Scottish & Southern Electricity Networks

TRANSMISSION

# Annual Innovation Summary

2023/24

# Contents

# Welcome to our
# Annual Innovation Summary 2023-24

**At SSEN Transmission, we are committed to delivering our ambitious £20 billion Pathway to 2030 investment programme, which aims to modernise network infrastructure and unleash the potential of the north of Scotland as a renewable energy hub.** Our investment is crucial for driving change and meeting Scotland and the UK's renewable energy targets by expediting our efforts to meet the 2030 offshore wind connection deadlines.

Our entire network transformation relies heavily on safe, secure, and reliable grid infrastructure, and innovation will play a key role in helping to achieve net zero. Through an innovative mindset, we can identify and evaluate new ways to accelerate change, such as transporting more power through our existing infrastructure and building new assets sustainably and with minimal impact on the environment and local communities – all while continuing to offer value for money to the consumer through efficient operations.

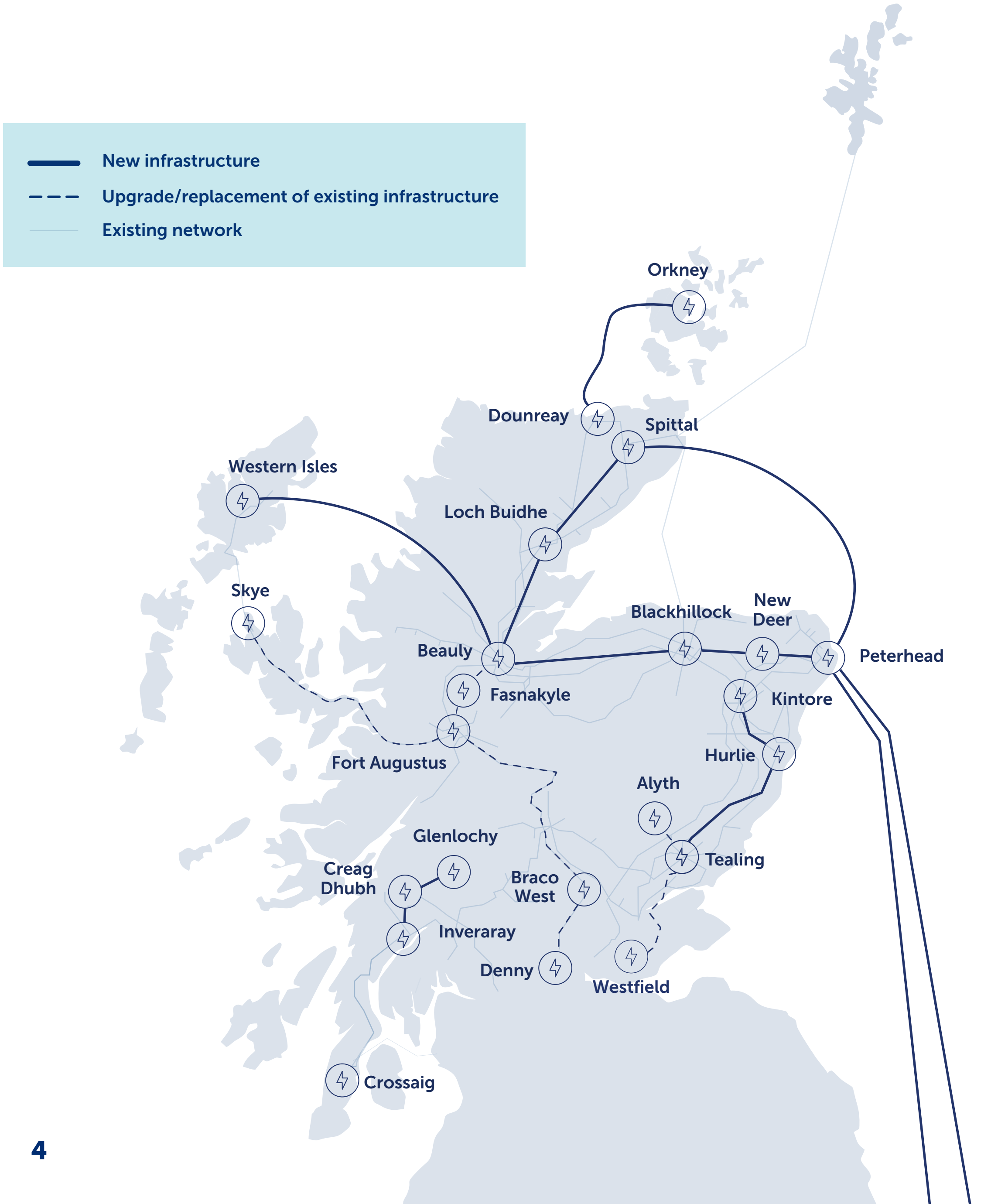
We recently unveiled our new business Innovation Strategy, which outlines a fresh vision and focus for innovation at SSEN Transmission. Our strategy was developed through horizon scanning and engagement at all levels to ensure it meets the needs of our stakeholders and customers and aligns with our wider business goals and values. In line with our innovation strategy, we continue expanding the boundaries of innovation by building a collaborative innovative culture where everyone has the opportunity for innovative thinking and action.

Over the past year, we have made significant progress across our innovation portfolio. We have strengthened our innovation team and established distinct development, delivery, and support functions to implement a clear strategy and innovation process. The team's principal goal is to integrate innovation projects into business as usual (BAU) maximising their value and benefits to the organisation and the consumer. We are also beginning our RIIO-T3 preparations with only two years left of the current price control period and will be submitting our business plan to Ofgem in December 2024.

This report provides a transparent overview of our innovation activities and achievements over the past year, covering the Network Innovation Allowance (NIA), Strategic Innovation Fund (SIF), and Business Innovation portfolio. This year, we achieved a 100% success rate in our SIF applications, with nine live projects in FY23/24. This includes our flagship Beta project, Network-DC, and our visual pre-connection tool Alpha project, REACT. Our NIA portfolio has managed 12 live projects over the past year, with the addition of four new projects, including exploring the use of robotics to monitor our high voltage equipment in our AIM High project.

If you have an innovative idea to help us deliver a reliable and resilient network in a safer, smarter, greener, and faster way, or if you would like more information on a project featured in this report, I invite you to get in touch with our innovation team via transmissioninnovation@sse.com.

**Alan Ritchie**
Senior Manager – Innovation
SSEN Transmission




# About SSEN Transmission

We are SSEN Transmission (the trading name for Scottish Hydro Electric Transmission), part of the SSE plc Group. Our responsibilities include maintenance and investment in the high voltage 132kV, 220kV, 275kV and 400kV AC electricity transmission network along with High Voltage Direct Current (HVDC) cables, overhead lines (OHLs) and convertor stations. Our operational area extends over a quarter of the UK's landmass, navigating some of the most challenging terrain and powering our communities by providing a safe and reliable supply of electricity.

The north of Scotland transmission network has a strategic role to play in supporting the delivery of the national net zero targets. We currently have over 9GW of renewable generation connected to the network, however, by 2050, the network is expected to need upwards of 40GW of low-carbon energy capacity to support net zero delivery.

As part of the network's ambitious £20 billion Pathway to 2030 investment programme, the construction of additional infrastructure consisting of new overhead lines, substations, convertor stations, and subsea links will be vital to unlocking Scotland's potential to be a clean energy powerhouse. Innovation will play a critical role in supporting the energy transition, continuing to make our network safe, secure and resilient for future generations.

# Meet our Innovation Team

**Alan Ritchie**

Senior Manager – Innovation

**Simon Stromberg**

Innovation Development & Strategy Manager

**Katie Fergus**

Innovation Development Project Manager

**Jonathan Powell**

Innovation Development Project Manager

**Amberle Gregory**

Innovation Development Project Manager

**Deepa Shaji Kumar**

Innovation Development Project Manager

**Brant Wilson**

Innovation Portfolio Manager

**Tania Shaw**

Innovation Delivery Project Manager

**Peter Taddei**

Innovation Delivery Project Manager

**Adnan Mahmood**

Innovation Delivery Project Manager

**Nithian Vejayan**

Innovation Delivery Project Manager

**Ariane Newlands**

Innovation PMO Manager

**Angeliki Spyroudi**

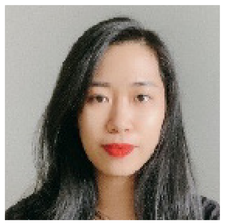
Senior Innovation Analyst

**Alex Pender**

Innovation Knowledge & Communications Officer

**Jennifer Dalrymple**

Innovation Project Coordinator



**Huyen Kieu**

Business Analyst

**Anna Weniger**

Commercial Graduate

# Our New Innovation Strategy

In March 2024, we launched our new SSEN Transmission Innovation Strategy which sets out our strategic innovation purpose, vision and focus areas, and has clear alignment with the ENA's Innovation Strategy which is focused on the energy system transition. This strategy acts as a guide to how we develop and implement the right innovations to help enable SSEN Transmission to support the UK's ambition to transition to a low-carbon economy.

At SSEN Transmission, we define innovation as the successful adoption of new ideas, technologies, and processes that can materially impact our strategic goals and deliver our vision. Our four focus areas – **safer, smarter, greener, and faster** - serve as the foundation of the Innovation Strategy and were identified through horizon scanning and stakeholder engagement, pinpointing opportunities where innovation can have the greatest impact.

## Safer

Using innovation to push to be safer than we are today. We will focus on the security of the network, reducing physical hazards, promoting safe behaviours, and do so by designing out risk and designing in safety from the start.

## Smarter

Becoming future ready by learning and adapting to maximise our assets. We will apply logic, data, and the right skills and experience to increase functionality and actively seek new ways of working and collaboration to improve efficiency.

## Greener

Applying the test of sustainability to everything we do. We will use innovation to quantify and communicate our contribution to net zero, reducing environmental harm throughout the lifecycle of our assets.

## Faster

Keeping pace, increasing productivity, and minimising delays through flexibility, agility, and empowerment. We will apply new tools and assets, focus on the output to remove barriers and champion efficient ways of working.

We recognise that without our people and stakeholders getting involved in innovation we cannot innovate on the scale we need to reach net zero. That's why we're continuing to build a strong culture of innovation across SSEN Transmission – so that everybody has the opportunity for innovative thinking and action. This strategy goes beyond the boundaries of our Innovation team, so that it lives and is embedded within the actions and behaviours of all our employees and stakeholders.

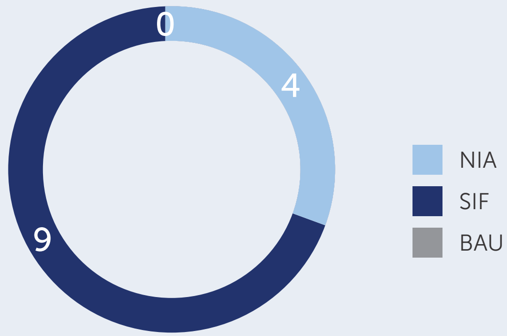
As we continue on the energy transition journey, our Innovation Strategy consists of objectives that span three horizons: now, near, and next. The now being today and up to two years ahead, such as lower-risk operational and maintenance innovation projects as part of Business Innovation activities; near spanning two to five years which routinely would be innovation within the regulatory price control; and next being five to ten years and beyond for large-scale and transformational innovation that could have long-term benefits.

**13** Innovation projects Live

**34** Project partners

**£9.5m** (18/19 prices) Allocated to our Innovation Portfolio

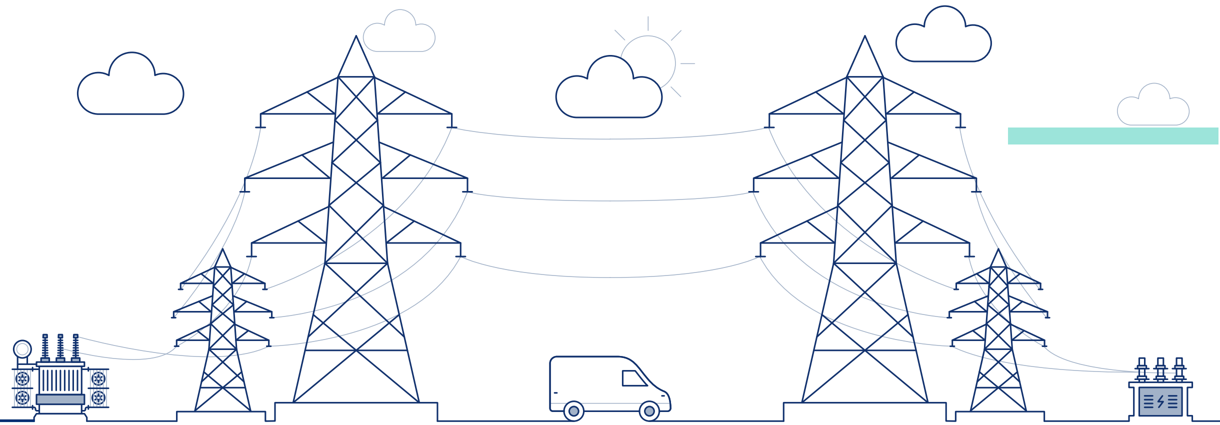
**£856m** Estimated potential benefits from innovation




Number of new Innovation projects

# Innovation Dashboard

Key Innovation Metrics for FY 23/24



# Network Innovation Allowance (NIA) Portfolio 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 mechanism 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 increasing Technology Readiness Levels (TRL) and to support the implementation of innovation into BAU operations.

In the RIIO-T2 price control period, we have been granted £8.0 million in NIA funding (18/19 prices) of which, we have invested £5.3 million into our portfolio so far. This funding has enabled us to progress 12 NIA projects in the last year that have a proven business case and significant forecasted benefits for future implementation on our network (at least £13 million of potential benefits in the T2 and T3 period).

In FY 23/24, we registered four new NIA projects on the ENA's Smarter Networks Portal with an approved budget of £1.9 million (18/19 prices) and estimated potential benefits of at least £6.4 million in T2 and T3 and £51 million extended to lifetime. In addition to the new projects, three NIA projects (Ice Mapping, Corrosion Mapping and Probabilistic Modelling for Connection Studies) were successfully delivered and are currently in the process of being adopted within the business.

**4**
New Registered projects

**3**
Completed projects

**£6.4m**
Potential benefits in T2/T3

**17**
Project partners in the NIA portfolio

**£51m**
Potential lifetime benefits

NIA Metrics for FY 23/24

# PSL-FC

## (Protection Solutions to perform for Lower Levels of Fault Current on AC networks)

The transition from traditional fossil fuels to renewable sources of energy is changing the characteristics of the transmission network. This is due to 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 fault current spike is marginal but prolonged. The objective is to evaluate how existing P&C products function and respond in such scenarios.**

Currently, a device called a Synchronous Condenser is being investigated as a mitigation measure for areas of the network with lower levels of fault current. This device replicates a traditional fossil fuel power source and responds with a sudden and large current spike in case of a fault. However, there are challenges associated with using Synchronous Condensers on the transmission system, and the installation cost is estimated to be £15 million.

If this project can evidence that a new P&C product, with costs of c£200k per installation, has 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.

In the past year, several P&C manufacturers have been engaged in the project and have provided P&C devices along with technical support to the project. A combination of Distance, Phase and Neutral Current Differential and Travelling Wave protection revised algorithm schemes have been provided for testing. Preparations are underway to begin a field trial for these devices following lab testing.

**Key learnings:** There have also been key dissemination papers to share the progress and research conducted during this project. This includes a paper at the Developments in Power System Protection (DPSP) International Conference 2024, 'Evaluation of Travelling Wave Protection Performance in Converter-dominated Networks' along with a CIGRE webinar, 'Protection and Future Power Networks Dominated by Converters: Recent Learnings on Challenges and Potential Solutions'.


**Project Partners:** The National HVDC Centre, University of Strathclyde

**Funded:** £717,000

**Start/End Date:** July 2021 – March 2026

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

# Low Profile 132kV Steel Poles

SSEN Transmission must provide connections to multiple wind farms characterised by their large electrical capacity or high altitude. A wood pole overhead line (OHL) is unsuitable in these cases as our existing 132kV poles are capacity-limited, and are not robust enough to endure the climatic conditions above 300m. 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, long lead times, 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 learnings from the project have the potential to aid the energy system transition by providing a lower cost OHL, compared to currently approved designs (lattice towers/NeSTS), enabling faster and lower cost connections for renewable generation. The project aims to provide an alternative supply chain to address the long lead times and creosote obsolescence risk associated with wood poles.

The low-profile pole could save up to 50% in construction costs compared to the conventional steel lattice towers. The cost benefits at the end of the RIIO-T3 regulatory period are estimated to be £9.8 million for all identified lines (including a risk factor of 20%).

An insulation coordination study has been completed, confirming the design meets the required performance parameters. The prototype structures at PLPC will be tested in Summer 2024. These tests will include ground conditions, foundation variants within similar ground conditions, and the completed structures. Additional testing of the pole structures will be completed at an accredited facility in late 2024. The University of Dundee is also supporting the project by undertaking centrifuge testing of the foundation design, with the results extrapolated to cover a range of soil conditions using fine element analysis modelling.

**Key learnings:** The learnings from this project have helped to inform the testing requirements for the 220kV Single Circuit Low Profile Design project.

Focus areas: Faster Greener

**Project Partners:** PLPC, Energyline, Norpower

**Funded:** £850,000

**Start/End Date:** January 2022 – July 2024

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

# TOTEM Extension

## (Transmission Owner Tools for EMT Modelling)

The UK'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. The potential for adverse control interactions between these devices is rising and needs careful consideration within the context of a potentially weaker UK power system.

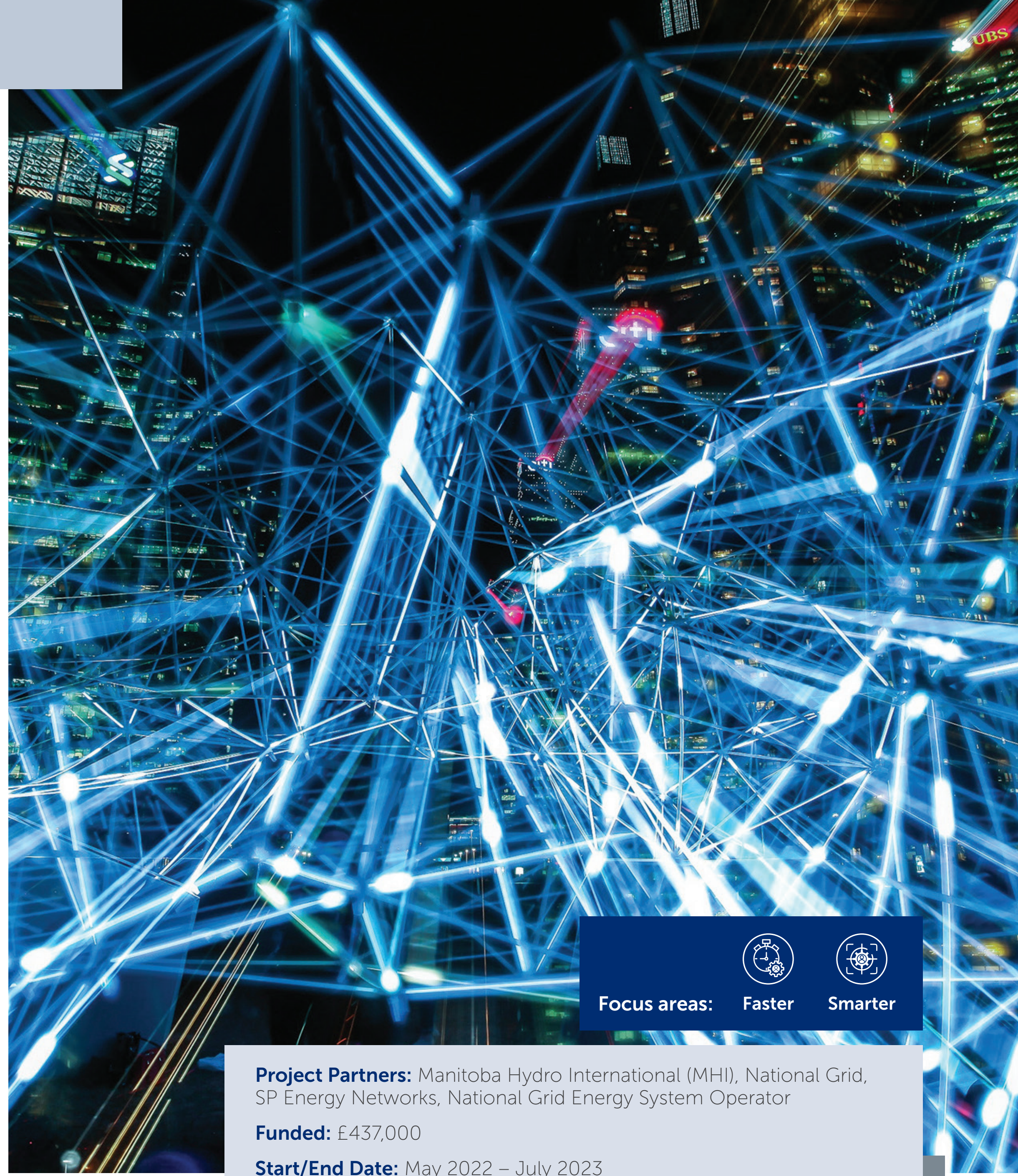
This project was an extension of NIA SHET 0032 TOTEM to complete the development and validation of a full-scale model of the UK's transmission system in electromagnetic transient (EMT) power system computer-aided design (PSCAD) simulation software.

**The TOTEM and TOTEM Extension projects are focused on developing innovative tools and resources for power system modelling and analysis. It will produce a model that can mimic large-volume power electronics and enable the formulation of mitigation measures to future-proof the GB network associated with the energy transition. The final product will be a valuable modelling tool however, it will still need to be validated and improved through studying actual system disturbances.**

The project positively developed a multi-party agreement that enables the UK TOs to work together to acquire and validate a new system model that will enhance and de-risk the integration of new technologies. MHI developed a full build of the PSCAD models for all TOs, and a full GB model was supplied along with supporting tools. A successful face-to-face knowledge transfer workshop was held, ensuring TOs have a more thorough understanding of the model features and best practices to follow when using the system.

The models delivered as part of the TOTEM and TOTEM Extension projects have enabled the development of the UK's first whole system model. This gives the TOs a much greater modelling ability for planning HVDC and renewable connections in the evolving system as we see the networks removing or replacing older generation facilities.

**Key learnings:** The learning from this project has also helped to positively shape the recently registered NIA SHET 0045 TOTEM 2 project, which is focused on incorporating additional capabilities into the current system.



**Focus areas:** Faster Smarter

**Project Partners:** Manitoba Hydro International (MHI), National Grid, SP Energy Networks, National Grid Energy System Operator

**Funded:** £437,000

**Start/End Date:** May 2022 – July 2023

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

# Condition Assessment of $SF_6$ Alternatives (CASA)

Gas insulated systems (GIS) in use across the UK electricity network currently rely heavily on pressurised sulphur hexafluoride ($SF_6$) gas, which has a high global warming potential (23,500 times that of $CO_2$). SSEN Transmission recognises the need to transition away from $SF_6$ and towards alternative gases with lower carbon footprints within the transmission network. This initiative aligns with our commitment to reducing greenhouse gas emissions by one-third as part of our RIIO-T2 business plan objective and is in line with the government's net zero emission targets.

With increasingly strict regulations regarding the use of $SF_6$, it is imperative to develop and adopt alternative gases for use in GIS. The failure of high-value GIS equipment often originates from small defects, typically caused by manufacturing errors. This defect can lead to gas ionisation and rapid charge acceleration, resulting in partial discharge (PD). Network operators must understand the characteristics of PD properties in alternative gas mixtures to ensure the integrity of GIS.

**This research project aims to provide this understanding, giving network operators greater confidence in assessing GIS equipment and mitigating the risk of equipment failure. Additionally, it will facilitate the early identification of potential failures and enable engineers to conduct necessary repairs through effective condition monitoring of alternative gases. By better understanding the characterisation of PD properties in alternative gas mixtures, network operators will gain greater confidence when assessing the integrity of GIS equipment.**

**Key learnings:** Cardiff University has delivered five progress reports in the project so far, providing useful findings. These findings have helped to shape a technical paper from the project, which will be presented at the CIGRE conference in August 2024.

**Focus areas:** Greener Smarter

**Project Partners:** Cardiff University

**Funded:** £700,000

**Start/End Date:** May 2022 – December 2025

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

# Probabilistic Modelling for Connection Studies

SSEN Transmission has seen significant interest in grid connections for renewable generation and storage projects in the north of Scotland. The current method of planning the network relies on a single challenging dispatch condition to test the network against the Security and Quality of Supply Standard (SQSS). This traditional approach was developed for a network dominated by large fossil fuel generators which are now being challenged with intermittent renewable generation and energy storage.

The current deterministic connection assessment does not account for this complexity, and it may be beneficial for Transmission network planners to consider more dynamic, probabilistic modelling to address these complex factors better. This could lead to more efficient development and connection of renewable generation and flexibility assets, ultimately enabling more efficient operation of the electricity system. This project set out to deliver a prototype probabilistic planning toolkit and study process to apply to connection studies, generating statistics and visualisations to provide a detailed picture of network capacity under uncertainty.

WSP has been engaged as consultants, developing a probabilistic planning process and a process framework that defines key requirements, high-level processes, and core techniques for modelling. The toolkit functionality was demonstrated and showed that probabilistic planning can help reduce the curtailment cost and allow more efficient planning of the generation resources within the network.

**The developed probabilistic model will be used to perform scenario analysis and investigate area system plans. The toolkit will be pivotal in developing our network modelling capabilities within our Digital Strategy for SSEN Transmission. Our strategy is predicated on better use of data; this is aimed at creating more informed and complex models about the network, allowing us to dive deeper into different energy scenarios and define our actions. It will lead to a better analysis of the network's resilience and future capability to understand where potential weaknesses are and how we should address these.**

**Key learnings:** Several reports have been generated for this project, including the probabilistic planning process methodology for the connection studies, and a design report summarising the models, tools and functionalities developed. In addition, the project outcomes were disseminated during a presentation at the Renewable Power Generation Conference through the Institute of Engineering and Technology.

**Focus areas:** Smarter Faster

**Project Partners:** WSP

**Funded:** £400,000

**Start/End Date:** March 2022 – March 2024

**Website:** [https://smarter.energynetworks.org/projects/nia_shet_0037/](https://smarter.energynetworks.org/projects/nia_shet_0037/)

# Ice Mapping

Ice accretion has the potential to damage transmission infrastructure and impair the performance of the exposed equipment. The current values of radial ice accretion defined in the British Standards (BS) are regarded as conservative with little basis in modern meteorological science, especially as applied in the north of Scotland. Applying these values may lead to the overdesign of OHLs being designed and constructed to enable the energy system transition.

**This project aims to develop a new ice accretion model and integrate it with existing global numerical weather prediction (NWP) models with high granularity topological and orographical parameters. It will use this composite model with extreme value analysis techniques to derive new values for radial ice accretion, which reflect modern meteorological practice. By combining the latest state-of-the-art NWP parameters and types of mechanisms leading to ice accretion, a new ice accretion model will be developed for several overhead lines and compared to current engineering standards and practices.**

OHL design is a complex process with widely varying inputs, therefore benefits and construction costs will vary by project. For a wood pole OHL, the benefits of reduced ice loading would result in increasing span which is estimated to provide a cost saving of £3,000 per km. For steel OHL, implementing the new ice map would mainly lead to lighter structures and foundations. This would only occur when wind and ice cause higher transverse loads than the wind weather case, resulting in estimated cost savings of £2,000 per km. Both cases offer environmental benefits due to the reduction of the number of wood poles and a saving on steel and concrete materials required to construct steel towers. We used our internal Project Carbon Calculator to calculate the impact of the new Ice map on the construction of different structures. Assuming a 25% saving in structural loads of steel towers, the carbon reduction was estimated to be approximately 19.3 tonnes of CO2e per structure. In the wood pole scenario, we expect a reduction in the number of wood poles needed per project where the carbon footprint is approximately 0.15 tonnes CO2e per structure. The project has successfully closed following the completion of the work packages. A new BS review committee has been formed for BS EN 50341, of which SSEN Transmission is a member. Met Office and SSEN Transmission will present the findings to the committee for consideration in updating the standard to include new ice values for structures.

**Key learnings:** Following an assessment, it has been agreed that the Ice Mapping values can be employed for ice conductor clearance calculations which provide significant value to the network. The new values have the potential to be used for the Accelerated Strategic Transmission Investment (ASTI) and T3 schemes. The methodology produced by this innovation project can also be adapted to other network licensees for their geographical area to minimise the overdesign of OHLs.

**Focus areas:** Smarter

**Project Partners:** Met Office

**Funded:** £359,080

**Start/End Date:** August 2022 – February 2024

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

# OHL Foundation Uplift

The method for designing overhead line (OHL) foundations has not changed considerably since the 1920's. Initial research work undertaken by the University of Dundee identified that the 'frustum method', which is adopted by most Transmission Operators in the UK and forms industry standards, is generally over-conservative and, in some cases, potentially underestimates foundation uplift capacity by up to 25%.

**The removal or reduction of over-conservative design for OHL foundations would reduce the amount of construction materials required. This would provide a significant reduction in carbon emissions associated with the construction of OHLs and deliver cost savings for energy consumers. The potential cost savings from the Foundation Uplift method were estimated to be at least £4.7 million (risk-adjusted) during the lifetime of the assets. Considering the use of the new method for calculating OHL foundations in five SSEN Transmission OHL projects (totalling approx. 1,500 towers), the estimated carbon saving is approximately 1,600 tonnes of $CO_2e$. This is equivalent to the annual electricity consumption of over 2,200 households.**

In addition, the new OHL foundations require smaller-scale excavations, therefore causing less disruption to the surrounding land and reducing associated costs. The potential lifetime cost saving for using OHL foundation uplift on identified projects is estimated to be at least £8 million.

Key elements of OHL design, including gaining a better understanding of the optimal edge profile and roughness, as well as how to reduce the materials and space required for OHL foundations were included within the scope of the project.

The University of Dundee hosts Scotland's only state-of-the-art geotechnical centrifuge, and with their expertise, a 17-month centrifuge testing programme was developed for the project. The centrifuge enables foundation samples to be spun at 150 revolutions per minute to simulate 50 times the force of gravity - testing sand, clays, gravels, and geogrids.

**Key learnings:** Lab testing in the centrifuge has produced promising results, returning strong correlations between the proposed new methodologies and test results for foundations in both sand and clay stratum. Greater uplift capacities have also been observed in foundations with chamfered edges, which may benefit projects in terms of carbon savings, as ultimately, OHL foundations would be able to use less concrete during construction.

**Focus areas:** Greener Smarter

**Project Partners:** National Grid Electricity Transmission, University of Dundee

**Funded:** £352,307

**Start/End Date:** December 2022 – December 2024

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

# Corrosion Mapping

The rate of deterioration on our assets caused by 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 in asset development and management. As a result, some issues have been observed if using this methodology, including the requirement for some substations which are in proximity to coastal environments to be unnecessarily enclosed, as well as unrealistic estimations of the remaining conductor service life of existing overhead lines. These limitations are further exacerbated by the limited granularity of the map which does not sufficiently account for local topography and orography, which can significantly affect the presence and persistence of airborne environmental pollutants.

**This project has assessed 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. The final output of this project is a map and data which covered SSEN Transmission's operating area, providing a visualisation tool to analyse corrosion rates. The new corrosion map is expected to allow for a better determination of the need for indoor substation assets to minimise the impact of corrosion.**

Based on the identified benefit of £1.81 million per single substation, an analysis of the scaled benefits was conducted to reflect the applicability of this innovation to the most recent SSEN Transmission substation pipeline. From the 14 substations under development in the pipeline, it is assumed that the new methodology may show that 50% of these are susceptible to corrosion. The remaining seven substations in the pipeline will therefore have the potential to be installed outdoors, resulting in total cost savings of at least £6.8 million (discounted, risk-adjusted, 2018 real).

In addition to the financial benefits, there is also the potential to reduce carbon emissions due to the construction avoidance of transformer buildings and the associated materials and equipment usually required during these activities. From seven applicable substations without transformer buildings, the avoided lifecycle carbon emissions could reach 2,402 $tCO_2e$ which approximately accounts for a carbon value of £717k.

**Key learnings:** The project has successfully delivered the four work packages that were detailed in the initial project scope. The Met Office has used high-resolution Numerical Weather Prediction (NWP) data to produce models for SSEN Transmission's licence area. This has allowed detailed corrosion models to be created alongside new corrosion rate maps. SSEN Transmission is currently integrating the data outputs with GIS systems and will conduct further reviews of the data for assessment of suitability to adopt in BAU applications.

**Focus areas:** Smarter

**Project Partners:** Met Office

**Funded:** £300,000

**Start/End Date:** February 2023 – April 2024

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

# AIM High

## (Autonomous Inspection & Monitoring of High Voltage Assets)

**This project aims to install and test an autonomous robotic system for conducting continuous monitoring within SSEN Transmission's expanding number of HVDC valve halls. These stations operate at an extremely high voltage level of electricity, meaning service personnel cannot access many of the electrical environments when energised and in operation.**

At present, HVDC converter stations are monitored using remote systems and static CCTV cameras to check for any issues, however, they do not provide full visibility of the electrical equipment and its condition. Instead, scheduled planned outages are put in place where the systems are shut down and isolated to allow engineers to carry out close inspections of the electrical components. In the instance of a condition-based equipment failure the system would need to be shut down through an unplanned outage. By monitoring the condition of equipment using the robot it is expected that these condition-based unplanned outages can be avoided.

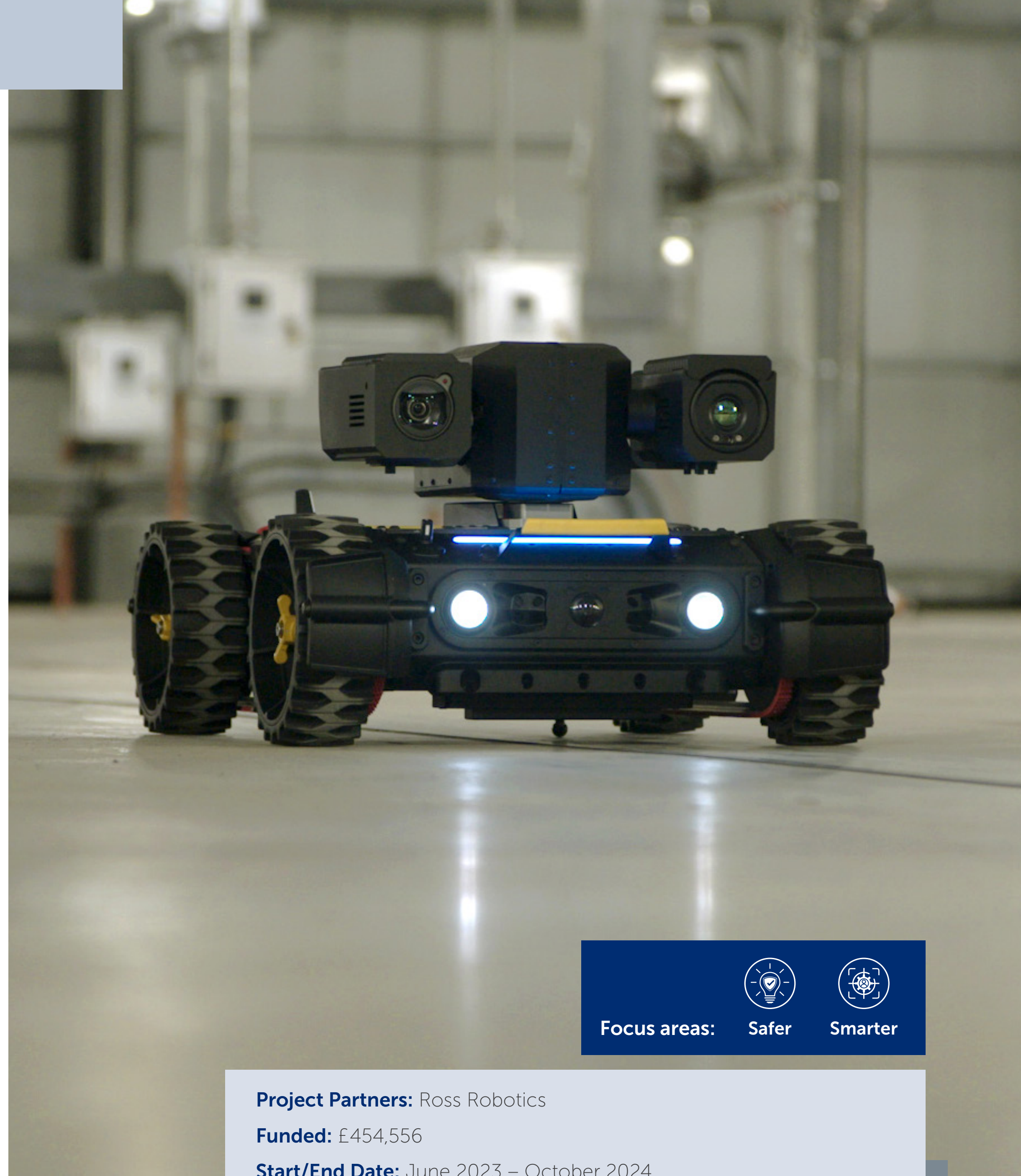
The use of an autonomous robot in an HVDC valve hall was calculated to reduce the operations and maintenance (O&M) cost by up to 61% until 2072, generating a potential benefit value of £6.2 million for the single converter pilot station. An analysis of the scaled benefit was conducted to reflect implementation of this innovation at ten applicable sites, generating potential lifetime cost savings of £49 million.

The project successfully completed a two-week trial at SSEN Transmission's Noss Head Switching Station in Wick at the end of 2023, which allowed the project team to run a series of tests and programmes for the robot. It marks the first time such technology has been used on the electricity transmission network in Scotland.

The robot is responsible for monitoring vital equipment via a series of cameras and sensors including state-of-the-art visual, thermal, and acoustic imaging. The data it collects means staff can make informed decisions for any future maintenance using a planned outage.

The robot's new home is at Blackhillock HVDC converter station, near Keith. Ahead of the deployment at Blackhillock, the project team led two local primary school engagement events where pupils were given the chance to operate the robot and find out more about its activities. Following a competition with the pupils, the robot has been named after Scotland's national dish – 'Haggis'.

**Key learnings:** The project will continue with the deployment, testing, and monitoring of Haggis the robot to fully assess the learning to date. This will advance the TRL of the learning for suitable use in BAU adoption as a reliable addition to the current asset monitoring design.



**Focus areas:** Safer Smarter

**Project Partners:** Ross Robotics

**Funded:** £454,556

**Start/End Date:** June 2023 – October 2024

**Website:** https://smarter.energynetworks.org/projects/nia_shet_0041/

# Pollution Monitoring

Severe pollution and harsh weather are some of the main issues for electric utilities causing flashovers and unplanned line outages. Currently, there is no pollution measurement information across the network.

**The project will use sensors which monitor leakage on insulators to capture and share information remotely. This will help characterise the risk of equipment degradation due to pollution and assist with designing and maintaining OHLs in pollution-high-risk areas of the network. With this, early design mitigation and maintenance procedures can be carried out to prevent faults due to flashovers.**

If the system can reduce the number of unplanned outages caused by flashovers and/or the need to carry out maintenance, then this will reduce the costs for consumers. Financial penalties for faults will also be avoided. Having data regarding pollution risks could be useful information for communities to take steps to reduce pollution risks.

This project will seek to capture information that can characterise the risk of asset degradation from pollution. A short section of 132kV OHL will be used as the innovation use case. The potential benefits from risk reduction are estimated to be at least £108k (discounted, risk-adjusted, 2018 real).

In addition to risk reduction benefits, there are also environmental benefits associated with pollution monitoring by reducing the need for unplanned outages. If the outcomes of the project reduce the prevalence of flashovers, then more renewable energy will be transferred through our network, resulting in a reduction of the average carbon intensity of the power grid. The potential $CO_2$e saving over a 45-year lifecycle may reach 86.9 tonnes of $CO_2$e.

**Key learnings:** The pollution monitoring system has successfully been installed on a section of a 132kV OHL at an extreme pollution case site. Data collection and sampling is ongoing from the site to enable analysis of the data during the monitoring period.

**Focus areas:** Greener Smarter

**Project Partners:** Verescence

**Funded:** £220,000

**Start/End Date:** July 2023 – August 2025

**Website:** https://smarter.energynetworks.org/projects/nia_shet_0042/

# Proof of Concept of Digitised Condition Monitoring

**This project aims to build a visual aid routine for operatives undertaking site surveys to support condition monitoring operations and efficient maintenance planning. The successful development and rollout of the structured approach to on-site data collection using the visual script on the operative's handheld device will lead to time and quality-based efficiencies as the relevant information and useful images will be collected.**

Currently when operators conduct inspections of components in our substations, they employ prior knowledge and thermal cameras to identify 'points of interest', predict expected faults, and capture images accordingly. There is minimal prescribed technique or structure for conducting these inspections and the approach varies from each site which could lead to random, unstructured data collection with reduced data value, and does not allow for repeatability.

Having a data collection routine on the hand-held device creates a repeatable framework for site surveys that can be followed easily and allows the data collected to be geo-tagged for location confirmation. This will in turn provide an opportunity to intervene with preventative measures simplifying the inspection process and reducing the number of unplanned outages required to conduct maintenance.

The cost comparison of the current case against the proposed innovative visual script development examined the benefits from the application of thermal imaging surveys on Cable Sealing Ends (CSE) only. CSE account for approximately 20% of the eligible substation parts that require thermal imaging surveys. The total risk-adjusted potential benefit value is estimated to £10.3 million.

**Key learnings:** The project is in early-stage development. As the project progresses, additional developments will be reported in future progress reports.

**Focus areas:** Smarter Faster

**Project Partners:** i4am Asset Management

**Funded:** £360,000

**Start/End Date:** March 2024 – August 2025

**Website:** https://smarter.energynetworks.org/projects/nia_shet_0043/

# 220kV Single Circuit Low Profile Design

There is an increasing need to connect renewable developments with increasing electrical capacity and geographic density. Current low profile overhead lines (OHL) lack sufficient capacity to accommodate large individual or aggregated electrical capacity. As a result, the only suitable alternatives in the current design suite are steel lattice towers, New Suite of Transmission Structures (NeSTS), steel poles, or underground cables, which carry a stepwise increase in construction costs compared to 132kV wood or steel pole designs.

For wind farm connections, the geographic density of these renewable developments is increasing, creating collection hubs. In many cases, these developments exceed the electrical capacity of wood pole designs, which could lead to cases where multiple OHLs are run in parallel to support the proposed load. The proposed 220kV low-profile designs will provide a lower-cost solution to assist the energy system transition by reducing the costs of large or aggregated renewable energy connections.

This project follows on from the design and development of the 132kV Low Profile Steel Poles (EaSTS) NIA project, using key learnings to inform the new 220kV design. While the EaSTS design creates some capacity increase, the 220kV designs will provide a solution for connecting large single-point connection windfarms at low to medium altitudes.

**The project objective is to create a 220kV low-profile design which replicates the visual consenting envelope, reliability levels, insulation level, and construction methods associated with wood poles. Application of the low-profile design within the existing design suite as a substitute for current steel structures could provide a significant reduction in construction costs.**

There is a 60% saving in construction per km of 220kV low profile poles compared to the conventional steel lattice towers. Although the construction cost per km of 220kV low profile poles compared to the single circuit wood poles is estimated to be 33% higher of the eligible projects identified as part of the cost benefit analysis (CBA), two parallel single wood pole lines would be required to accommodate the increase in capacity. In these cases, costs would be double that of a single wood pole line and therefore the use of 220kV low profile poles would result in a 50% saving in construction cost per km. The cost benefits at the end of the RIIO-T3 regulatory period are estimated between £2.5 and £9.5 million for all identified lines. During the lifetime of the assets, on average £34 million of cost savings can be gained from using this 220kV design (discounted, risk-adjusted, 2018 real).

**Key learnings:** The project is in early-stage development. As the project progresses, additional developments will be reported in future progress reports.

**Focus areas:** Faster Greener

**Project Partners:** Energyline, Norpower, PLPC, Allied Insulators

**Funded:** £1,430,000

**Start/End Date:** March 2024 – September 2025

**Website:** https://smarter.energynetworks.org/projects/nia_shet_0044/

# Strategic Innovation Fund (SIF) Portfolio 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. Funding is competitive and only awarded to those projects that demonstrate innovation, offer value for money to the consumer and will help deliver net zero in accordance with Government targets.

**SIF consists of three project Phases:**

- **Discovery:** Feasibility studies to de-risk technical uncertainties associated with the project's area of interest.
- **Alpha:** Using the findings of the Discovery Phase to develop a proof-of-concept.
- **Beta:** Develop full-scale demonstrators towards a maturity that either achieves or approaches Business as Usual (BAU).

The SIF mechanism was first introduced by Ofgem for the RIIO-2 price control period. Since our last report, we have had a 100% success rate with our SIF applications – progressing two projects into the Beta Phase, three from Discovery to Alpha, and adding three new Discovery projects. In total £4.8 million has been awarded to SSEN Transmission for our SIF projects, with SSEN Transmission contributing £517k (average SIF funding of ~89%).

The following pages provide insight into the progress made on SIF projects during the past financial year.

**SIF Metrics for FY 23/24**

Discovery phase
6
projects

Alpha phase
3
projects

Beta phase
2
projects

Project partners
20

SSEN Transmission: SIF offer
£4.8 m

SSEN Transmission: Contribution
£517k


Focus areas: Smarter Greener

**Project Partners:** The National HVDC Centre, Carbon Trust, National Grid ESO, The University of Edinburgh, SuperGrid Institute, Mott MacDonald

**Project Timeline:** SIF Beta Round 1: September 2023 – December 2026, SIF Alpha Round 1: August 2022 – February 2023, SIF Discovery Round 1: March 2022 – May 2022

**Website:** [https://smarter.energynetworks.org/projects/10067854/](https://smarter.energynetworks.org/projects/10067854/)

# Network-DC Circuit Breakers

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). There is a need to increase the DC 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.

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.**

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.

Now in the Beta phase, the project is increasing confidence in the technical, commercial, and regulatory aspects of DC Circuit Breakers, providing a pathway to making this innovation a viable option in HVDC network development projects in the UK. The project is currently in the process of tendering suppliers to support the simulation and design of DCCBs.

Focus areas: Smarter

**Project Partners:** National Grid ESO, University of Strathclyde, Carbon Trust

**Project Timeline:** SIF Beta Round 1: September 2023 – September 2024
SIF Alpha Round 1: August 2022 – February 2023
SIF Discovery Round 1: March 2022 – May 2022

**Website:** https://smarter.energynetworks.org/projects/10067856/

# INCENTIVE

## (Innovative Control and Energy Storage for Ancillary Services in Offshore Wind)

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 investigated 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 provides greater network stability and is regarded as synchronous generators. However, renewable generation does not offer 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 SP 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.

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).

In the Beta Phase INCENTIVE has so far studied three UK offshore wind farms on the GB network, using them as case studies to build technical confidence and create workable business models for the first-of-a-kind deployment to implement and demonstrate the innovative, grid stability supporting solutions.

**Focus areas:** Smarter Safer

**Project Partners:** The National HVDC Centre, University of Strathclyde, National Grid ESO

**Project Timeline:** SIF Alpha Round 2: October 2023 - March 2024
SIF Discovery Round 2: April 2023 - June 2023

**Website:** [https://smarter.energynetworks.org/projects/ukri10079053/](https://smarter.energynetworks.org/projects/ukri10079053/)

# INSIGHT

## (Innovative Network Status Intelligence Gathered by Holistic use of Telemetry and Simulation)

Inverter-based resources (IBRs) such as wind farms and solar photovoltaics introduce new system stability challenges onto the network compared to traditional fossil fuel-driven synchronous generation. IBRs can interact electrically with the network and with each other in ways that are difficult to predict and understand, leading to oscillations on the grid. These inverter-based oscillations have been experienced on power systems worldwide and can pose a serious threat to system security.

To manage IBR-based oscillations, there is a need to innovatively monitor, visualise and analyse to help network operators alert, identify, locate, and understand oscillation modes. In addition, control and mitigation tools can help network operators take appropriate actions to mitigate the escalation of such oscillations. INSIGHT aims to address this issue by delivering a real-time alert and control system that monitors and mitigates distinct types of power network oscillation events.

**The project combines learnings from past events with new modelling and simulation techniques to better understand the nature of these new oscillations and learn how to predict and address them in network design and operation for future events. A key part of developing the solution is to build upon previous innovative work that focused on system stability dominated by power electronics covering modelling and simulation of IBR-rich networks and power system oscillations, as well as identifying technology solutions for monitoring and mitigating oscillations.**

INSIGHT has completed the Discovery and Alpha phases. The Discovery phase sought to better understand the problem by identifying instances of oscillations across the globe and considering how this knowledge may be interpreted and utilised to provide solutions. Stakeholder engagement and a review of academic and global practical experience shaped the vision of the project, ensuring alignment with international best practices.

The Alpha phase was divided into 4 work packages in collaboration with project partners. The work included: understanding the causes of IBR-based oscillation events through modelling and simulation; assessing the current oscillation monitoring capability on the transmission network; understanding the availability of potential solutions through engagement with stakeholders and technology providers, and; starting to quantify the value provided by solutions through the development of a CBA.


**Focus areas:** Faster Smarter

**Project Partners:** Icebreaker One, Olsights, MapStand, SGN, National Grid Electricity Transmission

**Project Timeline:** SIF Alpha Round 2: October 2023 - March 2024
SIF Discovery Round 2: April 2023 - June 2023

**Website:** [https://smarter.energynetworks.org/projects/ukri10079052/](https://smarter.energynetworks.org/projects/ukri10079052/)

# REACT

## (Rapid Evaluation Areal Connection Tool)

The UK's annual electricity demand is expected to double by 2050 to meet net zero goals, leading to a tenfold increase in transmission connection applications with an average of a five-year delay for connections. This surge emphasises the need for optimal site selection for new developments, with difficulty presented for developers to obtain information on network availability at a given location before applying for a connection.

**REACT plans to create a geographical planning tool, providing users with the ability to view electricity grid connection opportunities in real time using an interactive visualisation map. Users of the tool will be able to identify the best possible locations to connect to the network, based on dynamic geospatial and network data, as well as a view of future demand and generation requests. This will help streamline the connection process where limited pre-application information creates difficulties for developers who struggle to assess network availability before making a connection application.**

Optimising the location of demand and generation is an enabler for improved network efficiency and provides the opportunity to reduce overall system operating costs. In addition, early visibility of the potential connection opportunities will be an enabler for pre-application discussions between developers, the ESO, and the TO, resulting in time and resource savings for all and reducing the number of speculative applications.

The project combines several interlinked threads that manage the increasing number of new connection applications and optimise the connection process, address the emerging growth of renewables such as hydrogen production and storage, and the development of a user-friendly platform that facilitates early dialogue between developers and the network.

REACT has completed the Discovery and Alpha Phase. The Discovery phase identified that a sophisticated, geographical planning tool providing the ability to visualise connection requests in real-time should focus on the pre-application stage where maximum impact will be achieved. The tool should facilitate exploratory development discussions providing applicants with timely insights to inform the optimal siting for connections.

Alpha delivered a demonstrator multi-layered tool that included displaying hydrogen developments in northern Scotland; the original use case. The original sandbox region was also expanded from northern Scotland to include Orkney and Shetland due to additional study interest in these areas. In addition, 'base maps' were developed in response to user requests and to experiment with geographic styles.

**Focus areas:** Smarter

**Project Partners:** Palantir, Icebreaker One, IBM, SSEN Distribution

**Project Timeline:** SIF Alpha Round 2: October 2023 – April 2024
SIF Discovery Round 1: March 2022 – May 2022

**Website:** https://smarter.energynetworks.org/projects/10079058-1/

# NIMBUS

## (Network Innovation and Meteorology to Build for Sustainability)

SSEN Transmission'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.

**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 the impact of climate change and extreme weather.**

The Discovery phase developed 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, the project ensured that the use case chosen addressed sector needs and was transferable. 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.

The Alpha phase focused on the development of a proof of concept centred on the 132kV Beauly to Shin line in Scotland, showcasing a novel operational workflow integrating weather risks into decision-making processes. This included integrating weather data into asset management decisions and enhancing feedback mechanisms to continually improve systems. This was facilitated by the development of an 'ontology', which acts as a digital twin for our network, and the construction of rules to assess weather-related risks to assets.

A key aspect of the Alpha phase was engaging with external stakeholders and project partners to ensure the solutions were aligned with industry needs. This included data sharing agreements and collaboration on objectives. NIMBUS has laid a solid foundation for future developments, demonstrating the potential of integrating meteorological data into energy network management.

Focus areas: Faster

**Project Partners:** Digital Catapult, Carbon Trust, The University of Edinburgh

**Project Timeline:** SIF Discovery Round 2: April 2023 - June 2023

**Website:** https://smarter.energynetworks.org/projects/ukri10057667/

# SECURE

## (Securing the future delivery of all HVDC projects by de-risking the HVDC cable supply chain)

Demand for HVDC connections is growing rapidly across Europe for grid reinforcements such as the Eastern HVDC links, interconnectors, and offshore wind connections. Globally, the HVDC cables market size exceeded $10 billion in 2021 and is anticipated to reach an annual deployment of 18,000 km by 2030, with c1,300km for UK grid reinforcements. The robustness, capability and capacity of the supply chain to support this HVDC infrastructure will be a critical factor in this growth.

**SECURE aims to strengthen the UK's energy system and support efficient and timely installation of new HVDC infrastructure to realise a net zero energy system. HVDC supply chains are a complex flow of materials and goods through a global network of suppliers and sub-suppliers. De-risking the HVDC cables supply chain will enable Transmission Operators to successfully deliver new HVDC infrastructure whilst reducing delay and cost risks.**

The project aimed to employ cutting-edge digital solutions and develop an innovative Digital Supply Chain Hub (DSCH) to achieve much greater visibility and knowledge of the HVDC cable supply chain. This will yield benefits to HVDC project developers and suppliers ensuring greater supply chain resilience and strategic insight.

In the Discovery phase, there was a focus on identifying means of strengthening supply chain resilience. HVDC was considered alongside its cross-linked polyethylene (XLPE) insulation given it is at risk of becoming a bottleneck in the supply chain. Through SECURE, it was realised that the digital supply chain gadgets identified as part of the project have the potential to be transferred to other infrastructure products beyond HVDC cables.

The Discovery phase also provided new learning in several areas. This included the detailed appraisal of HVDC cables and bottlenecks which were previously unavailable, and TOs stakeholder understanding of the pinch points or issues faced by procurement and HVDC engineering. In addition, learning was obtained on a generic critical pathway approach to net zero that may be applied to new products coming to market. The project provided insight into digital supply chain gadgets that have the potential to alleviate some of the current supply chain challenges and risks.

Focus areas: Faster Smarter

**Project Partners:** University of Strathclyde, National Grid Electricity Transmission, National Grid ESO, Met Office, Gilytics, Energyline

**Project Timeline:** SIF Discovery Round 3: March 2024 - May 2024

**Website:** https://smarter.energynetworks.org/projects/10101698/

# REVISE

## (Revisiting and Evaluating Environmental Inputs on Line Ratings)

To ensure transmission networks are maximising their current infrastructure for the transition to net zero, the REVISE project assesses revisiting the calculation process for assigning overhead line static ratings. This process currently uses historical environmental data captured in the 1980s in one location in England at Leatherhead, therefore does not take into consideration any local/regional climate variations.

Improving the industry's understanding of static line ratings, using up-to-date high-resolution weather data combined with the latest techniques for system modelling, will allow for improved targeted investment to ensure networks meet the demand for the connection of new renewables, securing a safer and greener future.

Successfully solving this problem could unlock additional capacity in circuits without the need for any physical change or increase in operating temperature. Furthermore, it has the potential to identify circuits at risk of overheating and needing intervention.

**The project aims to address the challenges of revising line capacity in three key areas.**

- Examining the current methodology to identify the critical inputs and assumptions that have the most impact on the rating calculated.
- For those critical inputs and assumptions, based on modern meteorological and data science principles, determine the regional/localised values that can be obtained.
- In using the regional/localised values calculate the potential increase or subsequent decrease in rating that should be applied.

Focus areas: Faster Smarter

**Project Partners:** National Grid Electricity Transmission, National Grid ESO, Carbon Trust

**Project Timeline:** SIF Discovery Round 3: March 2024 - May 2024

**Website:** [https://smarter.energynetworks.org/projects/10102926/](https://smarter.energynetworks.org/projects/10102926/)

# BluePrint

## (Building Industry Collaboration and Methodologies for Developing Offshore Wind Behind Constraint)

The BluePrint project is seeking to identify key risks and uncertainties for the connection of offshore wind farms into currently constrained areas of the GB network and to devise innovative and collaborative solutions to mitigate those risks. The solutions of interest include novel, collaborative connection methodologies and approaches to accelerate infrastructure development.

**This project will develop solutions that facilitate the connection of new low-carbon energy to already-constrained areas of the GB network (such as northern Scotland) as quickly as possible, and to maximise energy export, once connected, by avoiding constraint-driven curtailment.**

Progress is being made to alleviate such constraints inhibiting offshore development through the Holistic Network Design (HND) processes. However, even with this progress, innovative and collaborative development approaches are required. These are needed to add granularity to the HNDs, to explore the most efficient ways to deliver the HNDs, and to mitigate risks of delayed HND development.

BluePrint will address this by conducting a collaborative gap analysis between desired outcomes and the risks of developing offshore wind farms (OWFs) in constrained areas, with a focus on innovative solutions to address the gaps. This analysis will prioritise the issues from a TO, ESO, and OWF developer perspective, and will identify innovative, collaborative solutions to address those key issues.

The project addresses the 'Whole system planning for faster asset rollout' SIF Challenge. The Discovery phase brings together TOs, ESO, and OWF developers to develop an improved, collaborative understanding of the key risks of developing behind constraint. This will improve whole systems cross-industry planning. It will also improve understanding of how innovative solutions can accelerate the development of the HND network, optimise the use of the existing network, and hence accelerate OWF rollout in currently constrained areas.

Focus areas: Smarter

**Project Partners:** National Grid Electricity Transmission, UK Power Networks, National Physical Laboratory (NPL)

**Project Timeline:** SIF Discovery Round 3: March 2024 - May 2024

**Website:** https://smarter.energynetworks.org/projects/sif_shet_024_sysmet-1/

# SYSMET

## (System Strength Measurement and Evaluation)

The shift from fossil fuels to new sources of renewable power such as wind, solar, and battery storage presents challenges in ensuring network stability due to fluctuations in levels of generation. With an increasingly higher penetration of Power Electronics Interfaced Devices appearing on the grid, conventional fundamental frequency short-circuit level metrics lack accuracy in detecting potential instabilities. Currently, each network has its own approach to system strength assessment. Consequently, this means that there is no existing best practice or standard method for quantifying the system's strength.

To secure a net-zero grid, network operators need to monitor system strength conditions to implement mitigation measures. SYSMET is bringing together leading experts to create a pathway for implementing innovative tools that provide a comprehensive insight into system strength. The project objective is to deliver online system strength monitoring tools to enable the detection and mitigation of weak system conditions susceptible to power system oscillations.

**The Discovery phase aims to identify suitable system strength indicators and potential monitoring solutions. This involves:**

- Defining needs and use cases of network owners for system strength monitoring.
- Reviewing current industry practice, candidate indicators, and measurement techniques; engage with solution vendors.
- Identifying data sets, models, and test facilities necessary for solutions development in Alpha.

# Business Innovation Portfolio Progress

**Our Business Innovation portfolio is funded from other sources out with the regulatory stimulus of NIA and SIF.**

Our 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 includes some projects that are funded through additional external financial mechanisms.

The next few pages of this report provide insight into some of the projects that SSEN Transmission is working on within our Business Innovation portfolio.

# Transmission Network Digital Substation (TReNDs)

**The TReNDS project is exploring the opportunities presented by a fully digital substation secondary system design, based upon the IEC 61850 and associated suite of standards. With a move away from the conventional substation design, the project involves the concept of replacing the bulk of traditional copper cables found in our substations with new fibre optic communications.**

The adoption of digital substation solutions will replace extensive multi-core cabling with fibre optic communication alternatives. This technology comes with other advantages, not only providing significant savings in project delivery time, cybersecurity, and space but also reducing the environmental impact. As a testament to the pioneering work that will be delivered through this project, the project secured funding through Ofgem's RIIO-T2 Non-operational IT reopener.

The project team, consisting of six dedicated engineers and subject experts, has been mobilised to deliver the TReNDS programme. They have reached a significant milestone in finalising and delivering a standardised multi-vendor design for a typical feeder bay in a substation.

Despite facing interoperability challenges, the team was successful in developing a scalable solution that is ready for deployment. They have also initiated a quarterly forum for technical discussions and knowledge sharing with other GB Transmission Operators.

The project insights have been presented at the PAC World Conference 2023 through a paper titled 'Consideration of Software Defined Network (SDN) Deployment in Transmission Substations', as well as at the Energy Innovation Summit, run by the Energy Networks Association (ENA).

Moving forward, the team plans to develop the design for transformer bay and bus bar bay, and hand over the developed solution to a pioneer project, creating the world's first digital substation with a cybersecure SDN network.

**Focus areas:** Smarter Faster Greener

**Project Timeline:** October 2023 – March 2026

# Multi-Vendor Multi-Terminal (MVMT) Interoperability

**The project, known as Aquila, aims to deliver a multi-vendor, multi-terminal DC Switching Station (DCSS) to connect planned and future onshore and offshore HVDC connections, and which will connect and exchange information with a variety of devices within the power grid. Aquila was approved by BEIS to advance the development of multi-vendor operability on the DC network as a pathfinder project. The project was managed under our Large Capital Projects process.**

The project is an innovation opportunity to develop and demonstrate MVMT 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 the successful demonstration of a MVMT 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

Early engagement with Ofgem directed the project to be funded through the Net Zero and Re-Opener Development Fund to complete feasibility and early development. Continued engagement with Ofgem is in progress to clarify the funding mechanism for further work. The Large Capital project has recently been deferred, with the Workstream 1 development stopped until further clarity and confidence in funding can be reached with Ofgem. Workstreams 2 and 3 will continue, with the expected output to be a fully formed technical specification and commercial assessment to enable the deployment of MVMT interoperability into the UK networks.

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 the benefits of an increasingly coordinated offshore transmission network. These benefits included minimising the impacts on local communities and the environment, reduced overall costs, and the acceleration of offshore wind integration to the transmission network.

The National HVDC Centre demonstrated, and patent protected, interoperability methods to control and monitor performance. Generic modelling and specification were performed. The first "virtual replica" was received from a vendor and demonstrated to be interoperable with the generic models. The project has NDAs and collaboration agreements in place with 4 of the major vendors.

The Netherton DCSS initial design and expansion was performed, and consents related to materials developed to support the DC hub delivery. Control and protection approaches have been specified.


**Focus areas:** Smarter Greener Faster

**Project Partners:** National HVDC Centre

**Project Timeline:** June 2022 – December 2025

# North of Beauly Dynamic Line Rating (DLR)

**The project aims to develop and install a DLR system on the existing 275kV overhead line (OHL) circuits from Beauly to Loch Buidhe, and Loch Buidhe to Dounreay. The DLR system consists of sensors and meteorological stations placed at approximately 21 locations on the circuit. These installations will provide real-time environmental data to calculate the temperature of the conductor, and subsequently, the OHL rating. The updated OHL rating will then be communicated to the ESO to maximise the capacity of the existing OHL to transport more renewable energy securely. In future iterations of the technology, it is anticipated that the DLR system will communicate with an Active Network Management (ANM) platform.**

The project has made good progress, with the Met Office analysing the circuit using weather conditions, topography, and orography to identify the pinch points and offer guidance on suitable installation locations. A technology trial of DLR sensors, installed between towers 33 and 34 on BC3 in January 2023, was initiated to understand the outputs from DLR, installation techniques, and communication expectations.

The ESO conducted a CBA to assess the economic benefit of the minimum build solutions proposed to mitigate network constraints for the five-year period of 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, concluded that the B0 boundary is constrained between 2024 and 2028. The volume of constraints and associated cost justifies the need for DLR on the Beauly to Loch Buidhe to Dounreay 275kV double circuit OHL, therefore, the ESO recommends proceeding with DLR to help manage network constraints for 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 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.

In the last year, progress has included the selection of the preferred bidder, Ampacimon, from the Invitation to Tender. SSEN Transmission's technical authority performed a thorough review of Ampacimon's technology and has approved it for use on the North of Beauly project.

SSEN Transmission's operations teams have been familiarised with the sensors, and control room operatives have had the opportunity to understand the DLR system and its outputs. Planning is being performed to secure suitable outages this year to install the DLR system on the North of Beauly circuits.


**Project Partners:** Met Office, Ampacimon

**Project Timeline:** February 2021 – December 2025

# OHL Conductor Sag Measurement

Whilst operating in the north of Scotland, SSEN Transmission faces some of the most extreme weather conditions in the UK. During winter, temperatures can drop as low as -30°C with wind speeds up to 110 mph. Such weather conditions can result in thick, dense ice forming on the overhead lines, causing them to sag under the weight of the accrued ice.

The ideal operating height of such lines is typically around 6 – 7 metres above ground level, however under iced conditions ground clearance can reduce to as little as a few metres with the potential for serious issues to occur. This may present a hazard to third parties and/or require additional manpower because of potential outages. These conductors and transmission towers can be in hard-to-access locations which may require staff to walk long distances over difficult and often mountainous terrain to address issues.

**SSEN Transmission used the Innovate UK Innovation Exchange's programme to find a solution to monitor overhead conductor lines for sagging. From 21 credible technologies identified through the competition, InterBolt's bolt load monitors were selected for a trial on the network. These bolts can detect the increased mass of the conductor line in real-time, delivering improvements in network resilience and operational efficiency. The technology consists of wireless, battery-powered and internet-of-things enabled bolts with embedded measurement of the elongation of the fastener. This allows for real-time, remote bolt load measurements which eliminates the need for manual inspection.**

In this scenario, as ice accrues on an overhead line, the mass of the line will increase, and hence the load on a bolt fastening the power line to a tower will increase. Therefore, through remote monitoring of the bolt load, if an increase in baseline bolt load is observed through periods of inclement weather, SSEN Transmission can deduce that there is ice accrual on the line.

The project has agreed on terms, and SSEN Transmission and InterBolt are busy preparing for a live network trial over the 2024/2025 winter period, which will run alongside other technology assessments.

**Focus areas:** Smarter

**Project Partners:** InterBolt

Scottish & Southern Electricity Networks

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