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Scottish & Southern Electricity Networks

TRANSMISSION

Scottish Hydro Electric Transmission

Network Innovation Allowance Summary Report

1 April 2020 to 31 March 2021

Scottish Hydro Electric Transmission plc

Contents

Foreword

This report is a summary of the progress achieved by Scottish and Southern Electricity Networks Transmission (SSEN Transmission) license: Scottish Hydro Electric Transmission plc, in Network Innovation Allowance (NIA) projects during the period between April 2020 and March 2021. NIA funding is targeted at small scale innovation projects, which require further investigation and have the potential to deliver value and benefits to the business and network customers.

SSEN Transmission is the owner of the high voltage (132kV, 220kV, 275kV and 400kV) electricity assets in the north of Scotland. Our network consists of underground and subsea cables, overhead lines on wooden and composite poles, steel towers, and electricity substations. Our network extends over a quarter of the UK's land mass and across some of Scotland's most challenging terrain. We power our communities by providing a safe and reliable supply of electricity.

The foundation of our **Innovation Strategy**, which involved extensive engagement with our customers and stakeholders, published in December 2019 is a framework that centres on being a 'responsible innovator', focused on delivering benefits for our customers and wider stakeholder group by taking a proactive and forward-looking approach to innovation. We have put the needs of our stakeholders at the heart of our innovations, focused on engaging the right people at the right time including partnerships to drive innovation. We seek best value through continuous improvement and are committed to a smart, sustainable energy future.

Our Innovation Strategy sets out our plans and ambitions for getting the most from all our innovation activities before, during and after the RIIO-T2 price control period. The new strategy has been shaped by the learnings and benefits delivered through our RIIO-T1 innovation portfolio and is aligned to our overall company Strategic Objective of 'enabling the transition to a low carbon economy'.

Between April 2020 and March 2021, we had a portfolio of ten NIA projects, each of which addresses at least one of the four Focus Areas covering all our company activities, which are summarised in this report in Chapter 2 and covered in greater detail in our Innovation Strategy.

We deem our innovation approach to be consistent with our core purpose and our need to prioritise the relevant challenges faced by our networks, as well as those of the entire GB electricity sector. We also learn from our peers in the industry and engage with our stakeholders and other interested parties in the energy supply chain to ensure that our combined efforts can deliver the best possible value to GB customers.

Andrew Urquhart
Head of Whole System
SSEN Transmission

1

Update to the SSEN Transmission Innovation Strategy

The December **2019 SSEN Transmission Innovation Strategy** sets out our plans and ambitions for getting the most from innovation before, during and after the RIIO-T2 price control period.

Our overarching innovation objective is to enable the transition towards a low carbon economy, whilst maintaining 100% reliability in electricity supply and ensuring energy remains affordable for all. We see innovation as a means of identifying and proving new ways of working for the long-term benefits of our stakeholders and ourselves. This core principle is underpinned by the five values shown in Figure 1, which have been identified, following a review of innovation in RIIO-T1 and stakeholder engagement, as the necessary components to deliver successful innovation projects.

SSEN Transmission has four Innovation Focus Areas to support the SSEN Transmission Strategic Objective of enabling a transition to a lower carbon economy. Each of the four Innovation Focus Areas underpin the SSEN Transmission Values of: supporting customers, user driven, delivering efficiently, collaboration and sustainabilitym, and will be used to successfully deliver the projects.

To emphasise and reinforce the SSEN Transmission Strategic Objective of enabling a transition to a low carbon economy, the Innovation Focus Areas have been aligned as follows:

- Stakeholder-led strategy
- Sector-leading efficiency
- Safe and secure network operation
- Leadership in sustainability.

The following subsections will expand upon each of the Innovation Focus Areas and outline their associated innovation opportunities.

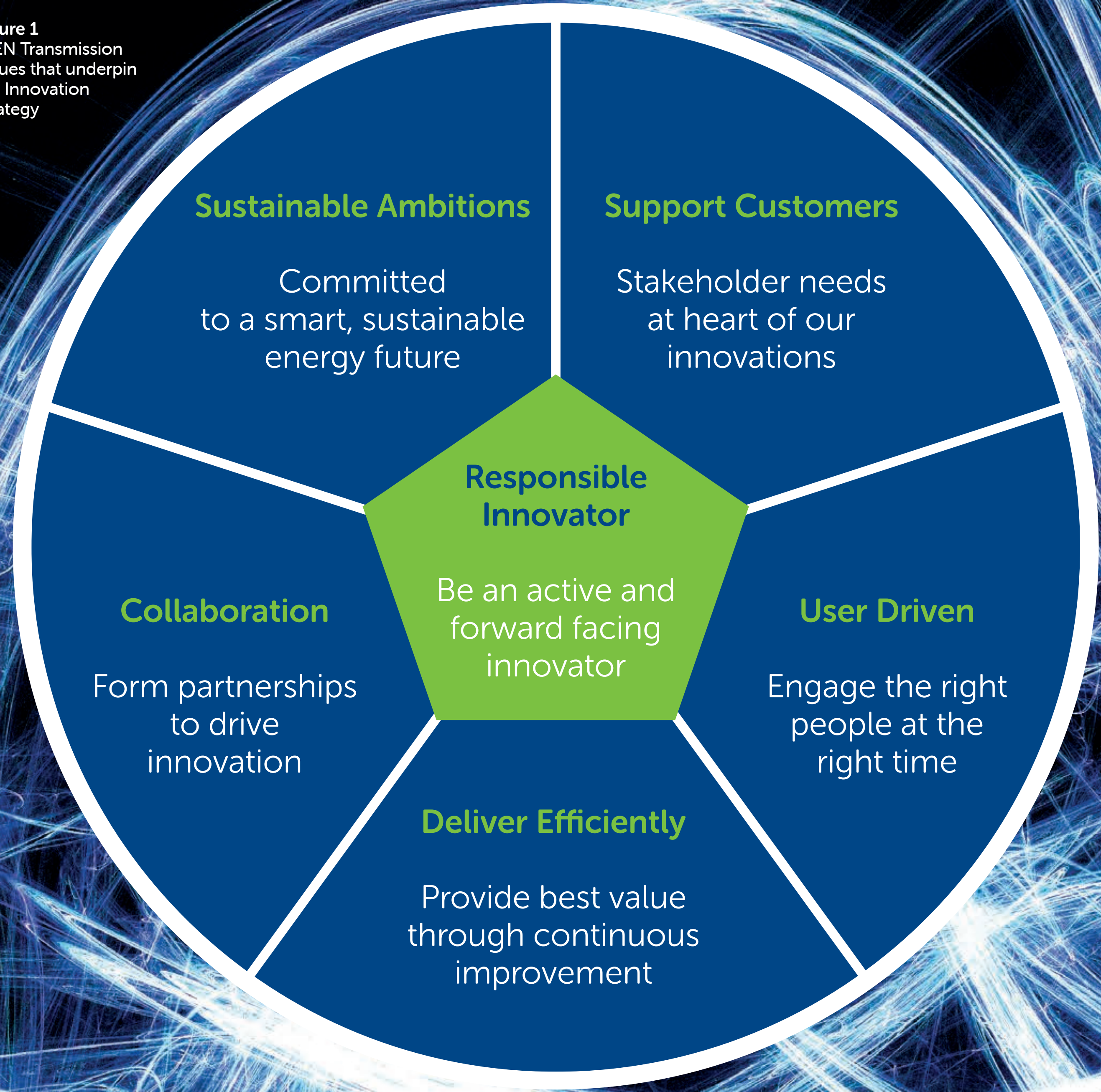
Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

Figure 1
SSEN Transmission Values that underpin the Innovation Strategy



1.1 Stakeholder-led Strategy

There will be a lot of change in the electrical power industry over the coming years, with the continued increase in renewable energy, the move towards a Distribution System Operator (DSO) and new equipment which steps away from traditional mechanical functions to electronic operation, to name only a few examples. This will be driven by stakeholder engagement.

Given the changing shape of the transmission network, the Phasor Instream Data Processing (NIA_SHET_0028) and Phasor Based Monitoring for HVDC Applications (NIA_SHET_0029) focused on novel ways to use real-time system data. Research into phasor measurements has the potential to enable a more holistic network view and may help the development of a 'whole system approach'. We foresee innovation opportunities in the following areas:

Supporting our customers

Customer engagement
- Enable customer choice
- Improved service delivery
- Provide relevant network information
- Improved outage management

Customer engagement
- Connection queue management
- Facilitate DSO transition
- Support new commercial models
- Commercial arrangement visibility

Wider Energy System Changes

Whole system approach
- Decentralised technologies
- Whole system planning
- Demand Side Response
- Understand DER flexibility

Energy system transition
- Support electric vehicle uptake
- Facilitate decarbonisation of heat
- Hydrogen economy development
- Collaborate across energy vectors

Enhanced Connection Approaches

Using network flexibility in connections
- Accelerated connections
- Managing connection flexibility
- Active Network Management
- Tailored connection solutions

Facilitating connections
- Implement smarter connections
- Wide area network management
- Managing changing network aspects
- Interface between TO and DNO

1.2 Safe and secure network operation

Network reliability and integrity is fundamental to SSEN Transmission. Maintaining and improving our existing standards at a time of unprecedented industry change is a significant challenge. We must develop new options to accommodate flexibility which enables electrical energy to flow from the customer into the network. This bi-directional flow will require new methods of working and new commercial arrangements, all whilst maintaining network resilience, and safety.

The energy system transition also brings new technologies that will change long-established electrical characteristics of a traditional network, as the system fault levels, inertia, network reactance and power quality parameters will be altered. Well-established techniques for network management need to be revised and updated to better reflect the changes on the network. Addressing this challenge, the Zero Missing Phenomenon project (NIA_SHET_0025) developed new methodologies and testing sequences for network modelling to be applied to new infrastructure proposals to investigate network resilience during a fault.

Similarly, new technology can provide improved visibility and transparency of the network's operating characteristics. Along this theme, the Partial Discharge (PD) Monitoring project (NIA_SHET_0014) explored the options around continuously monitoring the breakdown of electrical equipment insulation, focusing on enhancing substation safety.

We foresee the potential innovation opportunities within this innovation focus area as:

Planning and Development

Network planning
- Optimised design and development
- Probabilistic planning tools
- Detailed network modelling
- Generation and demand balancing capacity management

Data driven network development
- Smart network development
- Network development and stability reinforcement
- Enhanced data analysis
- Artificial Intelligence in system modelling

Asset and Network Management

Security and resilience
- Network reliability and resilience
- Countering physical threats
- Black start capability
- Extreme event planning and contingency management

Smart asset management
- Modernised enhanced control room
- Power quality management
- Operational technology developments
- Condition-based asset management

Network Monitoring & Operations

Network operations & control
- Network controllability
- Smart condition monitoring
- Cyber threats
- Interactive and adaptive condition monitoring

Facilitating connections
- Grid monitoring strategy
- Enhanced transmission fault
- Enhanced network stability analysis
- Remote asset monitoring

1.3 Sector-leading efficiency

In supporting the transition to a low carbon economy, we must make sure that we do so in an efficient way and deliver the best value for the consumer. Whilst identifying opportunities we will make sure to leverage maximum benefit from our existing assets, data, and relationships. This will include collaborating with other parties to identify industry best practice and learning from their experiences, thus helping to reduce the risk and improve the potential benefits of deploying any innovation.

The Refase project (NIA_SHET_0026) is a collaboration with Synaptec to seek a cost efficient and effective solution for remote monitoring of underground cable sections which have been installed within overhead line circuits at road crossings for safety purposes.

Gathering information from the field on the condition of our assets is very important. During 2015 to 2019, we embarked on the first UK-wide area monitoring trial of the communication medium LoRaWAN in the RainMan project. Given the success of low power information gathering on the remote island of Skye, Expanding LoRa (NIA_SHET_0027) was designed to investigate how to incorporate off-the-shelf LoRa enabled products into operational and maintenance protocols.

Within this innovation focus the following innovation opportunities have been identified:

Supply chain efficencies

Transformational health and safety

- Continue driving effective safety standards
- Continually improve process safety, environment and travel performance
- Transform contractor safety, operational safety and health and wellbeing
- Minimise human interaction through data and analytics

Data driven network development

- Demand plan analysis
- Supply chain engagement to negate non-compliance
- License to operate
- Responsible buyer

Modernising our network

Integration of new technologies

- Consider novel technologies and materials
- Drive a smarter network
- Digital substation evolution
- Further develop use of HVDC technology

Efficient network modernisation

- Drive staged smarter network development
- Big Data management
- Network stability reinforcement
- Network modernisation

Network monitoring and operations

Transparent and robust decision making

- Maximise use of existing asset base
- Engage customers earlier in the design development
- Investigate market-ready data and analytic platforms
- Demonstrate efficiency in outcomes

Efficient project delivery

- Evaluate new construction means
- Alternative access arrangements
- Bespoke network solutions
- Reduced onsite testing and construction

1.4 Leadership in sustainability

As we deliver innovation, we aim to prioritise the areas which will provide long term benefit. When thinking into the future, sustainability is a crucial component to consider, whether for environmental, social, or economic impacts.

The Wake Vibration Monitoring project (NIA_SHET_0031) was established to investigate the impact wind turbines may have on our network with regards to the wear and tear effects on our overhead line infrastructure. Mitigation solutions will be assessed if necessary, to prolong the operational life of the overhead line conductor and equipment.

Our TACAMA project (NIA_SHET_0030) conducted a desktop research study into modernising our approach to underground cable testing, focusing on looking for solutions to reduce the environmental impact at the testing locations.

When developing opportunities around sustainability, it is important for us to also support governmental initiatives, such as government targets for decarbonisation. We believe this holds the following innovation opportunities:

Reducing our environmental impact

Promoting natural environment

- Positively contribute to UN and Scottish biodiversity strategies
- Develop environmentally sensitive operations
- Consider network visual impact
- Collaborate on measuring biodiversity net gain

Optimising resources

- Life cycle and cost benefits
- Promote circular economy principles
- Waste minimisation initiatives
- Asset replacement strategy

Mitigating climate change

Carbon saving emissions

- Design new more energy efficient substations
- Implement energy efficiency to existing substations
- Support losses policy
- Decrease equipment losses

Energy efficiency and optimisation

- Set and deliver science-based targets
- Develop and implement SF_6 Strategy
- Embedded carbon reduction
- Reduce direct and indirect greenhouse emissions from our activities

Maximise benefit to customers

Supporting communities

- Enable local communities' use of low carbon technology
- Realise social and economic benefit from investment
- Support vulnerable customers
- Enable local community engagement in energy markets

Connecting for society

- Promote decarbonised and decentralised economy
- Review wider societal impacts of our investment
- Consider our investment affordability for consumers and generators
- Deliver low carbon energy connections

2
Summary of Progress

This Section summarises the ten NIA Transmission Projects which have been active during the review period. The summaries include key project details and achievements during the year.

Each project accumulates knowledge and learning which aligns with one or more Innovation Focus Areas and underpins the SSEN Transmission Values. Putting the needs of our stakeholders at the heart of our innovations, focusing on engaging the right people at the right time including partnerships to drive innovation and seek best value through continuous improvement, as we commit to a smart, sustainable energy future.

The relevant Innovation Focus Areas associated with the live NIA projects are represented via the icons below.

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

2.1 NIA_SHET_0014 Partial Discharge Monitoring to Reduce Safety Criticality

Key activities

This project installed two different technologies to monitor substation Partial Discharge (PD). PD is generated as electrical insulation starts to fail. Being able to assess the levels of emitted PD will also help to build an equipment replacement programme, focusing on asset efficiency and sustainability. The project's aim was to investigate if it was possible to continually monitor and trigger notifications in the event of unusual PD activity. With the PD monitors installed an initial base PD level was obtained, which then enabled the progression of a real-time PD alarm notification system to be established.

Benefits

The project successfully provided the ability for continuous PD monitoring and to raise notifications during high level PD activity. The learning gained from this project will also help inform substation 'smart monitoring' plans for RIIO-T2.

Progress

This project has positively demonstrated that real-time PD alarm notification systems could be set up and maintained, which will help ensure network operational security as well as increasing substation safety associated with personnel visiting site.

Collaborators

Elimpus / HVPD / High Frequency Diagnostics & Engineering

Funded
£1,300,000

Start/end date
January 2015 / October 2020

Website
https://smarter.energynetworks.org/projects/nia_shet_0014

Innovation Focus Areas

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

2.2 NIA_SHET_0023 Line Inspection by Semi-Autonomous Systems (LISAS)

Key activities

This project has explored the requirements and capabilities of using semi-autonomous robotic devices for monitoring overhead lines. Using robotic devices which can carry onboard monitoring equipment, with the ability to travel along an overhead line without requiring continual human intervention could allow the conductors to be accurately and efficiently monitored. A robot that requires minimal human intervention will also minimise associated personnel field safety risks and provides a substantial way to monitor more of the network.

Benefits

This project has developed a specification for the provision of a suitable semi-autonomous device for overhead line inspection and assessment. Gaining an accurate picture of the overhead line network will enable early identification and correction of damage, thus increasing the security of the network and prolonging the lifespan of existing overhead line assets.

Progress

Delays in identifying suitable suppliers and developers of devices appropriate for trial were encountered, therefore the project scope was scaled back to an evaluation of the types of robotic devices commercially available on the market against the developed specification.

Collaborators

Electric Power Research Institute (EPRI) / Williams Advanced Engineering Limited

Funded
£230,000

Start/end date
June 2018 / November 2020

Website
https://www.smarternetworks.org/project/nia_shet_0023

Innovation Focus Areas

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

2.3 NIA_SHET_0025 Zero Missing Phenomenon

Key activities

This project investigated the Zero Missing Phenomenon (ZMP) which arises from the increase of reactive power compensation equipment on the transmission network. The investigation focused on understanding the decaying Direct Current (DC) problem produced through the use of shunt reactors: its likelihood, its cause, potential consequences and risks, and the ability of existing Alternating Current (AC) circuit breakers to interrupt it.

Benefits

This project has improved the understanding of the ZMP DC current challenges associated with shunt reactor switching. Learning will be utilised to ensure safe network operations at the power flow modelling design stage to influence future circuit breaker design and shunt reactor use on the network.

Progress

The project successfully analysed standard network configurations susceptible to ZMP, which helped to identify suitable mitigation measures to ensure network operational security. The analysis was also used to determine the severity and effects of the ZMP. The learning was captured in a Technical Guidance Document which provides a structured approach for Transmission Planners and Operators to address the ZMP problem.

Collaborators

Scottish Power Transmission / Energy Innovation Centre Ltd (EIC) / Mott MacDonald Ltd

Innovation Focus Areas

Stakeholder-led strategy
Safe and secure network operation
Sector-leading efficiency
Leadership in sustainability

Funded	Start/end date	Website
£128,500	October 2018 / June 2020	https://www.smarternetworks.org/project/nia_shet_0025

2.4 NIA_SHET_0026 Refase

Key activities

Refase is a new control product that allows measured values from up to 50 current transformers to be acquired using a single optical fibre core over distances up to 50km. By centralising current measurements, this method negates the need for multiple protection relays, complex time synchronisation systems at measurement points, and telecommunications equipment among the distributed protection and control devices. This project is sector-leading for a new technology, and will conduct a series of desktop trials, which if successful will progress into the field where the performance of the Refase system will be benchmarked against traditional protection methods.

Benefits

This new protection product may provide a reliable and more cost-effective method of monitoring and pinpointing faults in the underground cables which are within overhead line circuits.

Progress

The first stage of laboratory testing has been completed successfully. The project is progressing to the next stage, with the necessary protection and control panels being built for testing at Braco research and development substation. If successful, installation is planned on a live 132kV site in late 2020.

Collaborators

Synaptec / ABB / Evolution Systems ltd

Innovation Focus Areas

Stakeholder-led strategy
Safe and secure network operation
Sector-leading efficiency
Leadership in sustainability

Funded	Start/end date	Website
£388,360	June 2019 / June 2021	https://www.smarternetworks.org/project/nia_shet_0026

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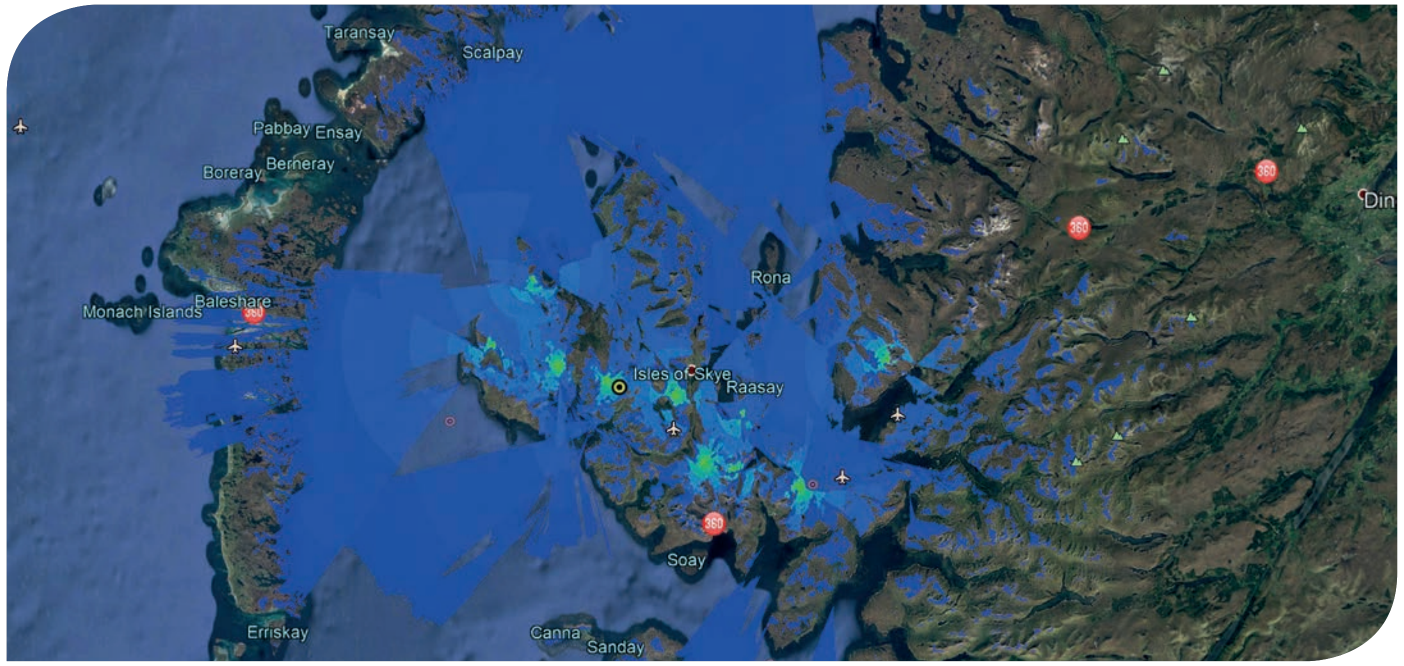
2.5 NIA_SHET_0027 Expanding LoRa



Key activities

LoRa enables long-range data transmissions with low power consumption for small data information packages. This is potentially a more economic and reliable method for monitoring communication in rural areas where mobile telephone coverage is limited. This project investigated how to connect off-the-shelf purchased LoRa enabled monitoring equipment, exploring how easy it is to view and make use of the resulting data.

Benefits

This project has the potential to support the introduction of LoRa communications methods as a means of collecting remote field data.

Progress

It was concluded that there are a number of LoRa enabled monitoring devices commercially available. The devices at the lower cost end of the scale measured a single parameter or had to be purchased in high volumes to lower the price. Generally, the unit cost increased with the number of measurement parameters required. The off-the-shelf LoRa enabled devices were easily installed. However, a significant level of IT knowledge is required to retrieve the monitored data. LoRa is certainly a communication medium to be considered when investigating options for remote monitoring devices.

Collaborators

EkkoSense / Power Network Demonstration Centre (PNDC)

Funded	Start/end date	Website
£72,500	September 2019 / March 2021	https://www.smarternetworks.org/project/nia_shet_0027

Innovation Focus Areas

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

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2.6 NIA_SHET_0028 Phasor Instream Data Processing (IDP)

Key activities

As technology has developed, projects such as Scottish Power Transmission's VISOR NIC project have shown the potential benefits in electrical phasor system measurements and their onward applications. One of the outcomes of the **VISOR** project highlighted the need to identify the requirements of a phasor measurement system at the component architecture levels. **The System Operator Transmission Owner Code (STC)** has recently changed to include requirements associated with phasor measurements. This project investigated the different system architectural options which could facilitate real-time phasor data manipulation and transfer to other Parties or Stakeholders.

Benefits

The development and presentation of several different system architectures suitable for real-time instream data processing. Information gathered as to the benefits and potential obstacles of the system architectures, to enable further technical discussions on selecting a solution.

Progress

Queen's University Belfast and Brunel University have jointly worked together to research potential architecture solutions associated with managing phasor data in line with SSEN Transmission protection and control requirements. A recommendation document was produced and shared with other interested Stakeholders during a well-attended dissemination event hosted in November 2020.

Collaborators

Brunel University / Queen's University Belfast

Funded	Start/end date	Website
£68,200	September 2019 / December 2020	https://www.smarternetworks.org/project/nia_shet__0028

Innovation Focus Areas

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

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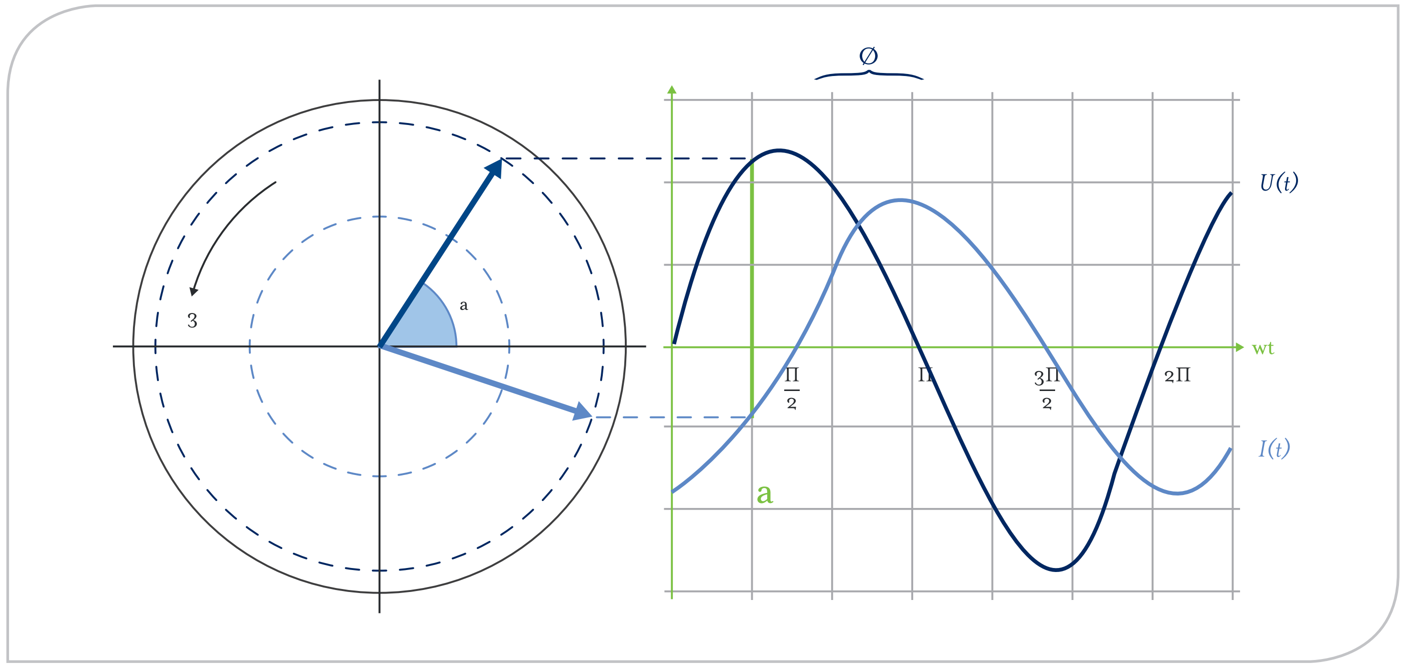
2.7 NIA_SHET_0029 Phasor Based Monitoring for HVDC



Key activities

The GB Electrical Transmission Network is expanding with an increase in the number of High Voltage Direct Current (HVDC) connection applications from Stakeholders. This project aims to build upon learnings from the **VISOR** and **MIGRATE** projects and explores the possibility associated with phasor wide area network monitoring and its application in controlling the incoming power from HVDC connections.

Benefits

The project at a computer simulation level will explore if it is possible, and efficient, to control electrical energy output from an HVDC power source via phasor measurements at key locations across the Transmission Network.

Progress

This project is a collaboration with GE Digital and the National High Voltage Direct Current (HVDC) Centre, using Ametek Phasor Monitoring devices. COVID-19 has introduced challenges around facilitating GE Digital with remote access to their equipment within the HVDC Centre, but a resolution was achieved mid-February. Following on from this, GE Digital have produced an initial phasor-based monitoring HVDC Controller and operational testing is underway to ensure it complies with network stability requirements, as well as an evaluation of operational performance, which may lead to refinement in functionality.

Collaborators

GE Digital / Ametek

Funded
£321,000

Start/end date
October 2019 / April 2021

Website
https://www.smarternetworks.org/project/nia_shet_0029

Innovation Focus Areas

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

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2.8 NIA_SHET_0030 Technical Assessment of Cable Management Approaches

Key activities

The testing of underground transmission cables follows well-established traditional methods. However, new testing technologies are emerging at the distribution network level. This project has been established to investigate the modern cable testing technologies, along with the likely efficiencies and benefits and to and to identify potential hurdles.

Benefits

We are seeking out information on new testing and diagnostic approaches for electricity cables operating at 132kV and above. The aim is to produce a recommendation of the preferred testing methods, along with the creation of an implementation strategy for SSEN Transmission which would also be applicable to other Transmission Owners.

Progress

A desktop review concluded that Very Low Frequency (VLT) and Damped AC (DAC) testing have the greatest potential to be further developed as an alternative to present cable testing solutions. These new tests have the potential to minimise the on-site environmental impact associated with present testing methods. Potential Discharge (PD) detection and cable impedance scanning were also evaluated, however it was felt that they would require more development work. The findings from the desktop study were shared via a virtual dissemination event in late 2020, which was well-attended.

Collaborators

High Frequency Diagnostics & Engineering

Funded
£59,800

Start/end date
December 2019 / December 2020

Website
https://www.smarternetworks.org/project/nia_shet_0030

Innovation Focus Areas

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

2.9 NIA_SHET_0031 Vibration Based Monitoring

Key activities

Some wind generation schemes may encroach or come close to existing infrastructure such as Transmission Overhead Lines. This project has been established to ddress the question “What effect and at what proximity do wind generators introduce an undesirable consequence on the existing conductor configurations and conductor types used on transmission overhead lines?”

Expected benefits

The project aims are firstly to accurately simulate and model the effect of wind turbine turbulence on overhead line conductors and evaluate associated wear and tear on the conductor. Secondly, to provide quantitative material to support recommendations and guidance for future scenarios where wind turbines proposed installations are close to existing overhead line infrastructure.

Progress

This year the first phase of overhead line conductor monitoring occurred between September and November 2020 to establish a vibration movement baseline prior to the installation of the nearby wind turbines. An extensive literature review has also been conducted by ESB International into ways of modelling the wear and tear on the overhead line conductor from the turbine, which has led to the placement of an air flow modelling contract with Wilde Analysis.

Collaborators

PLP / ESB International / Wilde Analysis

Funded	Start/end date	Website
£310,000	April 2020 / June 2021	https://www.smarternetworks.org/project/nia_shet_0031

Innovation Focus Areas

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

2.10 NIA_SHET_0032 TOTEM

Key activities

Conventional phasor-based simulation tools have limitations in studying weak, low inertia systems due to the level of detail that is represented. In conjunction with National Grid Electricity Transmission, National Grid Electricity System Operator and Scottish Power Transmission, there is a move to develop more detailed electromagnetic transient (EMT) based models which will address the present system modelling concerns.

Expected benefits

If successful, the new EMT power system model will help all of the Transmission Owners in GB to de-risk the integration of many of the technologies associated with the move towards the energy system transition, that may reduce system inertia, which is a necessary component to preventing unplanned system outages.

Progress

Extensive work has taken place on building a 4-Party Agreement to allow the procurement of services from the selected EMT power system modeller. It has been challenging to align the commercial terms and conditions across the UK Parties. It has now been passed to the EMT power system modeller for comment. Behind this the UK Parties have been agreeing and collecting the power flow system models that will be pasted onto the EMT power system modeller.

Collaborators

National Grid Electricity System Operator / National Grid Electricity Transmission

Scottish Power Transmission

Funded	Start/end date	Website
£580,000	May 2020 / April 2021	https://www.smarternetworks.org/project/nia_shet_0032

Innovation Focus Areas

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

2.11 NIA Collaboration Projects

This year SSEN Transmission have collaborated with Scottish Power Transmission on their Transient Recovery Voltage Investigation project. The project was run in parallel with the Zero Missing Phenomenon project. The outcome of the project included guidance information to help the Transmission Planning team identify and mitigate potential transient recovery solutions. For further information on the Transient Recovery Voltage investigation project please consult the Scottish Power Transmission progress reports.

3
Learning highlights of the year

3.1 Phasor Instream Data Processing (IDP) NIA

The aim of this project was to use researchers from Brunel University London and Queen's University Belfast to highlight the current and future direction of standards, protocols, and conventions in relation to the transport of streaming phasor measurement data.

The study found that SSEN Transmission currently has the necessary sensor devices, telecommunications infrastructure, and data centre capacity to fulfil its short-term and medium-term goals in relation to phasor Instream Data Processing (IDP). This includes the storage of synchro-phasor data for analysis and planning, and the sharing of data to National Grid ESO (NGESO) as required by STCP27-01 (before the end of 2026). However, existing synchro-phasor specific standards are not necessarily the best fit for granular, secure sharing of data, externally.

The project report highlights that a new synchro-phasor standard called Streaming Telemetry Transport Protocol (STTP) is on the horizon, but it may take several years to be fully ratified and adopted by vendors. A highly flexible interim protocol called Message Queuing Telemetry Transport (MQTT) was presented as an alternative which could be utilised to provide the more granular, secure, and scalable sharing required.

Several architecture options for the short, medium, and long-term processing of phasor instream data were explored. Recommendations were made in relation to the options which were broken down into three phases of deployment. This phased approach mitigates the risk associated with standards that are not yet adopted by industry, such as STTP, whilst delivering SSEN Transmission short- and medium-term goals.

3.1.1 Short-Term Requirements (0-2 years)

SSEN Transmissions network currently comprises 33 x Power Monitoring Units (PMUs) and 1 x Wave Monitoring Unit (WMU) device. In the short term an appropriate solution is required to effectively collect data from these devices, and to centralise this process, in order to enable easy digestion of the information this data represents. Initially, the data will mostly be utilised for internal planning and post-event analysis.

It is important to note that the data from the existing fleet of PMUs and one WMU is not currently being stored; a suitable solution has not yet been found that matches with SSEN Transmissions requirements. General recommendations in this area would be of paramount importance as a first step. It would be expected that these short-term requirements, as outlined in Figure 1, can be achieved within 2 years.

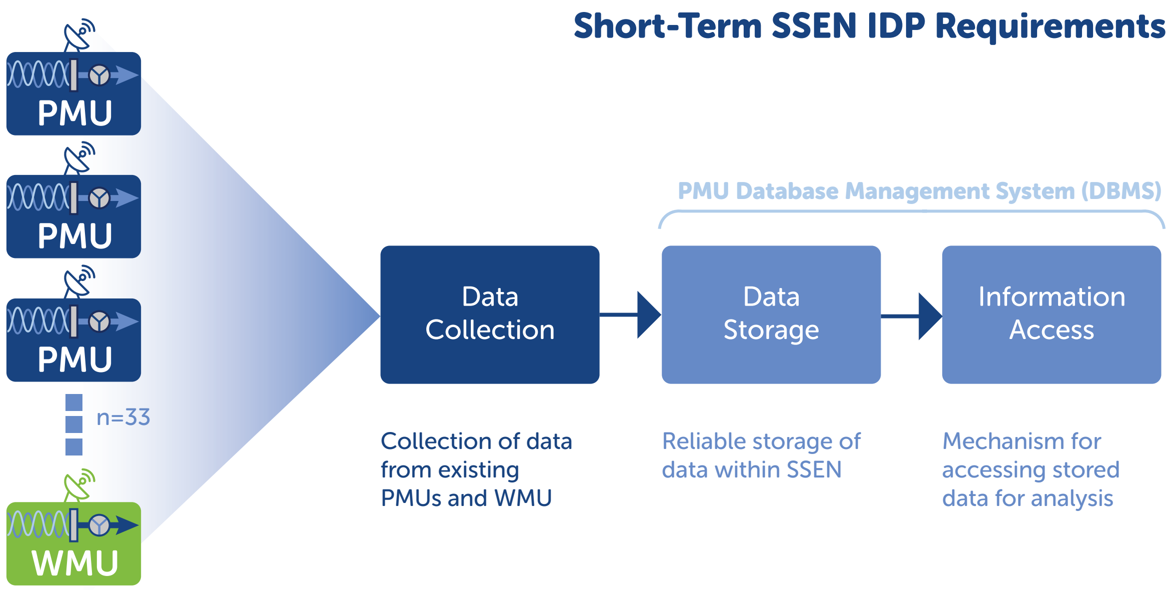


Figure 1: SSEN's short-term requirement to ingest, store and make available, data from existing PMU and WMU devices

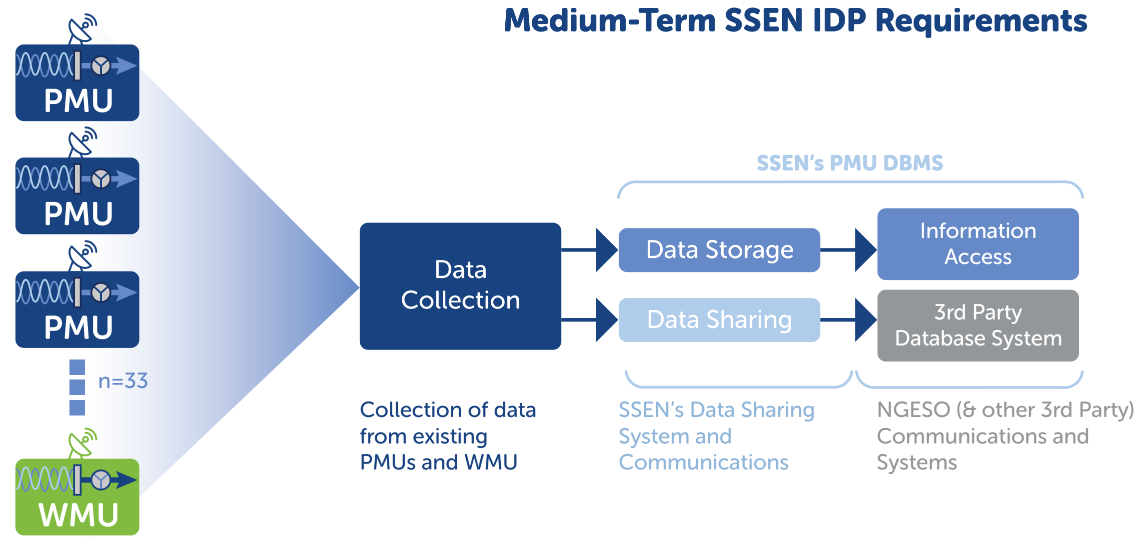
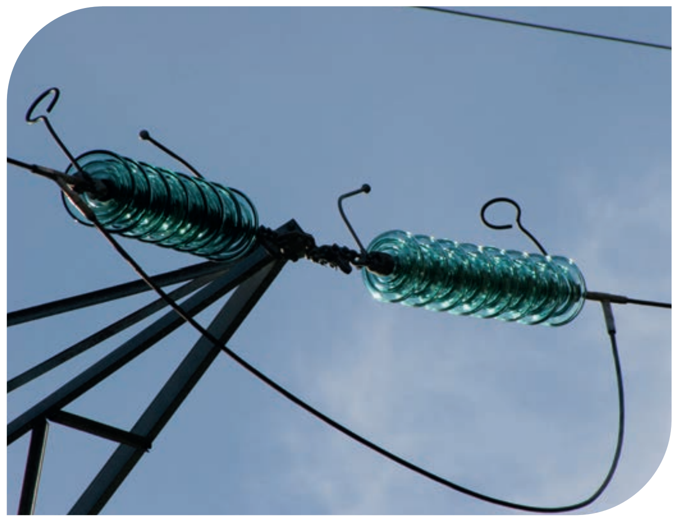


Figure 2: SSEN's medium-term requirements for a mechanism to share data with NGESO and other 3rd parties, as required.

3.1.2 Medium-Term Requirements (by end of 2026)

Once an effective data ingest mechanism is successfully trialled within SSEN Transmission, it will then become a priority to explore the potential to extend this data exchange mechanism to enable effective sharing of data with NGESO. The operation of this mechanism should be such that it is a 'one way' flow of metrology data from SSEN Transmission to NGESO, or other third parties as required. These requirements, which need to be met before the end of 2026, are illustrated in Figure 2.



3.1.3 Long-Term Requirements (6-10+ years)

SSEN Transmission's PMU and WMU network is expected to grow to support many more devices; it is expected that there will be approximately 200 PMUs on the network before March 2026. The infrastructure recommendations should therefore factor in support for larger deployment of sensor devices while utilising easily scalable architecture.

It is also anticipated that PMU and WMU devices may eventually be integrated with real-time/near-time systems; for technologies such as demand-response, dynamic constraint management, and automated post-fault actions. Architectures were presented to reflect this requirement, highlighting end-to-end latencies, dependability, and cyber security considerations as of paramount importance.

The longer-term requirements (6-10+ years) are illustrated in Figure 3.

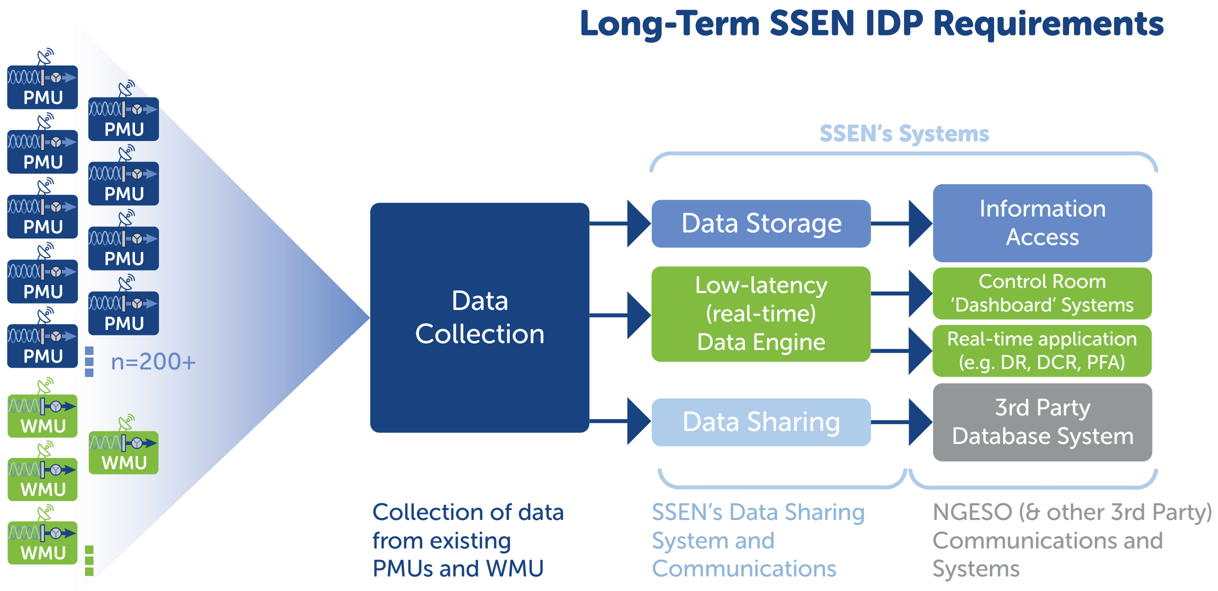


Figure 3: SSEN's longer-term objective in utilising real-time data from PMU and WMU devices for real-time and near-time operational purposesd.

3.2 Refase

Refase is Synaptec's multi-zone protection instrumentation product. It is designed to enable robust protection of complex, wide-area, or distributed power networks and assets. The ability of Refase to access many measurements over a wide geographical area, or traversing multiple feeder sections within a substation, can enable convenient centralised protection and control functions, including multi-zone protection (up to 16 zones per fiber) and highly-selective auto-reclose blocking for hybrid lines.

The system can make protection-class measurements over distances of up to 100 km (depending on the health of existing fiber infrastructure), which permits efficient unit protection of lines, cables, and other assets placed at very remote locations where it would be challenging and costly to install conventional monitoring equipment.

By centralising current measurements, this method eliminates the need to have multiple protection relays at each line end, complex time synchronisation systems at measurement points, and complex telecommunications equipment among the distributed devices, resulting in significant operational and infrastructure savings.

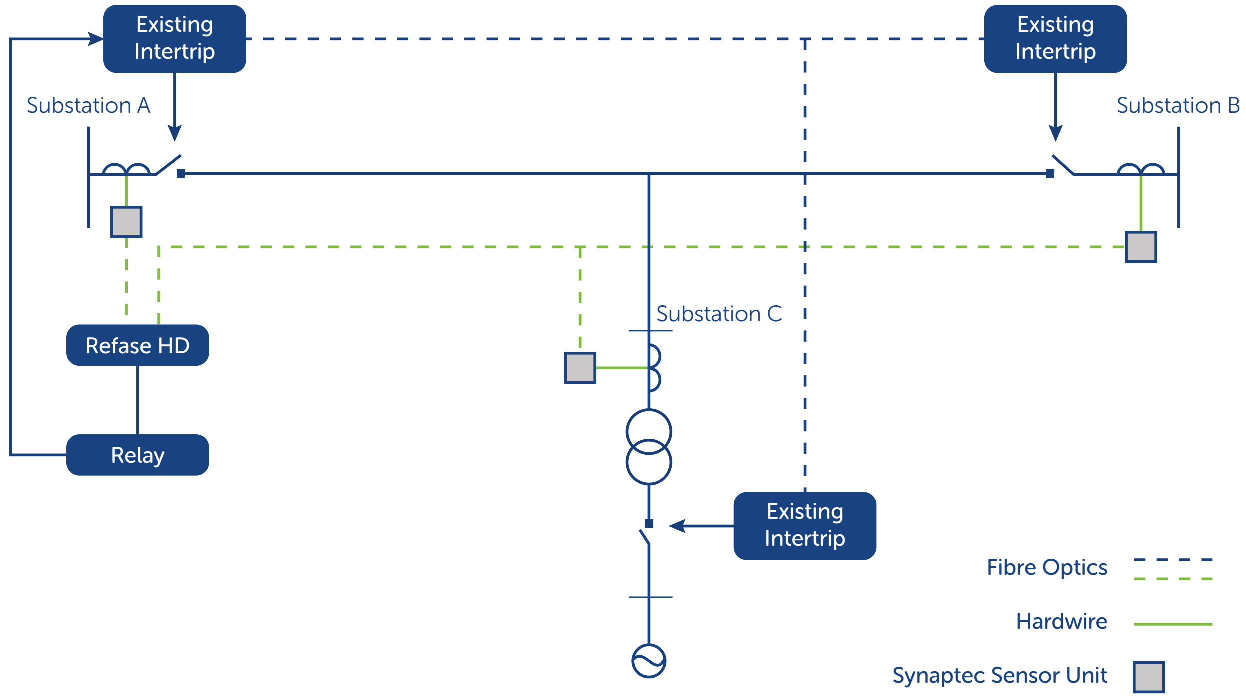


Figure 4: Figure 4 illustrates the instrumentation system that was deployed in this project. The system acquires passive (i.e. un-powered) measurements of the phase currents at each terminal of the multi-ended transmission circuit. These measurement data are published in IEC 61850-9-2 sampled value format at a single end, where an appropriate protection algorithm ran on a selection of IEC 61850-enabled relays provided by protection IED vendors (illustrated by Figure 5).

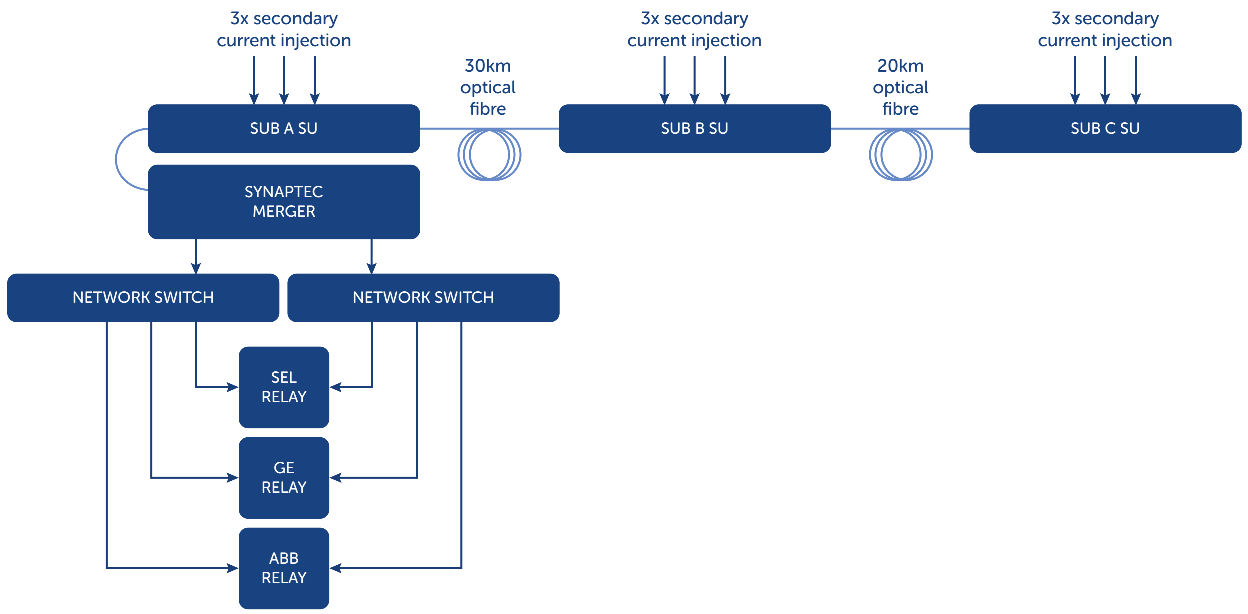


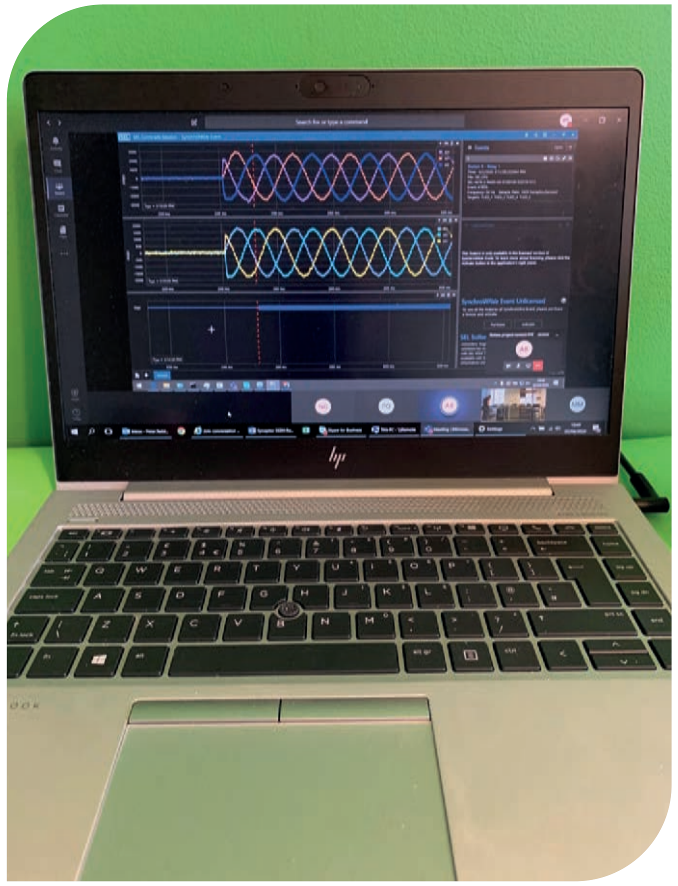
Figure 5

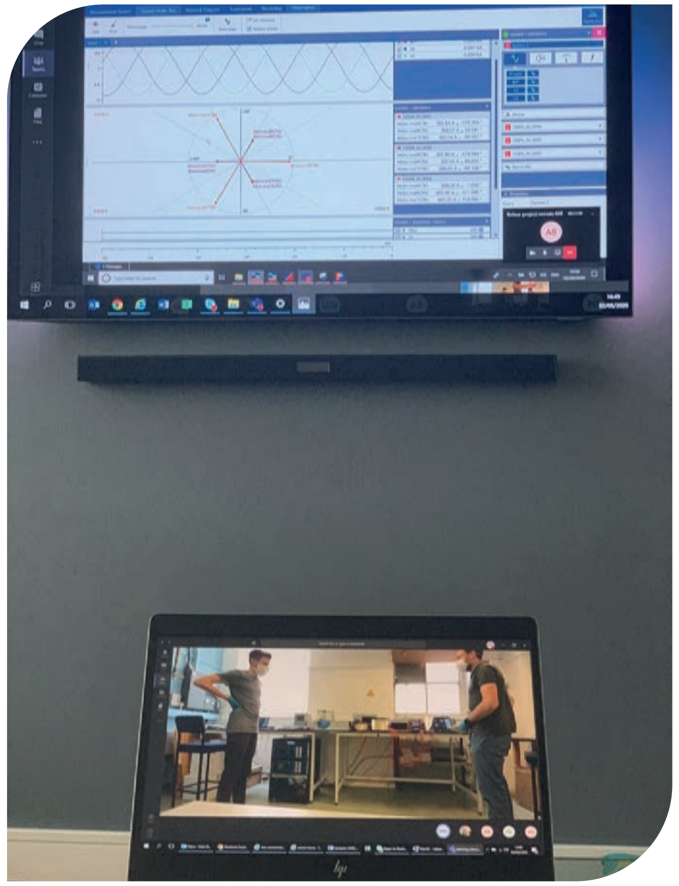
There are several technical benefits arising from this centralised, single-ended approach to line differential protection:

- Faster-acting multi-ended differential protection due to elimination of the typical wide-area communications delay of 2-6 ms, and elimination of other complications such as asymmetrical delay
- Removal of vulnerability to loss-of-sync errors between terminals, which in conventional schemes could cause incorrect tripping or require the scheme to be disabled
- Enables rapid and discrete post-event response – all measurements are accurately time synchronised and published in open format (IEC 61850/61869) which facilitates examining of fault records for complex events
- Publishing Continuous Point on Wave (CPOW) data to the process bus permits further analysis from the same data used by the protection scheme, including power quality and transient analysis
- Readily supports new grid connections with minimal civil engineering works by reducing the need for equipment housings

Synaptec's instrumentation schemes in general also have several functional benefits over conventional measurement schemes:

- Utilises substantially fewer fibres than conventional networked electronic sensor systems. A single fibre (single ended) may be used to deliver dozens of measurements to the central Interrogator.
- No power supplies, telecoms, or time-sync equipment required at remote terminals. The Interrogator is the only powered device in the system, while every sensor is completely passive and requires no local time synchronisation signal or active digital telecoms.
- No active electronic equipment required at the remote end to support instrumentation, hence no ongoing maintenance for IEDs which typically have a shorter lifespan than primary-connected equipment.
- Faster and safer to install due to the reduced equipment and the inherently safe optical isolation on the secondary side of sensors. This in turn reduces installation costs.





To date, SSEN Transmission has undertaken significant factory acceptance testing of the Refase product which has shown it can meet the required performance required to be installed in a live field trial. The field trials will extend beyond the end of the NIA project where SSEN Transmission engineers will continue to monitor the performance of the Refase system over an extended period.

Refase factory acceptance testing (FAT) is being conducted remotely via Teams and witnessed by experts in the UK and internationally due to the COVID-19 travel restrictions. Until this time, a FAT would only ever be conducted and witnessed in person.

4 Further information

The new SHE Transmission Innovation Strategy, published in December 2019 can be found at the link below:

2019 SHE Transmission Innovation Strategy

https://www.ssen-transmission.co.uk/media/3725/she-transmission-innovation-strategy.pdf

Further details of all the NIA projects summarised above can be accessed through the following link:

ENA Smarter Networks Portal – SSEN Projects

http://www.smarternetworks.org/project-results/1

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