Scottish & Southern Electricity Networks

TRANSMISSION

Annual Innovation Report

2022 /2023

ssen-transmission.co.uk

Contents

Welcome to our Annual Innovation Report 2022/23

> To enable the transition to net zero, we will be delivering the biggest transformation of our network since it was built.

Andrew Urquhart
Head of Whole System
SSEN Transmission

The electricity transmission network forms the backbone of our energy system, enabling the efficient transmission of electricity from generation sources to our homes, businesses, and communities. As we transition towards a net zero future it is essential that our infrastructure is fit for the future. We will be continuing to connect increasing levels of renewable generation to the electricity grid, as well as ensuring our assets are even more resilient in the case of extreme weather caused by climate change.

To enable the transition to net zero, we will be delivering the biggest transformation of our network since it was built. Innovation and collaboration are paramount to accelerating this change as well as achieving our collective goals as an industry. We are collaborating with our customers, stakeholders, industry innovators, and other transmission owners (TOs) to share ideas, research new concepts for our network, and maximise the value and benefits of pioneering technologies.

With the future growth and investment required for our network, we're taking a stakeholder-led and forward-thinking approach to revising our innovation strategy to ensure we are tactically aligned to address the challenges that matter the most to our network. We are looking to publish this later in the financial year.

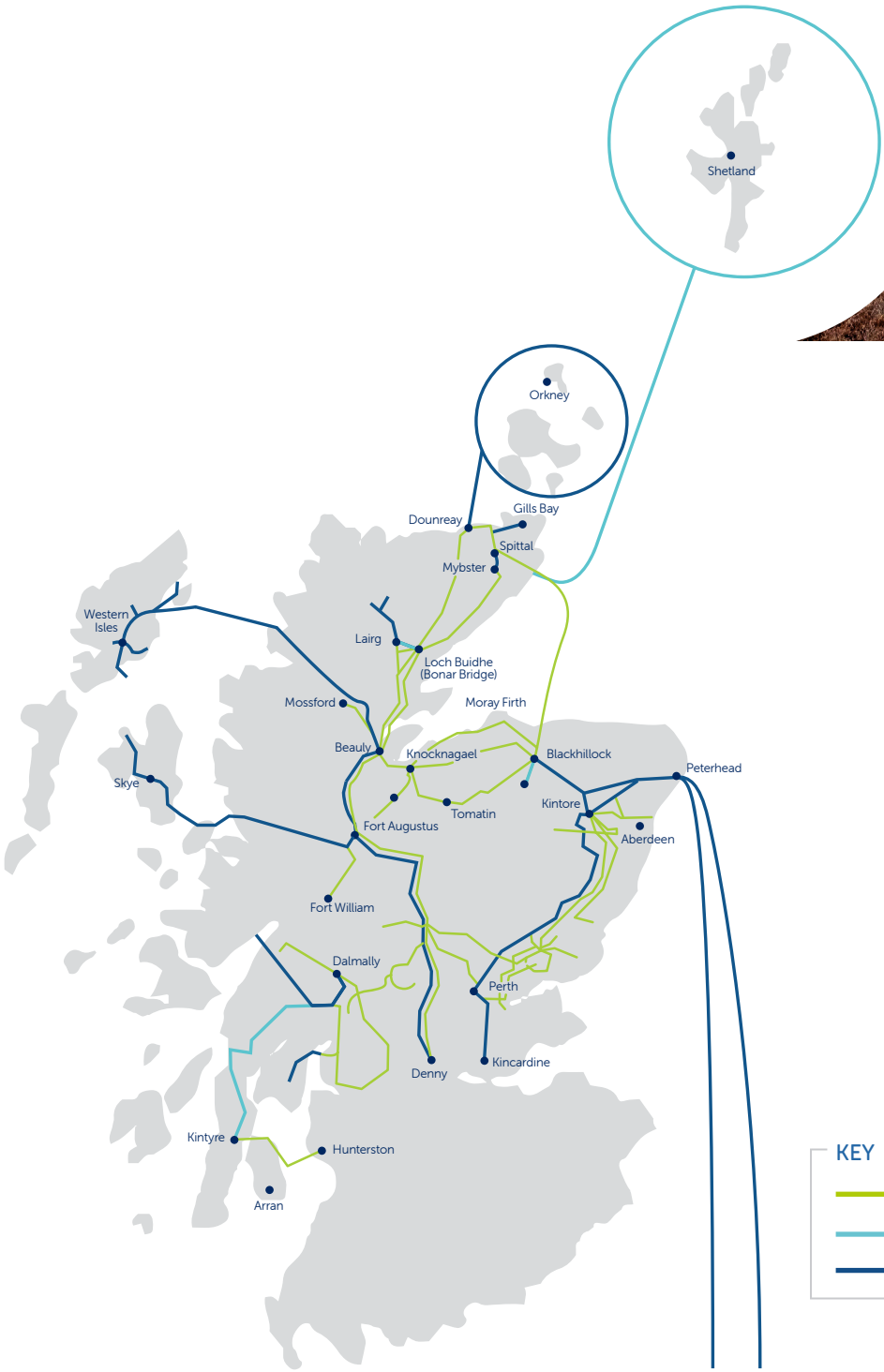
Over the last year, we have made a strong start on progressing our RIIO-T2 innovation portfolio and expanded our team to explore new ideas for our network and develop a range of projects. This report highlights our efforts in research and development, collaboration, and knowledge-sharing across the industry as we delve into some of the innovative ideas and solutions that we've been developing from April 2022 – March 2023 to address the challenges facing our electricity transmission network.

Our innovation portfolio has benefitted from Ofgem's funding mechanisms, the Strategic Innovation Fund (SIF) and Network Innovation Allowance (NIA). In addition, we have utilised external funding streams and internal investment to deliver our Business as Usual (BaU) portfolio. This year, we took on 6 new NIA projects, progressed two SIF projects from the Discovery phase into the Alpha phase, and have continued developing our BaU solutions for implementation on our network.

I invite you to explore the pages of this report, get inspired by our exciting innovation projects that are underway, and join us in our journey to shape the energy landscape of tomorrow. If you have an idea to help us deliver this significant shift in demand on our network or would like more information on a project featured in this report, please get in touch with our innovation team via transmissioninnovation@sse.com.

Andrew Urquhart
Head of Whole System SSEN Transmission

About SSEN Transmission



SSEN Transmission is responsible for the electricity transmission network in the north of Scotland. Our responsibilities include the maintenance and investment in the high voltage 132kV, 220kV, 275kV and 400kV electricity transmission network.

Our extensive network consists of underground and subsea cables, as well as overhead lines (OHLs) supported by wooden poles or steel towers, and electricity substations. It extends over a quarter of the UK's landmass, navigating some of the most challenging terrains and powering our communities by providing a safe and reliable supply of electricity.

Scotland's transmission network has a strategic role to play in supporting the delivery of the UK's Net Zero target. We're already a mass exporter of renewable energy, with around two-thirds of power generated in our network area exported south. We will continue to deliver a network for net zero, while providing the best value for our stakeholders, customers, and the GB consumer. Innovation is requisite for finding new ways of delivering net-zero energy systems and value for money.

Meet our Innovation Team

Andrew Urquhart

Head of Whole System

Alan Ritchie

Innovation Manager

Simon Stromberg

Innovation Development & Strategy Manager

Katie Fergus

Innovation Development Project Manager

Jonathan Powell

Innovation Development Project Manager

Brant Wilson

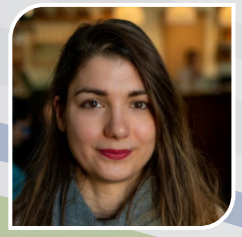
Innovation Portfolio Manager

Dominic Chan

Innovation Delivery Project Manager

Ariane Newlands

Innovation PMO Manager



Angeliki Spyroudi

Innovation Analyst

Tania Shaw

Innovation Delivery Project Manager

Peter Taddei

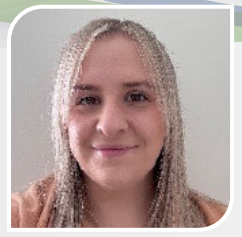
Innovation Delivery Project Manager

Adnan Mahmood

Innovation Delivery Project Manager

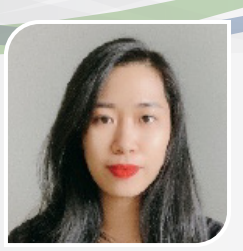
Alex Pender

Innovation Knowledge & Communications Officer



Jennifer Dalrymple

Innovation Project Coordinator



Huyen Kieu

Business Analyst

Anna Weniger

Commercial Graduate

About This Report

Innovation has a critical role to play in delivering our future network whilst continuing to deliver network reliability and value for our customers. At SSEN Transmission, innovation is embedded in our culture and is embraced across the business. Our Innovation team work collaboratively with subject matter experts across all areas of the business to understand our challenges, identify areas of improvement or new opportunities, and develop ideas into innovation projects.

This report is supplementary to our recently published NIA report, to provide a holistic overview of our innovative activities from April 2022 – March 2023. Over the last year, we have continued to expand our project portfolio which has been funded either by SIF, NIA or what we categorise as our BaU innovation activities.

We have developed our four Innovation Focus Areas that supports SSEN Transmission's strategic objective of enabling a transition to a lower carbon economy. 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.

Innovation Focus Areas

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

Innovation Dashboard

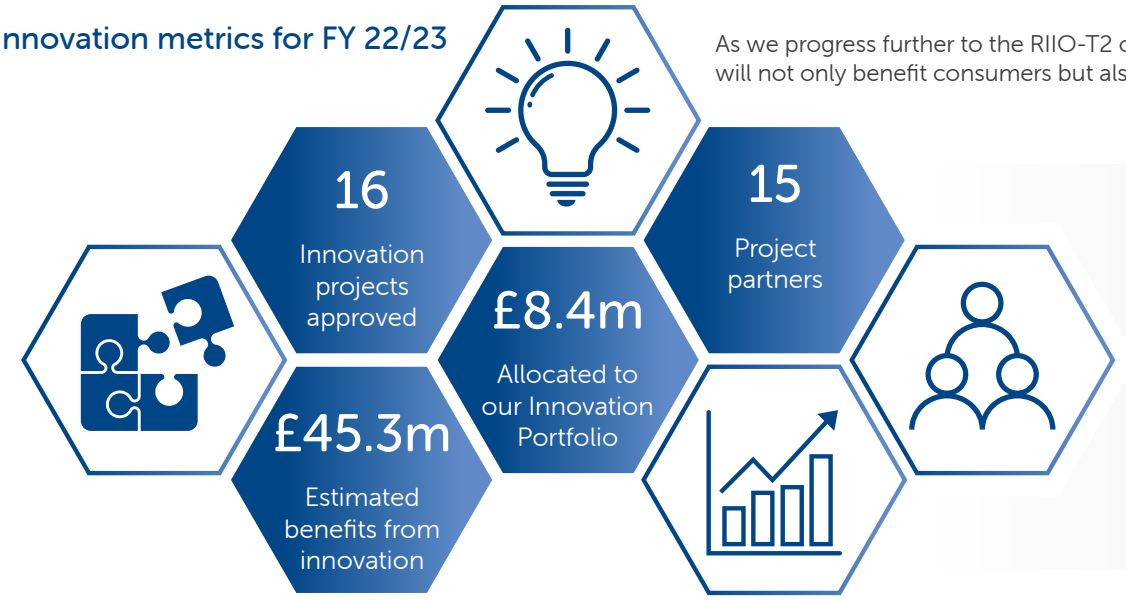
During the last year, our Innovation team continued to expand our innovation portfolio, adding 16 new projects with a total budget of £8.38 million spread across different funding streams (NIA, SIF and BaU). Six of these projects have been developed collaborating with several partners in academia, electricity network operators and public organisations.

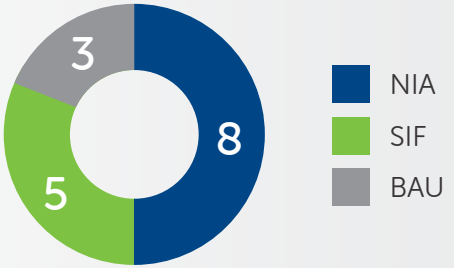
At this stage, cost benefits have been analysed for eight of our projects as some of our newest projects are at an early development stage, and benefits are yet to be understood. The innovation will therefore help inform and identify benefits further along in the process. The cost benefits analysed for eight of these projects for the financial year 2022 – 2023 based on availability of data are estimated to be £45.3 million.

This estimation refers to the discounted lifetime cost savings of these innovation projects across the 45 years of their design asset life, are adjusted to a risk factor (where applicable) and are expressed in 2018 real values; Ofgem's base year. However, cost is one aspect of our innovation priorities, so other types of benefits related to safety, socio-environmental impact, quality improvement and time saving are also investigated and captured quantitatively or/and qualitatively.

As we progress further to the RIIO-T2 our innovation portfolio focuses both on short term and long term solutions which will not only benefit consumers but also will support the business strategy on building a network for net zero.

Key Innovation metrics for FY 22/23





Total number of Innovation projects

Summary of Network Innovation Allowance (NIA) Progress

Ofgem's Network Innovation Allowance (NIA) is a set amount that each RIIO network licensee receives as part of their price control allowance. The NIA is a valuable tool that provides us with the autonomy to innovate and seek out new solutions that address our challenges head-on. Our NIA projects play an essential role within our innovation portfolio by accelerating technology readiness levels (TRL) and enabling us to implement innovation into our BaU operations.

In the RIIO-T2 price control period, we have been granted £8 million in NIA funding of which, we have invested £4.8 million into our portfolio so far. This funding has enabled us to progress 8 projects that have a proven business case and significant forecasted benefits for future implementation on our network.

- NIA SHET 0033 - PSL-FC (Protection Solutions to perform for Lower Levels of Fault Current on AC networks)
- NIA SHET 0034 - Low Profile 132kV Steel Poles
- NIA SHET 0035 - TOTEM (Transmission Owner Tools for EMT Modelling) Extension
- NIA SHET 0036 - Condition Assessment of SF6 Alternatives (CASA)
- NIA SHET 0037 - Probabilistic Modelling for Connection Studies
- NIA SHET 0038 - Ice Mapping
- NIA SHET 0039 - OHL Foundation Uplift
- NIA SHET 0040 - Corrosion Mapping

Safe and secure network operation

Sector-leading efficiency

NIA SHET 0033 -

PSL-FC (Protection Solutions to perform for Lower Levels of Fault Current on AC networks)

Key Activities

The transition from traditional fossil fuels to renewable sources of energy is changing the transmission network characteristics as there is a reduction in very large spinning machines which can inject high levels of current onto the network during a fault. The Protection & Control (P&C) systems are presently designed to monitor and react to a very large and sudden current event.

This project aims to simulate a future electrical network where the fault current spike is marginal but prolonged and evaluate how present P&C products function and respond. Based upon the findings it will determine if a P&C solution can be further developed to address the future network issue. This project is testing new P&C products designed to respond to a future electrical network where the fault current spike is low but prolonged.

The present mitigation measure for areas of the network that may be exposed to lower levels of fault current is a device called a Synchronous Condenser. A Synchronous Condenser can replicate a traditional fossil fuel power source and in the event of a fault it will respond with a very large, sudden, single bolt of current enabling currently deployed P&C devices to respond but would cost around £15m per installation on the network.

If this project can evidence that new P&C product, with costs of c£200k per installation, have the potential to respond effectively in a lower-level fault current environment and identify any changes needed in P&C policies and procedures then the costs of Synchronous Condenser deployment may be avoided.

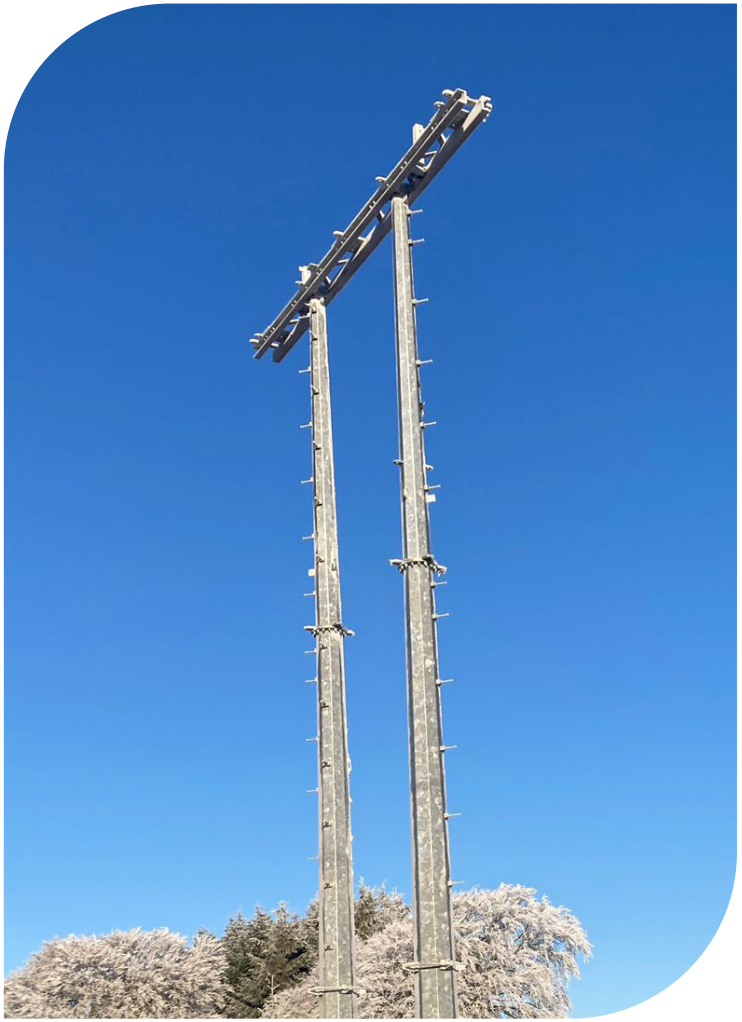
Lab testing in the Hardware-in-Loop (HiL) testing environment is in progress. Initial tests on Travelling Wave and Distance protection relays have been carried out with Differential and Neutral Current relay testing getting underway imminently. Preparations for the field trial commencing in Autumn 2023 are underway for Thurso South and Spittal substations. This trial will run for two winter periods.

Research Partners: University of Strathclyde, National HVDC Centre

Funded: £671,000

Project Timeline: July 2021 - April 2025

Website: https://smarter.energynetworks.org/projects/nia_shet_0033



Stakeholder-led strategy

Sector-leading efficiency

Leadership in sustainability

NIA SHET 0034 -

Low Profile 132kV Steel Poles

Key Activities

Within the next five years, SSEN Transmission must provide connections to multiple wind farms characterised by their large electrical capacity or high altitude. A wood pole OHL is unsuitable in these cases as our existing 132kV poles cannot be used above 300m and are capacity limited. At over 250MW and 300m altitude, where most of the future wind farm connections will be installed, steel lattice and New Suite of Transmission Structures (NeSTS) are the proposed solution, however, they are associated with high costs and a larger carbon footprint than traditional wooden poles.

This project has researched and designed a new and innovative pole for our OHLs at altitudes above 300m using the new design as an alternative to steel lattice towers across our Transmission network. The new structures remain similar in design to current wooden OHLs to ensure there is a limited visual impact on the landscape.

The structures will be more resilient in adverse weather conditions, can be used at higher altitudes, and can carry higher loads enabling an increase in the line's capacity without further impacting the landscape or using additional materials. The design also encompasses multiple safety improvements for operatives and removes the need for concrete and access tracks during construction as foundations are directly buried in the soil. SSEN Transmission has identified a £4.8m of lifetime cost savings if using the new steel pole design across 7 projects.

Two prototype poles were constructed in December 2022 and a design review has been conducted with several stakeholders from SSEN Transmission and PLPC. Following this, some minor design improvements have been incorporated to date with a full suite of engineering drawings now in progress. Testing of the structures is planned for summer 2023 and a testing outcome report will follow.

Collaborators: PLPC, Energyline, Norpower

Funded: £1,650,000

Start/End Date: January 2022 – July 2024

Website: https://smarter.energynetworks.org/projects/nia_shet_0034

Stakeholder-led strategy

Sector-leading efficiency

NIA SHET 0035 -

TOTEM (Transmission Owner Tools for EMT Modelling) Extension

Key Activities

The GB's power system is rapidly evolving as greater levels of renewable energy are being connected, leading to a much lower level of system inertia and lower short circuit levels. In addition, there are increasing numbers of HVDC links and Flexible AC Transmission Systems (FACTS) devices being connected in close proximity to parts of the system.

The potential for adverse control interactions between these devices is rising and needs careful consideration within the context of a potentially weaker GB power system. This project is a continuation of NIA SHET 0032 TOTEM to complete the development and validation of a full-scale model of the GB Transmission System in electromagnetic transient (EMT) Power System Computer Aided Design (PSCAD) simulation software.

If successful, the new EMT power system model will help all the Transmission Owners in GB to de-risk the integration of many of the technologies associated with the move toward the energy system transition that may reduce system inertia and contribute to unplanned system outages.

To date the project has positively developed:

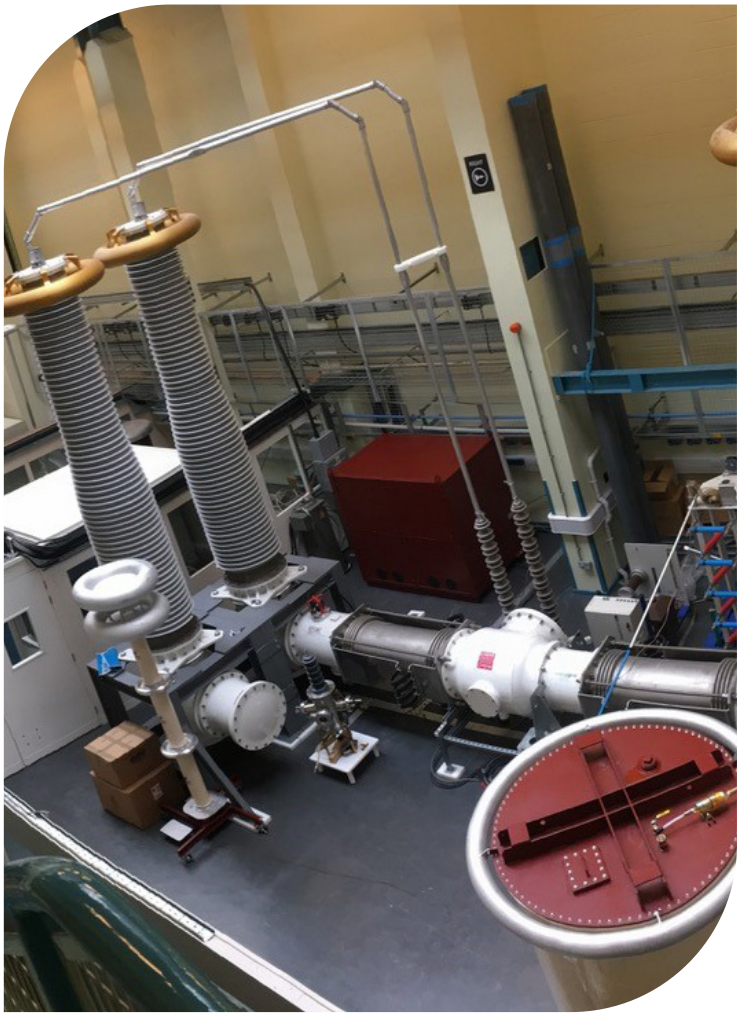
- A multi-Party Agreement which enables the GB Transmission Owners to work together to acquire and validate a new system model that will enhance, as well as de-risk the integration of new technologies.
- Our project partner, MHI, have completed the build of the PSCAD models for all TOs and provided the first version full GB model along with first version supporting tools.
- Computing resource for GB Transmission operators and NGESO has been selected and procured.

Research Partners: MHI, National Grid Electricity Transmission, SP Transmission, National Grid ESO

Funded: £437,000

Start/End Date: May 2022 – July 2023

Website: https://smarter.energynetworks.org/projects/nia_shet_0035



NIA SHET 0036 -

Condition Assessment of SF_6 Alternatives (CASA)

Key Activities

Gas insulated systems (GIS) currently use large volumes of pressurised sulphur hexafluoride (SF_6) gas which has a high global warming potential (23,500 times that of CO2). SSEN Transmission is in the process of transitioning to alternative gases that have a lower carbon footprint compared to SF_6 for GIS within the transmission network. This project will provide greater understanding of the condition monitoring requirements of the alternative gases to allow engineers to identify an incipient failure and carry out repairs.

The move towards reducing the use of SF_6 will play a role in supporting our RIIO-T2 business plan objective of reducing our greenhouse gas emissions by one third and is in line with the Government's net zero emission targets.

This project will help to understand the characterisation of the Partial Discharge properties of alternative gas mixtures which will give greater confidence to network operators when assessing the integrity of online GIS. The insights into the type and severity of defect(s) in these systems will improve the chances of detecting defects earlier to enable preventative maintenance, thereby reducing network vulnerability and unplanned power outages.

CASA is in early-stage development. Some delays were encountered while recruiting a research associate however, the research work is now in progress and this delay will not impact the overall project timescales. The procurement of the required equipment has been completed.

Research Partner: Cardiff University

Funded: £700,000

Start/End Date: May 2022 – December 2025

Website: https://smarter.energynetworks.org/projects/nia_shet_0036

Safe and secure network operation

Leadership in sustainability

Stakeholder-led strategy

Sector-leading efficiency

NIA SHET 0037 -

Probabilistic Modelling for Connection Studies

Key Activities

SSEN Transmission have received significant interest in grid connections for renewable generation and storage projects in the north of Scotland. It is possible that transmission network planners could carry out more dynamic, probabilistic, modelling to account for complex factors which could yield more efficient development and connection of renewable generation and flexibility assets.

This project will develop a prototype probabilistic planning toolkit and study process to apply to connection studies. The toolkit will generate statistics and visualisations to provide a detailed picture of network capacity under uncertainty, consisting of a dataset and automated calculation processes. The project will enable SSEN Transmission, as well as other networks, to identify the most efficient way to develop the network for the transition to net zero with the optimal level of infrastructure. This is expected to enable grid connections to be achieved at minimal cost and impact to the environment and local communities. In addition, improvements made in investment decision making could result in substantial benefits in cost and improvements to the time frame of connecting renewable generation and flexibility assets.

WSP have been engaged as consultants to develop a probabilistic planning process, design, and build a prototype probabilistic planning toolkit which integrates with SSEN's power system analysis software application PowerFactory. The process will be demonstrated through case studies and assessing the benefit of this approach versus a Business as Usual (BAU) deterministic assessment.

Research Partner: WSP

Funded: £400,000

Start/End Date: March 2022 – March 2024

Website: https://smarter.energynetworks.org/projects/nia_shet_0037

Stakeholder-led strategy

Sector-leading efficiency

Leadership in sustainability

NIA SHET 0038 -

Ice Mapping

Key Activities

Ice Accretion has the potential to damage Transmission infrastructure and impair the performance of the exposed equipment. All new overhead lines are designed subject to environmental loadings which are derived from the ice map Figure NA.2 of British and European engineering and construction standards. Deficiencies in ice map Figure NA.2 may lead to the overdesign of transmission overhead lines in the North of Scotland.

This project will develop a new ice accretion model and combine it with existing global Numerical Weather Prediction (NWP) models with high granularity topological and orographical parameters.

SSEN Transmission have 54.5km of wood pole overhead lines and 27km of steel overhead lines currently contracted at a pre or early design stage. The project involves developing a model to provide a more accurate figure for the potential for ice accretion, which will enable more efficient designs and minimise excess construction associated with projects.

Subject to assumptions outlined in early cost benefit analysis (CBA), a reduction in overdesign due to ice accretion miscalculation could result in benefits of up to £1.47m if applied to the currently contracted pre-design overhead line projects in the SSEN Transmission area.

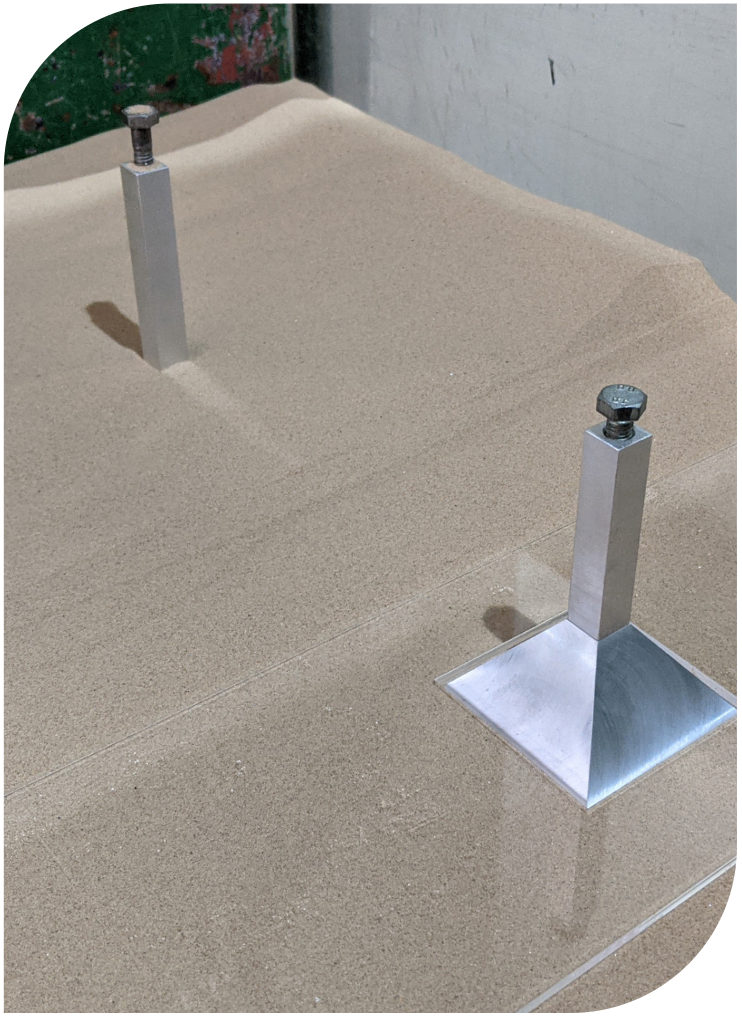
The development of an ice load map is being undertaken in two phases with distinct work packages for each phase. Phase 1 has been fully delivered by the Met Office. This included a discovery phase, data retrieval, data processing, ice accretion modelling and validation, extreme value modelling, and mapping and data delivery across SSEN Transmission's network area. Phase 1 reports are available for sharing with other network licensees. Phase 2 is now in progress which will further develop the Ice Map model to maximise the learning.

Research Partner: The Met Office

Funded: £359,080

Start/End Date: August 2022 – February 2024

Website: https://smarter.energynetworks.org/projects/nia_shet_0038



Stakeholder-led strategy

Sector-leading efficiency

Leadership in sustainability

NIA SHET 0039 -

OHL Foundation Uplift

Key Activities

This project aims to improve the design for OHL tower foundations by minimising materials to allow for a more efficient and environmentally friendly foundation. This includes gaining a better understanding of the optimal edge profile/ roughness, and how this can reduce the materials/space required. It will also provide an understanding of any associated cost savings and benefits and assess OHL projects due for design and construction across the SSEN Transmission network. The learning from this project can facilitate energy system transition by better understanding OHL foundation design and potentially provide a saving in embedded carbon and carbon emissions expended during the construction phase by reducing the foundation size and the amount of concrete used to erect OHLs.

Considering the use of this method in five SSEN OHL projects of 1,529 towers (suspension and tension), the estimated carbon saving is approximately 1,360 tonnes CO2e equivalent to the annual electricity consumption of over 2,200 households. In addition, the new OHL foundations will reduce the disruption to the surrounding land from smaller excavations. There is an approximate £8 million total saving for lifetime scaled cost benefits for the identified OHL projects.

Preliminary investigation through numerical modelling has taken place and will undergo further numerical investigation and validation of findings through scaled physical model testing to develop full design approaches and appropriate safety or partial/model factors for implementation.

The project is in early-stage development, and work has begun to prepare soil samples for the research work to be undertaken. As the project progresses, additional developments will be reported in future progress reports.

Research Partners: The University of Dundee, National Grid

Funded: £352,307

Start/End Date: December 2022 – December 2024

Website: https://smarter.energynetworks.org/projects/nia_shet_0039

NIA SHET 0040 -

Corrosion Mapping

Key Activities

The rate of deterioration on our assets from the impact of corrosion on galvanised steel is currently estimated using the Galvanisers Association corrosion map. This methodology has become outdated based on modern meteorological practices and therefore does not provide high levels of confidence for strategic decision making. The project will assess whether, by providing more accurate and relevant weather and environmental data, a more efficient and cost-effective process could be used to design, construct, and maintain our network assets in the North of Scotland.

For example, decisions such as the placement of substations near coastal areas and estimating the remaining service life of existing OHLs cannot be made with sufficient confidence. If the new corrosion map provides evidence that a substation does not require to be housed indoors then early CBA indicates potential cost savings of £1.81m per substation.

Cost benefits related to condition monitoring and corrosion protection of other assets (such as OHLs) are also anticipated but are yet to be fully ascertained. Reducing the resultant costs associated with renewable energy transmission could assist in the SSEN Transmission RIIO-T2 business plan goal to transport the renewable electricity that powers 10 million homes, contribute to national Net-Zero targets, and provide benefit to customers.

The project is in early-stage development and therefore no performance data is available. This will be reported during future progress and close-down reporting.

Research Partner: The Met Office

Funded: £300,000

Start/End Date: February 2023 – April 2024

Website: https://smarter.energynetworks.org/projects/nia_shet_0040

Sector-leading efficiency

Leadership in sustainability

Summary of Strategic Innovation Fund (SIF) Progress

These projects are funded by network users and consumers under SIF, an Ofgem programme managed in partnership with UK Research and Innovation (UKRI). The SIF mechanism is designed to drive the innovation needed to transform gas and electricity networks for a low-carbon future.

The fund consists of three project phases:

- **Discovery: The completion of feasibility studies to de-risk technical uncertainties associated with projects**
- **Alpha: Using the findings of the feasibility studies to develop proof-of-concept projects**
- **Beta: Developing full-scale demonstrator projects further up the technology readiness level (TRL) towards implementation.**

The SIF mechanism was first introduced by Ofgem for the RIIO-2 price control period. Since our last report, we have completed the first round of Discovery projects where we had three active projects. From these projects, we were successful in progressing two into Alpha phase, enabling us to develop a deeper understanding for proof-of-concept project development.

The following pages of this report provide an insight into the progress made on these three projects throughout the course of the year.

- Network-DC Circuit Breakers
- INCENTIVE: Innovative Control and Energy Storage for Ancillary Services in Offshore Wind
- NIMBUS: Network Innovation and Meteorology to Build for Sustainability

Network-DC Circuit Breakers

Key Activities

Usually, electricity is transmitted as an alternating current. However, we now need to connect large amounts of wind power from remote locations over long distances. To do this, we need to make use of high-power direct current (DC), rather than alternating current (AC). Using Direct Current is a new development for the transmission network to meet the UK's net-zero energy targets.

Direct Current Circuit Breakers (DCCBs) could help combine HVDC links that join two points in the network and an export cable from a wind farm in one hub, without needing to build additional convertor stations to change the electricity current from DC to AC and back. This will reduce the amount of infrastructure required to deliver net-zero, reducing environmental impact, and delivering a more flexible and cost-effective network.

DCCBs can save valuable space by reducing the number of transmission assets, thus reducing impacts on local coastal communities and those who would otherwise be disrupted by expanded transmission infrastructure. It also reduces costs by avoiding the need to build additional infrastructure. This approach increases the DC network's flexibility, allowing wind power to be routed more efficiently to centres of demand with reduced constraints and likely reduced curtailment on the wind generation.

This project will help to de-risk the implementation of DCCBs by further developing industry knowledge and understanding of the opportunities, challenges, and timelines to deliver DCCBs from a technical, regulatory, and commercial perspective. This project has completed both the Discovery and Alpha phase this year.

Despite DCCB use in China, the Alpha Phase project confirmed that DCCB deployment is not a simple "lift and shift" exercise. This project is spurring innovation by increasing confidence in the technical, commercial, and regulatory aspects of DCCB use for manufacturers, operators, and owners. As part of the Alpha phase, SSEN-T selected a use-case for DCCBs based on a DC switching station (DCSS) proposed at Peterhead that could support HVDC links connecting energy transmission in North East Scotland to locations in England and international interconnectors. The Alpha Phase highlighted the best arrangement and number of DCCBs optimising electrical circuit selectivity: should a major fault occur, the fault can be isolated immediately by the DCCBs, preventing a shock to the system. As a result, the network users are unaffected and wind farms can continue operating while repairs are made.

The cost-benefit analysis conducted by Mott MacDonald during the project so far shows a combined positive benefit of ~£3.5 million over the first ten years of operation and ~£350 million in the expected 35-year lifetime of operation. The Beta Phase project will address confidence issues by demonstrating the performance of DCCBs through detailed testing of a DCCB replica as part of a UK network model.

Funding Phases:
SIF Discovery – Round 1 (Mar 2022 – May 2022)
SIF Alpha – Round 1 (August 2022 – Feb 2023)

Project Partners: University of Edinburgh, Carbon Trust, National Grid Electricity System Operator, SuperGrid Institute, National HVDC Centre, Mott MacDonald

Website:
https://smarter.energynetworks.org/projects/10036946/

INCENTIVE:

Innovative Control and Energy Storage for Ancillary Services in Offshore Wind

Funding Phases:
SIF Discovery – Round 1 (Mar 2022 – May 2022)
SIF Alpha – Round 1 (August 2022 – Feb 2023)

Strategy Themes: Whole energy systems

Project Partners: University of Strathclyde, Carbon Trust, National Grid Electricity System Operator

Key Activities

With the increasing capacity of offshore wind, innovative solutions are required to facilitate the rapid roll-out of this intermittent generation to support grid balancing and address stability challenges. Without this, the GB grid will become weaker which will lead to issues in system operation including increasing the likelihood of blackouts and maintaining reliance on fossil fuel generators.

This project will investigate new solutions to address this challenge by demonstrating the use of innovative voltage, current and frequency control technologies coupled with energy storage at the point of onshore connection of offshore wind farms. Traditional power generation provided great network stability and is regarded as synchronous generators. However, renewable generation no longer offers the same stability levels due to greater intermittency, therefore it is critical to ensure system stability is achieved when connecting increasing volumes of non-synchronous renewable generation.

The current provision is through redispatch of synchronous generation, which carries significant financial and environmental costs, and the development of new, standalone assets procured through Stability Pathfinder (SP). Published figures suggest that the £1.3bn contract cost from SP3 could deliver benefits of £14.9bn between 2025 and 2035. INCENTIVE will deliver benefits over and above those achievable through SP by developing generation and network assets with in-built stability provision. Benefits include:

- Introducing design alterations to requisite/planned assets to enhance stability service provision for only marginal cost increases.
- Capturing co-development cost savings, e.g. in a shared network, access, and planning considerations
- Potential acceleration in connection of renewable assets by proactively addressing stability at the outset.
- Creating a more liquid market for stability services, potentially driving down market prices in the long-term. INCENTIVE project has completed both the Discovery and Alpha phases.

The Discovery phase evolved our understanding of the project by finding a range of innovative solutions that could be used to strengthen the stability of the network. It showed the commercial potential for INCENTIVE solutions, developed testing requirements to prove the solutions capabilities, and identified knowledge gaps regarding the commercial and technical implementation of these solutions.

The Alpha phase undertook a commercial assessment, finding positive economic cases for INCENTIVE solutions. This means that INCENTIVE solutions can provide inertia at lower costs than existing sources, which will reduce the cost of grid stability to GB consumers. From a whole system perspective, the lowest cost way to add inertia to the grid is through incremental additions to assets that are already planned for other purposes (such as reactive power provision, short circuit level or energy storage).

NIMBUS:

Network Innovation and Meteorology to Build for Sustainability

Key Activities

SSEN's electricity network assets run across the UK's most challenging terrain and are subject to the extremes of the UK weather. With a life cycle of 40-60 years, assets built today will need to remain resilient during a period when climate change is predicted to extend both the duration and intensity of the weather extremes experienced today.

NIMBUS has the potential to accelerate the transition to net zero by prolonging the life of assets, improving their reliability and management through the introduction of new, granular data sources and improvements to network asset design, investment, and operations.

The project aims to use high resolution weather and climate data to help accurately predict the impact of climate change on our assets over their lifetime. In turn, this will lead to improved intervention planning and asset protection, which could extend asset lives by 10 to 20 years. This will help reduce costs to consumers by extending the life of our assets, avoiding the costs of replacing assets early due to climate change and extreme weather.

Our Discovery phase scope was to develop business-driven use cases for the application of detailed meteorological data to improve the design and decision-making of energy assets. Through convening industry, academia and public stakeholders, reaching 50+ participants via interviews and workshops, as well as ongoing transparent publishing, we were able to ensure that the use case chosen addressed sector needs and was transferable.

Our project partner, Icebreaker One, undertook an analysis of sector and user needs for improved asset risk methodologies for the design, maintenance, and decision-making of electricity network assets. A preliminary CBA indicated a net saving of approximately 4.5% to the consumer across the asset base.

Funding Phase:
SIF Discovery – Round 1 (March 2022 – May 2022)

Strategy Themes: Optimised assets and practices

Project Partners: The Met Office, Icebreaker One

Summary of Business as Usual (BaU) Progress

With the focus on establishing our SIF portfolio over the previous year, we now look ahead to growing our BaU portfolio.

Our Business as Usual (BaU) portfolio is funded from other sources out with the regulatory stimulus of NIA and SIF. Our BaU portfolio has a mix of projects, including those funded by SSEN Transmission, projects that are low-risk and high-maturity solutions that will add proven value to improve our network operations, and contains some projects which are funded through additional external financial mechanisms.

Over the next year, we will be continuing to grow our BaU portfolio with initial work being undertaken internally to develop our concepts, identify funding routes, and expanding our team with additional resources. The next few pages of this report provide an insight into some of the projects that SSEN Transmission are working on within our BaU portfolio.

- Multi-Vendor Multi-Terminal Interoperability: Peterhead DCSS Aquila
- North of Beauly Dynamic Line Rating (DLR)
- Ice Monitoring

Multi-Vendor Multi-Terminal Interoperability:

Peterhead DCSS Aquila

Key Activities

Aquila was approved by BEIS to advance the development of multi-vendor operability on the DC network as a pathfinder project. The project aims to deliver a multi-vendor DC Switching Station (DCSS) to connect a number of planned and future onshore and offshore HVDC links and connections, and that connects and exchanges exchanges information with a variety of devices within the power grid.

The need for Aquila was an innovation opportunity to develop and demonstrate multi-terminal, multi-vendor interoperability which could unlock the future of integrated DC networks. A report published by the European Commission on the 'Implementation Plan on HVDC and DC Technologies' identified short- and medium-term targets required to make the transmission system fit-for-purpose by 2050 and deliver on net-zero targets. A fundamental development required to de-risk the core challenges, is successful demonstration of a multi-terminal, multi-vendor HVDC project.

Project Aquila is split into 3 different workstreams for de-risking different areas of development:

- Workstream 1: Construction of Peterhead DCSS for interoperability demonstration
- Workstream 2: Aquila Interoperability Package development
- Workstream 3: Commercial readiness in Interoperability demonstration (to be confirmed)

The Early Opportunities workstream for the Offshore Transmission Network Review (OTNR) enabled developers of inflight projects to pursue innovative solutions for network design, and potentially realise benefits of an increasingly coordinated offshore transmission network. These benefits included minimising the impacts to local communities and the environment, reduced overall costs, and acceleration of offshore wind integration to the transmission network.

The project is in early-stage development and is expected to reach Gate 1 in September 2023. Following a successful Gate 1, the project will be broken into two to three workstreams as outlined above depending on the number of suppliers engaged under Eastern Green Link 3 and Peterhead Spittal DC Connection.

The project is procured as part of the Pathway 2030 invitation to tender and would share the timeline for design and cost estimation with the Accelerated Strategic Transmission Investment (ASTI) projects. Early engagement with Ofgem directed the project to fund through Net Zero and Development Fund (NZARD). Continued engagement with Ofgem is in progress to clarify the funding mechanism between Gate 1 to Gate 3 for the recovery mechanism of Early Construction activities. The funding mechanism is expected to be clarified with Ofgem at or before Gate 1.

Collaborators/Research Partner:
HVDC Centre, SSEN Transmission Offshore Delivery, Pathway 2030 team

Innovation Focus Areas: Sector-leading Efficiency and Leadership in Sustainability / Pathfinder project for Net zero development

Start/end date: TWS1: June 2022 – March 2031,
WS2: June 2022 – July 2024,
WS3: June 2022 – December 2025

North of Beauly Dynamic Line Rating (DLR)

Key Activities

The project aims to develop and install a Dynamic Line Rating (DLR) system on the existing 275kV OHL circuits from Beauly – Loch Buidhe and Loch Buidhe – Dounreay.

The DLR system will consist of DLR sensors and meteorological stations placed at approximately 21 locations on the circuit. These will relay real time environmental conditions to an Active Network Management (ANM) system to calculate the real time temperature of the conductor and in turn the OHL rating, maximising the capacity of the existing OHL to securely transport more renewable electricity.

The project has performed a trial of different DLR sensors to best ascertain the suitability of the technology for our network. Two different sensors were acquired and installed between towers 33 and 34 on BC3 in January 2023 which provided valuable experience and lessons learned for our Operations teams. Since the installation, our Project Engineering team have monitored the outputs and assessed the service platforms. An invitation to tender for the DLR sensors was completed in May 2023 and the process of procuring devices from the preferred supplier is ongoing.

The ESO undertook a CBA to assess the economic benefit of the minimum build solutions proposed to mitigate network constraints for the five-year period 2024-2028. Two contracted scenarios considered in the CBA:

- Scenario 1 – All contracted generation north of Beauly
- Scenario 2 – All contracted generation north of Beauly except transmission contracted generation located on Orkney (91MW) and Marine generation (222MW)

The ESO CBA assessed against the Future Energy Scenarios (FES) 2020 background. The two requested contracted scenarios concluded that the B0 boundary is constrained between 2024 and 2028 and that the volume of constraints and associated cost justifies the need for DLR on the Beauly to Loch Buidhe to Dounreay 275kV double circuit OHL at a projected cost of approximately £3.5m. The ESO therefore recommends that we proceed with DLR to help manage network constraints for the period 2024-2028.

For DLR, the worst regret considering FES 2020 is £158m, which rises to £351m when including the two contracted scenarios. The worst regret is therefore still significantly lower for DLR only than for the 'do nothing' option. For the Steady Progression scenario, the regret for the DLR option is £8m compared to the regret for 'do nothing' of £21m considering the cost of the minimal build solutions proposed.

The Met Office has provided an analysis of the circuit considering weather conditions, topography, and orography to identify the pinch points and offer guidance on the appropriate installation locations. A technology trial of DLR sensors was initiated in December 2022 to gain some understanding of the outputs from DLR, installation techniques and communication expectations. A full invitation to tender was completed in May 2023 and a preferred supplier identified. Technical Authority approval of the sensors is underway, and the project expects to procure the DLR system before September 2023 for installation in late 2023 / early 2024. A submission for Medium Sized Investment Project (MSIP) funding was made to Ofgem in January 2022 where the need was approved but further detail on costing was requested. An updated cost estimate submission was sent to Ofgem in August 2024, and we await a response from Ofgem.

Collaborators/Research Partner: Met Office

Innovation Focus Areas: Sector-leading Efficiency and Stakeholder-led Strategy

Funded: £2,303,000

Start/end date: February 2021 – April 2025

Ice Monitoring

Key Activities

Extreme ice was not a historical consideration when designing OHLs in the UK. As such many lines do not have clearance under heavy ice and there may be over 2,000 infringements on the current network. For example, 178 of 310 spans from Loch Buidhe to Spittal have been found to have ice infringements, of which, 33 were greater than 1.5m. Retrofitting a line during refurbishment to remove ice infringements can cost between £21,000 and £400,000 per span dependant on tower and severity of infringement. It also adds health, safety and programme risks into the project.

Ice monitoring is a potentially cost effective and easy to implement solution however, no off-the-shelf solution exists. The Open Innovation process was used to search the wider industry for potential solutions which received 15 applications.

From these applications, 7 were selected to pitch, and two were selected for further investigation with one to be installed. Data will be compared with our DLR sensors already installed on the network.

Ice monitoring would be used where a project identifies an ice infringement in a particular span of the network. The mitigation of this would cost substantially more than £50k to provide an engineering-based resolution. The span would be monitored for a period of time, with yearly reviews of ice events occurring. Where regular, significant ice events occur, mitigation would then need to be carried out. Otherwise, no mitigation is required, and ice monitors are removed. The estimated lifetime savings range between £146k and £350k per installation.

The project is in early-stage development and therefore no performance data is available. Contact has been made with the supplier, and the location for the installation has been identified.

Collaborators/Research Partner: Sedwell

Innovation Focus Areas: Safe and Secure Network Operation and Sector-leading Efficiency

Funded: £50,000

Start/end date: August 2023 – April 2024

Our Focus This Year

As we navigate the rapidly changing energy landscape towards a net-zero future, our focus for the year ahead will be to continually evolve and improve our innovation processes. We aim to capitalise on new key learnings across the industry by engaging with our stakeholders and placing them at the heart of our refreshed innovation strategy.

Collaboration will be a key driver of our efforts. We are committed to identifying new innovative project partnerships, seeking opportunities for network collaboration, and supporting industry knowledge-sharing. By fostering collaboration, we can leverage collective expertise and new solutions to drive impactful change for the network and our stakeholders.

Over the next year, we aim to increase the number of projects in our BaU portfolio. This will include adding a dedicated resource to focus on identifying innovative solutions that provide efficiency savings throughout the RIIO-T2 period, which ties into one of our five clear goals from our 'Innovation Framework'.

Our innovation approach considers not only the innovation needs of today through our BaU portfolio, but also anticipate and prepare for the future by making use of the NIA and SIF mechanisms. At this point, we are over halfway through the RIIO-T2 price control period. During this time, we have diligently managed our NIA budget to select projects that we believe will have a tangible impact on our network and accelerate our progress towards achieving net-zero. We will continue to identify and carefully select our final projects to add to our portfolio, utilising the remaining £3.2m budget allocated to SSEN Transmission by Ofgem RIIO-T2 and focus on delivering and expanding our SIF portfolio.

We are excited to embrace the year ahead and make significant strides towards achieving our innovation goals.

If you have an idea or solution to help build our network for net zero, please get in touch via transmissioninnovation@sse.com

Scottish & Southern Electricity Networks

TRANSMISSION

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