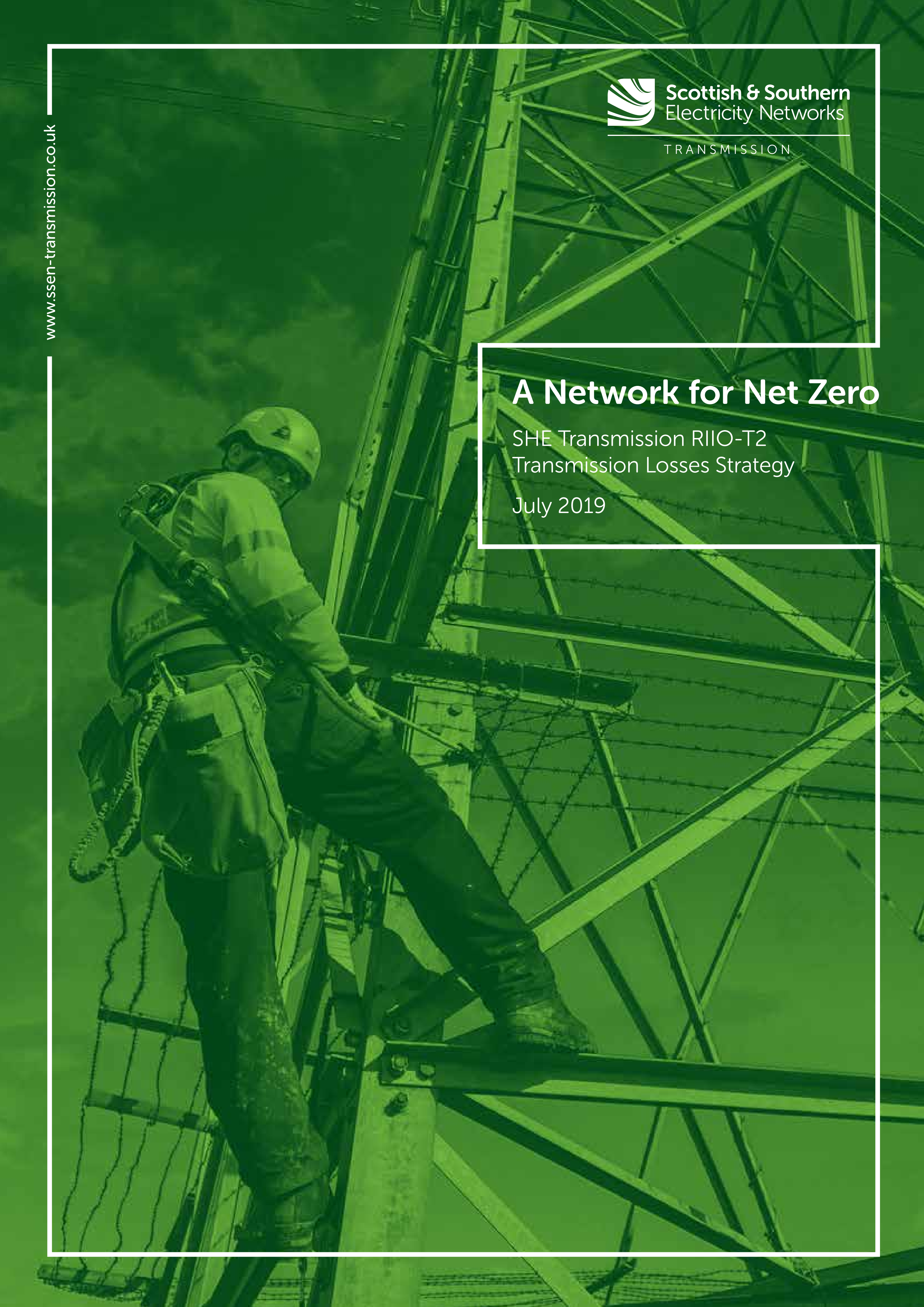


Scottish & Southern Electricity Networks

TRANSMISSION

A Network for Net Zero

SHE Transmission RIIO-T2
Transmission Losses Strategy

July 2019

www.ssen-transmission.co.uk

About us

We are Scottish Hydro Electric Transmission (SHE Transmission), part of the SSE Group, responsible for the electricity transmission network in the north of Scotland. We operate under the name of Scottish and Southern Electricity Networks, together with our sister companies, Scottish Hydro Electric Power Distribution (SHEPD) and Southern Electric Power Distribution (SEPD), who operate the lower voltage distribution networks in the north of Scotland and central southern England.

As the Transmission Owner (TO) we maintain and invest in the high voltage 132kV, 275kV and 400kV electricity transmission network in the north of Scotland. Our network consists of underground cables, overhead lines on wooden poles and steel towers, and electricity substations, extending over a quarter of the UK's land mass crossing some of its most challenging terrain.

We power our communities by providing a safe and reliable supply of electricity. We do this by taking the electricity from generators and transporting it at high voltages over long distances through our transmission network for distribution to homes and businesses in villages, towns and cities.

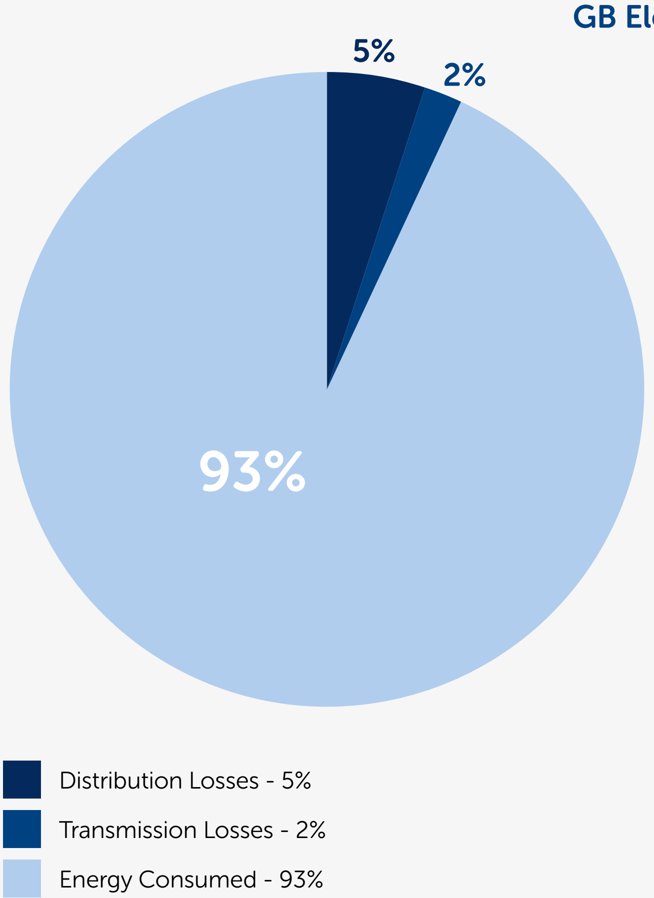
Introduction

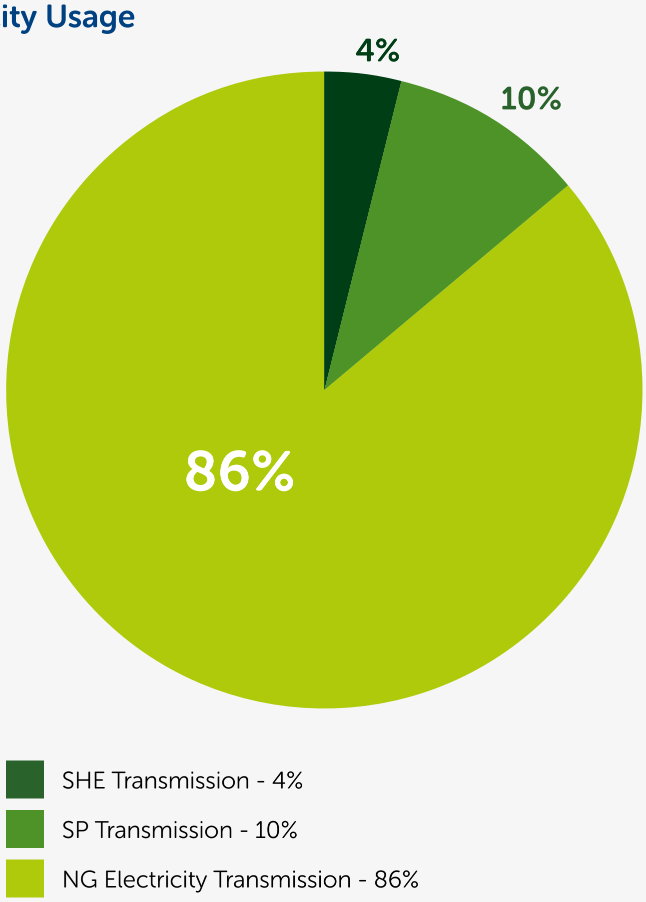
Through a legislative and regulatory framework and pursuant to our Transmission Licence, we are obligated to develop and maintain an economic system of electricity transmission. This is important in order for us to support a smart transition to a low carbon economy to achieve the optimum outcome for customers. One of the ways of achieving efficiency in transmission is to reduce the network losses. The impact of losses is factored into the cost benefit analysis during equipment procurement and when assessing solutions to system needs and undertaking strategic optioneering assessment, which presents an opportunity for us to make decisions that can reduce losses.

Power losses are an inevitable consequence of generating, transmitting and distributing electricity to consumers. In general, there are two main components of losses in a transmission system: technical losses and non-technical losses. Technical losses are energy lost as heat from power flows though electrical equipment such as cables, overhead lines, and transformers, while non-technical losses are caused by inaccurate metering, billing and energy theft.

Technical losses are further categorised into fixed and variable losses, also known as no-load losses and load losses respectively. Fixed losses occur in a transmission system by virtue of it being energised and are independent of loading conditions. The fixed losses include corona losses in overhead lines and iron losses in transformers. Variable losses occur due to the loading of the transmission system and are dependent to the load and increase disproportionately with increasing load. The variable losses are heating losses due to the resistance of electrical equipment to the flow of electric current, such as the conductors and copper transformer windings.

GB Electricity Usage





Introduction

The power losses on GB transmission network is typically 2% of electricity generated. In 2017/18, the National Grid Electricity System Operator (NGESO) determined that the SHE Transmission's transmission losses were 0.25TWh, which was 4% of total GB transmission losses. It could potentially supply 80,645 households assuming the 3100kWh electricity usage of a typical GB domestic household.

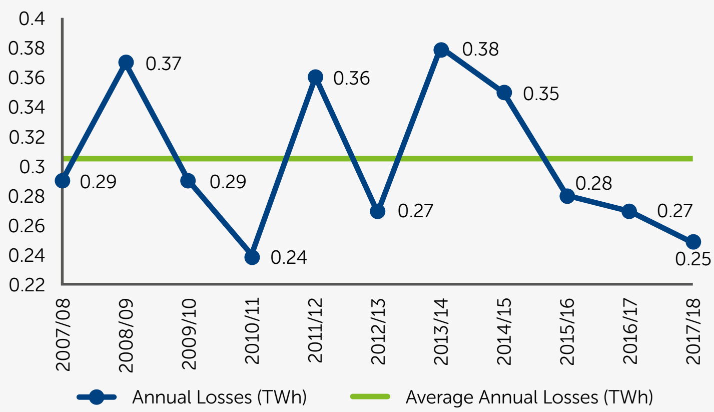
The figures below show the total energy and losses on distribution and transmission networks and how the transmission losses are split between the three transmission operators.

The average annual losses in the last 10 years for SHE Transmission's network is 0.30TWh, peaking at 0.38TWh in 2014/15 and with a minimum of 0.24TWh in 2010/11. Losses vary from year to year. What is interesting to see is the steady decline of transmission losses in the last four years, where our major projects, such as Beauly-Denny 400kV overhead line and Crossaig-Hunterston 220kV subsea cables, have had a strong impact in reducing losses by offering an additional parallel power flow path, which decreases the loading in circuits. The increased volume of large embedded generators at grid supply points during that period is another significant contributory factor to a decrease in transmission losses by reducing the power required to feed Grid Supply Points flowing within the relatively high-losses 132kV circuits. It should however be noted that with more embedded generation connecting to the distribution network, increasingly exporting power to the transmission system, this effect on losses reduction may begin to reverse.

Losses can be reduced through existing overhead line reconductoring, voltage upgrade, e.g. uprating from 132kV to 275kV operation, use of Flexible AC Transmission systems, HVDC technology and use of low-loss transformers. For the 120MVA 132/33kV GSP transformers, the losses of the most efficient ones are 23kW (no-load) and 103kW (load), compared to a high losses transformer with 29kW (no-load) and 163kW (load), potentially saving 30% in terms of losses. While every measure is taken to minimise transmission losses, there are still a number of factors which must be considered when making investment decisions, and not all of these result in a reduction of transmission losses. These factors include capacity requirements to accommodate higher load requirements and the need to increase efficiency through maximising asset utilisation.

This paper thereby presents our approach to minimise the level of transmission losses and the associated Scope 3 indirect carbon emissions on the SHE Transmission system in order to support our RIIO-T2 sustainability ambitions – mitigating climate change while connecting for society with a **science-based target.**

Annual losses on the SHE Transmission system



Methodology

Power losses on our network are mainly determined by the overall power dispatch. However, as a Transmission Owner (TO), we do not dispatch generation and demand on the transmission system – this is the responsibility of NGESO under its licence. We have very little opportunity in system operation to reduce losses. Approximately 98% of energy is traded on the electricity market and the NGESO intervenes the dispatch of remaining 2% of energy via their System Operator's role. It is also NGESO's role to calculate annual losses for each TO area and we only review the calculations to understand the loss performance of our network and evaluate the impact of our network development activities on the losses. Due to above reasons, it is critical that we focus on our role in the specification of assets we install on our network to ensure that we take into account their lifetime losses impact and cost. We also consider the losses impact of the design options we develop in reinforcing the system.

Opportunities to reduce losses occur when there is need to replace an existing asset, driven by deteriorating asset condition or the need for more capacity, or when new assets are required to extend the transmission system. Due to the high capital cost of transmission assets, the losses reduction on its own generally does not yield an economic case for capital projects, but we recognise that it is important to include losses in our cost benefit analysis (CBA) when comparing alternative solutions for network reinforcement. We therefore consider the impact of losses when undertaking cost benefit analysis on procurement and reinforcement options to incorporate full societal, economic and environmental factors.

Quantifying Transmission Losses with CBA

A CBA-based approach allows the cost associated with network losses to be fairly balanced with other network costs. It can help to strike a balance between the total costs including losses, and constraint reduction and carbon savings. It also allows innovative smart grid technologies to be deployed on the network where the net benefits outweigh any increase in losses or in upfront capital investment. A full lifecycle costing of investments would ensure that informed decisions are made before deploying any smart grid technologies and that network losses are fairly considered within any network investment.

We propose two elements associated with losses as inputs for the CBA: cost of electricity production and transmission on our network; and the traded carbon price associated with each tonne of CO2 emission for the non-renewable portion of electricity energy in the north of Scotland. This quantification of SHE Transmission's losses cost (£/kWh) can then be used in our equipment procurement and investment option assessment to include the whole lifetime financial and environmental impact from losses.

Material and Equipment Specifications

The procurement of materials and equipment takes account of the whole lifetime costs including transmission losses. The typical loading profiles for the different asset types, at all transmission voltage levels, will be provided to suppliers for use in the estimation of the whole lifetime fixed losses and various losses. It is important that, to ensure fairness in the tendering process, the methodology for determining the asset loading profiles and calculating the estimated losses are availed in a transparent manner.

SHE Transmission will undertake the overall CBA to determine the optimum selection, considering the associated cost of losses described above in addition to other capital costs. Consideration is also given to the inclusion of post completion performance tests to provide confirmation that losses are no different to loss values provided by suppliers in its tender.

When replacing overhead conductors, an assessment of suitable replacements consistent with the capability of the existing tower structures is undertaken. Where appropriate, this can include a review of the conductor size versus cost and replacing conventional ACSR conductors with AAAC conductors or new technology conductors with a lower resistivity. When selecting underground cables for asset replacement or reinforcement projects, consideration is taken on the type of conductor, dielectric material and sheath of the cable, in order to select cables offering optimum installation costs and losses.

SHE Transmission will also request all the detailed impedance information to be provided for the material and equipment we have in the procurement catalogue, which facilitates the future losses evaluation for comprehensive projects involving various assets and options. We will also proactively engage the manufacturer and supply chain stakeholders to optimise the design under the specific operating conditions in the north of Scotland, detailed in our **Innovation Strategy**[1].

Load and Non-load Related Reinforcement Projects

Power flow studies are used to determine the impact of the proposed load related reinforcement projects and non-load related asset replacement projects on transmission losses against generation background at system peak demand in the completion year of the project. Our studies are carried out against GB generation and demand backgrounds provided by NGESO, based on Future Energy Scenarios (FES), Electricity Ten Year Statement (ETYS), Grid Code "Week 24" submissions from the local Distribution Network Owner (Scottish Hydro Electric Power Distribution). The subsequent power flow studies for the transmission system planning and investment are applied to determine the transmission losses at cardinal loading points such as at the time of peak power flows on the transmission system, in order to estimate the annual losses and select the optimum design using the CBAs.

[1] https://www.ssen-transmission.co.uk/media/3396/our-innovation-thinking-for-the-future-final.pdf

Annual Reporting

We have a licence obligation to publish an annual transmission losses report for the previous financial year on or before 31 October in accordance with the Special Condition 2K of our licence conditions to monitor the transmission losses.

To provide a consistent and coordinated approach to the measurement and monitor of transmission losses for each TO, a joint methodology “Transmission Losses Calculation – Joint TO Methodology” was agreed between the respective TOs and NGESO to utilise the existing metering on the National Electricity Transmission System and the apportionment of losses for each respective TO licencee’s system. The NGESO’s calculation is carried out using data from the Elexon SAA-IO14 data feed, which allows each TO to report on their metered Transmission Losses as per the TOs Special Condition 2K.4.

For the avoidance of doubt, the NGESO is responsible for the accuracy of the annual transmission losses figures. SHE Transmission’s focus is on modelled losses which are assessed against predefined generation and demand background.

Approach to New and Alternative Technologies

SHE Transmission’s approach to new and alternative technologies is to apply solutions that offer the greatest potential benefit for GB consumers, developers and our wider stakeholder groups. Our stakeholder-led priorities within this approach are to maintain security of supply and to keep costs to a minimum. In order to do this as well as reduce the environmental impact of our activities, we are pursuing opportunities to reduce losses through new technologies.

A good example is a recent trial at Tealing 275kV substation, collaborating with Edinburgh Napier University to reduce the electricity usage (transmission losses) at substations in terms of heating and lighting. The study shows the annual losses at Tealing 275kV substation is 192MWh/year. The proposed intervention measures include intelligent lighting controls and luminaire replacement and a range of building fabric upgrades to mitigate the electricity usage on site. The estimated losses saving can be up to 109MWh/year. It shows that readily available intervention measures can achieve savings of up to 41MWh/year per building on average which, extrapolated across the SHE Transmission’s network portfolio, could amount to potential losses reductions 2GWh/year. It also highlights an opportunity to adopt onsite generation (e.g. solar panel) to cut the losses at substations. This improvement for the substation electricity usage has now been included in our RIIO-T2 plan to bring long term benefit for the customer in terms of losses and carbon cost savings going forward.

We have also completed the assessment and trial installation of an Aluminium Conductor Composite Core (ACCC) conductor on a 132kV wood pole transmission line. The design of the ACCC maximises the area of conductive material in the conductor, providing the same power-carrying capacity at a lower operating temperature than in conventional conductor designs.

The lower comparative operating temperature leads to reduced losses, as well as a high current-carrying capacity that can defer or avoid the requirement for costlier conventional network reinforcement. With a typical resistivity of 106mΩ/mile for ACCC compared to 139mΩ/mile for ACSR, the losses using ACCC could be 24% smaller when carrying the same power flow. We are currently undertaking analysis of the trial results prior to potential transfer to business-as-usual practise in RIIO-T2. We will also continue to explore conductor opportunities in addition to the ACCC conductor which may offer further opportunities to reduce losses as well as increasing capacity.

We believe the set of new technologies described in this section highlight the need to reduce losses on our network and we remain committed to continuing to assess and deploy new technological solutions which deliver the greatest net benefit for the GB users and wider stakeholders.

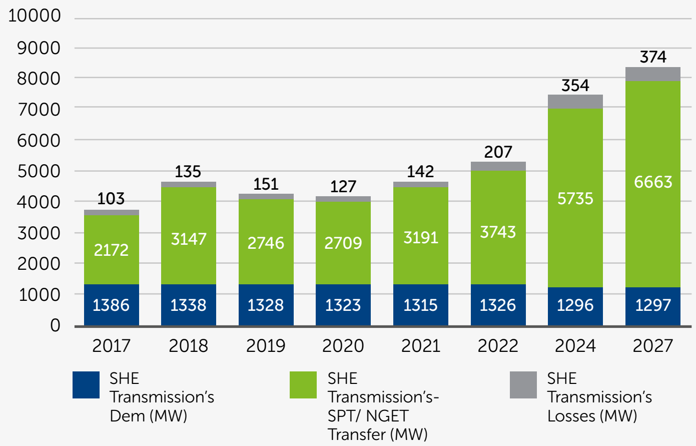
Impact of Future Developments on Losses

During the RIIO-T2 price control period, SHE Transmission is developing a number of key transmission reinforcements to accommodate the rapid growth in renewable generation in the north of Scotland. These developments include various conventional asset replacement and reinforcement works such as transformer replacements, new overhead lines and substations, re-insulation and re-profiling of existing overhead lines as well as High Voltage Direct Current (HVDC) technology, phase shifting transformers, power flow controllers and dynamic reactive compensation.

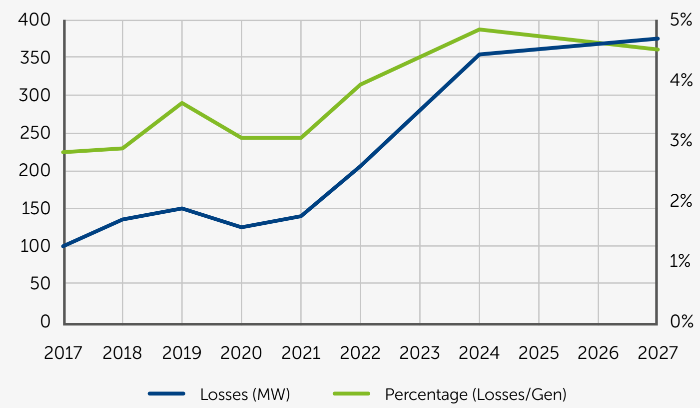
Figures below illustrate a forecast of the demand (in blue), power exports from north to south (in orange) and losses (in grey) on our network at the time of GB winter peak demand time between 2017 and 2027 based on the ETYS 2018 model under the '2 Degrees' future energy scenario. The total of demand, exports and losses represents the generation output at the time of winter peak.

While all of the above developments have a beneficial impact on transmission losses, the rapidly increasing expansion of renewable generation in our area at both Transmission and Distribution levels (3661MW in 2017 vs an anticipated 8314MW in 2027) and resulting power exports through the network, means that overall losses will inevitably increase over time (103MW in 2017 vs an anticipated 374MW in 2027). The increase of absolute losses suggests we must focus on losses that we can influence through implementation of this strategy giving sufficient consideration of losses in equipment selection and network development options. In the meantime, the percentage of losses over generation levels on our network is quite stable (3% - 4%) in the 10 years, which reflects our reinforcement development and efforts in losses reduction are effective. Subject to the increasing weight of renewable generation, the corresponding relative contribution from electricity losses to the carbon footprint could drop as well.

SHE Transmission's Network Losses Estimation Using ETYS Model for GB Winter Peak Time (2 Degree)



Losses MW vs %



Summary

Our losses strategy is built upon our sustainability strategy[2] which looks to enable a smart transition to a low carbon economy to achieve the optimum outcome for customers. SHE Transmission will proactively adopt the whole system CBA approach to make sure losses are minimised where possible to ensure costs to the GB consumer are minimised and to reduce the associated environmental impact (carbon footprint), as we are committed to being the trusted partners of customers and communities, realising long-term benefit for society, economy and the environment.

During the RIIO-T2 price control period, SHE Transmission proposes a number of transmission developments to accommodate the rapid growth in renewable generation in the north of Scotland, critical to the transition to a lower carbon economy and the government's carbon reduction targets. These developments include various conventional reinforcement works, such as new overhead lines and substations, re-insulation and re-profiling of existing overhead lines, new HVDC links as well as substation energy usage improvement.

While all above have a beneficial impact on transmission losses, the rapidly increasing renewable power generation through the network could still mean that our overall losses remain flat or increase over time. However, the power losses associated carbon footprint will be expected to decrease along with a massive drop of non-renewable generation's proportion.

[2] https://www.ssen-transmission.co.uk/media/2701/sustainability-strategy.pdf

Scottish & Southern Electricity Networks

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We want to hear from you

This document is our draft Losses Strategy for the RIIO-T2 period, from 1 April 2021 to 31 March 2026. We issue this document for consultation with our draft RIIO-T2 Business Plan, and would welcome any feedback by 30 August 2019. We will update this draft Strategy and publish our final Losses Strategy with our final RIIO-T2 Business Plan in December 2019. This will take into account feedback from stakeholders and regulatory guidance (including the May 2019 RIIO-T2 Sector Specific Methodology Decision).

This document and future revisions will be hosted on **www.ssen-transmission.co.uk**

To find out more about our RIIO-T2 plans visit: **https://www.ssen-transmission.co.uk/news-views/RIIO-T2**

If you would like to get in touch with the team to ask questions, and provide feedback and comments then please email us at: **YourPlanOurFuture@sse.com**

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