Scottish & Southern Electricity Networks

TRANSMISSION

Scottish Hydro Electric Transmission

Network Innovation Allowance Summary Report

Stakeholder-led strategy

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Scottish & Southern Electricity Networks
TRANSMISSION

FOREWORD

We are at a crucial point in our industry as we strive to prepare our network for the future while continuing to deliver value to our customers. At Scottish and Southern Electricity Networks Transmission (SSEN Transmission), we have evolved our approach to innovation to become a leading energy company in a net zero world.

Scotland's transmission network has a critical role to play in supporting the delivery of the UK's net zero targets. By 2050, the north of Scotland will require around 50GW of renewable energy capacity to support net zero delivery. For context, we currently have around 8GW of renewable generation connected in the north of Scotland. Innovation is fundamental to this transformational change across our network.

With all the future growth and investment required for our network, we've taken 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're looking to publish this later in the financial year.

Our innovation portfolio consists of a strategic and balanced selection of projects that target carbon emission reductions, improve network and operational efficiency, and transform our transmission infrastructure. The Network Innovation Allowance (NIA) is a valuable tool that provides us with the autonomy to seek out and explore new methods that would otherwise be considered too risky to explore.

Our NIA projects play an essential role within our innovation portfolio as we can de-risk a number of the uncertainties that net zero presents and progress learnings and solutions that directly address our unique network challenges head-on. The mechanism is suitably designed to identify advanced projects that will deliver tangible solutions, benefits, and cost savings for our network. By offering the flexibility to choose pioneering initiatives based on our specific challenges, we can bring significant change and long-term benefits for net zero.

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.

We are extremely pleased with the progress made across our innovation portfolio in the last year. Within this report, we will summarise the progress made by SSEN Transmission for our NIA-funded projects from April 2022 to March 2023.

If you have an idea which may help us to deliver this significant shift in the demand on our network, or would like more information on a project featured in this Annual Summary Report, please get in touch with our innovation team via **transmissioninnovation@sse.com**.

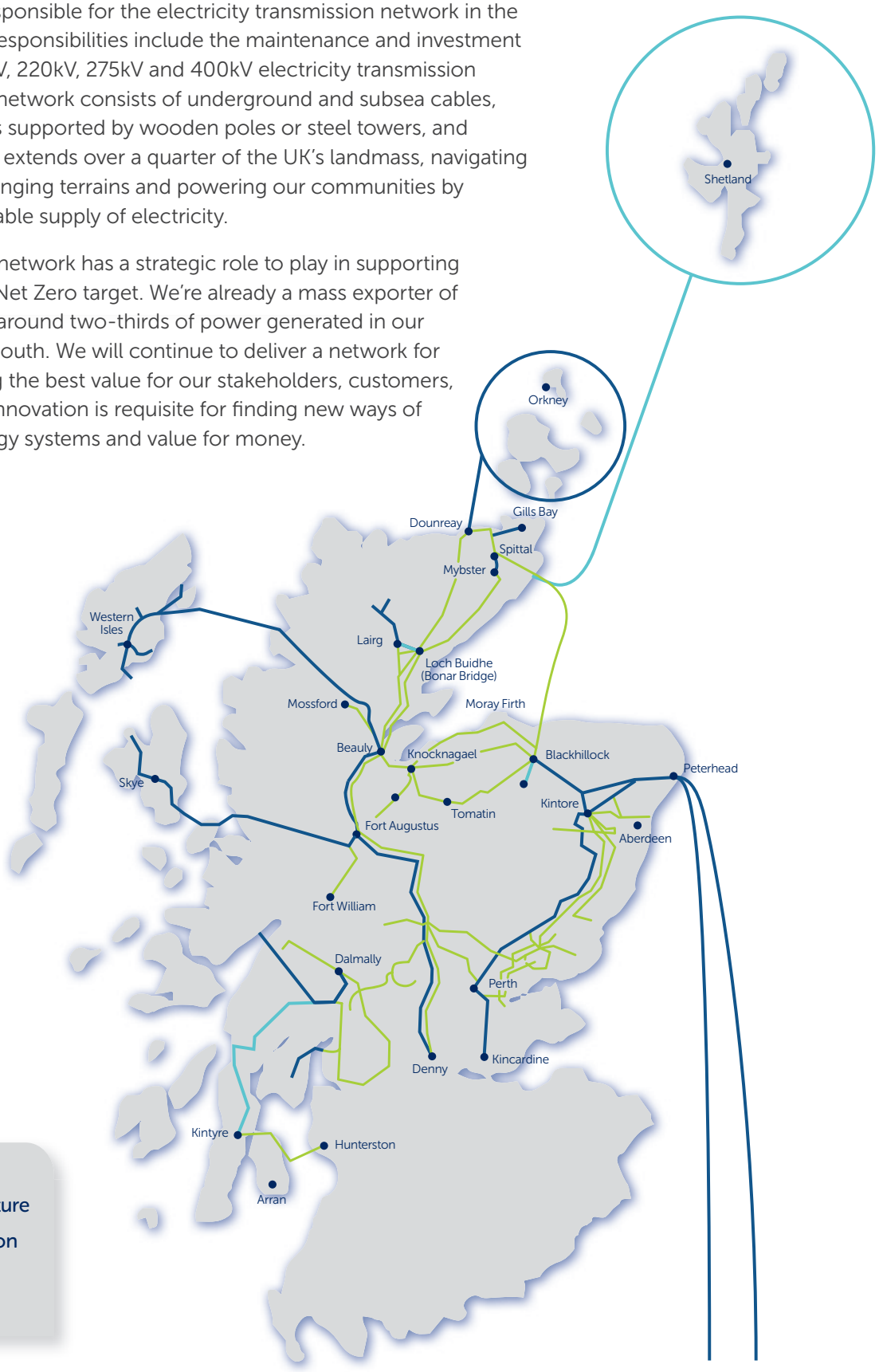
Andrew Urquhart
Head of Whole System
SSEN Transmission

Scottish & Southern Electricity Networks
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 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.

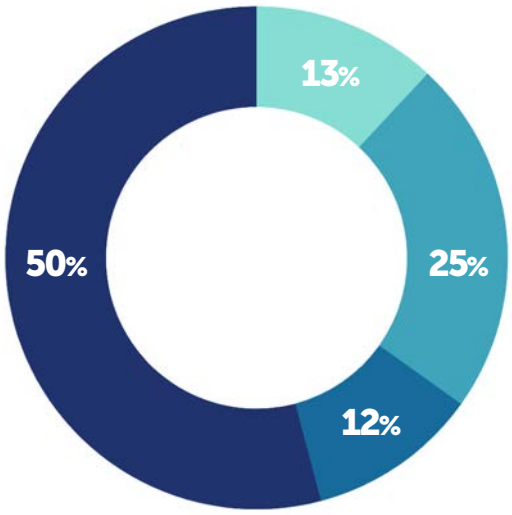


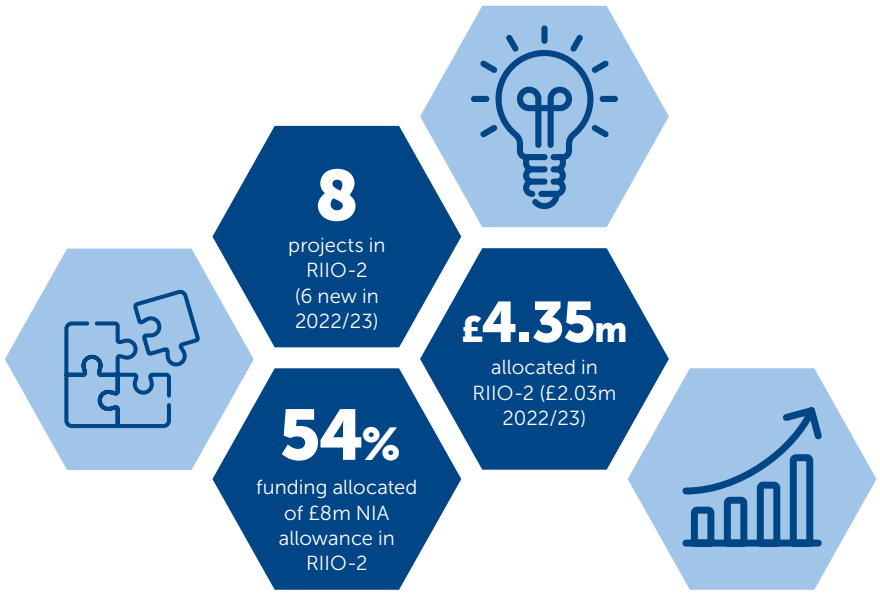
OUR NETWORK INNOVATION ALLOWANCE (NIA) DASHBOARD

We aim to find and undertake projects across our portfolio that will deliver significant value and cost-savings back to the consumer. From our NIA projects approved between April 2022 to March 2023, for every £1 spent of consumer money, we expect to see £3.5 in cost benefits by 2030/31 and a £9.2 lifetime cost benefit. Our dashboard provides a snapshot of how we have allocated our NIA funding so far.

Percentage of projects by Technology Readiness Levels (TRL)

- TRL2 Invention and Research
- TRL3 Proof of Concept
- TRL4 Bench Scale Research
- TRL5 Pilot Scale





Funding allocation by Transmission Innovation theme (£m)

SECTOR LEADING EFFICIENCY	£1.46 MILLION
LEADERSHIP IN SUSTAINABILITY	£1.23 MILLION
STAKEHOLDER-LED STRATEGY	£0.98 MILLION
SAFE AND SECURE NETWORK OPERATION	£0.69 MILLION

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SUMMARY OF PROGRESS

Our Innovation Strategy sets out how we plan to use innovation to achieve our goals during and beyond the RIIO-T2 price control period. This strategy aligns with the wider Electricity Network Innovation Strategy.

Fossil fuels are the largest single source of carbon emissions on the planet. Over 70% of emissions come from the energy sector, for heating, transport, and industrial use. To tackle this, the energy system needs to transition to deliver new forms of low-carbon energy. This drives the need to invest in our own infrastructure to meet these new demands, so we need to build bigger and faster to support this.

We have four Innovation Focus Areas to support 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.

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

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

1.1 NIA SHET 0033 — PROTECTION SOLUTIONS TO PERFORM FOR LOWER LEVELS OF FAULT CURRENT ON AC NETWORKS (PSL-FC)

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.

BENEFITS

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 products, 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.

PROGRESS

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

Strathclyde University, National HVDC Centre

INNOVATION FOCUS AREAS

Funded	Start/end date	Website
£671,000	July 2021 / April 2025	https://smarter.energynetworks.org/projects/nia_shet_0033

1.2 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 overhead line (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.

BENEFITS

The new structures remain similar in design to current wooden OHLs to ensure there is a limited visual impact on the Scottish 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.

PROGRESS

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

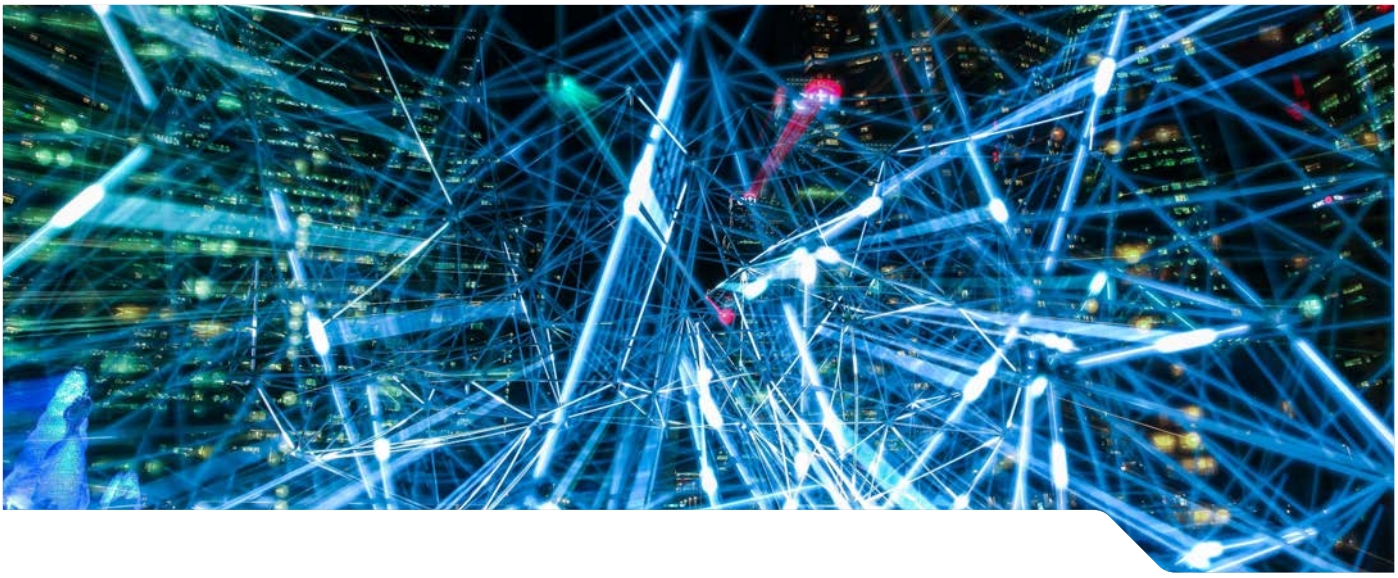
Start/end date
January 2022 / July 2023

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

INNOVATION FOCUS AREAS

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

1.3 NIA SHET 0035 – TOTEM 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.

BENEFITS

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.

PROGRESS

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 TOs and NGESO has been selected and procured.

RESEARCH PARTNERS

MHI, National Grid Electricity Transmission

INNOVATION FOCUS AREAS

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

Funded
£437,000

Start/end date
May 2022 / July 2023

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

1.4 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 CO_2). 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.

BENEFITS

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.

PROGRESS

The project 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

INNOVATION FOCUS AREAS

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

Funded
£700,000

Start/end date
May 2022 / December 2025

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

1.5 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.

BENEFITS

This 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.

PROGRESS

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

INNOVATION FOCUS AREAS

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

Funded
£400,000

Start/end date
March 2022 / October 2023

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

1.6 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 (OHLs) 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 OHLs 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.

BENEFITS

SSEN Transmission have 54.5km of wood pole OHLs and 27km of steel OHLs 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, 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 OHL projects in the SSEN Transmission area.

PROGRESS

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

INNOVATION FOCUS AREAS

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

Funded
£359,080

Start/end date
August 2022 / February 2024

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

1.7 NIA SHET 0039 – OHL FOUNDATION UPLIFT

KEY ACTIVITIES

This project aims to improve the design for overhead line (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.

BENEFITS

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 CO_2e 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.

PROGRESS

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 and National Grid

INNOVATION FOCUS AREAS

Stakeholder-led strategy

Safe and secure network operation

Sector-leading efficiency

Leadership in sustainability

Funded	Start/end date	Website
£352,307	December 2022 / December 2024	https://smarter.energynetworks.org/projects/nia_shet_0039

1.8 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.

BENEFITS

For example, decisions such as the placement of substations near coastal areas and estimating the remaining service life of existing overhead lines (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 cost benefit analysis 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 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.

PROGRESS

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

INNOVATION FOCUS AREAS

Stakeholder-led strategy

Safe and secure network operation

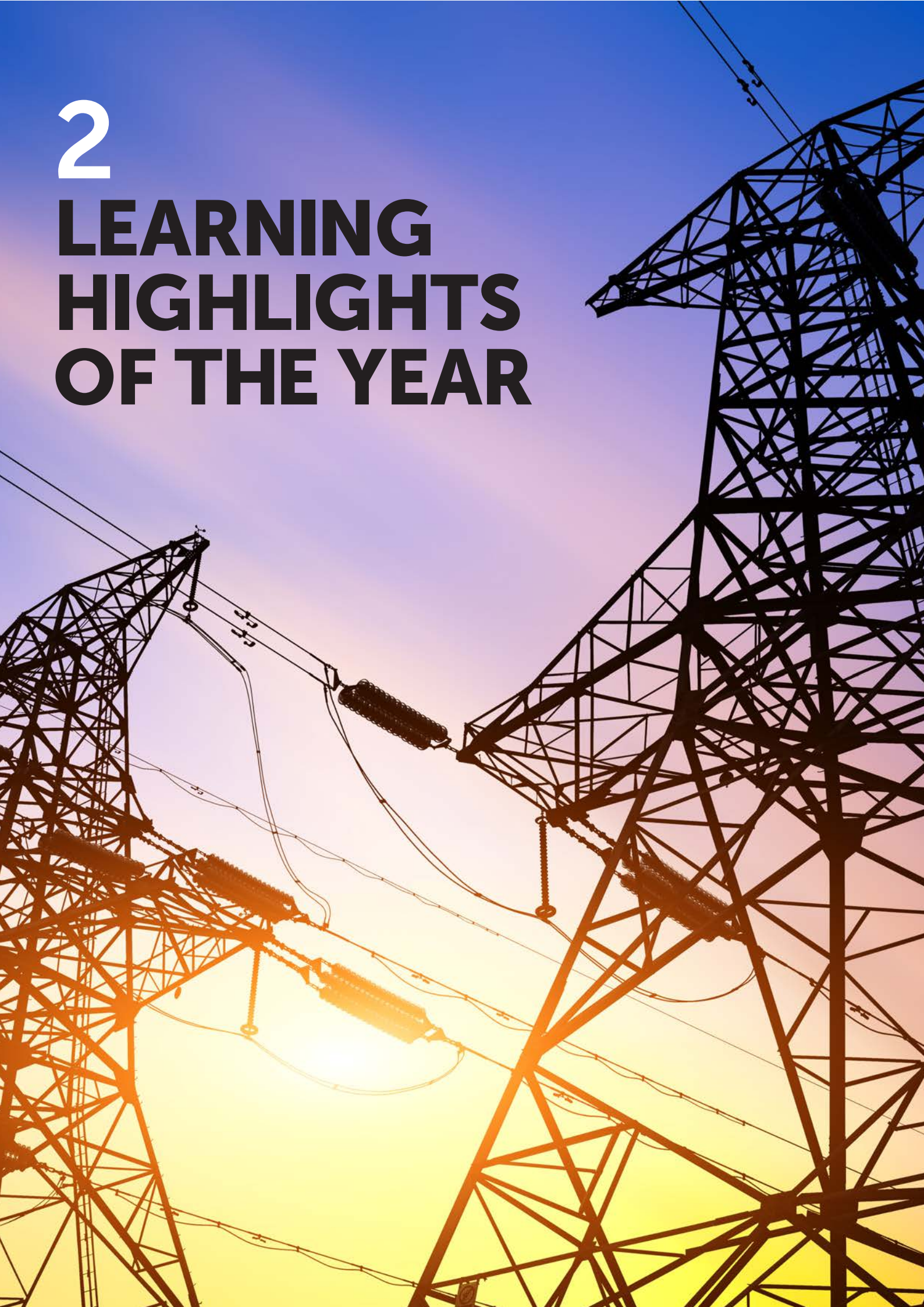
Sector-leading efficiency

Leadership in sustainability

Funded
£300,000

Start/end date
February 2023 / April 2024

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



2 LEARNING HIGHLIGHTS OF THE YEAR

2.1 LOW PROFILE 132KV STEEL 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.

By 2029, creosote production will be removed in Europe due to growing concerns around the environmental impact of its production and use which will impact the construction of wood poles across our network. Using previous project learnings from the Dorenell Wind Farm Connection and NeSTS trial, we have been working with the project contractors, Energyline, Norpower, and PLPC to develop the steel pole alternatives which will remain similar in design to wooden overhead lines.

The prototype design minimises the amount of steel required to construct poles compared to other large structures and completely removes the need for concrete and access tracks during construction, as foundations are buried directly in the soil. In addition, multiple safety improvements have been included in the design, such as additional attachment points for fall arrest systems, handles to ease the transition from the pole to the crossarm when climbing, and additional working space on the crossarms of the structures.

The aim of the design was to maintain the aesthetics and construction techniques of the wooden poles as much as possible while delivering increased capacity and a more cost-effective solution for our customers. We have identified future projects across our network to implement the new steel pole design, following successful testing in Summer 2023.

SSEN Transmission has identified a £4.8m of lifetime cost savings if using the new steel pole design across 7 projects.

2.2 PROTECTION SOLUTIONS TO PERFORM FOR LOWER LEVELS OF FAULT CURRENT ON AC NETWORKS (PSL-FC)

To address the future protection challenges associated with the proliferation of converter-based resources (CBRs) on the system, SSEN Transmission in collaboration with The National HVDC Centre and University of Strathclyde (UoS), have embarked on this project to assess the performance of different protection solutions proposed by protection relay manufacturers, i.e., travelling wave protection, revised distance protection, neutral current differential protection and differential protection, using the realistic lab and field trial-based testing approaches.

In the initial stages of the project, UoS have developed representative Real Time Digital Simulator (RTDS) network models and test configurations for the comprehensive lab testing of travelling wave and revised distance protection solutions with remaining protection schemes to follow.

The lab testing carried out so far has returned promising signs that protection solutions to address the challenges of power systems dominated by CBRs may be met through the improvement of existing and/or emerging protection solutions and potentially further enhanced by the revision of CBR control strategies to assist in protection.

2.3 ICE MAPPING

The Ice Mapping project was set up to determine new values for the predicted weight of ice on transmission line conductors. The values in use were derived in the 1980s based on meteorological records and science at the time, where there was a lack of recorded ice weights and has been considered extremely conservative across the industry. This has resulted in substantial additional high-risk work on transmission overhead line projects with the corresponding network, safety, cost and programme implications.

The Met Office has produced a localised climate model of SSEN's transmission territory based on an 8km grid. This was used, with the latest icing theory, to simulate the potential ice events which could have occurred over the last 40 years. This produced a theoretical dataset of ice events, which in the absence of recorded ice events, could be used to produce statistics of the likelihood of ice events occurring and their potential magnitude. Whilst there is still internal work to do in interpreting the values provided by the Met Office, significant learning has already been gained:

- Confirmation that the historical ice map is conservative in a large number of places.
- The patterns of ice loading in the standards and the formula used to modify it are not representative of the value produced by numerical weather modelling.
- New numerical modelling techniques and powerful computing, combined with suitable experts, can be used to address challenges where a lack of data has stymied progress in the past.
- Values in standards can be overly simplified or rely on historic data. Overreliance on them can result in carrying out additional unnecessary work.
- There is a discrete difference between science and engineering. The values produced by the Met Office are scientific values for a range of ice, height and conductor combinations. Work needs to be undertaken to rationalise them and determine how they are to be used in an engineering context.
- The use of less conservative loading values makes the choice of load cases more critical to ensure structures are not under-designed.

Subject to assumptions outlined in early cost benefit analysis, 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 OHL projects in the SSEN Transmission area.

4 FURTHER INFORMATION

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

ENA Smarter Networks Portal – SSEN Projects

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

5 CONTACT DETAILS

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