SSEN Distribution's RIIO-ED1 Losses Strategy

March 2021

Scottish and Southern Electricity Networks (SSEN)

Scottish Hydro Electric Power Distribution
Southern Electric Power Distribution

Document Control

Revision History

Version	Date published	Author	Change Details
April 2015	1st July 2015	Alistair Steele	
April 2016	1st July 2016	Alistair Steele	Minor annual update
April 2017	1st July 2017	Alistair Steele	Minor annual update
April 2018	1st July 2018	Rhys Williams	Moderate annual update
April 2019	1st July 2019	Rhys Williams	Minor annual update
March 2021	31st March 2021	Alannah Simpson	Moderate annual update

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1 Executive Summary

1.1 What are losses?

Distribution losses refer to the electricity lost from our Distribution network either as a function of the electricity travelling through our equipment or through measurement inaccuracies and theft. Either way, this lost electricity presents a cost to both customers and the environment and we are compelled to manage this so that distribution losses are as low as reasonably practicable.

There are measures that we can take to reduce this loss and this is primarily demonstrated through:

- The choice of network assets we install; and
- The improvements we make to our processes to reduce measurement errors and theft.

Understandably, this cannot be at any cost and we have to balance the measures taken with the costs and benefits of implementing them.

1.2 Today's challenges

Importantly, the more distribution network assets are utilised (or 'sweated'), the greater the distribution losses.

Despite a reduction in the amount of electricity distributed through our network in 2020-21 as a result of the Covid-19 pandemic, the general drive is towards greater demand for electricity and steps to ensure that the existing electricity infrastructure is used as efficiently as possible. This is most evident through the following initiatives:

- The decarbonisation of transport and heat and the resulting increase in demand for electric options.
- Whole System thinking – where network owners and operators must consider the wider impacts of their system development and decision-making.
- Ofgem's review of how customers are charged for access to the network and what rights they have. This is about understanding spare capacity on the network and, where possible, potentially making this available to others.
- New obligations and commitments around the procurement and use of flexibility services where this is an economic alternative to investment in traditional network assets. These mechanisms generally result in an increased overall utilisation of existing assets, which has an incremental relationship to losses. Again, this seeks to make better use of the existing network.

By increasing the amount of electricity passing through our assets, and working our existing assets harder, all of the above will cause losses to increase in the absence of counteracting measures. As a result, our ability to reduce the losses on our network is increasingly at risk.

1.3 Our strategy

To date, our aim has been to reduce losses on our network, as a percentage of units distributed, whilst removing barriers and empowering solutions that benefit the whole system. In the current eight-year price control period (RIIO ED-1), we have been delivering this through:

- The strategic installation of lower loss assets, where this is demonstrably the right approach;
- The trial of known and new losses reducing techniques, such as methods to stabilise power factor and improve power quality, to assess suitable applications within our network; and
- Tackling electricity theft and calculation anomalies through investigation works and wide-reaching communications highlighting the issue.

1.4 What's changed in this latest edition of our Strategy?

Over the course of RIIO-ED1, the transposition of EU Directive 2009/125/EC, which established a framework for the setting of 'ecodesign' requirements for energy-related products into GB law, has meant that certain lower loss assets have become obligatory.

Previously, we took the decision to 'strip out' reductions delivered as a result of installing assets that met the requirements of this EU Directive because they were no longer driven by a SSEN-specific policy. However, on reflection, these still constitute improvements in our losses performance, and we believe reductions delivered as a result of these new minimum standards should still be counted and included in our reporting.

1.5 Focus for the remainder of this price control period (RIIO-ED1)

During the remainder of the RIIO-ED1 period, we plan to:

- Continue to drive reductions in losses through our justified and evidenced asset choices, such as the types of conductor or transformer we install.
- Further reflect on and embed the learning from key innovation projects which target losses, such as our LEAN innovation project which is being considered for wider rollout in ED2.
- Increase our deployment of monitoring devices and use of more advanced smart meters (SMETS2) to improve our understanding of network loading.

Notwithstanding the impacts of the Covid-19 pandemic, which has seen a temporary reduction in units of electricity distributed in 2020-21, we continue to anticipate an increase in network utilisation as further efficiencies are driven in the operation of our network and the decarbonisation of transport and heat increases the demand for electric solutions. This will result in increased losses in the absence of any measures to counteract this.

Therefore, whilst our focus for the remainder of this price control period will be to continue to reduce losses as set out above, we are broadening our approach in this area, including working with the Science Based Target initiative to strengthen our approach and exploring opportunities to reduce the carbon impact of any losses from our activities. Informed by stakeholders, this will be a strong focus in the next price control period.

1.6 Progress to date

Table 1: RIIO-ED1 performance overview

Intervention	Losses savings to 2020/21 (MWh)	Forecast ED1 losses savings (MWh)
Upsizing to three phase 500kVA GMTs and 50kVA PMTs	684	1,140
Cable upsizing at LV and 11kV	7,688	20,266
Cable upsizing at 33kV	0	2,144
6.6kV to 11kV network upgrade	1,838	3,433
LEAN - Switching out underutilised plant (trial sites only)	124	331
Losses savings consistent with EU Ecodesign Directive requirements:		
Installation of Low Loss Transformers	20,822	48,293
Replacement of historical high loss transformers	941	2,294
Total	**32,097**	**77,901**

2 Background

Electrical losses are the difference between the amount of electricity that comes into our network from embedded generators and the national transmission system, and the metered amount that is taken off the network by customers. These losses can either be technical (as electricity can turn to heat as it is transported) or non-technical (for instance, due to theft or measurement errors). Electrical losses are included in our Business Carbon Footprint (BCF) because they represent fuel consumed and emissions produced in the process of electricity generation, which are then lost from the network before reaching the consumers.

2.1 Technical losses

Technical losses consist of two elements: a fixed amount (a function of the network itself, irrespective of the usage of the network); and a variable amount which is dependent on the amount of energy moving through the network. The variable loss will change as demand increases and decreases. Additional factors such as the effect of network imbalance, power factor and power quality also has an impact on the technical losses.

2.1.1 Fixed losses

The fixed element of losses is the energy which is required when plant such as transformers or conductors are energised. For example, as transformers require electrically produced magnetic fields to operate, the energy used to create these fields is dependent on the applied voltage but is essentially fixed as the applied voltage is relatively stable while they are energised.

2.1.2 Variable losses

The variable element of losses is created due to the heating effect of energy passing through conductors. These conductors have a small resistance and when currents are passed through them, they heat up. This heating effect is a function of the resistance and the square of the current flowing through the conductor. High load (when an item of equipment is running near or at full capacity) produces proportionally more losses than when an item of plant or network is partly loaded.

The resistance of a cable reduces as its cross-sectional area increases so the effect of losses is reduced in larger cable sizes. There is a very similar variable loss element created through the wires and windings which are found in all transformers. The cross-sectional area of winding conductors, and the material used for them, dictates the level of variable losses seen in transformers.

2.2 Non-technical losses

Energy lost that is not directly related to the transportation of electricity through the system is categorised as a non-technical loss; this could be from theft or measurement errors. Situations where there is no registered supplier at a connection point, or no meter installed also occur from time to time. In many cases however, non-technical losses are due to illegal activities for example, consumers bypassing the meter or making an unauthorised connection to our network.

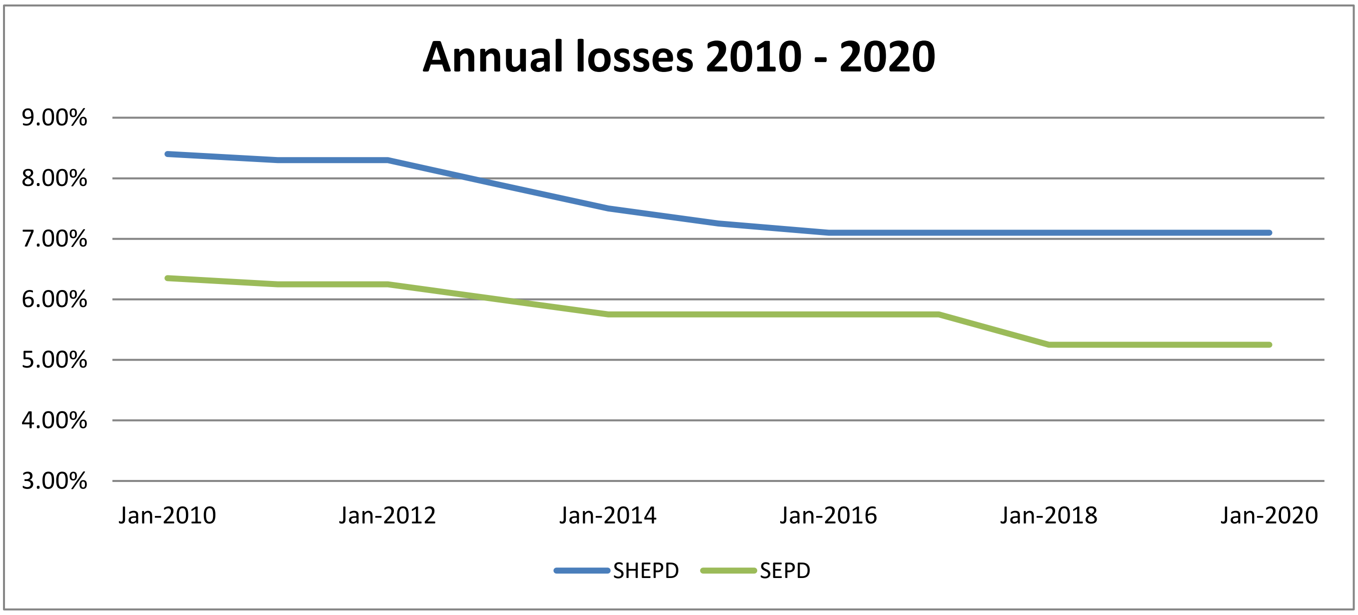
Measurement errors can occur through legitimate unmetered supplies as the energy demand is estimated rather than metered in these circumstances. Our substations are an example where the total energy is projected from:

- battery charging;
- transformer cooling;
- protection / control systems; and
- substation auxiliary supplies – heating, lighting and security systems.

2.3 Historical approach and performance

Currently, around 5-8% of the electricity distributed on our networks is reported as losses; however, this varies every year depending on customer demand. We calculate and report on losses in order to monitor the changing levels.

Figure 1: Annual electrical losses 2010 – 2020



The total amount of electrical losses on our network is calculated by subtracting the number of energy units known to be delivered to customers from the number of units that originally entered our network. Whilst this value is a good guide to overall performance, it is not an exact representation of our network's losses as factors including street lighting and energy used in between domestic meter reads make calculating the exact value challenging. We have worked to ensure the measurements of energy entering and leaving our network are as comprehensive as possible using metering data which helps to ensure the calculation of losses is as accurate as it can be.

The losses depicted in Figure 1 are higher in SHEPD than SEPD as technical losses are a function of the resistance of the network, and this is partly dependent on the length of circuits. Whilst there is less electrical demand on our network in SHEPD, energy generally has to be transported over a far greater distance which increases the losses.

The downward trend in SEPD in 2017 is related to a calculation change to set the 2017/18 Line Loss Factors (LLFs). This resulted in a 0.5% reduction in losses.

3 Traditional methods of reducing losses

Traditional methods of reducing losses taken by SSEN are described in more detail within this section. The approach we have taken to managing losses in previous price control periods has been to complete a high level CBA at the procurement stage of any investment decision. For instance, in our transformer framework contracts we specify that the manufacturers provide the fixed and variable losses for each particular unit. This allows a comparison, between manufacturers, of the lifetime costs as opposed to simply the initial capital cost.

The Ofgem specified societal CBA allows the lifetime benefits of lower loss plant to be predicted in more detail. The specified CBA incorporates a starting value for lost energy of £48.42 per MWh; this is discounted over time, with consideration given to the predicted cost of carbon. This methodology allows us to make investment decisions based on more accurate lifetime costs and defines whether installing an asset with a higher capital cost will result in long term savings for customers in the SSEN licence areas. This allows us to improve upon our decision making for reducing losses through the traditional methods described below. Details of CBA outcomes for the below measures are detailed in section 5.

3.1 Transformers

The nature of distribution networks dictates that power is transferred at differing voltages; this necessitates the use of transformers to step the voltage up or down. Although transformers generally have total efficiency percentages in the high nineties, the substantial volumes of energy throughput mean that a small percentage improvement can result in significant energy savings over a potential 60 year plant lifetime. At present, transformers on the distribution network account for approximately one third of our total network losses.

3.1.1 Low loss transformers

Transformer manufacturers now understand the importance of losses in the cost calculation and as a result now offer a range of high-performance lower loss units. The exact design improvements vary between manufacturers; however, they generally consider improvements to the core material or a reduction in the winding resistance. As of July 2021, all new transformers will need to comply with the EU Transformer Ecodesign Directive[1] Tier 2 specification.

The Directive sets minimum losses values for transformers and has been implemented to provide an increased focus on equipment losses from a manufacturer's perspective and to drive innovation in this area. The Directive has two tiers, the first which was implemented in 2015 and the second in 2021. This means that it is now mandatory for all EU network

[1] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0548&from=EN

operators to purchase transformers that meet or better the efficiency criteria set out in the Directive.

3.1.2 Minimum sizing of transformers

Over sizing transformers for a predicted load has the advantage of future-proofing sites for potential load growth. This has an associated additional cost over the minimum scheme, however, in addition to providing extra capacity, the larger capacity equivalent transformer will generally reduce losses.

3.1.3 Replacement of historical transformers

Historical transformers that pre-date a range of design specifications can have significantly higher levels of fixed technical losses than comparable modern units. Replacing existing legacy units before end of life with units that meet the EU Transformer Ecodesign Directive specifications can reduce losses, as modern units have a more efficient construction, design and core.

3.2 Conductors

An increase in the capacity of the cross-sectional area of a cable reduces the impedance and hence reduces losses. Installing larger conductors at LV, 11kV & 33kV could therefore reduce losses over smaller size alternatives. Cables with a larger cross-sectional area will also futureproof the network, making it better equipped to cope with any higher loading requirements in the future.

3.2.1 Conductor type

Increasing the cross-sectional area is a beneficial action in reducing losses, however benefits can also be realised by changing the conductor material from aluminium to copper. Copper has a lower resistance for equivalent cross-sectional area and therefore, less energy is lost for the same power transfer. Copper is more expensive than aluminium alloy however, hence, from an initial cost perspective, aluminium is normally the preferred option.

3.3 Upgrading network voltages

As losses are proportional to the square of the current, and current is directly proportional to the voltage, increasing network voltages can reduce losses for the same power transfer. For example, increasing the voltage of legacy 6.6kV networks to 11kV, although generally driven by capacity requirements, can reduce losses by approximately two thirds.

4 Potential methods of improving losses

4.1 Improving power factor

Power factor is a ratio between the real and apparent power flowing through a conductor. Apparent power is the scalar product of the current and the voltage of the conductor. Where the power factor is less than unity, the total current has to increase to deliver the required amount of power. This is inefficient and the losses increase. Traditionally, larger industrial and commercial installations have had a bigger impact on power factor. However, it is implicit with all energy usage, including domestic customers.

4.2 Switching out underutilised plant

At times of low load at twin or triple transformer sites, it is theoretically possible to switch off one of the transformers. As the total energy lost in a transformer is a combination of the fixed losses (generally referred to as the iron losses) and the variable losses (known as copper losses), switching off a transformer at times of low demand saves the fixed iron losses, and causes the variable copper losses to be redistributed amongst the remaining plant. At times when a transformer is loaded at less than 45% of its given rating and the combined iron losses are greater than the combined copper losses, this process can reduce total losses at the site.

Altering the network operation in this manner, does however have some significant technical and security of supply implications that would need to be addressed. The system would also not be suitable for high load sites and is dependent on the particular plant at that location.

4.3 Power quality

Certain loads connected to the network, such as switched mode power supplies can cause voltage and current distortions (harmonics) to the power system waveform. As well as disturbing adjacent customers' supply, this can cause inefficiencies in the way power is transferred, resulting in increased losses on our network.

Although the individual devices are usually compliant with existing manufacturing product standards, the sum of the individual harmonics may create a total value close to or above limits. For industrial customers, detailed assessments of the connected load are carried out to ensure compliance with the mandatory levels. For residential loads, this would prove more difficult as the individual customers may be within the limits, however, the cumulative impact on the network may be out with acceptable limits. This is an area which may increase in severity with the uptake of electric vehicles or other LCTs which rely on this type of technology. Thus, improving the harmonics on the network by solutions including active harmonic filters for example, could reduce network losses.

4.4 Reducing network imbalance

The GB network operates mostly on three phases where energy is transported along three conductors. A network which is not balanced across all three phases will have higher currents in at least one phase. Due to the non-linear relationship of losses with the current, these imbalanced currents can increase losses compared to a "balanced" flow.

The nature of the GB low voltage network means this imbalance is changing all the time as the connected loads increase and decrease. On higher voltage networks, imbalance can be caused by multiple factors including the uneven distribution of single-phase transformers or two wire spurs. In order to rebalance the network, first the imbalance must be identified, and then the connection redistributed across the three phases. It is worth noting that perfect balance is not possible as the load will ebb and flow throughout the day as customers use energy as they need it.

By improving visibility of the power flows on the LV system, networks that may suffer from imbalance can be identified. These can then be subject to a number of methods to reduce imbalance, ranging from altering network configuration to the installation of more sophisticated network balancing equipment.

4.5 Network configuration

Networks are electrically separated via switches, or 'Open Points'. These open points are strategically positioned to optimise customer numbers, load and to reduce switching operations under first circuit outages. Moving an open point to better balance customer numbers between two or more feeders usually results in improved balancing of load and hence lowers losses.

As the networks evolve, original network configurations can become inefficient. In certain cases, it may be beneficial to modify the existing circuits or substation configurations to enhance the operational flexibility. This can lead to a losses reduction in some cases.

5 Analysis conclusions

This section describes the CBA work completed on the losses reduction measures described in sections 3 and 4. A summary of the CBA conclusions and the losses savings forecast for ED1 are detailed in Table 2.

Table 2 – Summary of CBA outcomes and losses savings forecast for ED1

		CBA outcome	Savings to 2020/21 (MWh)	Forecast for ED1 (MWh)
Intervention	**Transformers**			
	Low Loss Transformers	Implemented	*20,822**	*48,293**
	Super Low Loss Transformers	Not Implemented - cost prohibitive		
	Minimum Sizing of Transformers	Implemented	684	1,140
	Replacement of historical high loss transformers	Select Incidences	*941**	*2,294**
	Conductors			
	Minimum Cable Sizing at LV	Implemented	4,552	10,986
	Minimum Cable Sizing at 11kV	Implemented	3,136	9,280
	Minimum Cable Sizing at 33kV	Select Projects	0	2,144
	Upgrading of 6.6kV to 11kV	Implemented	1,838	3,433
	Operational Measures			
	Power factor correction	Not Implemented - not currently applicable		
	LEAN - Switching out underutilised plant	Implemented at trial sites	124	331
	Power quality	Not Implemented - not currently applicable		
	Low voltage static balancers	Not Implemented - cost prohibitive		
	Measures to alter network power flows	Not Implemented - not currently applicable		
		Forecast Total Losses Saving ED1 (MWh)		**77,901**

*these measures are now the minimum standard, as per the EU Ecodesign Directive.

Key:
Green = Positive CBA – outcomes implemented from outset of ED1
Amber = Marginal CBA – outcomes implemented in select incidences, or have potential for future implementation
Red = Negative CBA – outcomes not implemented

5.1 Capital measures to reduce losses

Low loss transformers

We have updated our procurement policy to ensure all purchased transformers meet the EU Ecodesign Directive minimum requirements from a losses standpoint. To date, we have installed over 170 transformers meeting the EU Ecodesign Directive minimum requirements for Tier 2. This equates to a saving of over 20,000 MWh to date and a projected 48,000 MWh by the end of ED1 compared with higher loss alternatives.

Super low loss transformers

The cost of procuring super low loss transformers is around double that of standard transformers. The high capital costs associated with procuring and installing this equipment do not currently pay back in losses savings over the life of the plant. Therefore, we are not planning on implementing this initiative. Additionally, the larger size of the equipment will increase transportation and civil costs for any potential deployment, which makes cost effective deployment even more challenging.

Minimum sizing of transformers

We have completed analysis of the minimum rating of transformers we intend to install within ED1. The potential losses savings gained when upsizing three phase 315 kVA ground mounted transformers (GMTs) to 500 kVA, is around 114 MWh per transformer over the 60 year life based on a typical load cycle. The additional cost of a 500 kVA transformer is around 20% more expensive than a smaller 315 kVA unit. This analysis supports the roll out of 500 kVA GMTs as the minimum rating for three phase GMTs. We have concluded similar analysis for pole mounted transformers (PMTs) and plan to only use 50 kVA three phase transformers going forward. This upsizing will equate to around 1,140 MWh losses savings over ED1.

Whilst the upsizing to 500 kVA GMTs and 50 kVA PMTs is now our procurement standard, in a limited number of circumstances, such as sites with space restrictions, we may install smaller bespoke units.

Replacement of historical transformers

The work completed under a joint Innovation Funding Incentive project, ‘Management of electricity distribution network losses’ by Imperial College and SOHN Associates, funded by Western Power Distribution & UK Power Networks, provides an analysis of historical transformer losses. It concluded that secondary transformers installed before circa 1960 may have significantly higher combined fixed and variable losses than modern equivalents. Whilst the age of these assets also makes them appropriate to be replaced before their end of life with modern equivalents, this is further supported from a losses perspective.

SSEN has so far replaced over 36 pre-1960 secondary transformers in ED1 and expects to replace a further 19 by the end of the price control period. This will equate to over 2,000 MWh losses saving in ED1.

Minimum cable sizing at LV

Increasing conductor size in cables will reduce losses. We have assessed the potential for increasing the minimum cable size from 95mm^2 to 185mm^2 and 300mm^2 for Low Voltage Mains cables. Based on a typical load profile for an LV circuit, we have concluded:

95mm^2 to 185mm^2

- Cost uplift £4.51/m of cable
- Lifetime losses benefits 553 kWh/m of cable
- Lifetime NPV losses benefits £19.08/m of cable

95mm^2 to 300mm^2

- Cost uplift £15.06/m of cable
- Lifetime losses benefits 778 kWh/m of cable
- Lifetime NPV losses benefits £26.85/m of cable

Based on this, we have made the decision to upsize the minimum cable size from 95mm^2 to 185mm^2 for the majority of new installations, unless space constraints make upsizing not possible. Increasing cable size to 300mm^2 provides a greater lifetime losses benefit over the 185mm^2 cable, but the increased cost for procuring and installing this cable means the overall lifetime net benefits are less than the 185mm^2 cable. Therefore, we have set our procurement standard to 185mm^2 for new LV installations.

When considering replacing existing cable, the additional cost of excavation, jointing and associated outages, combined with the cost of the remaining asset life of the existing cable, results in the cost of replacement being in excess of £125/m of cable. Therefore, the losses benefit of upsizing does not justify the cost of replacing existing cable, so only new installations will be subject to upsizing at this point.

Minimum cable sizing at 11kV

Similar to LV cable upsizing, the losses benefit associated with upsizing 11kV 70mm^2 to 150mm^2 is outlined below:

70mm^2 to 150mm^2

- Cost uplift £2.58/m of cable
- Lifetime losses benefits 494 kWh/m of cable
- Lifetime NPV losses benefits £17.06/m of cable

The losses benefit associated with installing the 150mm^2 cable size outweighs the additional cost per meter to procure the cable. Based on this we have made the decision to upsize the minimum cable size from 70mm^2 to 150mm^2 for new installations, subject to there being sufficient space. The costs of replacing existing cable is in excess of £125 per meter due to the additional costs for excavation, jointing and loss of life of the existing cable. This outweighs any benefits made through losses reduction, so upsizing will only be considered for new installations at this point.

Minimum cable sizing at 33kV

We have considered the benefits quantified in industry and from other DNOs in conjunction with our own modelling and although there is a losses saving from upsizing 95mm^2 to 240mm^2, we have made the decision not to upsize new installations due to the increased cost of the larger cable outweighing any losses gain after net present value is taken into account.

95mm^2 to 240mm^2

- Cost uplift — £14.01/m of cable
- Lifetime losses benefits — 184 kWh/m of cable
- Lifetime NPV losses benefits — £6.35/m of cable

However, in specific instances, there may be opportunities to cost effectively increase the size of 33kV cables to reduce losses. An example of this is submarine cables, which are generally more bespoke. The Pentland Firth submarine cable, which connects the Orkney Islands to the mainland, underwent replacement in 2020. The 240 mm^2 cable was being upsized to 400mm^2 due to its additional current carrying capacity. Whilst this increase in cable size was capacity driven, it will deliver a losses saving of 2,143 MWh over the remainder of ED1, and over 30,000 MWh over the cable's life. For more information see: https://www.ssen.co.uk/SubmarineCables/Pentland/

Upgrading of 6.6kV to 11kV

As part of our network capacity increase and standardisation, it is possible to upgrade our 6.6kV network to 11kV utilising existing cables without significant additional costs. Whilst capacity driven, the supporting CBA considers in detail the losses savings over the lifetime of the equipment to inform any upgrade. We have identified 12 projects during ED1 to replace 77 km of 6.6kV network in our SEPD region. As of 2021, 11 of these projects have been completed with the remaining 125 m upgrade in Southampton scheduled for 2021/22. These projects present a losses saving of 3,433 MWh over ED1.

5.2 Operational measures to reduce losses

Power factor correction

The work completed within an earlier SEPD IFI project modelled the distribution network on the Isle of Wight and completed a detailed CBA on the benefits of installing equipment to move the power factor closer to unity. The benefits did not justify the investment as the power factors calculated were on average above 0.95, which does not leave significant room for improvement and hence our networks are currently operating efficiently. There may however be specific locations where the power factor is low enough to justify intervention. Further analysis will be conducted should suitable locations become apparent.

In addition to this, ongoing industry work is modelling the typical power factor on the network and its impact on losses. We will review the findings of this work when they are published and consider if it is appropriate for the SSEN network.

Switching out underutilised plant

SSEN's Low Energy Automated Networks (LEAN)[2] innovation project (supported by Ofgem's Tier 2 Low Carbon Networks Fund (LCNF)) has developed and applied Transformer Auto Stop Start (TASS) technology to reduce losses at 33/11kV primary substations.

The key principle of TASS is to switch off one of a number of transformers in a primary substation at times of low demand to avoid the fixed iron losses associated with that transformer. The TASS system provides local, automated control within the substation to monitor the loading, control the switching and to respond to SCADA alarms and status information from other network assets. In addition, commands incorporated into the Distribution Management System provide the central network Control Room with remote supervision and management capability.

The TASS system commenced trial operation in June 2018, and over the 18-month trial period demonstrated losses savings of over 100 MWh across two substations. The technology remains in place and continues to operate as designed, demonstrating the ability to both reduce losses and respond appropriately to different network situations and mitigate security of supply risks.

The business case assessment demonstrates that TASS offers a financially viable, as well as technically feasible option for reducing losses at individual substations based on current costs. Further, a broad range of factors have been identified that will further influence the costs and benefits of implementing TASS both now and over future years, and the proportion of sites at which TASS would be economically viable. SSEN will evaluate the wider

[2] https://www.ofgem.gov.uk/publications-and-updates/low-carbon-networks-fund-submission-sse-power-distribution-%E2%80%93-lean

application of TASS at additional primary substations throughout the rest of the RIIO-ED1 price control period and into ED2.

Power quality

Large volumes of LCTs, controlled by power electronics have the potential to produce harmonics which may have a cumulative impact of increasing network losses. At present, the penetration of LCTs, such as EVs, is not sufficiently high for this to be a major issue. However, there are ongoing NIA and NIC projects that are looking to examine this issue in more detail. We will consider and reflect on the learning from these projects as they progress.

One possible solution to mitigate the impact, is the use of active harmonic filters. SSEN demonstrated the use of these devices within its New Thames Valley Vision[3] (NTVV) project on the LV network, as part of energy storage deployment. Whilst these devices did help to resolve the harmonic issue, they also consumed energy, which in some circumstances exceeded that of the losses prevented.

This is likely to become a potential future issue as the number of LCTs increases on the network. The learning from our NTVV project and the wider portfolio of innovation projects in this area will help ensure that we have options available to resolve any future issues. In addition, we will continue to engage with the supply chain to ensure we are fully aware of future solutions as they are developed.

Low voltage static balancers

These devices essentially take power from a highly loaded phase and transfer it to a lower loaded phase, thereby stabilising the voltage across the three phases. The device is normally installed at the end of a long feeder circuit with an uneven distribution of load between phases. Although installed primarily to address voltage problems, the device also has the benefit of reducing the peak power on a particular phase, which can reduce the total feeder circuit losses. The imbalance does have to be of a significant magnitude for a sustained period of time for the losses saved to outweigh the energy consumed by the device itself.

CBA and learning from the NTVV project suggests that whilst there is a losses saving of around 210 MWh over the 40 year life of a static balancer, this benefit does not outweigh the cost of procuring and installing the equipment. As such, we have not deployed this solution over RIIO-ED1 but will keep the CBA under review should specific circumstances result in positive benefits.

[3] www.thamesvalleyvision.co.uk

Innovative measures to alter network power flows

As consumer demand for energy isn't consistent throughout the day, there are times when energy use leads to a peak in demand. This causes our network to be run harder and thus increases losses. Although our network is built to cope with peak demand, future uptake of LCTs could extenuate the peak or cause it to be extended for longer periods of time which will increase network losses. SSEN have a variety of innovation projects targeting network power flows to minimise the impacts of peak demand.

Our ongoing EV smart charging projects[4] and recently completed Social Constraint Managed Zone[5] project could be particularly effective in reducing peak demand and helping to minimise network losses. The projects look to better balance consumer demand by using constraint managed services and flexible charging systems to redistribute peak demand. The outcomes and learning from these projects will be further developed and considered for optimising network power flows in the future.

[4] https://smartenergycodecompany.co.uk/modifications/allow-dnos-to-control-electric-vehicle-chargers-connected-to-smart-meter-infrastructure/

[5] https://www.ssen.co.uk/SmarterElectricity/Flex/

6 Non-Technical Losses

The following section details the work focused on non-technical losses. The outputs are expected to have an impact on the total network losses within our licence areas. However, given that the impacts cannot be predicted in the same manner as in the technical losses section, this does not quantify the losses savings in the same way.

6.1 Network protection team

SSEN's Network Protection team focus on reducing non-technical losses by addressing MPAN (Metering Point Administration Numbers) discrepancies. This can range from identifying sites without MPANs, or historical MPANs that must be closed off. The team investigate on average 4778 records per month and have resolved an average of 7821 records per annum since being established in 2014.

The activities of the Network Protection team include:

- Responding to network tampering notifications and 'tip-offs' from a range of stakeholders;
- Undertaking targeted customer site visits and network plant and equipment inspections;
- Effecting repairs to electricity services and mains supplies;
- Assessing unrecorded energy and updating information systems accordingly;
- Participating in industry and government groups regarding energy theft; and
- Preparing cases for enforcement action and pursuing prosecutions.

6.2 Conveyance & settlement inaccuracies

Situations arise where energy is delivered and consumed but is not accurately recorded in the electricity settlement system and therefore, becomes lost energy. The main causes of these non-technical losses include missing and unregistered metering points, incorrect recording of the energisation status for metering points and incorrect registration of metering system information leading to inaccurate customer consumption data. Such non-technical losses are often regarded as 'Conveyance' related. We work closely with suppliers and metering service providers to improve settlement data and metering point registration accuracy. We will continue to focus on reducing the numbers of metering points without a registered supplier and some operators have already implemented tighter controls on the allocation of new MPANs to property developers.

We will also continue to proactively monitor the number (and check the status) of metering points registered as disconnected and de-energised by suppliers. We will cooperate fully in Elexon Audits to check settlement data and resolve any inaccuracies identified with corresponding commitments to refine internal processes to prevent any reoccurrences.

During the roll-out of Smart Metering where high volumes of meters will be changed within relatively short timeframes, we will work with all relevant stakeholders to develop robust industry procedures to ensure settlement.

6.3 Unmetered Supplies Team

Non-technical losses associated with unmetered supplies can be attributed to incomplete database records of unmetered customer loads, inaccurate equipment inventories and errors regarding the assumed demand characteristics. Typically, these considerations result in the under-recording of unmetered energy consumption.

We continue to work with the main unmetered supplies customer groups to ensure equipment inventories are regularly updated. We actively pursue customers where inventories have not been received. A proportionate approach will be adopted to improve the accuracy of unmetered supply records by targeting both local authorities and large national companies who operate within our networks.

Where customers are unwilling to engage regarding asset inventories for their unmetered supplies, we reserve the right to undertake selective and targeted equipment audits in accordance with the Managing Unmetered Energy Street Lighting Inventories (MUESLI) document in order to establish accurate consumption information for inclusion in energy settlements.

SSEN's 2018 #NotWorthTheRisk campaign has led to a significant increase in engagement with customers and the general public by the Network Protection Team. The campaign which was re-run in 2020 aims to educate on non-technical losses and highlight the risks of energy theft whilst promoting a platform where the public could potentially aid in the detection and resolution of incidents. This campaign has so far engaged with 1.6 million stakeholders and will continue going forwards.

7 Conclusions

We have continued to target a reduction in losses on our network as a percentage of units distributed, whilst removing barriers and empowering solutions that benefit the whole system.

To date this has led to savings of approximately 32 GWh through the measures detailed and we anticipate that by the end of the price control period (RIIO-ED1), we will have made close to 78 GWh energy savings.

To put this into context, based on an average home in the UK using 3,700 kWh of electricity per year, a reduction in our losses of 78 GWh is equivalent to the amount of electricity used by over 21,000 homes.

We recognise that we have a lot to do to deliver this saving in the remaining years of this price control, but as our forecast is based on choosing lower loss assets which are now our procurement standard, we believe we have the measures in place to be able to deliver this.

Going forward, we recognise that reductions in losses will be increasingly challenging as the demand for electricity increases and efficiencies are made to the way in which the network is utilised. We will continue to seek further measures to improve our losses performance whilst recognising its importance in our business planning for the next price control period.

Intervention	Losses savings to 2020/21 (MWh)	Forecast ED1 losses savings (MWh)
Upsizing three phase 500kVA GMTs and 50kVA PMTs	684	1,140
Cable upsizing at LV and 11kV	7,688	20,266
Cable upsizing at 33kV	0	2,144
6.6kV to 11kV network upgrade	1,838	3,433
LEAN - Switching out underutilised plant (trial sites only)	124	331
Losses savings consistent with EU Ecodesign Directive requirements		
Installation of Low Loss Transformers	20,822	48,293
Replacement of historical high loss transformers	941	2,294
Total	**32,097**	**77,901**