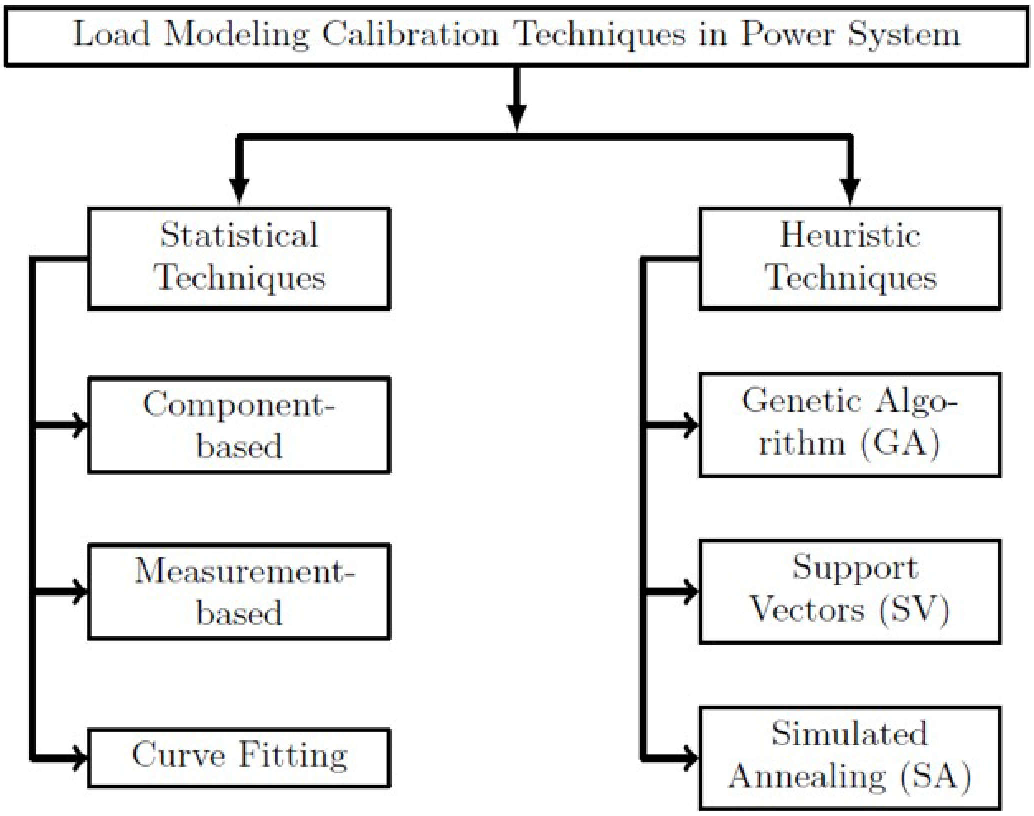


Figure 3: Load Modelling Calibration Techniques

Research on load modelling was focused on an attempt to improve the existing exponential recovery load model. By assessing load response, it was noted that next to the exponential recovery, load sometimes demonstrates oscillatory nature. This has motivated a research of integrating a superimposed damped oscillatory component to the existing exponential recovery load model. As a result of this work, a new oscillatory component load (OCL) model was derived. The model takes into account the above mentioned oscillatory nature of load response, expressed e.g. in damped oscillations of load active power. Such a model is much more complex than the original exponential recovery load model. Consequently, estimation of its unknown model parameters is becoming a challenge, which had to be carefully considered. The entire model for estimation of unknown model parameters became nonlinear and by this much more complex for its practical application. This was also one of our focuses. Appropriate solutions were proposed.

After deriving a new load model, appropriate DIgSILENT PowerFactory dynamic simulations showed its advantages against the original exponential recovery model.

Using data obtained from real network, the new model was tested and very optimistic results were obtained.

Both the model and its testing using different types of data were formulated in a form of a journal paper, which has been submitted to the IEEE for publication.

2.4 | NIA SPT 1601 – Power 2 Tower: Stage 1

There are many requirements for monitoring along the length of, or at specific points on, overhead lines – examples include dynamic line rating, partial discharge measurement on tower based cable sealing ends and fault location. However, the provision of 230 Vac single phase supplies to individual towers to power the monitoring equipment is problematic and unlikely to yield economically viable solutions. This collaboration with Elimpus is the first of a proposed three stage development of a monitoring system that can be used along the length of a transmission line, comprising of tower-mounted, wirelessly communicating monitoring platforms which are powered by energy harvesting from the immediate environs of the transmission tower.

The monitoring system solution would be such that measurements made from one tower can be wirelessly transmitted to the next tower and so on until the data reaches an access point, such as a substation or a fibre optic cable joint. Hence, the tower-mounted hardware (TMH) units will have three functions:

1. Power management
2. Local monitoring
3. Store and forward node for adjacent TMH units comprising the system.

This project is based on the following design assumptions:

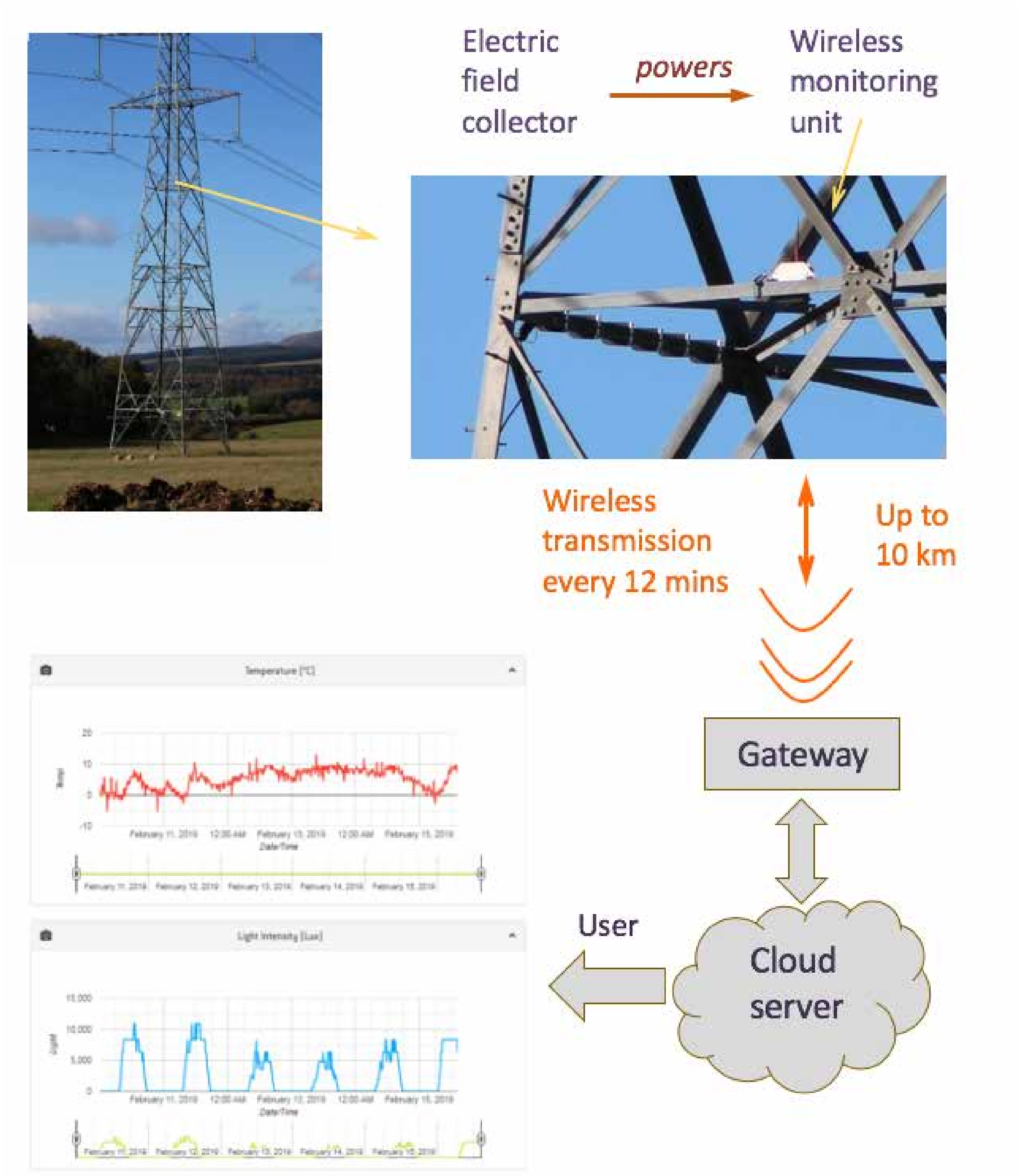
- The tower mounted hardware will be non-invasive, not requiring any outage for installation.
- The TMH unit will be bolted to the tower steel-work and will be lightweight to facilitate rapid deployment.
- The TMH design will be based on commercially available, power-efficient components that will be designed for operation under all weather conditions commonly encountered on OHL routes.
- TMH unit design life-expectancy > 10 years.
- No periodic maintenance of the TMH units will be required.
- The data output of the monitoring system will be compatible with ScottishPower's business systems.

2.4.1 | NIA SPT 1601 Project Progress

Aeolian vibration: Tests using a prototype rig incorporating a piezoelectric harvesting device have demonstrated a harvesting ability of 0.2 mW under the most favourable conditions which are unlikely to be consistently present on an overhead line tower. Although there is potential with this approach, significant engineering challenges would have to be overcome to develop a commercial harvesting device. The variability of the energy source is a particular concern. Due to the engineering difficulties and low energy yield, this approach was not further developed for an overhead line trial.

Earth wire current: Measurements conducted on a 400kV overhead line circuit have shown that the earth wire current varied between 22 and 37A. Further analysis showed that the current is a function of both the load current and the tower geometry. To efficiently harvest energy from the earth wire using a compact design would require an iron-cored flux concentrator which would need to withstand the effect of fault currents. A particular concern is any potential damage caused to the earth wire by the device. Similarly to the Aeolian vibration, the earth wire current approach was not developed into an overhead line trial.

Electric field: a trial version of the electric field harvesting device was successfully installed on a 400kV overhead line tower in January 2019. To demonstrate a monitoring ability the device incorporated both temperature and solar radiation sensors. The recorded measurements are wirelessly transmitted to an internet gateway, and then to a cloud server where the data is served to the user.


Electric field collector
powers
Wireless monitoring unit
Wireless transmission every 12 mins
Up to 10 km
Gateway
Cloud server
User

2.5 | NIA SPT 1604 Introduction of Environmentally Friendly Alternatives to SF6

SP Transmission Limited (SPT) have implemented a project to reinforce the 400kV and 275kV substations at Kilmarnock South to facilitate the planned amount of renewable generation capacity contracted to be connected to the transmission system in South West Scotland. A new 400kV double busbar Gas Insulated Substation (GIS) will be provided and built with a footprint designed to accommodate a total of 15 bays with an initial provision of 3 bays equipped with 400kV GIS switchgear. The employment of GIS offers benefits over AIS such as reduced space requirements (10% of AIS at 400kV) high reliability, improved safety, long service, reduced maintenance requirements, and low life cycle costs.

The main disadvantage of GIS is the use of large quantities of SF6. SF6 is an excellent insulator, and is widely used in the electrical industry in high-voltage air or gas insulated switchgear, but it is a greenhouse gas with an extremely significant impact on global warming. It is one of the six gasses listed in the 1997 Kyoto Protocol designed to lower greenhouse gas emissions worldwide.

As part of the RIIO T1 Business Plan, SPT aspires to identify measures to improve the overall business carbon footprint where appropriate. SPT manage their SF6 inventory in accordance with industry good practice, but until recently, there was no alternative to SF6
that featured equivalent switching and voltage-withstand capabilities.

A number of companies are looking to develop environmentally friendly SF6 alternatives. GE Grid Solutions are one company who is leading this field and can now offer a revolutionary SF6-free solution, g3 which has been jointly developed with 3MTM, a leader in environmentally sustainable solutions. g3 has 98% less impact on global warming than SF6. With performances comparable to SF6, it is a suitable technology for the development of today's new generation of clean high voltage equipment. GE Grid Solutions has been contracted to install the new 400kV GIS switchgear including a Gas Insulated Busbar (GIB) at Kilmarnock South and has confirmed that one 400kV (GIB) can be installed with g3 as part of an

2.5.1 | NIA SPT 1604 Project Progress

The installation work on the g3 compartment Work on the 400 kV GIS switchgear and GIB sections is completed. This includes 177m of GIB. Based on a 40 year life, the estimated equivalent emissions of CO2 into the environment will be reduced by 6,350 tonnes.

We have updated our policies and Safety Rules covering working with SF6 gas to include alternative dielectric gases and have purchased specialised equipment for detecting g3 gas and for testing the quality of the gas.

2.6 | NIA SPT 1605 Cable Diagnostics for HVDC Cables

The application of HVDC cables over long distances is on the increase and it is becoming clear that the ageing characteristics of the insulation in such cables are not well understood. As this is a project to obtain better understanding, the method is one of understanding what is currently known about the ageing characteristics and then to consider what else needs to be done to address the knowledge gap.

From the gaps in the knowledge identified through the review, a systematic and logical experimental work plan will be developed to understand partial discharges in HVDC cable systems. The work plan will be based on laboratory experimentation as well as computer simulation (where appropriate) to allow a better understanding of how partial discharges are generated in a HVDC cable system and the mechanism responsible.

The new knowledge generated from this research will inform subsequent innovation activities that are expected to lead to improved asset management techniques with benefits including the following: -

- Asset replacement before failure.
- Reduced number of faults.
- Targeted investment on cables that are in greatest need of replacement.

2.6.1 | NIA SPT 1605 Project Progress

A second year progress review of the project was conducted by the Department of Electronic & Electrical Engineering University of Strathclyde and all reviewers were satisfied with project progress. Following the review, the second-year report was submitted to SP Energy Network satisfaction of the condition of funding for their reference. The literature review showed that nanodielectric materials (when used in cable insulation) indicated a superior performance over XLPE by exhibiting a higher operating temperature, a better space charge suppression and an environmentally friendly property. The research is now re-focused on the nanoparticles doped polymer insulation materials for potential use in HVDC cables rather than nanoparticle-doped field grading materials.

To meet the demands, nano-Al_2O_3 /LDPE and nano-Al_2O_3/ PP were chosen to be investigated as candidate material and their results obtained would be compared with existing HVDC cable insulation material. A few nano-Al_2O_3/ LDPE thin film samples were produced in the Chemistry Department at University of Strathclyde. However, the quality of samples produced was not good enough due to limited experience and lack of proper equipment. To solve these problems, a 3-month academic visit to Tsinghua University, Beijing, China was scheduled to manufacture nano-Al_2O_3/ LDPE and nano-Al_2O_3/ PP thin film samples and to conduct PEA measurements for thin film samples. Both unmodified and surface-modified nano-Al_2O_3 will be made with varying contents, i.e. 0 wt%, 0.5 wt%, 1 wt%, 3 wt% and 5 wt%. For each formula, 20-30 samples are expected for the subdequent electrical and chemical tests such as DC breakdown test, DC conductivity test and DSC analysis. In addition, space charge behaviour of the prepared samples will also be studied in Tsinghua University as space charge retention is one of the most important characteristics of DC insulation material to be overcome. DC breakdown and DC conductivity measurement are expected to be done within six months after visiting.

2.7 | NIA SPT 1606 Reuse of Existing Concrete Assets

There is a very large asset base of concrete structures within ScottishPower that are approaching or have potentially reached the end of their service life. Current practice within ScottishPower is to demolish these concrete structures and replace them with new steel structures.

It has been identified that alternative methods are available that can possibly extend the lifespan of the existing structures. Where it is identified within the concept design that certain existing structures can be reused then ScottishPower want to investigate the viability of this. To realise the potential benefit of this, ScottishPower wants to review current practice and identify a methodology that is more sustainable, requires less outage time to construct and is more economical.

The aim of this project is to create an assessment process and specification to determine whether these existing concrete assets are suitable for reuse. This project will develop a methodology to determine the assessment criteria, reuse, strengthening and repair process. The methodology will then be used to implement the recommendations from the design assessment which will be collated through the design reporting stage. This will allow recommendations to be implemented within each asset replacement programme to allow existing concrete assets to be re-furbished as appropriate. It is anticipated that this approach will allow ScottishPower and the wider industry to achieve cost and time savings on major construction projects which in turn will provide increased network resilience by reducing outage requirements. The reuse of these structures will also support ScottishPower's sustainable development policy.

2.7.1 | NIA SPT 1606 Project Progress

Initially a methodology has been developed for analysing concrete structures for the possibility of re-use. This methodology looked at different testing arrangements for assessing the condition of concrete with regards to its visual condition as well as taking samples to test and other non-destructive testing.

Based on the research provided in the methodology this was applied to three sites in the SP Energy Networks area, Westfield 275kV, Gateacre 132kV & Colwyn Bay 132kV substations. At each site a single bay was targeted to be tested. A number of concrete tests were undertaken and were found to provide adequate information to allow a reasonable engineering decision to be taken on the structures being examined.



The condition results of the structures fed into the structural analysis stage to determine if or any reduction factors would be applied to each structure being analysed. A full structural assessment was carried out for the line landing gantry at Westfield 275kV, the strained gantry at Gateacre 132kV and the disconnector structure (JW8) at Colwyn Bay 132kV substations, to assess if the structures capacity was sufficient for re-use. The assessments were carried out in accordance with the processes set out in the NGTS and Eurocodes.

As the onsite work has completed the final stages to complete the final methodology are coming to an end. The learning from the onsite works is being used to update the methodology to allow SP Energy Networks to deploy this as business as usual. There is still a little bit of work to do to develop the scoring matrix that structures can be scored against which will allow a person to decide if a structure can be re-used.

2.8 | NIA SPT 1608 Reducing Energy Losses from Transmission Substations

At present, substation energy consumption is uncontrolled and unmonitored. Energy is consumed for a number of processes (e.g. heating, battery charging or dehumidifying) to ensure network resilience and ensure the security of the electricity network. Typically, the supply for Grid substations comes from the secondary windings on 33kV neutral earthing transformers, and is unmetered. As such, substation demand is not monitored or accounted for while it contributes to the SPEN transmission losses.

This project will initially aim to establish, through audits and metering, the baseline level of energy usage of a number of trial substations in the SP Transmission licence area, and then use the collected data to model the performance of the substation buildings. These data models will allow opportunities for energy efficiency to be identified, then enable the development for a plan for substation energy efficiency.

2.8.1 | NIA SPT 1608 Project Progress

This project is now near completion. Through the data monitoring, it was determined that the five substations monitored had a mean consumption of 214 kWh/year/m². This represents the energy used for heating the substation and for the internal and external lighting, splitting into approximately 206 kWh/year/m² for heating, and 8 kWh/year/m² for lighting.

Alongside this monitoring, Edinburgh Napier University's Scottish Energy Centre has worked on modelling each of these five substations. This allowed for building construction to be taken into account, and potential energy saving measures to have their impact modelled. These models have also allowed the substations to be categorised as archetypes, with each archetype having an associated energy usage per metre squared. This will allow energy usage in other substations to be more accurately estimated based on the substation construction and floor area.

This data and modelling gives an understanding of the energy usage within substations, and provides a starting point for working to reducing the carbon footprint of our substations. As heating is the major component of the substation energy use, controlling this is important. Any action to do this however must take a wide range of business stakeholders into account, as heating within the substation impacts on a number of technical and operational components within the substation. As an example, reducing heating usage during the summer months may prevent the temperature being raised unnecessarily, but it could impact on the substation's dew point. This could cause a build-up of condensation, which could damage communications and control technology in the substation, or pose issues for switching or moving components. Similarly, during the winter, heating could be controlled to keep the temperature closer to the minimum operating temperatures to reduce energy usage. It would need to be possible to override this however, for example, if there were people working within the substation, this would be too low to be considered a safe working environment.

One potential solution to come from this project is the introduction of a micro Building Energy Management System (microBEMS). This is a device which takes input from a number of sensors within a building – such as temperature, humidity or door sensors – and uses logic algorithms to control and optimise the heating and lighting in the building.

2.9 | NIA SPT 1609 The Planning Data Exchange System between Network Licensees to Enable a Smarter Grid

DNOs and National Grid have a long track record of successful interaction in operational planning and investment planning coordination. However, the expected uptake of low carbon technologies and the advent of the Smart Grid will impact on the required level of interaction between the DNO and the System Operator (SO) in the future.

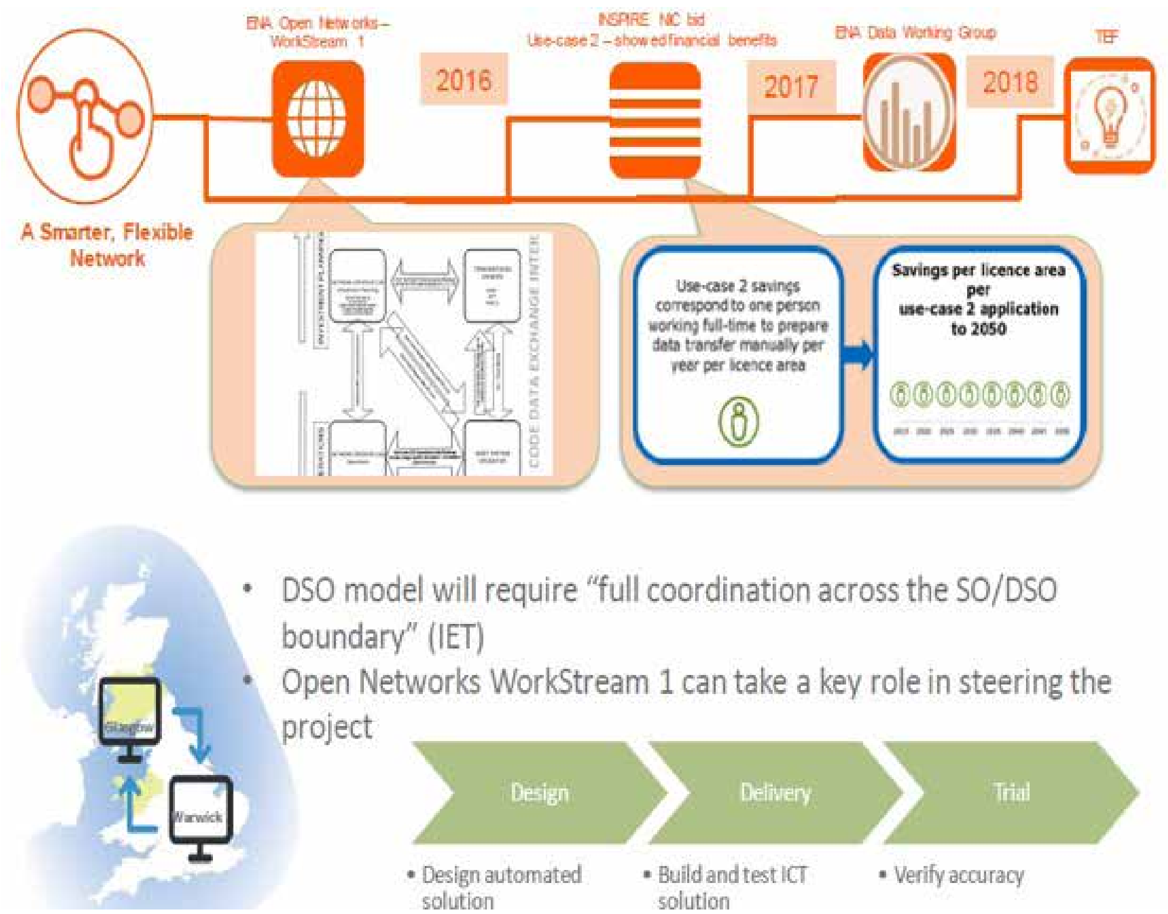
Greater interaction will be necessary as distributed energy resources (DER) become increasingly required to provide not just energy but whole-system services as well. For example, embedded generation, demand response and energy storage, along with distribution system services can contribute to system balancing. To achieve this, "full coordination across the SO/DSO boundary" will be required.

Presently, operational and planning information is transferred between the DNOs and SO in accordance with Grid Code requirements. For example, DNOs provide "Week 24" network planning data to National Grid annually and in return, National Grid supplies "Week 42" data, which is a network-equivalent data model for fault level assessments.

The "Week 24 Authorised Network Model" is an official snapshot in time of the distribution network and sets the baseline for all subsequent data exchange. This model includes all the detailed network data, including topology, connectivity, electrical parameters, and all embedded generation up to 1MW. It also contains the long-term (i.e. >12 months) demand and generation forecasts.

The existing method of information collection and submission between the DNO and SO is highly dependent on key personnel extracting data from a number of different systems manually. Furthermore, the analysis of the data is undertaken in uniform manner without taking into account the characteristics of the DNO region. This process is not sustainable when the requirement for more frequent transfers of a richer set of information is taken into consideration.

A holistic approach is required to clarify the existing and future roles of DNO, TO and SO in an involving (but also changing at accelerated pace) energy sector. This project is aiming to provide a tool to facilitate such a transition.

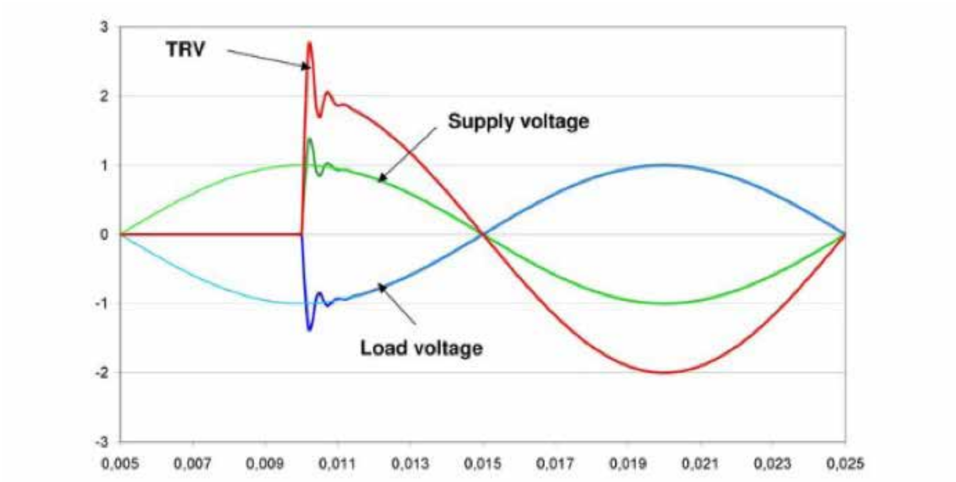


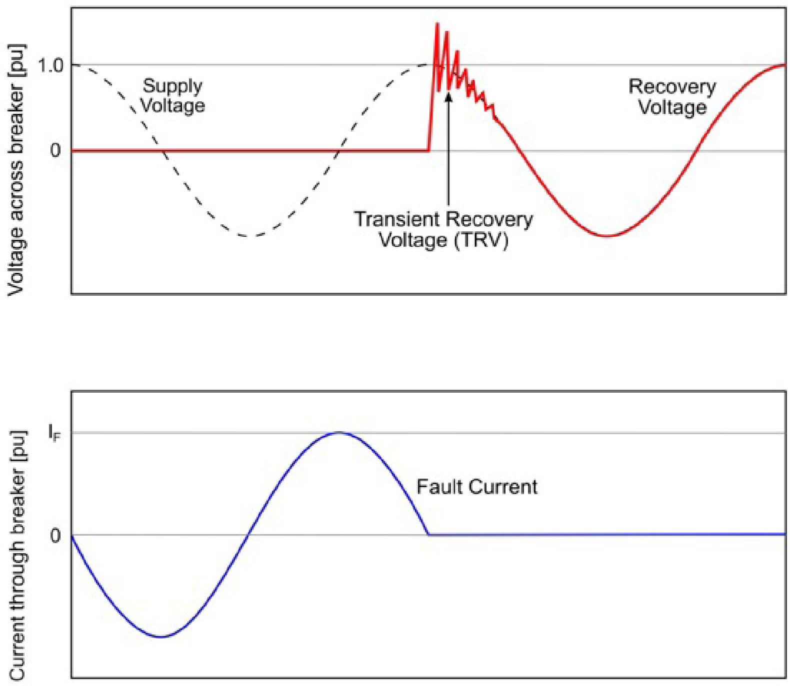
2.9.1 | NIA SPT 1609 Project Progress

The ENA Open Networks project Work Stream 1 Product 12 recognises that an increased frequency of data transfer between Transmission and Distribution would be beneficial. Discussions are on-going with the GB System Operator and Distribution licencees to define how this can best be trialled.

2.10 | NIA SPEN0035 Transient Recovery Voltage Investigation

Transient Recovery Voltage (TRV) can be defined as the voltage which appears across a circuit breaker's terminals upon interruption of the current resulting from a switching operation. When specifying circuit breakers, designers are often unsure about the TRV requirements that should be requested, particularly when switching e.g. series reactors or transformer circuits. This can lead to issues including over specification of TRV capability within circuit breakers or a requirement for additional TRV studies, both of which lead to additional cost.





This project proposes a technical method that involves engaging researchers to investigate the issue of TRV and produce conclusions that will impact circuit breaker selection and application in a variety of networks. The investigations will address the TRV issue through network modelling, estimating the prospective TRV, identifying potential consequences and risks, and the means to mitigate these. The planning, training, operation and maintenance requirements of any viable mitigation options will also be established.

The scope of the project covers voltage levels from 33 kV up to 400 kV and considers the characteristics of the SPT, SPD, SPM, SHET and SHEPD networks. Based on the outcome, standard TRV requirements can then be established. Also, guidance will be formulated on how to identify cases where this standard TRV capability is insufficient and how to remedy the situation.

2.10.1 | SPEN0035 Project Progress

The project was formally kicked off in 2019 with Mott McDonald appointed as project supplier and is programmed to last 12 months. Due to the fact that the project has only recently commenced there is not a significant amount of progress to report at this stage. Initial work which has commenced includes literature review and identification of network scenarios to be analysed.

2.11 | NIA SPEN1802 Project SIARA - System Integrity and Restorative Actions

As the generation profile has and will considerably change within SP Transmission area during the period of 2021-2030 with a significant penetration of renewables, the challenges of maintaining system security, integrity and restoring system in the event of loss of generation will be different from how it is today. Resilience is becoming a key factor and key concern with significantly lower levels of controllable generation in Scotland.

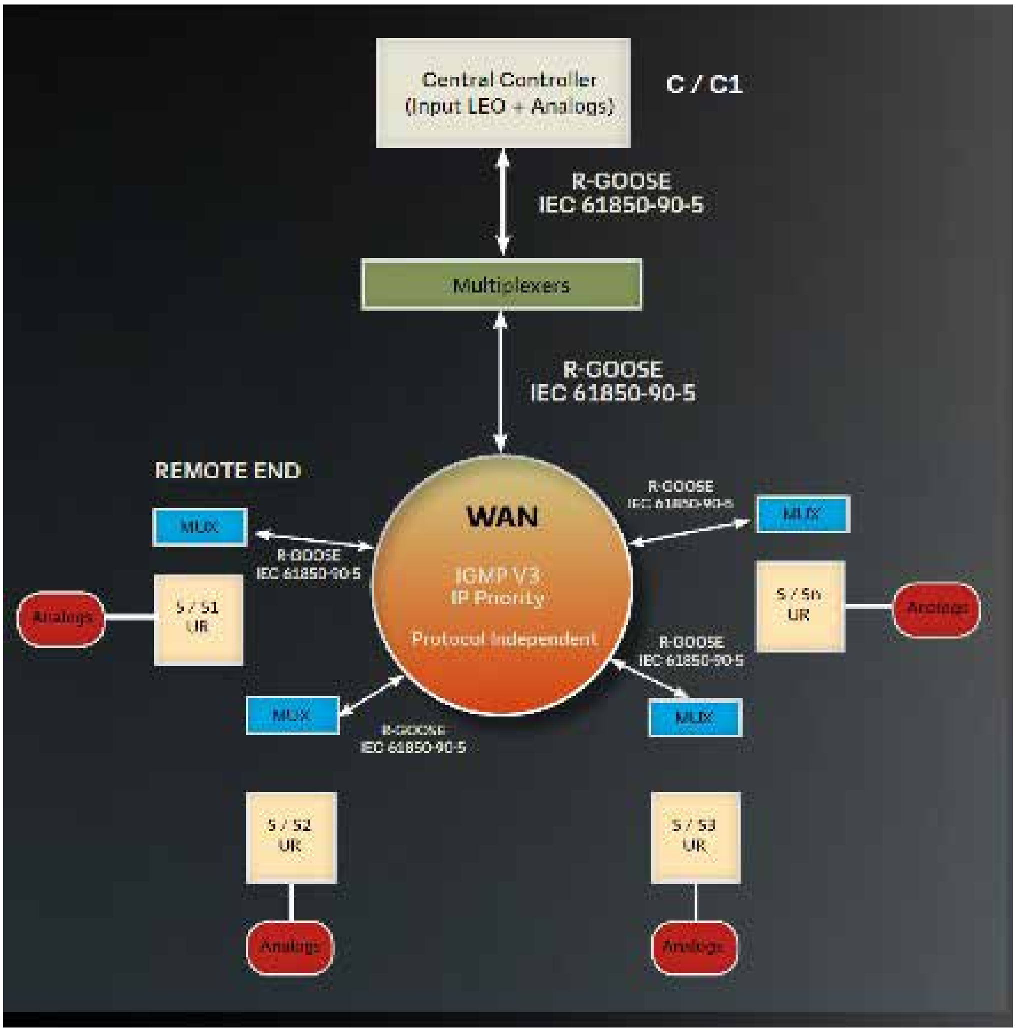
There will be requirements for new Wide Area Protection and Control (WAPC) schemes iin different parts of SP Transmission's network to maintain balance between generation and demand and if required shed generation and/or load to maintain system integrity.

Project SIARA (System Integrity and Restorative Actions) explores the feasibility of deploying wide area protection and control (WAPC) in SP Transmission and SP Distribution networks using IEC61850-90-5 routable GOOSE (R-GOOSE). R-GOOSE messaging is based on IP/Ethernet technology and can achieve information exchange between substations. This can potentially replace the existing communication for protection and control.

The key objective of project SIARA is to demonstrate feasibility of use of R-GOOSE over SP EnergyNetwork's wide area network (WAN) and highlight the communication, time-synchronisation and other infrastructure requirements for future roll-out of R-GOOSE for WAPC applications across the SP Transmission and SP Distribution networks.

SIARA will explore use of high-speed and secure R-GOOSE for WAPC applications, and deploy a piggy-back trial at Strathaven substation.

SIARA - System Integrity & Restorative Actions



2.11.1 | NIA SPEN 1802 Project Progress

A hardware-in-the loop testbed consisting of a real time digital simulator, IEDs (Intelligent Electronic Devices) with R-GOOSE messaging, PTP (Precise Time Protocol) time synchronisation, network simulation and monitoring equipment has been established in the Power Networks Demonstration Centre (PNDC) and offsite laboratory testing carried out as follows:

Base Case Test

The base case test was conducted at a power network steady state with R-GOOSE signals created by the use of relay pushbuttons and the following measured:

- Network Propagation Latency
- Asymmetrical Latency
- Occupied Bandwidth

Event Response Time Test

The testbed arrangement for event response time tests was similar to the base case test and power events such as faults and frequency disturbances were introduced. In the event response time test, the R-GOOSE messages were generated by relay protection operations upon power system fault, under-frequency and over-frequency events.

Other tests carried out included:

- Bit Error Rate
- Communication Network Switching
- Relay Synchronisation Loss
- Applied incidents (i.e. communication device failure)
- Analogue R-GOOSE

3 | Collaborative NIA Projects Led By Other Transmission Companies

3.1 | NGET 0088 Transformer Research Consortium

This project was started in April 2013 and is scheduled to last four and a half years. This research project being undertaken by the University of Manchester builds on initial work undertaken assessing ester based alternatives to conventional insulating oil and seeks to enhance understanding of transformer health and the key variables that can lead to premature failure. The research focuses on ageing indicators, partial discharge diagnostic, dissolved gas and thermal analysis.

While this project is being undertaken at laboratory scale consideration is being given to system application issues. The outcome of this project is expected to inform asset management policies with the aim of optimising operational and capital expenditure.

It is believed that the work packages will provide outcomes that can realistically be deployed in short to medium term timescales that will allow SPEN asset managers to benefit from new test methods and data collection techniques that will directly contribute towards the transformer asset decision making. This development of transformer specifications that include online monitoring and condition data collection techniques that reduce maintenance costs and provide more accurate condition assessment information.

The ongoing research into alternative fluids should give the required confidence for the deployment of these fluids at higher voltage levels. This will provide network operators with a solution that has environmental and fire safety attributes that traditional mineral oil does not have.

3.1.1 | NIA NGET0088 Project Progress

This project has been registered as a joint project by National Grid (NIA_NGET0088), and therefore they will provide a progress summary in their NIA Annual Report 18/19 consequently; no project progress has been included in this report.

4 | NIA Activities Linked to SPT Innovation Strategy

It is recognised that innovation cannot be a prescribed by rigid process but must stimulate creativity and new ideas. However, to ensure good governance, SPT has applied an over-arching framework to ensure that it is managed efficiently and delivers the benefits without constraining creativity.

The five innovation objectives within SPT are:

1. Innovation meeting the needs of stakeholders;
2. Innovation opportunities are identified in a timely manner, which will benefit these stakeholders;
3. Innovation is managed in an efficient and proactive manner;
4. A balanced portfolio of innovation is pursed which includes commercial, process and technology innovation. Our activity has a relevant focus on developments at different technology and commercial readiness levels to which balances radical with incremental innovation; and
5. 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.

Figure 6 outlines the general R&D management structure within SPT.

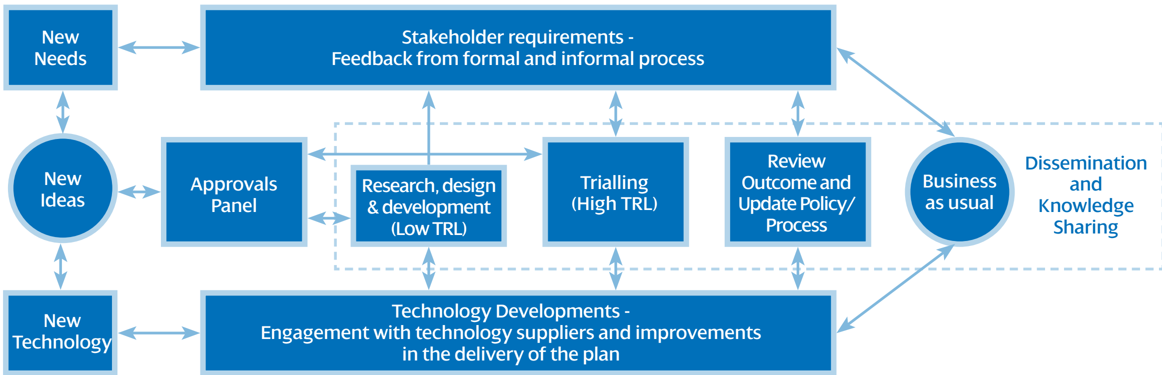


Figure 4: SPT Innovation Management Procedure

As part of our long term innovation strategy, stakeholder engagement will be central to ensuring that our innovation plans are meeting customer's expectations. The involvement of stakeholders is also a vital source of ideas for innovation – particularly the academic community, equipment suppliers and other network operators (DNOs and TOs).

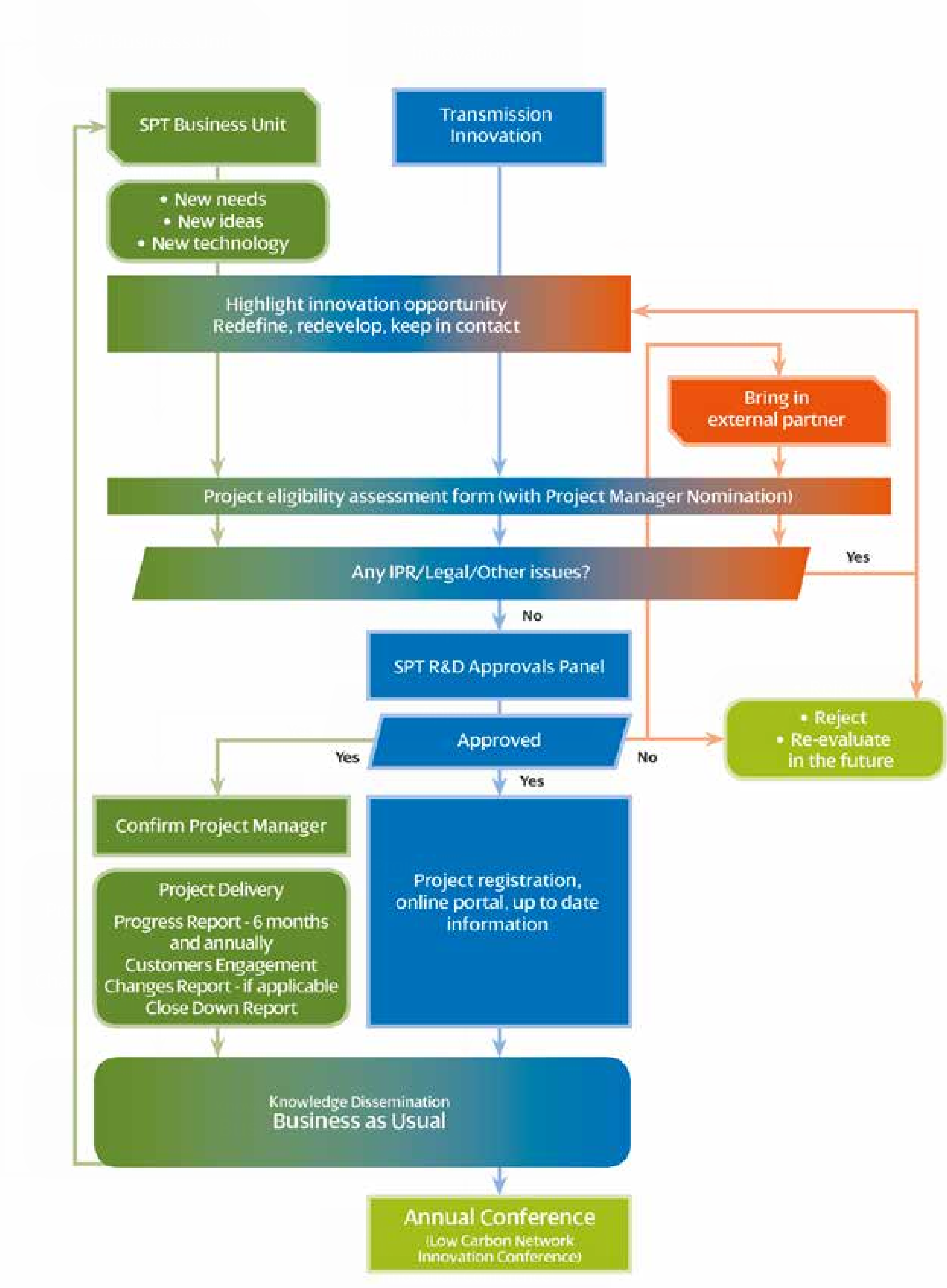


Figure 5: SPT NIA Development Process

Our approach to innovation development is summarised in Figure 6 below which contains five steps:

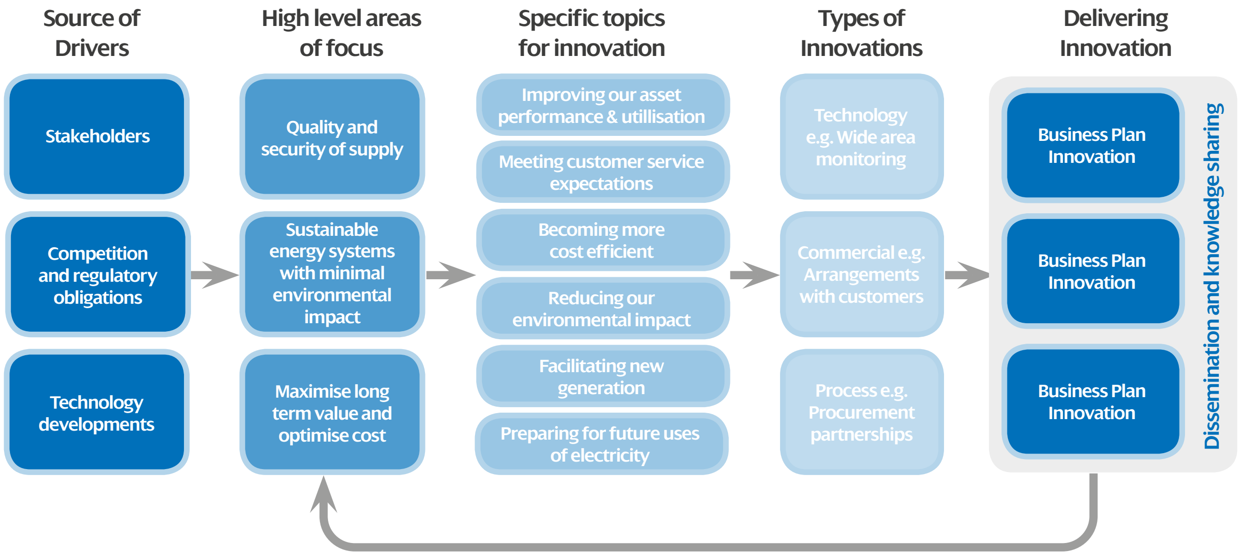


Figure 6: SPT Approach to Innovation Development

In order to realise our future network vision we have identified the following five dimensions that require to be addressed:

1. **Visibility:** The combination of monitoring devices, computing process and communications infrastructure provides an effective means to present the real time information for wide area monitoring. This visibility can cover almost all the aspects regarding transmission network performance, ranging from steady state thermal limitation of critical boundaries to sub-synchronous oscillation behaviour in the local area. This visibility provides a new dimension and reference for system operation and protection.

2. **Controllability:** The visibility of transmission network at the GB level requires review of some control algorithms which had been designed based on a centralised approach. Smart grid control involves many more controlled elements than in the conventional design, together with greater uncertainty in generation. The increasing complexity requires new approaches to observing, modelling and controlling the interactions between generation, transmission, distribution, and load. How to react to the information available requires a defined and coordinated approach to ensure that the existing supply quality and reliability standards are not compromised, and that customers can realise maximum benefit from the latest technology.

3. **Intelligence:** As a result of the improved visibility and control of the network, active management of generation output around network constraints will improve the time required to connect new demand and generation. Wide area monitoring combined with real time asset ratings, will ensure that maximum capacity is utilised before reinforcement is required. Processing of network data will also inform designers of when reinforcement is required and inform the deployment of appropriate, cost effective, solutions.

4. **Interoperability:** The variety of new technologies deployed on the network will require to be interoperable such that new solutions can be readily integrated, for example through the application of technology standards such as IEC61850. We will work with the wider industry nationally and internationally to develop open-access standards. Reliable and secure communication systems will also be required to transfer data across the network combined with IT systems that can effectively manage the new data that is generated. This will require a significant extension of our communications systems using internal and external services to achieve the necessary coverage.

5. **Commercial Mechanisms:** Our network will be reliant on commercial arrangements with network users as there are close linkages with many of the technology solutions.

To achieve these five dimensions, we consider three different ways in which we invest in the network. These investments can be described as follows:

Enablers: This includes smart-ready asset replacement and other investments which create a robust foundation and enabler for the smart grid applications. These are considered as "no regrets" investments which can be deployed in a top-down manner and are an essential component of the network. Having the enabling technology in place will allow us to flex between different future scenarios. Typical enablers are Remote Terminal Units for SCADA with expansion capability and the installation of additional network monitoring.

Applications: This is the implementation of a solution which has an immediate application to directly address an output within RIIO-T1 such as meeting load growth, facilitating new customer connections or improving quality of service. Where we have proposed a smart application, a cost benefit analysis (CBA) will be undertaken as in most cases a comparison with a traditional solution can be made. Typical applications are real time thermal ratings, intelligent voltage control or active network management.

Future Proofing: Where a positive business case exists, we will identify where additional enabling technologies are considered to be of long term benefit to customers, although not necessarily required in the short term. This category is also regarded as top-down investment as it is required to further enable other applications in the longer term. Future proofing investments are also subject to a CBA to ensure that they are efficient investments for the customer. Typical future proofing includes oversizing conductors for future load requirements and switchgear being pre-wired for sensors and automation.

The variety of new technology and commercial arrangements deployed on the network are vital to meeting the future requirements of our customers in a responsive and cost-effective way. However, it will be through the effective management and stewardship of the existing asset base that we will ensure value for money and that a sustainable network solution is delivered.

4.1 | SPT NIA Project Mapping with Innovation Strategy

Network Investment			Figure 7 NIA Projects Mapped to SPT Innovation Strategy	Specific Dimension				
Enabler	Application	Future Proofing		Visibility	Controllability	Intelligence	Interoperability	Commercial Mechanism
✓		✓	NIA 1504: Managing Uncertainty in Future Load related Investment		✓	✓		
✓	✓		NIA 1505: Trial of Open Innovation in Utilities Sector					✓
✓	✓	✓	NIA 1507: Modelling of Static and Dynamic Loads	✓	✓	✓	✓	
✓	✓		NIA 1601: Power 2: Tower Stage 1					
	✓	✓	NIA SPT 1604: Introduction of Environmentally Friendly Alternatives to SF6					
	✓	✓	NIA SPT 1605: Cable diagnostics for HVDC cables	✓	✓	✓		
	✓	✓	NIA SPT 1606: Reuse of existing concrete assets					
	✓		NIA SPT 1608: Reducing Energy Losses from Transmission Substations	✓	✓			✓
✓	✓	✓	NIA SPT 1609: The Planning Data Exchange System Between Network Licensees to Enable a Smarter Grid	✓	✓	✓	✓	
		✓	NIA SPEN 0035 Transient Recovery Voltage Investigation			✓	✓	
✓	✓	✓	NIA SPEN 1802: SIARA - System Integrity and Resorative Actions	✓	✓	✓	✓	
✓	✓	✓	NIA NGET0088: Transformer Research Consortium	✓	✓	✓		

5 | Areas of Significant New Learning

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

5.1 | Project Learning: NIA 1504 Managing Uncertainty in Future Load Related Investment

A number of points of learning have been gained from this project.

- The macro-scenario/operational-scenario approach has been found to be very useful in characterizing different sources and timescales of uncertainty, and in focusing engineering attention on the judgements necessary to consistently represent different possible future outcomes in terms of network development, demand change and deployment of new technologies.
- Flexible and modular approaches to the integration of statistical models (for example, of EV behaviour and of renewable generation output) have been found to be relevant in allowing the straightforward use of location-specific models based on historical data for appropriate to the network being studied. They also permit the replacement of models with more accurate or efficient versions as these become available.
- Selective re-simulation of constraint violating conditions, together with the use of simplified models for selection of appropriate interventions, has proven valuable in minimizing the simulation cost of assessing the applicability of smartgrid interventions.
- The value of graph databases in identifying potential network reconfigurations, and for evaluating their effects on the expected reliability indices of the network has been demonstrated.

5.2 | Project Learning: NIA 1505 Trial of Open Innovation in Utilities Sector

Through this project, we have learned a lot about the challenges inherent in changing a company's culture to increase how innovative it is; for example, the difficulty in obtaining a good number of responses to challenges made to the business. In this instance, it was found that specific challenges – such as asking about improving the customer experience, or how we handle OHL faults – fared much better than open-ended challenges which asked for any and all ideas. When this is done, it also helps ensure that all levels of the business feel able to contribute, rather than focus on "big issue" topics which may be relevant to only a few people in the business.
That being said, it is also important to ensure that issues which are key to directors and high-level management can be handled and solved at an early stage. In doing this, business buy-in will increase and ensure that, further down the line, it is easier to ask for resources to contribute to other projects. This is also true on a department or section level – such as an operational district, where future support may be necessary to make a project a success.

5.3 | Project Learning: NIA 1507 Modelling of Static and Dynamic Loads

Key learning points are provided below:

- The nature of some loads is such, that they expose oscillatory nature after experiencing a step change in the supply voltage. In other words, given a 3% step change in the supply voltage, the active power of the load will follow the exponential recovery model, but will also demonstrate damped oscillatory nature, superimposed to the exponential recovery.
- The oscillatory nature can be included into the existing exponential recovery model. This was successfully done and dynamically simulated using DIgSILENT PowerFactory software package.
- The new oscillatory load model has its parameters. They can be estimated using state of the art parameter estimation algorithms.

The applicability of parameter estimators was tested using computer simulated and real-life data. The results obtained were optimistic.

5.4 | Project Learning: NIA SPT 1601 Power 2 Tower: Stage 1

Although all three approaches considered in the study are capable of yielding some level of energy harvesting capability, the electric field approach was more successful for the following reasons:

1. The level of engineering resource required to develop a prototype system was lower.
2. The cost of the prototype was lower.
3. The energy yield was higher.
4. The energy yield is constant.

The electric-field device is capable of consistently harvesting 1mW which has proved sufficient to record the temperature and solar radiation values and transmit these over a distance of 3 km to the gateway at approximately 12 minute intervals. Tests have demonstrated that the gateway could be located up to 10 km distance from the overhead line tower. A particular feature of the device – the ability to start from a zero electric-field – has proved to be an essential design feature since the overhead line has been switched out on several occasions during the trial: in each case the device returned to the normal operating state after ~30 minutes.

The electric-field device is constructed from readily-available, competitively-priced components, and benefits from an outage-free installation that takes ~40 minutes. It is estimated that a four-fold increase in the harvested energy could be achieved through efficiencies in the conversion electronics, based on the knowledge gained through the site trial. The extra power harvested would be sufficient to power additional sensing capabilities including GPS, vibration, partial discharge, etc. as well as improving the reporting interval.

5.5 | Project Learning: NIA SPT 1604 Introduction of Environmentally Friendly Alternatives to SF6

We have shared our learning on the use of g3 gas with SSEN Transmission and a number of their engineers have visited site to discuss what considerations are required when specifying GIS equipment containing alternative gasses including identification of gas compartments, special filling valves, test requirements etc.

5.6 | Project Learning: NIA SPT 1605 Cable Diagnostics for HVDC Cables

From the analyses, it was found that adding nano-alumina particles into polymers affected their electrical performance and morphology structure. The spherulite size of both nanocomposites became smaller than pure polymers and the size decrease with increased filling content. The DC breakdown strength of LDPE/KH570-alumina samples was increased to 433 kV/mm compared with 340 kV/mm for pure LDPE samples and it was 517 kV/mm for PP/KH570-alumina samples, compared with that for pure PP of only 427kV/mm. As for DC conductivity, the DC resistivity of LDPE/KH570-alumina samples with less than 1%wt filling was around 4.7 times than that of pure LDPE samples under 30 kV/mm at 30 and DC resistivity of PP/KH570-alumina was one order of magnitude bigger than that of pure PP sample under the same test condition. Both of the nanocomposites have shown good results as cable insulation and the work has enabled a better understanding of charge transportation mechanism in nanocomposite. In conclusion, PP based nano-alumina-composite is a promising option for recyclable HVDC insulation material with higher operating temperature and advanced electrical properties compared with LDPE nano-alumina composites.

5.7 | Project Learning: NIA SPT 1606 Reuse of Existing Concrete Assets

The learning from the project has been that data collection for historic sites is difficult due to a loss of quality in the data when it was converted to microfilm many years ago. The reduced quality of the drawings makes it difficult to see the overall dimensions and in particular the reinforcement details. Whilst collecting site data it has been found that quality of data has been varied with some sites providing better quality information than others. With gaps in the information this increases the risk as assumptions may need to be made which could lead to wrong conclusions being drawn. To mitigate this risk a risk matrix has been introduced to account for gaps in on-site data which will provide a decision tree approach for a person to consider when deciding the approach to take.

There are a large number of testing methods available but through development of the methodology it has been found that a small standard suite of testing is better to be applied rather than specifying a large number of tests that will cost a lot of money. The more testing could actually be counterproductive as it could possibly skew the results. Therefore a standard testing suite is considered more appropriate with the addition of further testing to be included if considered to be necessary by the engineer or if results are inconclusive. The majority of concrete structures tested were found to be in a reasonably good condition with only low levels of corrosion which would indicate that certain structures can be re-used with certain restrictions. Although, as expected some did exhibit severe signs of degradation which will make it difficult to re-use these structures.

It was found that the structural assessments demonstrated that the columns and beams of the structures assessed are underutilised and have sufficient capacity to withstand the loads acting on the structure under the Ultimate Limit State (ULS) combination. However the gantry structure assessments have shown a potential area of concern, of which directly appears as a failure under the strict criteria of the NGTS environmental loadings assessment process. These results are driven by a change in the way ice is allowed for under the National Grid guidance which recently changed to utilise the Eurocode BS EN 1993-3-18. The Eurocode imposes a much larger ice thickness allowance on the conductors, compared to earlier versions of the NGTS limitation, which leads to the subsequent increase in deflections. To mitigate this it needs to be considered if a previous version can be utilised. A relaxation the of loading is available via NGTS 3.01.045 which allows for judgement to be made where experience exists in the management of the substation assets gained over approximately 50 years. This should be considered in light of the analysis results and a view taken on whether an alternative approach is necessary.

Structures that were previously considered end of life may now be re-used with only minor remedial works, although this will be considered against a scoring matrix that will consider the risk and whole life cost.

5.8 | Project Learning: NIA SPT 1608 Reducing Energy Losses from Transmission Substations

A potential area of learning for this project is in changes to worker behaviour. It is clear that some level of substation energy loss is related to inefficient management of heating levels within substations. This may be due to workers leaving heating on unnecessarily, or putting it on higher than is necessary, for example. It is possible, then, that a behavioural campaign could reduce energy usage.

5.9 | Project Learning: NIA SPT 1609 The Planning Data Exchange System between Network Licensees to Enable a Smarter Grid

There is no learning to report at this stage of the project.

5.10 | Project Learning: NIA SPEN 0035 Transient Recovery Voltage Investigation

Since the project has only recently kicked off the project has not yet generated any significant learning. Once complete the project will provide new learning about:

- The TRV problem and any potential consequences and associated risks.
- The capability of circuit breakers to interrupt the prospective fault current.
- Mitigation options and strategies for this problem and their viability.
- The planning, training, operation and maintenance requirements of any viable mitigation options.

5.11 | Project Learning: NIA SPEN 1802 Project SIARA - System Integrity and Restorative Actions

The offsite testing of project SIARA proved that the OTN Systems MPLS-TP communication devices (XT-2210) could carry the R-GOOSE messages generated by GE C30 and N60 protection devices. These R-GOOSE messages were used for remote tripping and analogue signal exchange in a hardware in loop set-up. The R-GOOSE messages generated during the test were of size between 209 bytes and 239 bytes. When there was no other background traffic and no artificial delay, the network propagation latency and asymmetrical latency of R-GOOSE messages going through two XTran nodes was up to 70 s and 2.5 s. These values satisfied the requirement of ENA TS 48-6-7 where the propagation latency should not exceed 6 ms and the asymmetrical latency should not be greater than 400s. The bandwidth occupied by a single R-GOOSE stream (packet size between 209 bytes and 239 bytes) was about 80 kb/s.
The instantaneous over-current (IOC) protection, under-frequency protection and over-frequency protection were used on GE N60. The associated local tripping time (when there was no other background traffic and no artificial delay) were:
• Local IOC protection for fault: about 22.65 ms
• Local under-frequency protection for under-frequency disturbance: either 92.7 ms or 112.8 ms
• Local over-frequency protection for over-frequency disturbance: either 97.8 ms or 117.8 ms
The analogue R-GOOSE from N60 could only update the value of analogue quantities every 0.1 s, which might not be suitable for a protection scheme requiring instantaneous measurement. The tests provided valuable insight regarding bandwidth, time synchronization requirements, latency, and different protection schemes overall operational times using R-GOOSE over wide area network.
There were some limitations to the offline testing that did not take into account the cyber security requirement on the wide area network and this test needs to be performed with appropriate encryption on the network. This may or may not have implications on the latency and the overall operational times of the R-GOOSE based WPAC schemes provided adequate bandwidth requirements are considered during the deployment.
The offline testing has provided SP Energy Networks with enough confidence to trial R-GOOSE based WPAC schemes on the SP Transissions network.

5.12 | Project Learning: NIA NGET 0088 Transformer Research Consortium

Please refer to National Grid Electricity Transmission's NIA Annual Report 18/19 for any details of areas of significant new learning on this collaboration project.

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