SSEN RIIO-ED1 Losses Strategy

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Contents

1. Executive summary ... 4
1.1. Challenges over ED1 ... 4
1.2. Smart meters ... 5
1.3. Measures to be implemented ... 5
1.4. Progress to date ... 6
1.5. Non-technical losses ... 7
1.6. Summary numbers ... 8
2. Background ... 9
2.1. Technical losses ... 9
2.1.1. Fixed losses ... 9
2.1.2. Variable losses ... 9
2.2. Non-technical losses ... 10
2.3. Historical approach and performance ... 11
3. Traditional methods of reducing losses ... 13
3.1. Transformers ... 13
3.1.1. Low loss transformers ... 13
3.1.2. Replacement of historical transformers ... 14
3.1.3. Minimum sizing of transformers ... 14
3.2. Conductors ... 15
3.2.1. Conductor type ... 15
3.3. Upgrading network voltages ... 15
4. Potential methods of improving losses ... 16
4.1. Power quality ... 16
4.2. Reducing network imbalance ... 16
4.3. Improving power factor ... 17
4.4. Network configuration ... 17
4.5. Switching out underutilised plant ... 17
5. Measures outside our direct control ... 19
5.1. Demand side response ... 19
6. Analysis conclusions ... 20
6.1. Capital measures to reduce losses ... 20
6.2. Operational measures to reduce losses ... 22
6.3. Innovative measures to alter network power flows ... 24

7. Non Technical Losses 26
7.1. Network protection team 26
7.2. Conveyance & settlement inaccuracies 26
7.3. Unmetered Supplies Team 27
8. Conclusions 28

1. Executive summary

This section provides a summarised view of the SSEN Losses Strategy to cover the current 8 year price control period RIIO-ED1 (ED1). The aim of the Strategy is to provide economic justification for specific loss mitigation measures. The analysis work completed has been determined through Cost Benefit Analysis (CBA) in line with Ofgem's ED1 guidance. The CBA considers the cost of lost energy over the lifetime of the intervention and makes allowance for the predicted reduction in the cost of carbon.

The work undertaken to complete the Losses Strategy and our ongoing monitoring of its effectiveness has allowed us to evaluate in greater detail the benefits of replacing traditional plant and equipment with lower loss alternatives. To compliment the traditional methods of loss reduction we have considered a number of innovative measures including a review of the potential benefits from the GB Smart Meter rollout.

This latest version of our Losses Strategy provides an update on the progress of our work to implement the required measures to reduce losses since the publication of our original strategy in 2015. The Strategy will be reviewed on an annual basis to ensure the proposed losses saving measures remain valid and to update the total predicted loss savings over ED1.

1.1. Challenges over ED1

Our networks today are facing a substantial challenge to keep future network losses broadly in line with the previous price control period. The challenges are predominately from an increase in low carbon technologies. Initially, this has been to accommodate significant increases in Distributed Generation (predominately wind and solar power), in a cost effective manner, which requires the network to operate at higher import and export extremes and in the process be driven much harder. More recently, we have started to identify an increase in demand from the electrification of heat and transport, which again means the network will be driven harder in order to deliver the increased energy demand. The result of these factors is that peak and total energy flows will increase and hence, so will the network losses.

In addition, there is widespread recognition that the GB network needs to become more flexible. Delivery of the best whole system outcome for consumers will depend upon DNOs evolving their current activities to continue to deliver an efficient, coordinated and economical system. This will require active use of new technologies, solutions and providers, with significantly increased engagement between the DNOs, ESO and TOs. This transition toward the new Distribution System Operator (DSO) model promises significant benefits for consumers but presents all licensees with new challenges and risks. Having a more coordinated approach to network planning and operation has the potential to reduce network losses in certain circumstances. SSEN will continue to actively monitor this area and will ensure that network losses are considered in the transition toward a DSO, as we progress through ED1.

A key driver in this transition to DSO is the ENA-led Open Networks project. This is a collaborative project involving a wide range of industry stakeholders which will help to determine the transition to DSO and a more flexible energy system, further details on the project can be found at: http://www.energynetworks.org/electricity/futures/open-networks-project/

1.2. Smart meters

The rollout of the Smart Meter programme within the latter half of ED1 will provide both challenges and opportunities for network operators. Firstly, it must be noted that to provide the increased functionality the new meters require more energy to operate. This increase although small at the individual property level has a significant aggregated effect across our SEPD and SHEPD licence areas. Despite the increased demand, the new meters could facilitate significant reductions in peak demand from the implementation of time of use tariffs and hence reduce losses. However, this requires suppliers to be able to offer a wider range of more flexible retail options to consumers, which have not as yet appeared in the market place. A key factor in the successful transition to DSO will be to facilitate new retail models for suppliers and consumers.

Additionally, we see further scope to benefit from smart meters in multiple areas; from demand side response and to improve investment planning. Finally, we intend to continue to further develop our existing work to assess the potential for the use of smart meter data, in conjunction with substation monitoring, to be able to measure losses more accurately and identify appropriate interventions to reduce losses.

1.3. Measures to be implemented

The analysis completed has provided an understanding of the measures that we can justify purely on the bases of losses reduction:

- Installing transformers that exceed the EU Ecodesign Directive losses requirements at all required voltages.
- Increasing the minimum size of 3 phase secondary transformers to:
    - 500kVA 3 phase ground mounted units; and
    - 50kVA 3 phase pole mounted units (some exclusions apply).

- Increasing the minimum cable size to the next size up:
  - at low voltage; and
  - at 11kV (some exclusions apply).

In addition to the core measures outlined above, we have also considered a range of innovative methods. A number of the techniques that initially provided promising results, did not fully justify the upfront cost against the lifetime losses benefit. These measures will remain a potential option and will be re-evaluated throughout ED1 to ensure our CBA is consistent with current market conditions.

1.4. Progress to date

To make certain the measures defined at strategy level are fulfilled as stated, we have made the necessary changes to our Strategy, Policy, Work Procedures and Technical Guides. In order to ensure that the information is successfully communicated we have undertaken a comprehensive programme of engagement both internally and externally. These strategy changes have also been shared with our Procurement and Connections teams to ensure they understood the implications and critically can predict the future volumes of particular items of plant.

Internal briefing sessions have been undertaken with key departments including:
- Network Planning;
- System Planning; and
- Operational Regions

Following the internal dissemination and agreement, the operational alterations were shared with external stakeholders. This process consisted of:

- Updating our Losses Strategy published on SSEN website;
- Undertaking a formal consultation with Independent Connection Providers (ICPs);
- Publishing our Policy on the SSEN website; and
- Updating and approving plant and equipment procedures to reflect strategy.

The formal consultation allowed ICPs to understand the reasons behind the design alterations and to have their concerns addressed. In addition to the formal consultation with ICPs we have completed face to face discussions with a range of other interested stakeholders within SSEN's ongoing engagement programme.

The nature of the measures in the Strategy dictated that a number of the measures that only affect SSEN could be implemented immediately. The remaining measures were not able to be implemented immediately in 2015/16 as the measures affected external stakeholders and we had to ensure the appropriate consultation was completed. The necessary documentation relating to changes in policy have now been approved, communicated and were published on the SSEN website 1st April 2016. Therefore, all of the measures outlined have now been implemented.

1.5. Non-technical losses

The strategy outlines the main objectives of the newly created Network Protection team. The key focus of the team is to address MPAN discrepancies within our licence areas. The team were able to investigate an average 4421 records per month and resolve on average ~724 in 2018/19. This is a vital activity in reducing settlement inaccuracy and ultimately contributing to lower non-technical network losses and we are pleased that our continued focus and investment has paid off with substantial increases in productivity.

1.6. Summary numbers

The strategy predicts a total saving of circa 34GWh based on the introduction of the discussed measures and policies. This is broken down in greater detail in the table below:

Table 1 – Updated estimated savings from SSEN losses strategy over 8 year price control period ED1

Intervention	Anticipated energy saving through ED1 (MWh)
Transformers that exceed EU Ecodesign Directive minimum requirements	Significant savings but not reported as this is considered the new baseline
Upsizing three phase 500kVA GMTs and 50kVA PMTs	1,140
High & low voltage minimum cable upsizing	32,904
Total	34,044

It should be noted here that significant losses savings will be made from replacement of transformers to those that meet the new EU Ecodesign Directive specifications. These savings, although significant, have not been included here as this activity is considered standard i.e. All DNOs must do this as law, it is not a policy that SSEN has implemented to specifically target losses reductions.

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 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 paying customer.

2.1. Technical losses

Technical loss is made up 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 can also have 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 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.

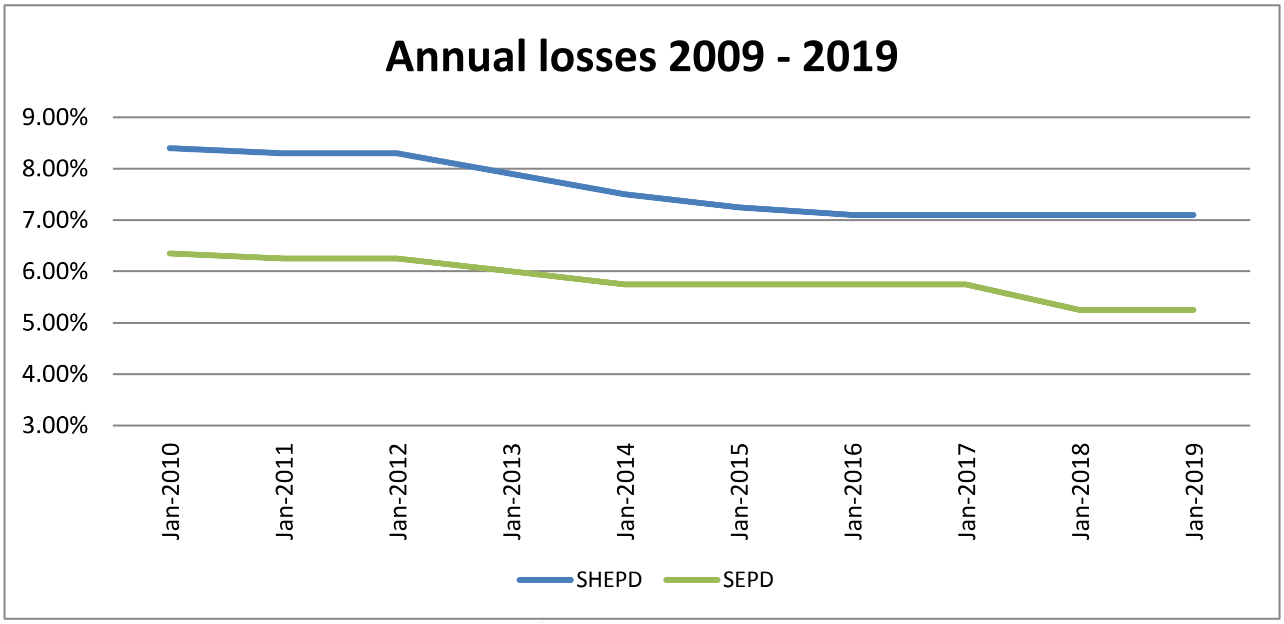
Measurement errors can occur through legitimate unmetered supplies as the energy demand is estimated rather than metered in these circumstances. Our substations are an example where the total energy is projected from:

- 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 2009 – 2019



A review of the SEPD Settlement Losses Trend Analysis indicated that it was appropriate to reduce the previous 5.75% of sales volume for total network losses to 5.25% in order to set the 2017/18 Line Loss Factors (LLFs). This was due to the settlements data showing a 0.74% gap between the corrected and uncorrected losses. This is why you can see a sharp decline in the green SEPD losses line after 2017. It should be stated clearly here that this is due to a calculation change rather than a deliberate attempt to reduce losses through targeted practices e.g. increasing cable size.

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 has a number of limitations. For example, today's domestic metering does not record when energy is used in between each reading – this means it is not possible to completely align measurements of energy entering and leaving our network. Similarly, this sum is complicated by uses of energy which are not metered i.e. street lighting or fraudulent use (theft).

Technical losses are also a function of the resistance of the network and this in part is dependent on the length of circuits. It is primarily this latter feature that results in losses, depicted in Figure 1, being higher in SHEPD than SEPD. Whilst there is less electrical demand on our network in SHEPD, energy generally has to be transported over a far greater distance.

The way in which we manage our network can also help to reduce losses. Firstly, we have worked to ensure the measurements of energy entering and leaving our network are as comprehensive as possible using the metering data available at present – this helps to ensure the calculation of losses is as accurate as it can be. Secondly the way in which we plan, operate and maintain our network can help reduce losses. For example, the specification of the plant and equipment we install or the physical configuration and design of the network can have an impact on the amount of energy lost in the process of power distribution.

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 intention in ED1 is to utilise more detailed prediction of load duration values to feed into the Ofgem specified societal CBA in order to quantify the lifetime benefits of lower loss plant. 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 or not 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.

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.

As discussed in previous sections the total energy lost in a transformer is a combination of the fixed losses (generally referred to as the Iron loss) and the variable losses (known as Copper 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. All transformers must now comply with the EU Transformer Ecodesign Directive[1] Tier 1 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 being implemented in 2015 and the second in 2020. This means that it will be mandatory for all EU network operators to purchase transformers that meet or better the efficiency criteria set out in the directive. This directive will significantly reduce losses associated with transformers, although we have not calculated these loss savings as this is now a regulatory and legal requirement. We only calculate loss savings in this strategy document that exceed minimum requirements due to internal policy changes specifically designed to reduce losses.

3.1.2. Replacement of historical transformers

We replace transformers based on asset health, rather than on an age related replacement basis. This means that we have significant numbers of transformers on our network that pre date a range of design specifications. We believe that some of these transformers have significantly higher losses than a comparable modern unit and hence, it may be beneficial to replace the asset before end of life from a losses perspective. To date we have not yet replaced any transformers purely due to losses but we will continue to review the benefits of early replacement throughout RIIO-ED1

3.1.3. Minimum sizing of transformers

Over sizing transformers for a predicted load has the advantage of future proofing sites for potential load growth, although this does have an associated additional cost over the minimum scheme. However, in addition to providing extra capacity the larger capacity equivalent transformer will generally reduce losses. We have completed analysis to consider the lifetime benefits of oversizing transformers and discontinuing the use of minimum size units. Over and above the losses benefit this measure could help facilitate procurement discounts and reduce the stock holding requirements at our operational depots with fewer equipment variations available.

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

3.2. Conductors

An increase in the capacity of the cross-sectional area of a cable reduces the impedance and hence reduces losses. The analysis completed in this area has not considered the proactive replacement of cables or overhead lines as the conductor costs form only part of the total cost. The CBA work has considered the benefits of installing larger conductors and the implications of discontinuing the minimum size conductors currently specified. Analysis was completed at LV, 11kV & 33kV. Again, there are additional benefits to reducing the number of conductor sizes available; from increased procurement buying power to a reduction in jointing requirements between cable sizes. These additional benefits are not quantified within the CBA.

3.2.1. Conductor type

Increasing the cross sectional area is a beneficial action in reducing losses, however an alternative is to change the conductor material from aluminium to copper. Copper has a lower resistivity for equivalent cross sectional area and therefore, less energy is lost for the same power transfer. The downside is that copper is more expensive than aluminium alloy, hence from initial cost perspective aluminium is normally the preferred option. Lifetime cost analysis to include losses is reviewed as part of our procurement process in order to determine the most cost effective conductors. Presently Aluminium conductors remains the most cost effective 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 the voltage from 6.6kV to 11kV can reduce losses by approximately two thirds, for the same power transfer.

It is possible to upgrade some networks to a higher voltage utilising existing cables without significant additional costs. This upgrade, although capacity driven, will consider the loss savings over the lifetime of the equipment to provide a robust CBA as to whether a particular network should be upgraded. In particular, the upgrade of legacy 6.6kV networks to 11kV has, in certain circumstances, proven to be a cost effective measure for capacity upgrades with significant associated losses savings.

4. Potential methods of improving losses

4.1. 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 sum of the customers may not be. The solution for this could be to install filters at strategic points on our network.

Improving the harmonics on the network will improve the losses, however the energy associated with the equipment operation to improve harmonics is potentially greater than the value gained through improvement in network losses.

4.2. 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. There are multiple methods to reduce imbalance from altering network configuration to installation of balancing equipment and the CBA considers the value of the lost energy from imbalance.

4.3. 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, and hence 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. Ongoing work has modelled the typical power factor on our networks and the costs of improving power factor at different voltage levels from a losses perspective.

4.4. Network configuration

Networks are electrically separated via switches colloquially called 'Open Points'. These open points are strategically positioned to optimise customer numbers, load and to also 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 is beneficial to modify the existing circuits or substation configurations to enhance the operational flexibility of the substation, this can lead to loss reduction benefits in some cases.

4.5. Switching out underutilised plant

At times of low load at twin or triple transformer sites it is theoretically possible to switch out one of the transformers. This would save total losses when the combined iron losses are greater than the combined copper losses – generally this occurs when the site is loaded less than 45% of its given rating. A simple algorithm could be implemented to switch the plant back in when load increases to provide the optimum losses profile annually.

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. SEPD are currently investigating this approach as part of a Low Carbon Networks Fund (LCNF) Tier 2 project; 'LEAN'[2].

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

5. Measures outside our direct control

The most significant factor governing losses on our networks is the magnitude, length and frequency of peak power flows. These power flows are determined by the nature of the demand and generation customers connected to the network. At present there is limited scope for DNOs to influence these power flows. However, learning from innovation projects and the future Smart Metering rollout have suggested that there is scope for this to potentially change.

5.1. Demand side response

Again, an area where we see significant potential benefit in terms of reducing network peak, however, at present this is not fully within the control of the DNO. The most simplistic form of demand side management is the historical off peak tariffs offered by suppliers to charge space and water heating overnight.

At present we have a number of innovation projects in this area, such as SAVE and NiNES, that have provided positive results in terms of reducing peak demand and hence a losses benefit. The projects range in scale and scope; from domestic customers offering control of heating or electric vehicle charging, up to controlling the building management system of large commercial customers.

The management of demand in this manner will be of interest to the system operator and supply businesses. Work is currently on going led by the Energy Networks Association (ENA) in the form of working groups such as those within the Open Networks Project.
The aim of the Open Networks project is to smooth the transition towards DSO where one workstream looks specifically into Distributed Energy Resources (DER) such as demand side response (DSR). It also to avoids unnecessary competition between electricity network operators by sharing learning outcomes.

Flexibility continues to be a key element of a number of SSEN ongoing innovation projects, this includes the TRANSITION NIC project and the associated Local Energy Oxfordshire project funded from the UK Government's Industrial Strategy Challenge Fund. These projects are seeking to demonstrate both SSEN's capability to operate as a DSO and more importantly to support the development of a local energy system in Oxfordshire. If successful, this will see further development of local generation in the county, which will be closely linked with local flexible demand. This local production and consumption of energy should lead to an improving losses performance compared with traditional alternatives.

6. Analysis conclusions

This section describes the measures we have considered implementing with the primary objective to reduce losses on our networks. The measures in Green will be implemented at the outset of ED1. The measures highlighted as amber have potential to be implemented with ED1, however more analysis is needed and the red measures will not be implemented. The figures quoted have been updated to reflect the latest CBA and to include the predicted connections figures. Accurate figures on the numbers installed will be submitted as part of the annual RIGS reporting packs 'E4 Losses'.

Key:
Green = Positive CBA
Amber = Further work required to confirm CBA
Red = Negative CBA

6.1. Capital measures to reduce losses

Low loss transformers

We have updated our procurement policy to ensure all purchased transformers exceed the EU Ecodesign Directive minimum requirements from a losses stand point. Going forward we will consider this standard as our baseline when considering losses savings i.e. we only account for losses savings if we have specifically chosen transformers that exceed the EU Ecodesign Directive minimum requirements for losses reasons (as oppose to financial or technical reasons).

Super low loss transformers

The cost of installing super low loss transformers is extremely expensive. The high capital costs in this instance did not pay back over the life of the plant. Therefore, we are not planning on implementing this initiative. The larger size of the equipment was an additional factor that made this intervention unfeasible.

Minimum sizing of transformers

We have considered the industry findings and completed an analysis internally of the numbers of minimum size transformers we intend to install within ED1. The potential savings do not appear to pay back significantly, unless the predicted loading level is high. Despite the marginal case for implementation we intend to increase our minimum size three phase transformers to 500kVA ground mounted transformers (GMT) and three phase 50kVA pole mounted transformers (PMT), but may exclude pad-mounts, split phase GMTs, small sized PMTs. This has now become our procurement standard. However, under special circumstances, such as space restrictions, we may install smaller bespoke units. We feel that the additional benefits of standardisation and the procurement advantage make it a worthwhile measure to implement.

Minimum cable sizing at LV

We have considered the benefits quantified in the industry and from other DNOs in conjunction with our own modelling and have made the decision to upsize the minimum cable size from 95sqmm Wavecon up to 185sqmm Wavecon for the majority of new installations. In some instances, it may not be possible to upsize due to space constraints.

Minimum cable sizing at 11kV

We have considered the benefits quantified in the industry and from other DNOs in conjunction with our own modelling and have made the decision to upsize the minimum cable size from 70sqmm XLPE up to 150sqmm XLPE for the majority of new installations. In some instances it may not be possible to upsize due to space constraints.

Minimum cable sizing at 33kV

We have considered the benefits quantified in industry and from other DNOs in conjunction with our own modelling and have made the decision not to upsize the minimum cable from 95sqmm Triplex XLPE up to 240sqmm XLPE for new installations.

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. This upgrade although capacity driven will now consider in detail the losses savings over the lifetime of the equipment to provide a robust CBA as to whether a particular network should be upgraded.

Replacement of historical high loss transformers

The work completed under a joint IFI project, 'Management of electricity distribution network losses' [3] by Imperial College and SOHN Associates, funded by Western Power Distribution & UK Power Networks provides an analysis of historical transformer losses. Secondary transformers installed before circa 1960 have a significantly higher combined fixed and variable loss than modern equivalents. It is therefore cost effective to replace these units before end of life with modern equivalents. However, as stated previously this is not currently occurring as replacement of transformers is done on a health and criticality basis, which is deemed to provide greater customer benefits than replacement specifically for losses. This will be reviewed over RIIO-ED1 to identify if priority replacement can take place without adversely affecting the health and critically programme that currently exists.

6.2. 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, including the LV network, where the power factor is low enough to justify intervention and further analysis will be completed throughout ED1 to ascertain this information.

Switching out underutilised plant

SSEN's Low Energy Automated Networks (LEAN) LCNF project has developed and applied Transformer Auto Stop Start (TASS) technology to reduce losses at 33/11kV primary substations.

The key principal 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 and control

[3] http://www.westernpower.co.uk/docs/Innovation-and-Low-Carbon/Losses-strategy/SOHN-Losses-Report.aspx

this 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.

This takes forward the work completed through the Losses Reduction IFI project, which identified two methods for reducing losses:

- Transformer Auto Stop Start (TASS) - this is the automated switching out of one of the transformers in a primary substation at times of low demand to reduce energy losses
- Alternative Network Topology (ANT) - this would make use of existing 11 kV feeder automation where available to allow a TASS site to operate in parallel with an adjacent primary substation

However, the conclusion from the CBA undertaken in the first phase of the LEAN project is that it is not considered financially viable to deploy ANT alongside TASS.

The TASS system commenced trial operation in June 2018 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. A suite of monitoring approaches are being used to obtained asset health and power quality data to evaluate any potential implications associated with the deployment of TASS.

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. However, 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. More work is required here to understand these costs before we implement this system on a broader scale.

Power quality

The area of power quality has been one of significant interest, from the uptake of low carbon technologies connected to our network. We investigated the impact of active harmonic filters within the New Thames Valley Vision[4] project on the LV network as part of an energy storage deployment. From our analysis it was clear that problem is not as significant as had been

[4] www.thamesvalleyvision.co.uk

predicted and therefore, the scope to reduce losses is minimal. This factor in combination with the energy consumed by the harmonic filtering equipment dictates that we will not be installing devices to mitigate harmonics for the sole purpose of losses reduction in ED1. There may however be instances where we have significant harmonic problems that justify the installation of this equipment from a power quality perspective.

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 and needs to be for a sustained period of time for the losses saved to outweigh the energy consumed by the device itself. Cost benefit analysis suggests that the benefits are so marginal that it will be hard to find any application for this technology. However, we will review this technology over RIIO-ED1 to see if there are specific circumstances that could lead to this technology providing positive benefits.

6.3. Innovative measures to alter network power flows

EV smart charging

The work we are completing in the area of smart charging will not reduce losses from today's baseline. However, it will significantly reduce the potential demand peak should Electric Vehicles (EVs) become widespread. This reduction in potential peak will limit the additional losses associated with EV charging. There is however a significant area of uncertainty on the uptake of EVs – we believe greater uptake will be seen in the last four years of ED1 and into ED2. The successful outcome of our LCNF Tier 2 project 'My Electric Avenue[5]' will provide a tried and tested means of managing peak power flows from EV charging and could be implemented to reduce losses. However, there is uncertainty here as DNOs may not be able to control power flow, but this could still be done by 3rd parties. Building on the success of 'My Electric Avenue', SSEN launched the Smart EV project [8] which set about informing the development of an Engineering Recommendation for smart charging.

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http://www.smarternetworks.org/project/nia_ssepd_0026 [6] https://www.ofgem.gov.uk/ofgem-publications/84803/lcnfsubmissionfromsepd-solentachievingvaluefromefficiency.pdf

Customer energy efficiency measures

We are currently investigating the potential benefits of efficiency measures targeted at customers connected to the same feeder circuit / substation. This particular methodology is being investigated by our LCNF Tier 2 project 'SAVE'[6]. If it is possible to implement this method to reduce peak demand, at a cost less than traditional network upgrades, there will be a losses benefit from both network peak loading and customers' domestic loads. We intend to alter the way we complete the analysis of this method to account for the benefits from losses, based on the outcome of these projects.

SSEN are currently developing this approach further with the launch of our Social Constraint Managed Zones project. This project looks to put in place a framework which will help communities improve energy efficiency in the local area, to provide constraint management services for DNOS. The project has recently started and is currently engaging with a number of communities across our southern distribution area.

Energy storage

From the extensive work we have completed in energy storage projects and the specific modelling of utilising energy storage purely for losses mitigation we have a very good understanding of the potential benefits. The CBA work completed within our Innovation Funding Incentive (IFI) project 'Losses Reduction Study' demonstrated that it is not cost effective to implement storage to reduce losses alone. We will however consider losses in more detail when making a justification for energy storage. However, we are mindful of the general presumption against DNOs owning and operating Energy storage, so any storage projects will most likely be carried out by third parties.

[6] https://www.ofgem.gov.uk/ofgem-publications/84803/lcnfsubmissionfromsepd-solentachievingvaluefromefficiency.pdf

7. 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, impacts can't be predicted in the same manner as the technical losses section. Therefore, we have not assigned numbers in MWhs to the losses savings expected from this team.

7.1. Network protection team

To support both SHEPD and SEPD we set up a new Network Protection team at the end of 2014 in preparation for the ED1 price control. The team consists of 10 staff members focused on MPAN (Metering Point Administration Numbers) discrepancies, e.g. sites without MPANs or historical MPANs that must be closed off. In 2018/19 the team were able to investigate ~4421 records per month and resolve on average 724.

Network protection implemented activities include:

- Planning and also undertaking targeted customer site visits along with network plant and equipment inspections;
- Responding to network tampering notifications and 'tip-offs' from a range of stakeholders;
- Making installations safe;
- Effecting repairs to electricity services and mains supplies;
- Assessing unrecorded energy and updating information systems accordingly;
- Liaison with enforcement agencies;
- Participation on industry and government groups regarding energy theft;
- Storing meters, network plant and equipment where interference has been identified for evidence purposes;
- Provision of stakeholder training and awareness initiatives; and
- Preparation of cases for enforcement action and pursuing prosecutions.

7.2. 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 intend to 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.

7.3. 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.

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8. Conclusions

The work completed as part of our losses strategy has demonstrated that there are a number of challenges facing our network in terms of keeping losses at the existing levels of ~5-7%. The increase in distributed generation that must be accommodated and the additional electrical demand, from the electrification of heat and transport, dictate that peak demand and network utilisation will increase. This will inevitably increase losses on our networks if the network remains unchanged.

Despite the discussed challenges there is scope to implement capital, operational and innovative measures to reduce losses over the *do nothing* scenario or to stop losses increasing significantly above the existing baseline.

The total energy we expect to save is close to 34GWh and broken down in further detail in table 2. This is the saving from predicted measures and does not consider the potential savings from smart metering benefits or the work completed by our Network Protection staff.

Table 2 – Updated estimated savings from SSEN Losses Strategy through ED1

Intervention	**Anticipated energy saving through ED1 (MWh)**
Transformers that exceed EU Ecodesign Directive minimum requirements	Significant savings but not reported as this is considered the new baseline
Upsizing three phase 500kVA GMTs and 50kVA PMTs	1,140
High & low voltage minimum cable upsizing	32,904
Total	34,044

In additional to the measures we intend to implement to address technical losses we have detailed our strategy to manage non-technical losses through Network Protection team. Although it is not possible to quantify the expected savings in the same manner as the technical losses sections we believe that the Network Protection team can make an important contribution to both settlement inaccuracies and non technical losses.

From a long term perspective, we see the smart metering rollout, despite the additional energy required to operate the equipment, as a key facilitator in the mitigation of network losses. This saving we believe will come primarily from the implementation of time of use tariffs and hence a reduction in peak power flows. Secondly the facilitation of DSR and improved losses monitoring will provide further benefits to DNOs to keep losses as low as reasonably practicable.