Tranche 2 Losses Submission

Scottish & Southern Electricity Networks

Executive summary

Scottish and Southern Electricity Networks (SSEN) as a responsible network operator are fully committed to leading the industry in our understanding and reduction of network losses.

Since our initial Tranche 1 submission, we have continued to:

- develop our understanding of the cause of network losses;
- make losses a key component of our BAU activities;
- engage with key stakeholders to increase our knowledge and share best practise;
- identify methods of utilising new data sources such as smart meter data to manage losses; and
- continue to identify innovative new solutions for managing losses.

SSEN has a long established well embedded commitment to sustainability. As one of our core corporate values Sustainability has been defined as – **'Our decisions and actions are ethical, responsible and balanced, helping to achieve environmental, social and economic well-being for current and future generations'.** Reducing losses will help to support this commitment to operating a sustainable distribution network.

In addition, we have further developed our understanding of the emerging trends that will influence losses in future. This will include increased volumes of electric vehicles (EV), energy storage and the use of flexibility resources as we move toward a Distributor System Operator (DSO) operating model. Our work to date has clearly demonstrated that network losses are a complex issue, driven by a wide range of influencing factors, many of which are outside our control, and if considered in isolation can be difficult to address cost effectively. Therefore, we have moved to adopt a strategy which is based on taking a more holistic and targeted approach to managing the Low Voltage (LV) network, using the new sources of data available to us to determine areas of the network which may have issues with losses, headroom for EV connections or require maintenance.

Addressing each of these issues in isolation is not cost effective, however, by taking a holistic approach and addressing all the issues simultaneously allows the benefits to be "stacked" improving the financial viability. Therefore, we have further refined the concept of Losses Teams described in our T1 submission to move to a Network Efficiency Team to allow us to realise the incremental benefit of addressing multiple issues simultaneously. Therefore, our focus during Tranche 1 has been on identifying and evaluating each of these potential benefits streams, to better understand their viability. This includes using new data sources such as network monitoring and smart metering data combined with external data such as EV registration and innovative analytics to allow us to identify these areas of the network and target them for attention. We have also continued our work on non-technical losses by monitoring and evaluating energy consumption in our key substation sites and by raising awareness of power theft through a successful media campaign

Throughout this document, we will describe the work we have undertaken since our previous submission and the plans we have for the remainder of ED1. We are determined to continue to drive down the cost to customers from losses; only by taking a proactive approach, considering losses in all of our activities, working with a broad range of stakeholders and exploiting new sources of data will we be able to achieve this. We have made solid progress since our initial submission and we will continue to build on this to achieve the best outcomes for customers.
In summary during the last two years we have moved significantly closer to deploying an evidenced systematic, comprehensive justified programme of losses reduction as part of our wider approach to network efficiency

Colin Nicol
Managing Director SSEN

Our Vision – a Holistic Approach

Scottish & Southern Electricity Networks

In this submission, we will describe our achievements to date and set out our future plans. This will build on our earlier work and allow us to further develop upon our strategy for managing losses.

SSEN are absolutely committed to ensuring that losses on the network are managed as effectively as possible to reduce the impact on customers. Our goal is to identify and cost effectively tackle losses to reduce them to the lowest practicable level. The learning from our T1 work has provided a firm foundation for us to progress toward this objective and we have already implemented measures into our BAU activities. The learning and outputs from work undertaken during T1 support our original principles of knowing **where** to intervene, knowing **how** to intervene and ensuring that we intervene **effectively.** As set out below;

- Understanding **where** to intervene;
  - we have concluded our Losses teams study and have developed a better understating of where losses appear in the network. From our ongoing work on the deployment of EVs we have recognised a strong correlation between networks which are likely to have high losses and those which may require attention to allow EVs to connect;
  - from our work with the University of Strathclyde and TNEI we have begun to prepare for the utilisation of smart meter data to let us better identify losses;
  - we are working with the Office for Low Emission Vehicles (OLEV) to access the data which will allow us to identify where EVs are connecting on the network. This will allow us to identify "clusters" of EVs, and we will combine this data with our substation monitoring data and smart meter data to identify networks which may require intervention;
  - we have identified best practise in losses management from other sectors and internationally to refine our approach; and
  - we have undertaken detailed studies at a community level to understand the impact on losses as the volume of LCT increases.
- Understanding **How** to intervene;
  - by working with the supply chain in a number of our ongoing innovation projects we have developed tools which allow us to monitor the LV network in a cost-effective manner crucially, without the need to interrupt customers, supplies. SSEN are funding a "business as usual" project to roll out a further 250 sets of this monitoring equipment to gather further details on power flows on the LV network; and
  - by working with UKPN we have undertaken detailed studies to establish best practise for connections close to the DNO boundaries.
- Intervening **effectively;**
  - we have undertaken a successful media campaign to raise awareness of the risk and cost of power theft, this included press, radio and TV coverage. The material was also widely on social media, and is amongst the most successful SSEN has ever delivered;
  - we have continued to be active in supporting the work of the ENA Technical Losses Forum; and
  - losses management is now embedded within the SSEN Network Investment Strategy for the first time.

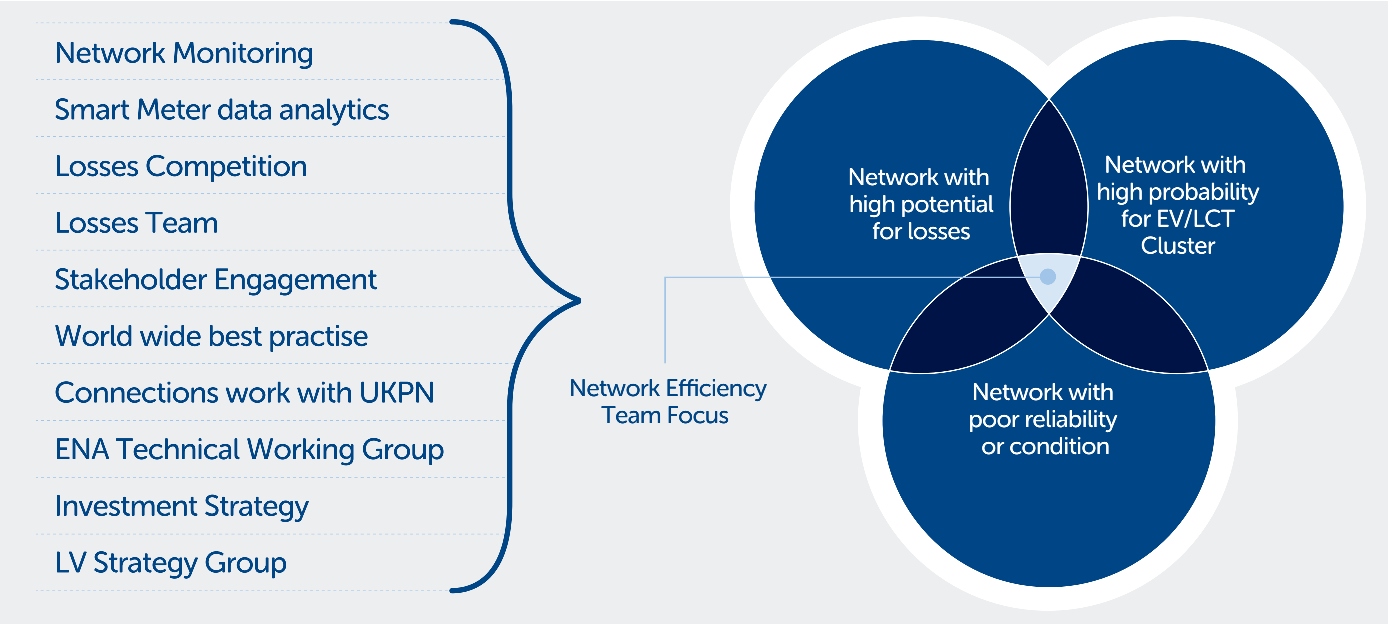


Figure 1 – Network Efficiency Teams

This key learning outcome is that losses are a complex and multi-facetted issue which are challenging to address cost effectively in isolation. Therefore, we have had to change and rethink our original Losses Teams proposal to develop a more rounded and holistic solution.

Network Efficiency Teams – Our Vison Updated

The outputs from our Losses Teams project demonstrated that we can identify sections of the network which are likely to suffer from higher losses by the intelligent use of existing and new data sets. However, the financial analysis on the deployment of suitable remedial interventions proved that addressing losses in isolation is very challenging.

Despite this, we firmly believed that Losses Teams was a sound concept, therefore, we evolved our thinking to consider losses as part of a more holistic approach to managing the network. From the work, we had done it was clear there were strong synergies between those networks which experience high losses and those which had limited headroom for the connection of EVs i.e:

We followed a similar philosophy when considering reliability and condition issues. Taking this holistic approach allows the benefits to be "stacked", significantly improving financial viability. Therefore, we began to reassess the Losses Teams concept and reshaped it to reflect this holistic approach we have named – **Network Efficiency Teams.** This is outlined in Figure 1.

The key premise of the Network Efficiency Team is to identify these areas of the network where multiple issues occur and can then carryout a series of interventions to resolve any issues.

Our key focus during T1 has been to develop an understanding of how to identify these sections of the network. The various initiatives we have delivered in T1, some of which are shown in Figure 1, have delivered learning which has helped us to better understand the data we require to identify the networks to target, the cost of collecting that data, how we can use analytics to help minimise this cost and to add to the current portfolio of interventions available to us.

In summary, we have concluded that in order to meet our ambitions for losses efficiently and cost effectively we have to simultaneously address other network related opportunities. With the implementation of the measures in our published Losses Strategy, and the outcomes from our T1 programme of work, we have built a solid base upon which to move forward. Our plans for Tranche 2 and beyond will see us develop further knowledge and identify firm interventions to make a material difference to losses on the network.

A. Understanding Losses

1.1 Demonstrate how are continuing to improve their understanding of the current level and sources of losses on their networks (including through the use of smart meter data)

Through our Tranche 1 activities it was clear that by utilising a combination of data from smart meters and substation monitoring it is possible to identify networks which are most likely to be subject to high losses (see CIRED paper in Appendix 1). However, it also became apparent that it was much more challenging to identify cost effective options for addressing losses on existing networks, if they were to be treated in isolation.

In developing our strategy on how best to manage the anticipated rise in EV numbers, we identified that there is a strong correlation between the types of network which will be impacted by EVs and those which are likely to be incurring high losses. Therefore, we have focused our efforts on trying to gain a better understanding of these networks and develop a range of interventions to address any issues.

The LV network is an area where we have traditionally had limited visibility which has generally been operated on a "fit and forget" basis. However, rapidly changing demands on the LV network necessitate a move to a more proactive approach, where we can make capacity available for customers to connect EVs, simultaneously address losses and any other network issues.

Key to this is being able to develop a cost effective approach to understanding power flows and loading on the network. It is also important to understand how these will alter as demand on the network changes with the connection of EVs etc. Therefore, we have developed an approach to understanding losses which is based on a combination of the factors shown in Figure 2:

- **Substation monitoring** – we have successfully installed low cost substation monitoring equipment, which could be widely deployed;
- **Smart meter data** – when available, to understand customer demand; and
- **Analytics and new data sets** – we will use analytics to better estimate demand if data is not available.

Our work to date has shown that managing losses is very cost sensitive, therefore, it is important that the collection of the data required is achieved without entailing excessive cost. Importantly, the use of multiple sets of data allows us to optimise the deployment of monitoring equipment.

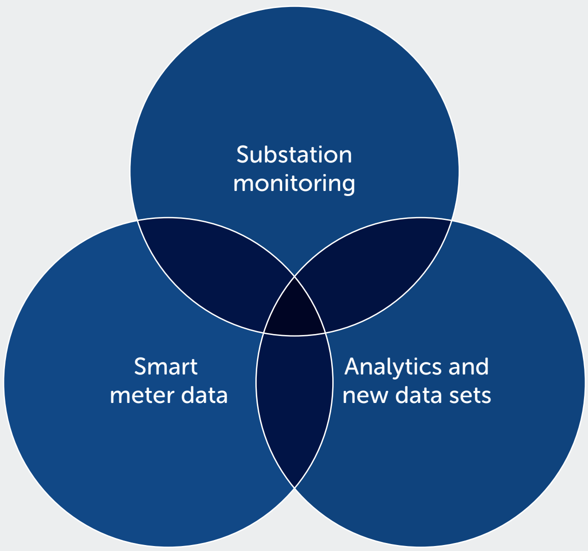


Figure 2: Overlapping Circles Diagram

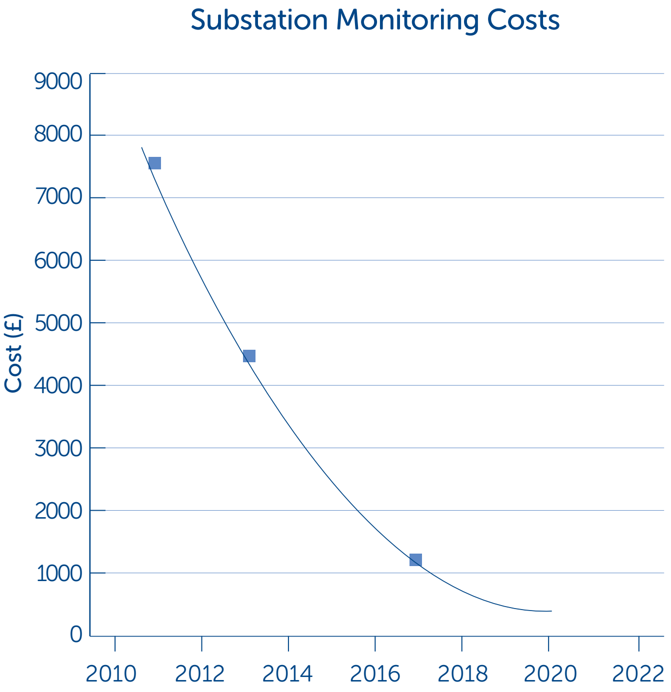


Figure 3: Low Cost LV Substation Monitoring Cost Curve

1 Low Cost Substation Monitoring

Improved visibility of the LV network has long been recognised as being key to our understanding of losses as well as many other network issues. The learning from our initial deployments of substation monitoring in our LCNF New Thames Valley Vision project informed the specification for the equipment. This has been continued through our ongoing NIA project SSEPD 0027 – Low Cost Substation Monitoring project. By working with the supply chain and learning from the initial installations, the improvements in the design and installation practise now make it economically viable to fit LV monitoring devices in large volumes to secondary substations. The equipment can be retrofitted into the majority of substation designs without the need for an outage.

The improvement in unit costs is shown in Figure 3 above. The NIA project has installed monitoring in approximately 250 substations and SSEN propose to fund the installation of an additional 250 sets of equipment. The procurement process to commence the deployment is currently underway.

2 Preparing for Smart Metering

University of Strathclyde Study

In conjunction with the roll out of our LV monitoring we need to be prepared to make best use of the data from smart metering. From the Losses Teams project we know that the combination of smart meter data and monitoring can provide robust information on network conditions. Therefore, we have been working along with our Smart Metering team to understand how best we can use the data available. However, it will take some time for the roll out of SMETS 2 meters to be completed and for the existing SMETS 1 meters to be able to communicate with the DCC and be available to DNOs. Therefore, SSEN commissioned a study with the University of Strathclyde (UoS) to look at the penetration of smart metering required to allow for the estimation of network losses.

This was achieved by using actual test data from a previous research project in which a typical residential network in which all of the 123 premises had been fitted with a smart meter and the low voltage feeders had been monitored. Using this data, a model was created to calculate the network losses. Over the study period of 101 days, network losses were calculated to be 7.2 MWh or 4.6%. The model was then rerun with different penetrations of smart meter data (1,2, 5,10 and 61 (~50%)).

Unsurprisingly, the largest variations in approximation accuracy are exhibited through the use of one smart meter. Increasing the number of metering devices within a network was found to improve the approximations of total losses, with the best estimation offered by 61 smart meters, or 50% of the consumer data within the network. However, the study showed that even at smart meter penetrations of as low as ten percent it was possible to make a reasonable assessment of losses.

This work has provided valuable insight into how smart meter data can be used to estimate our losses within a residential network, without having a full set of smart metering data available. This gives us confidence that we can start to utilise smart meter data at relatively low levels of penetration, if it is combined with substation monitoring to help us to identify losses. We will continue to refine and develop this approach with further work planned in this area.

Losses Competition

To help us further understand losses we looked for international best practise. From our Losses Competition, we identified the work of Canadian utility BC Hydro and their supplier Awesense. In conjunction with Awesense, BC Hydro introduced innovative methods to reduce the 850GWh of power theft and losses that it faced each year. In the three years since the project started, losses have been reduced by over 50%. The BC Hydro area has very high levels of smart meter penetration and this data was key to the success of the project. SSEN have funded a pilot project with Awesense to assess if a similar approach could be successful in GB. Further details of this pilot project are described in Section 3.

Smart Fintry Project

In addition to understanding losses on our network, we recognise the importance of looking to the future and developing an understanding of the impact of changing demand patterns caused by the uptake of LCTs, EVs and potential new retail models including more local energy trading.

While the ENA Technical Losses Task Group commissioned a study to model the impact of various levels of LCT deployment, SSEN sought to understand the specific impact on areas which have community owned renewables connected and where there is a strong desire to move to a more localised energy market. In the move to a DSO model it is likely that localised energy markets will become more prevalent; thus this scenario could become commonly adopted.

To understand the effect of LCT uptake, we commissioned a project in conjunction with Fintry Development Trust on the Smart Fintry project. Smart Fintry is a community project based in the Stirlingshire village of Fintry, pioneering a new way of trading and charging for electricity, enabling householders and businesses to buy their electricity directly from nearby renewable energy generators, using the existing electricity grid infrastructure. The project has been funded by the Scottish Governments Local Energy Challenge Fund [1].

Fintry's network has been modelled by TNEI to assess the behaviour of the existing network as a baseline and forecast future behaviour in 2030 and 2040 under different, load profile altering, scenarios. These scenarios include deployment of EVs, PV and energy storage as well as using demand side management (DSM) and other flexibility solutions to optimise the use of locally produced energy. The outputs demonstrate that there are opportunities for local DSM solutions and other customer-led network solutions to delay reinforcement and mitigate LV network losses.

This builds on the learning from SSEN's previous work with local communities on Mull and Shetland where local DSM solutions have been trialled and proven to be successful in reducing losses. This is an area which SSEN has actively promoted in our recently published "Supporting a Smarter Electricity System" [2] document which sets out plans for transitioning to a DSO.

3 Analytics and New Data Sets

Smart meter data and substation monitoring provide a useful understanding of demand levels on the network which we can use to derive network losses. However, the cost of monitoring the entire network is likely to be prohibitive and there will be areas where monitoring is impracticable for example in rural areas with predominantly overhead network. The work by UoS, Awesence, TNEI and ENA TLTG alongside our earlier learning from NTVV have shown that data analytics can be a crucial tool in leveraging additional value from the data that is available. We will also look to combine our analysis with other data sets such as EV registrations, fault information and asset condition data to determine the optimum places to intervene.

Conclusion Our proactive approach has shown that by optimising the use of monitoring, smart meter data and analytics is possible to identify the areas which are suffering from losses in a cost effective fashion. The crucial first step is to be able to identify these areas cost effectively, then target interventions to allow benefits to be "stacked" This approach maximises the potential for benefits without excessive cost to customers. We will continue to trial this concept throughout T2.

1 (http://smartfintry.org.uk/)

2 (https://www.ssepd.co.uk/SmarterElectricity/)

Substation Non-Technical Losses — As well as looking at technical losses on the LV network we have also continued our work to understand non-technical losses. A key area of focus has been energy consumption at our larger substation sites which is defined as a non-technical loss due to it being unmetered, making it difficult to quantify and identify the primary source.

Initially, SSEN deployed monitoring equipment at Tealing Substation near Dundee in order to understand the non-metered usage at the sitefor heating, lighting and building utilisation. Edinburgh Napier University then undertook a study which reviewed the current energy usage patterns at Tealing Substation and identified a range of intervention measures suitable for the building archetypes. By applying the readily accessible intervention measures identified by Edinburgh Napier University (such as lighting control and roof insulation) a saving of 161kWh/yr[2] could be achieved alongside a carbon reduction of $56tCO_2/m^2$. Based on the results from Tealing Substation and existing asset information, a desk top study was undertaken to extend the application across a similar range of substation archetypes. When this was extrapolated across the 47 buildings in the study it was found that savings in the order of 1.24GWh could be achieved through applying the readily accessible interventions.

Based on these results SSEN have committed to undertake further assessments to determine the practicalities of retrofitting these measures into existing substation buildings. Appendix 3 provides a more in depth view of the study and its results.

1.2 Are DNO groups considering the network in a holistic manner and making efforts to understand how losses and their actions to manage losses on their network affect others?

Considering the network in a holistic manner is critical for SSEN to understand and tackle losses. As described earlier, we have already implemented measures to manage losses in several key areas within our overall LV Strategy, which provides the opportunity to combine benefits and reduce costs for customers. For example, in our EV Strategy we are assessing our LV networks to identify areas of potentially high EV uptake and those that are likely to have limited capacity remaining. From this, we identified that there were strong synergies between those networks most at risk from overloading and those most likely to be suffering high levels of losses.

By combining investment on loses reduction along with investment in capacity improvements this enables us to deliver cumulative benefits for customers that are greater than the sum of each activity in isolation.

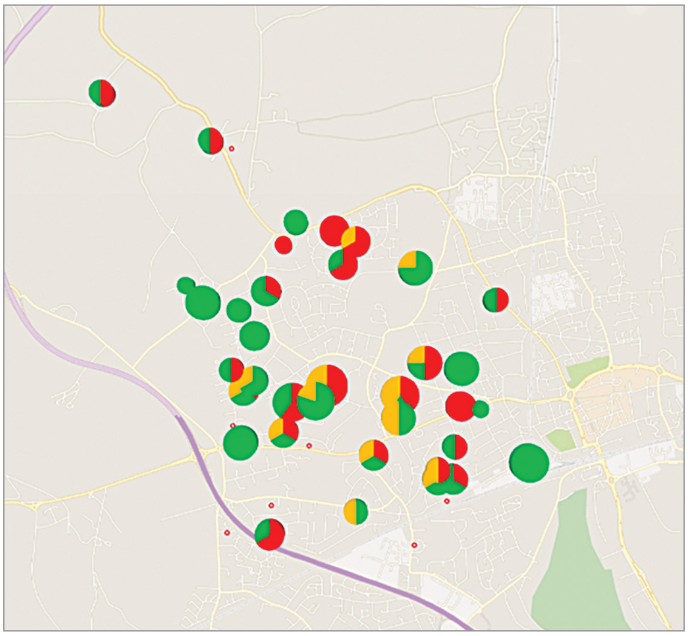


Figure 4: Network Capacity EV Uptake Mapping Identifying Headroom Remaining Per Customer

SSEN have long recognised the need to consider losses as an essential part of determining the best "whole system outcome" for consumers. Therefore, we have worked hard to ensure that losses are recognised within the ongoing Open Networks project and we have also included losses as a key consideration in our new NIA project – NIA_SSEN_030 – Whole System Growth Scenario Modelling.

This builds on the learning we have gained from our involvement in other local energy projects that have considered the wider energy system including our NIA SSEPD_011 Mull ACCESS project and and the Smart Fintry project. This has allowed us to look more holistically at our network in specific areas to understand different current and future energy scenarios and the impact that this will have on losses.

Possible Solution		Implementation Status
Installation/replacement of low loss transformers	✓	SSEN Implemented
Setting a minimum transformer size	✓	SSEN Implemented
Setting a minimum conductor capped for LV and 11kV	✓	SSEN Implemented
Load balancing equipment	?	Not financially viable in isolation
Load monitoring for power factor improvement	?	Not financially viable in isolation
Network Meshing	?	Investigating with LEAN

Figure 5: Interventions adopted by SSEN

Our work to understand and combat losses has also led us to incorporate losses measures into our BAU flexible connections and planning processes. The flexible connections process increases the amount of monitoring and data we have on our network which gives greater visibility of power flows and improves the network modelling for these areas, including assessment of losses. Our ambition is to deploy flexible connections more widely and this will further improve our ability to identify and address losses issues.

However, we recognise that there is a potential conflict between the use of smart interventions such as flexibility and the management of losses. It is crucial that losses are considered in any investment decision to ensure that the best long term solutions for customers are identified. Hence, losses have been specifically identified in our investment management process and any investment decisions now consider losses.

1.3 What improvements have DNO groups made since T1 and how has their understanding of losses developed? Can they identify areas (from T1) and have allowed them to improve their understanding of losses?

Losses Team Project

Following the Tranche 1 reward, SSEN commissioned TNEI Services Ltd. and Element Energy Ltd. to undertake a project investigating losses on our distribution network. The project aimed to identify and define losses, and the causes of such, in a sample area of our network consisting of four Primary substations with over 300 downstream Secondary substations. This task, commonly referred to as 'Losses Team', provided recommendations for several losses reduction interventions. Figure 5 presents the interventions delivered through the Losses Team and their SSEN implementation status. Our detailed studies have demonstrated that while losses teams could be effective at reducing losses alone, the cost per kWh recovered would not represent good value for customers. However, by stacking the losses reduction with other valuable benefits such as EV readiness, network reliability and lower cost asset management, we can obtain an economically justified losses reduction. To help alter mindset, we have deliberatively altered the working title of this approach from "Losses Teams" to "Network Efficiency Teams".

The outputs from the Losses Team work was disseminated across the industry via published paper at CIRED 2017 and via a knowledge sharing webinar hosted by SSEN. This work demonstrated that it was not cost effective to carry out many losses interventions in isolation and or without an appropriate market mechanism. The outputs from the Losses Teams project has helped evolve and change our thinking on losses and was fundamental in developing the evolution of the Network Efficiency Teams described earlier. We will also examine options for market based solutions to allow DNOs to procure procuring demand side services to help manage losses.

B. Effective engagement and sharing of best practice with stakeholders on losses

2.1 How are DNO groups planning to utilise stakeholder engagement to inform their losses management actions and allow them to understand their impact? How have DNO groups already engaged with stakeholders in this regard?

At SSEN we have been engaging with a range of stakeholders on both technical and non-technical losses. In our Tranche 1 Submission we identified that learning best practise from other industries, specifically water and gas was crucial to our understanding of losses. Building further on this we have also engaged internationally with other network operators and organisations who are also working to understand and reduce their own network losses.

Other Industry Sectors – During Tranche 1, we have engaged with a number of other network operators from the water and gas sector to develop a deeper understanding of their approach to managing leaks or shrinkage. It quickly became apparent that their preferred approach was to use a combination of data sources to identify networks which may be experiencing leakage. The process for the water industry was fairly similar across all of the companies we engaged with, namely:

- The network is split into a number of "zones" of between 1000-1500 customers. The volume of water flowing IN to these zones is measured and recorded by the water companies;
- The companies then use a combination of meter data (if available) and customer profiling to estimate the volume of water which is being used in these zones (i.e. flowing OUT);
- The data is profiled in half hour segments and the difference between the water flowing IN and the water flowing OUT gives a strong indication of the level of leakage in the network;
- This analysis is done across the entire network and is used to prioritise networks for further investigation and intervention; and
- Dedicated teams are then dispatched for further investigation and to and take any appropriate remedial action.

Appendix 5 shows the Portsmouths Water Four Pillars of Leakage Management process. The key learning from this is that the problematic networks are identified using accurate metering combined with metering data and customer profiling. Therefore, as described in the previous section we have embodied this approach of combining "top down" monitoring with "bottom up" analytics within our holistic approach to managing losses.

The engagement with the water companies also identified opportunities for similar in-field tools employed in the water industry to be trialled in our network to identify faults and non-technical losses. In addition to engaging with the water industry we also had discussion with SGN to identify learning that can be transferred regarding gas leakage and shrinkage.

We plan to maintain these relationships going forward and will continue to share best practise.

International Best Practise – during Tranche 1 we have also looked to identify and engage with best practice world-wide. Through our Losses Competition we were exposed to the success that Canadian company Awesense and their work with Canadian electric utility BC Hydro to tackle there 850 GWh of power theft each year. By employing a combination of smart meter data, existing SCADA devices and Awesenses monitoring devices and analytics platform, in 3 years BC Hydro have reduced network losses due to theft by up to 50%. Based on these results, and the fact that BC Hydro have a large penetration of smart meters we felt it was important to engage with Awesense to under-take a pilot project to demonstrate the learning that could be transferred to GB. The initial outputs are described in Appendix 8

Non Technical Losses – To help build further awareness of Non Technical losses SSEN developed the #NotWorthTheRisk campaign. This was an internal and external campaign deigned to raise awareness of the cost and safety implications of power theft. This included:

- The SSEN Electricity Theft webpage was updated. This acted as a foundation for Internal and External Stakeholders, and provided further information on identifying and reporting potential cases of illegal abstraction. There were also links to SSEN's collaborative partners stayenergysafe

3 https://www.stayenergysafe.co.uk/

	% Difference
Emails received	9.35
Calls received	17.54
Case files opened	21.05

Figure 6: Revenue Protection communication

- **Five Day Internal Awareness Campaign** – this was aimed at all SSEN staff members and included a briefing to the Managing Director and his senior management team. This formed the foundation for the Internal five day internal engagement launched at the beginning of February 2018; #NotWorthTheRisk.

- The Internal engagement had two objectives, firstly to raise awareness of the work the of SSEN's Revenue Protection team and also to increase awareness of Non-Technical Losses. The materials used provided information on how to recognise potential issues, in particular safety issues and also gave guidance on how to report issues.

In parallel, our external stakeholder engagement, was delivered collaboratively with Crime Stoppers and Stay Energy Safe, and ran across Twitter and Facebook. The objectives of the engagement are to Increase public awareness of electricity theft and the dangers it poses, promote the 'Stay Energy Safe' reporting portal and any other avenues of reporting electricity theft and to improve understanding of what customers should do if they think they come across electricity theft. The biggest medium for engagement was via Television and Radio with the campaign being broadcast across a number of TV and Radio stations and the iPlayer with an estimated audience of up to 1 million. Key messages included

- Electricity theft is not a victimless crime;

- Not only is it illegal it's highly dangerous;

- It's not only potentially fatal to the perpetrator, electricity theft can put neighbouring properties and the wider community at risk

- You can help: please contact us if you see anything suspicious.

The video used to support the campaign is available at – http://news.ssen.co.uk/news/all-articles/2018/february/electricity-theft-is-not-worth-the-risk.

Within the first week after the campaign Revenue Protection department received a significant increase in the volume of information received from a number of different channels, as can be seen from **(Figure 6: Revenue Protection communication):**

Again we intend to build and develop upon our successful campaign form the remainder of ED1

2.2 How are DNO groups engaging with stakeholders. This could include initiating a joint project where a reduction in losses is the primary driver or identifying opportunities with existing projects to help manage losses.

Throughout Tranche 1 we have collaborated with a range of stakeholders to build our knowledge and share good practise, this has provided valuable insights and learning which has helped shape the development of the "holistic approach" to managing losses we described previously.

Smart Fintry Project

Smart Fintry, is a community project based in the Stirlingshire village of Fintry pioneering a new way of trading and charging for electricity so that householders and businesses can buy their electricity directly from nearby renewable energy generators, using the existing electricity grid infrastructure. The project has been funded by the Scottish Governments Local Energy Challenge Fund with the aim to reduce both electricity costs and carbon impacts. Project partners include suppliers, metering companies, academia as well as local community.

SSEN have funded additional complimentary work to assess the losses within the Fintry network. While the primary aim of the project is not to directly reduce losses, we identified that it offered an opportunity to look at the impact distributed generation will have on network losses alongside LCTs and EVs. The modelling work also considered the impact of new retail models such as local energy trading could have on the network. Modelling the Fintry network and forecasting future behaviour we were able to demonstrate opportunities for local DSM solutions and customer – led network solutions to delay reinforcement and mitigate losses in the LV network.

DNO Network Boundaries

Historically DNOs have focused on managing losses within their own licence areas, but to find the optimal solution, a wider cross boundary view is required. SSEN and UKPN initiated conversations about the optimal solution with a large demand customer looking at connecting close to the boundary. Through the associated analysis, it became clear that there was a gap in our knowledge and further work was required to inform connection and reinforcement process optimisation at licence boundaries and this collaborative approach was committed to by SSEN and UKPN within our individual Losses Discretionary Reward submissions in 2016.

SSEN reviewed each of their boundaries and identified the interface with UKPN in the South of England being the most active currently. The two DNOs initiated a joint study, looking at LV and HV/EHV connections examples alongside infrastructure reinforcement schemes. Further details of the study can be found in Section 3.3, but the core findings highlighted a potential opportunity and has enabled SSEN and UKPN to define criteria on which to check new connections and infrastructure projects against before opening cross boundary discussions. Ahead of any new process being defined, testing is required to understand the scale of potential losses savings and how we can ensure any development still fits within regulations such as Competition in Connections and Data Protection. This will continue during Tranche 2.

ENA Technical Losses Task Group

The ENA Technical Losses Task Group has endeavoured to encapsulate learning from separate DNO initiatives, feeding this into its work to date. See Appendix 2 for further details. However, to effectively draw the increasing learning together and coordinate future efforts SSEN recognised that further collaboration was required.

Following discussion, the six GB DNOs have agreed to optimise losses stakeholder engagement in 2018 and 2019 through alignment of local communications and industry wide event collaboration. This has the potential to enhance knowledge share and facilitate future collaboration while improving the experience for our stakeholders. Additionally, to aid development of future losses projects and transfer to BAU, a workshop for the subject matter experts in each network organisation has been agreed in principal and is expected to be organised via the ENA Technical Losses Task Group.

ENA Open Networks Project

The ENA Open Networks Project looks at facilitating the transition to a DSO model. As we have learnt, network losses are best viewed as part of a wider system context, hence do not feature as a standalone Product within any of the Workstreams. Instead, they are to be considered in all relevant Products in 2018 and we would expect losses to play a more active role in the scoping of 2019 and beyond. The learning to date alongside planned work on losses in the coming months will feed into the agreed workshop to be hosted by the ENA Technical Losses Task Group. Outputs from this workshop shall pass directly into the Open Networks Project where applicable. This process enables SSEN and the other DNOs to further their work in this area, discuss learning as a peer group and pass a more refined set of outputs to Open Networks.

Joint Call for Innovation

To further build our collaborative working we have issued several calls for innovation in recent years. These have been issued either directly by SSEN via notifications on our website or via a more formal procurement route such as OJEU notifications. We have also issued calls via partner organisations such as the Energy Innovation Centre. The latest call was launched in late 2017 in conjunction with Electricity North West (ENWL) and listed a number of "challenge areas" including Efficient Network Development with a requirement to Reduce the visual and/or environmental impact. Overall the call for ideas yielded over 65 responses including many which are relevant to managing losses, specifically in areas such as whole system optimisation and use of data. These are currently being assessed by each DNO with a view to identify options for progressing these either directly funded by SSEN or via NIA or NIC funding.

2.3 Are DNO groups able to demonstrate that they have processes in place to share their own best practice with relevant stakeholder identifying any outcomes of T1 and what they intend to do/ carry on doing. This could include engaging with one another, the Transmission System Operator (TSO) and the Transmission Owner (TO) to facilitate a holistic and co-ordinated approach to losses management as they transition to DSO roles.

During Tranche 1 we have put in place a programme of dissemination activities to allow us to share our work across the industry. We intend to maintain and add to this programme throughout T2.

Future Networks Quarterly Newsletter

SSEN produce a quarterly newsletter “Future Networks”, which has a broad range of readership amongst over 1000 external industry subscribers. The September 2017 issue, contained details on our work to reduce technical losses entitled **“Network Losses, a £1bn problem for the GB Grid”.** The article underlined SSEN’s commitment to manage losses and introduced the SSEN Losses Strategy. The article also described the outputs from our Losses Team, along with an introduction of SSEN's Revenue Protection team. We will ensure that Losses is included in future editions of our newsletter.

Losses Teams Webinar – In addition to dissemination activities at LCNI and our quarterly newsletter we hosted a ‘Losses Team Webinar’ in 2017. The webinar entitled ‘Network Losses, a £1bn problem for the GB Grid’ shared detailed outputs from our losses team work and provided an overview of our future approach to managing network losses. The webinar was very well attended with over 100 external participants including attendees from other DNOs, TOs, suppliers, OEMS and other interested parties. The webinar included a Q+A session which allowed for a positive debate on reducing losses The webinar was very successful, receiving positive feedback from participants, as displayed in figure 7 the positive feedback we received from other DNOs and stakeholders on our losses webinar.

Losses Competition – During 2017 we also launched our Losses Competition through our collaboration and support of the UK Energy Innovation Awards. The Losses Competition was sponsored by SSEN through the UK Innovation Awards focusing on the reduction of network losses. With a prize fund of £10,000, the call we open on anyone with a process, technology or solution to for managing network losses.

Figure 7: Losses Webinar Feedback

The call was shared with over 1,000 SSEN contacts and more by the EIC as well as via various social media channels. in order to encourage stakeholders and suppliers to enter. The response from the competition was very successful with 14 entries from as far afield as Canada.

The competition was won by Turbo Power Systems, with Awesense and Grid Key as runners up. As described in section 2.2 one of the runners up was a Vancouver based company Awesense that had success in detecting non-technical losses with BC Hydro. Based on the Awesense submission and their experience with BC Hydro we decided to run a pilot project that looks at how this learning can be implemented to the UK. Gridkey have also been involved in the development of our substation monitoring equipment described earlier.

Due to the success of the losses competition we will expand this in the future to run a 'hackathon' by making data available to industry to encourage innovative thinking to solving losses problems. Potentially this will include data such as the outputs from the 250 sets of substation monitoring we are currently rolling out, suitably anonymised data from smart metering installations, asset data such as LiDAR and External data such as weather, EV registrations etc.

Given the importance of data analytics to the future success of loses management we feel that this should be an important area of focus for Tranche 2 and we believe that the "hackathon" will provide an innovative way of stimulating interest in the area. Again, SSEN are proposing to make a prize fund available for the hackathon.

2.4 DNOs must verify that any stakeholder engagement actions are not already rewarded under the Stakeholder Engagement incentive that forms part of the Board Measure of Customer Service to ensure the same activity is not rewarded multiple times.

We can confirm that none of the engagement activities described above have been included as part of our Stakeholder Engagement submission.

2.5 Following T1 what collaboration have DNOs had with each other and other stakeholders? How have they and how will they continue to ensure collaboration on losses management?

For the #NotWorthTheRisk campaign we approached stayenergytheft to work collaboratively with to aid engagement with stakeholders on Non-Technical Losses **Figure 8: SSEN Webpage extract.** Linking with stayenergysafe enabled us to tap in to their strong knowledge of energy theft and enabled their support on the campaign. Using such an organisation that is affiliated with Crimestoppers authenticated our messaging and creates a consistent approach to energy theft across all DNO's and Government Departments.

We wanted to promote a service that allowed customers to feel comfortable reporting electricity theft or interference, not just within our Central Southern England and Northern Scotland regions, but also outside of this into other DNO's regions. SSEN and stayenergysafe are keen on focusing their messaging around safety and have been the leaders in this for several years. By focussing on the safety concerns we feel that this is most likely to encourage customers to report suspicious activity.

As part of the #NotWorthTheRisk campaign we also updated our website to better align with stayenergysafe and promote their reporting form as a primary method to inform us about electricity theft.

Figure 8: SSEN Webpage extract

stayenergysafe are keen to build a strong working relationship with us and their digital/marketing teams want to develop more collaborative campaigns going forward. Working with stayenergysafe and our internal Revenue Protection team we will build on our successful campaign and create a strategy for further engagement and collaboration, including targeting specific stakeholder groups such as landlords, housing associations and the emergency services.

3.1 Do DNO groups continue to look at best practice both nationally and internationally, when considering processes and methods to manage losses on their networks? What have DNO groups learned from T1, which they have used or will intend to use going forward?

SSEN have sought to draw on learning within the wider utility industry through engagement with several water companies operating inside our licence areas. International best practice has also been explored through initiating correspondence with non-GB electricity network companies and working with one of their partners.

GB Utility Companies

In the Autumn of 2017 SSEN engaged with Portsmouth Water and Scottish Water as part of a wider exercise aimed at interacting with sectors out with the traditional network boundaries. Leak management is a key driver in the water industry, whilst less complex, some of the developments in monitoring and management were found to be directly transferrable and thus warrant further investigation.

To further develop this, we also engaged with Wessex Water. The Wessex Water area also overlaps with part of the SSEN licence area and some of their plants are supplied fed from our distribution network. Further investigation could enhance understanding of best practice and inform the processes changes that would be mutually beneficial if we take a whole system approach to losses management.

Gas networks have similar leakage or shrinkage problems and so to support validation and verification of water industry practices we contacted SGN to better understand their approach. Discussions highlighted that further engagement could support the development of an enhanced cost benefit analysis model, designed with low carbon technologies in mind. SSEN propose to continued engagement with water and gas network companies throughout T2 to share best practice and consider the whole system view.

International Electricity Networks

Through a review of international electricity network losses projects, Canadian utility BC Hydro was found to have conducted network studies aimed at reducing electricity theft. Awesense, working on behalf of BC Hydro, utilised LV network monitoring alongside consumer meter data to pinpoint high likelihood of theft, thus we were keen to understand their process and whether this could be applied wholly or in part to GB networks (see Section 3.2 for full details).

Conducting a small study has enabled SSEN to better understand the dependencies of the method and begin to build a picture of associated costs. Through working with Awesense and drawing on their work with BC Hydro in Canada, we have identified an opportunity to gain understanding of losses reduction initiatives in other developed countries with slightly different regulatory setup. Engagement with Enedis (France), Energy Queensland (Australia) and Vector Limited (New Zealand) is in the early stages, but we seek to build on these links through 2018, comparing our approaches to network losses and gaining greater visibility of relevant learning.

Wider Industry Knowledge Share

Through working with other utility providers in GB and electricity network companies internationally we believe there is no common platform on which to share learning and best practice on topics such as losses. While through the ENA Technical Losses Task Group we have secured agreement to holding a knowledge share workshop, this only considers the six GB DNOs at this stage. Hence, SSEN propose to host a webinar exclusively for the topic of losses in 2018, facilitating wider industry knowledge share. Presently this would include water companies and the international electricity network companies we are engaging with.

In addition to our engagement with the other DNOs described previously we have delivered a wide ranging campaign on non-technical losses. By engaging with a wide range of partners from other sectors and internationally, we have been gain a better understanding of how other utilities use a cost effective combination of monitoring, metering information and analysis to be able to target interventions. This has shown that it is possible to identify areas of the network for intervention by using the information which is available, this has been fundamental in informing the development of our Network Efficiency Team concept.

3.2 How are companies preparing to effectively use smart meter data to develop specific actions to manage losses? What processes do the DNOs have in place now, following T1 submission?

Awesense Project

Our work to better understand losses presented in Section 1 has confirmed the uptake of LCTs will have an impact on our LV network losses and that identification of areas experiencing highest levels of loss need not require full smart meter and LV monitoring penetration. Further validation, is required before we can fully incorporate this into our BaU processes, to help accelerate this we have looked internationally to identify best practise.

Awesense have been able to help BC Hydro significantly reduce both technical and non-technical losses using data recorded by a high penetration of smart meters. Thus, we engaged to initiate a pilot project looking at whether the same approach could be taken in GB and whether their findings supported the outputs of the University of Strathclyde (UoS) and WSP (via Technical Losses Task Group) studies.

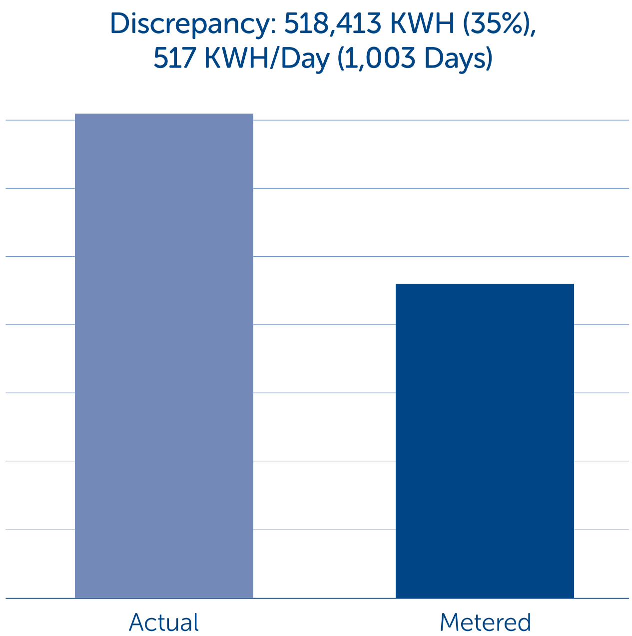


Figure 9: Awesense TGI Energy Balance Analysis

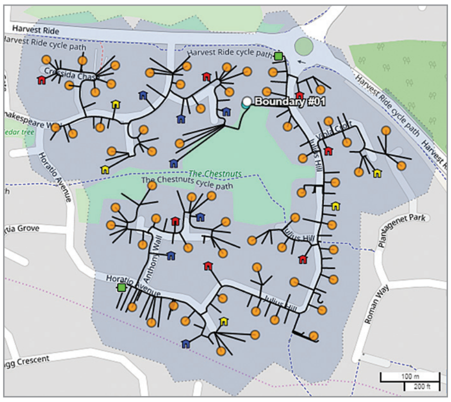


Figure 10: Awesense TGI Network Visualisation Example

The example results presented in figure 9 and 10 highlight the notable discrepancy between actual and measured energy consumption. If rolled out across the network, it would be possible to identify areas experiencing highest losses and guide an inspection team to search for the source along that specific feeder. SSEN propose to commission a new project, building on the pilot with the aim of identifying the minimum level of monitoring required to identify the areas of our network experiencing the highest electrical losses. The pilot has verified that there is an optimum level of monitoring (as outlined in the UoS report), yet a more detailed study with more robust customer meter data is required.

Awesense TGI can interpolate the missing customer meter data, so once we better understand the minimum baseline and quality the system should be able to estimate the missing profiles. Estimating profiles based on data with notable percentage tolerances (typically 2%) and slight timing synchronism will never produce a truly accurate percentage loss figure, but if the methodology employed is robust and consistent, the highest percentages should correlate to the areas of highest loss that we would wish to investigate. There may be exceptions to this, particularly if the network includes a large three phase customer, hence the project will seek to identify and present potential methods to mitigate. If successful, the approach could help DNOs efficiently deploy substation monitoring and confidently identify the LV networks requiring investigation ahead of full Smart Meter penetration.
As identified previously, the EV uptake in particular will increase asset utilisation and as a result increase losses, thus early visibility of high loss LV networks will assist deployment of an optimal solution. We will continue to develop this approach during T2 to help us identify the most economic combination of meter data, network

monitoring and analytics to allow us to target our Network Efficiency Teams. Further details on this project can be found in appendix 7.

3.3 Do the DNOs consider any of the actions they have taken from T1 and T2 will help feed into RIIO-ED2 when managing and understanding losses?

Substation Non-Technical Losses

In Section 1.1 work undertaken by Napier University since the Tranche 1 submission to better understand the non-technical losses at our substations was discussed. The study showed that there were potentially notable losses at our Bulk Supply Points (BSPs) due to the energy consumed to run the ancillary services, such as lighting and heating, at the site. However, the report identified that to fully optimise existing sites, offsetting some of these losses through introduction of photovoltaic generation or utilisation of rejected heat from site equipment for the heating of buildings may be an efficient solution. The two options have merit, but are not simple to implement effectively. Currently domestic customers pay for losses equally as a proportion of their overall energy consumption, with larger consumers having a more bespoke charge applied, both of which being calculated through the line loss factor. Therefore, to pass through the savings to customers, more than a physical installation of hardware is required. SSEN propose to investigate this option further, identifying if this is a practical and financially viable solution. This study will consider the substation type, voltage and geographical location to assess the size of the opportunity and whether investigation of line loss factor modifications is warranted.

DNO Network Boundaries

As introduced previously, DNOs have historically focused on managing losses within their own licence areas, yet to find the optimal solution, a wider cross boundary view is required. SSEN and UKPN committed to collaboration in their respective Tranche 1 submissions to Ofgem in 2016. The results of this collaborative working will be presented at the ENA Technical Losses Group. The study focused on our boundary with UKPN and considered three areas with unknown collaboration potential:

1. Reconnection of SSEN or UKPN LV "convenience customers";

2. Interconnection possibility across DNO boundaries, rather than only within DNO borders;

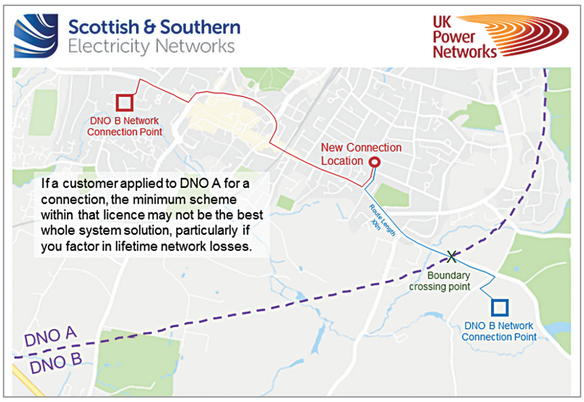


Figure 11: DNO Boundary Example

3. Analysis of losses comparisons between alternative major customer connection offers near the SSEN and UKPN border.

The first consideration found that there is little value in pursuing alteration of existing convenience customers. In a number of instances, customers were found to already have the lower loss connection and where this was not the case, associated losses did not have a value sufficient enough to justify such change of connection.

However, in the cases of interconnection and major connections, the findings were more positive. The installation of a link across boundaries was found to be a valid alternative to traditional intra-DNO reinforcement and could therefore be added to the suite of options available to our infrastructure planning teams for schemes close to the boundary. Yet, it was noted that before introducing a new process into BAU, further work was required to quantify the potential benefit realisation and any barriers to this form of collaboration.

Figure 11 depicts an example of a new connection requested close to the licence boundary. While a simplistic example it does highlight that unless a whole system view is taken, the optimum lifetime solution cannot be definitely defined. Presently, DNOs would not seek to discuss pursuit of an alternative connection offer from the neighbouring DNO, yet this does not facilitate peer to peer analysis or the consideration of lifetime network losses. Thus, to gain the benefit identified by the study we would have to define a new approach. Importantly, due to the small sample size we have identified further work to quantify the size of the opportunity needs to be completed before implementing fully within our BAU processes. SSEN and UKPN have agreed to share the learning with our respective network planning and connections teams in the short term, committing to the sharing of information where opportunities for cross-DNO reinforcement are identified by either party and believed practicable. In the case of new connections, volume and sensitivity of the data means that more work is needed, but we aim to look at defining a potential process for effective peer to peer communication through 2018/2019. Implementation of any new process into policy is presently limited by regulations, the defined value of losses and lack of a whole system cost benefit analysis (CBA) tool. The solution will require industry wide input and aligns with some of the challenges the ENA Open Networks Project and associated working groups are trying to address. SSEN are committed to supporting through these channels and will consider further studies to complement and inform the industry wide initiatives. One such study we have identified will look at across industry and international electricity network good practice, building on our established and embryotic relationships to understand not only replicable losses reduction initiatives, but the differences in the governing rules and regulations which may either prohibit or enable particular solutions.

We also have committed to an ongoing series of information sharing workshops between ourselves on a half-yearly basis (frequency can be increased if agreed beneficial). These will give us the opportunity to collate and share potential cross-DNO reinforcement opportunities and discuss our understanding of major connection projects near the border. While no formal process has yet been defined, we have outlined some criteria to help initiate more detailed discussions with our network planning and connections teams. When collating information ahead of our workshops we will aim to work to these criteria and optimise as deemed appropriate. Please see Appendix 7 for details.

Network Innovation Competition (NIC)

In 2017, the TRANSITION Project led by SSEN, featuring ENWL as an active partner, was awarded funding. This project includes the trialling of a neutral market facilitator platform, a complex function with strong and multiple interactions between system components such as markets, customer experience, business models, the network infrastructure, reliability and network losses. The learning SSEN and ENWL have accrued to date will inform the design phase of this project, enabling trials to test an informed version of the function.

While drawing on the learning of two DNOs is a strong baseline, SSEN aim to draw on the outputs of other losses related projects through the ENA Technical Losses Task Group workshop (see Section 2.2) and the other two NIC projects looking at elements of the DSO transition. SSEN are working closely with SP Energy Networks and Western Power Distribution to align elements of the projects and ensure best value for our customers. This collaboration will continue for the duration of the three projects and the group will have coordinated interaction with the ENA Open Networks Project, thus increasing the sharing of detailed and transferable learning. We are also aware on other innovation funded projects which, while not specifically focussing on network losses, may generate outputs relevant to losses. This includes, but is not limited to, the Active Response (UK Power Networks) and LV Engine (SP Energy Networks) projects also funded through the 2017 NIC process. While no Gas Network projects awarded funding through the 2017 NIC process appear relevant, SSEN do propose to continue building cross industry relationships to share current best or good practice as discussed in more detail in Section 3.1.

The proposed approach allows both independent and collaborative projects to continue through RIIO-ED1, but importantly encourages active sharing of the learning with more coordinated outputs being transferred directly to BAU or preparation for the transition to a DSO model.

Future Mechanisms

There are still several questions to be addressed before any future mechanism can be effectively defined. An example applicable across the network is monitoring. Work across DNOs, the Water industry and Gas industry highlights that monitoring is an important enabler for consistent quantification of the benefits, yet there is still a gap in the understanding of true cost. SSEN propose to install LV monitoring in a target area to increase the penetration and build up a BAU cost profile for the install and enduring costs associated with collection and storage of the data. From this we will be able to build on the work independently conducted by Strathclyde University and Awesense, providing a view on the minimum penetration of LV monitoring and Smart Meter data required to make robust network decisions. However, while such work continues, we can consider how best to effectively treat electricity losses in RIIO-ED2. One of the considerations of the ENA Technical Losses Task Group is any future incentive, reward or penalty mechanism for electricity losses.

Scottish & Southern Electricity Networks

While the group will not decide on the mechanism to be employed, it should help inform any decision. It is therefore important to have visibility of all relevant learning and hence why a cross DNO workshop has been agreed for later in 2018.

It is clear from the work conducted to date that losses on the electricity network are complex and that treating them as singular issue may not be the optimum way forward in RIIO-ED2. In the next price control period, we can build upon the learning DNOs have gained throughout RIIO-ED1 in this area and potentially seek to take a more targeted approach. Smaller packages could aid assessment, yet it is important any mechanism developed is proportional and that the metric selected for each package is suitable. The work carried out by the group thus far has highlighted the complexity of losses on the electricity network and that the move towards a low carbon economy can have a negative effect when losses is viewed in isolation. For example, ANM can be the most cost effective way of getting new DER connected onto the network, but by increasing asset utilisation, we increase network losses. Proportionally, the benefits of ANM may outweigh the increase in losses in this case, so any ED2 mechanism could look at accounting for this. On the other hand, where we have identified particularly high losses in an area of network, processes should be in place to rectify where efficient to do so. SSEN are committed to informing any future mechanism, helping it deliver a sustainable network at the lowest whole system cost to consumers.

D. Innovative approaches to losses management and actions taken to incorporate these approaches into business and usual activities.

4.1 How are DNO groups planning to use innovative approaches to manage losses (including through the use of smart meter data) outside of projects funded through RIIO-ED1 price control and the innovation stimulus mechanisms? What innovative approaches have DNO groups identified from T1?

Throughout T1 SSEN have used a variety of innovative approaches to help in our understanding and management of Losses. This has included our first of a kind Losses Competition described earlier, and a wide spread media campaign on non-technical losses and engagement

With #NotWorthTheRisk Non Technical Losses Campaign, we utilised a number of innovative communication resources to inform both our internal and external stakeholders.

The SSEN Comms App, accessible to SSEN employees only, was launched on 4th December 2017 and currently has approaching 1000 users in SSEN and operates on a full range of platforms including Apple, Android and PC. The #NotWorthTheRisk campaign pushed automatic notifications to users throughout the five day campaign, The campaign reached staff members across the organisation including field staff, project management and design staff significantly raising the profile of the issue. This sustained approach to communication with a series of discrete self contained messages over a sustained period has been demonstrated to be more effective than a single message.

#NotWorthTheRisk SSE Web pages

In addition the Revenue Protection section of the SSEN website were upgraded to refelct the key messages from the #NotWorthTheRisk campaign, including links to partner organisations such The webpages SSEN used to promote Revenue Protection – Electricity Theft were updated with relevant information and collaborative links to the www.StayEnergySafe.co.uk website.

#NotWorthTheRisk Radio and TV coverage

By far the biggest platform SSEN used to inform awareness of Electricity theft external stakeholders via Radio and TV. The campaign broadcasted on three BBC Radio stations and two BBC TV News broadcasts as shown in figure 12 – see appendix 4 for estimated

Figure 12: BBC Coverage of #NotWorthTheRisk Campaign

viewing figures. Following the successful engagement from our Losses webinar and Electricity theft campaign it is our intention to extend the concept of our losses competition in the future and run a 'hackathon'. A hackathon is typically a gathering of stakeholders to work collaboratively 'hack' data, product or service to innovate for new value. For both technical and non technical losses this will be an innovative way to encourage new ideas and approaches to solving losses problems. The event would bring together people with different backgrounds and areas of expertise – for example data analysis, customer relations social scientists, engineers, emergency services personnel etc. To 'hack' losses SSEN would provide network data to participants. Subject to data privacy conditions, data obtained from our low cost LV substation monitoring project and smart meters could be utilised. We aim, by engaging a broad range of people who may normally not interact, to deliver a set of completely new ideas and fresh viewpoints. In addition, we will offer a £10,000 incentive fund to reward 'winning' hacks and undertake further development of ideas. Further details of how we will run the hackathon are detailed in appendix 6.

4.2 How will DNO groups incorporate these approaches into "business as usual" activities? Have the DNOs incorporated any innovative approaches set out in T1 to BAU?

Non-Technical Losses

To build on the success of the #NotWorthTheRisk campaign, we are planning future similar initiatives, these will be led directly from the Revenue Protection Team and will become part of our regular programme of engagement.

LV Steering Group

SSEN have established an LV Steering Group, utilising our LV Strategy paper as a foundation, with the aim to develop new innovations and interventions to actively manage reduction of losses on our network. We have established methodologies for tracking losses and will incorporate trackers into interventions to ensure our focus on losses remains effective. Even once ready for wider application, new policies and changes will be passed through an internal audit process to ensure they are being applied as intended. The group is made up of representation across the SSEN business who have a part to play in managing losses for the business. This group will be chaired by the Head of DSO and Innovation and will report directly to the Director of Engineering and Investment.

Investment Strategy

In addition to our LV strategy paper and steering group, losses have been specifically included in 'SSEN Distribution Network Investment Strategy RIIO-ED1'. The Network Investment Strategy sets out the process for the cost benefit analysis undertaken to provide understanding of the interventions that can be efficiently applied to manage losses. Measures already identified include;

- Installing transformers that outperform, in losses terms, the EU Eco Directive at voltages of 132kV, 33kV, 66kV.
- Increasing the minimum size of 3 phase secondary transformers to 500kVA for ground mounted units, and 50kVA for pole mounted units. This is consistent with most of the other DNOs' position.
- Early replacement of pre-1960 secondary transformers.
- Increasing the minimum cable size to the next size up, at low voltage and at 11kV.
- Mitigating phase imbalance on the low voltage network.

We regularly review the measures we are deploying, to take account of changes in network usage, the cost ot technology or the availability of new data or analytics techniques.

Licence Boundary

Through joint study new initiated with UKPN, looking at LV and HV/EHV connections SSEN and UKPN have been able to define criteria for new connections and infrastructure projects being delivered close to the DNO boundary. This has ensured that we managed to reach as wide an audience of stakeholders as possible, to significantly raise the profile of the issue. This will be monitored and developed during T2 to assess the volume of projects, costs and benefits. The outcomes for this will be used to define new BAU process and potentially inform wider industry working arrangements.

Enhanced LV Monitoring

We are enhancing our monitoring and visibility of our LV network through the BAU deployment of low cost substation monitoring. We are in the process of funding the installation of a further 250 sets of monitoring equipment that will give us a greater visibility of the LV network which will be key to our understanding of losses.

DNO Peer Engagement

Through our engagement and participation on the Technical Losses Task Group we have been able to gather learning from separate DNO initiatives. Commitment from the six GB DNOs has been achieved to jointly host an industry wide losses event.

4.3 DNOs must verify that the innovative activities are not funded under any other RIIO-ED1 financial initiatives. This is to ensure DNOs are not rewarded multiple times for the same activity. The aim of the LDR is to encourage DNOs to undertake additional losses reduction actions over and above those set out in their business plans.

There is no doubt that the outputs from our innovation portfolio with projects such as LEAN, SAVE and NTVV has helped inform our approach to managing losses. However, the further development and implementation of all of the activities described within this submission have been funded directly by SSEN, with no funding from any of the RIIO-ED1 financial incentives.

Appendix 1:

CIRED Innovative Approaches to Identification and Reduction of Distribution Network Losses

INNOVATIVE APPROACHES TO IDENTIFICATION AND REDUCTION OF DISTRIBUTION NETWORK LOSSES

Dr Jorge ACOSTA
TNEI – UK
jorge.acosta@tnei.co.uk

Dr Charlotte HIGGINS
TNEI – UK
charlotte.higgins@tnei.co.uk

Dr Mark HUGHES
Element Energy – UK
mark.hughes@element-energy.co.uk

Timoleon MANOLOPOULOS
SSEN– UK
timoleon.manolopoulos@sse.com

ABSTRACT

Electrical networks are subject to losses, both technical and non-technical, where a proportion of the energy entering a network is not delivered to customers. On distribution networks these losses can often account for a material proportion of the energy entering the system and there are significant consumer costs associated with this due to increased system generation requirements. The UK energy regulator Ofgem has put in place a number of mandatory and incentive based mechanisms to encourage Distribution Network Operators (DNOs) to better understand and manage the losses on their networks. The following study was delivered as part of the work that Scottish and Southern Energy Power Distribution (SSEPD) have carried out for the SSEPD's Losses Strategy.

INTRODUCTION

Every system encounters losses. In the electricity supply system, these losses are for the most part a result of heat and noise generated through operation of equipment. These are known as technical losses. There is also a small amount of energy that is unaccounted for in that it is not fully recorded or, in some instances, stolen. These are known as non-technical losses. On distribution networks these losses can often account for around 6% of the energy entering the system and there are significant costs associated with this. The paper is focused on the technical losses and how they can be identified and reduced based on measured data and power systems modelling in IPSA2 [1].

The purpose of the project [2] presented in this paper was to develop a methodology to identify the losses in the LV network with limited data available and propose interventions in order to improve the overall efficiency of the distribution of power across Scottish & Southern Electricity Networks (SSEN) and reduce the respective cost (6%) to the customers.

QUANTIFICATION OF LOSSES

A review of other studies and their findings regarding losses in the LV network was undertaken. The outcome of this exercise showed that the technical losses are primarily caused by: loss in the conductors (I^2R); load phase imbalance; and power factor. Other causes that account for rest of the losses are: high harmonic distortion, high/low terminal voltage (depending on the load mix). These aspects were explored further in this study methodology.

Data availability

From SSEN New Thames Vision Project, it was provided one year of 10 minute from the average current and voltage data for 316 LV substations clustered within a specific network are of their southern distribution licence area for the purpose of analysing the losses at LV. The data was available for particular points in the network as described in Figure 1. The LV feeders were fully monitored including all three phases along with the substation and the 11 kV side of the primary substation (33/11kV). Also, the number of customers and type was made available for the LV substations. As not all LV substations were monitored along a single HV feeder, it was not possible to calculate HV feeder losses based on current data.

SSEN provided LV network power system data including circuit and transformer specifications to enable production of a power system model in the software IPSA2. This model was used to support verification of losses, apply interventions and estimate the reduction in losses after these interventions and test its cost effectiveness.

Customer load profile

The data available contained the annual 10 minute demand per LV feeder and secondary substation and the number of customers connected to that feeder. In order to be able to analyse LV feeder losses, the total LV feeder demand and the total demand based on all connected customers can be compared at each measurement point. A representative customer load profile is required for this purpose. SSEN provided 'End Point Monitoring' data for 254 customers that allowed validation of generic customer load profiles such as that shown in Figure 2, based on Customer Led Network revolution (CLNR) innovation project [3].

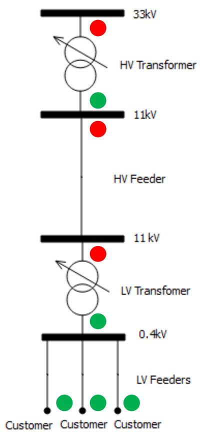


Figure 1 – Availability of Measurement Data for Loss Calculations

Loss calculation

To calculate the losses on the LV network i.e. along the LV feeder from the secondary substation to the customers, the following data was used:

- The secondary substation LV feeder monitoring data;
- The customer numbers; and
- Generic customer demand profiles described previously.

This was refined through use of approximated load profiles for customer type e.g. industrial, commercial and domestic.

Two methods were applied to calculate annual losses:

- Calculating the losses with annual real power energy consumption; and
- Calculating the losses with peak demand.

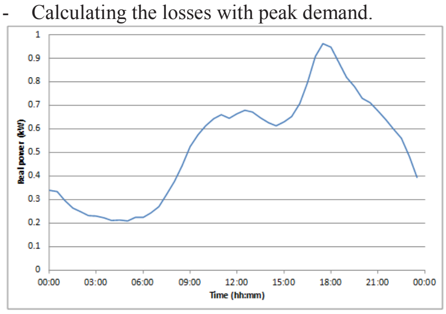


Figure 2 – Generic Domestic Customer Maximum Demand Profile from the CLNR Project

From these two methods it was found to be more reliable to use the peak demand calculation approach. The load profiles of Industrial & Commercial (I&C) customers are more bespoke and thus challenging to generalise. There was some variance in losses calculated including outliers that were considerably higher or lower than the rest, this is thought to be mainly due to the modelling of I&C customer load profiles (lack of visibility of specific load profile). Some margin of error has been considered for LV feeders where 50% of customers are I&C.

Site prioritisation

From the data analysed for the 316 secondary substations, the following aspects were explored in more detail:

- Customer type characterisation per LV feeder;
- LV substations with greatest data availability;
- LV feeders with high losses; and

These details were important to enable selection of an accurate and representative sample of LV substations on which to test interventions and to better understand uncertainties caused by prediction of I&C customers' load profile. This characterisation is based on the number of substations from 100% residential to mostly I&C customers (Figure 3). Selection of 73 representative substations for the purposes of exploring losses calculation, results interpretation and losses intervention is shown in Figure 4.

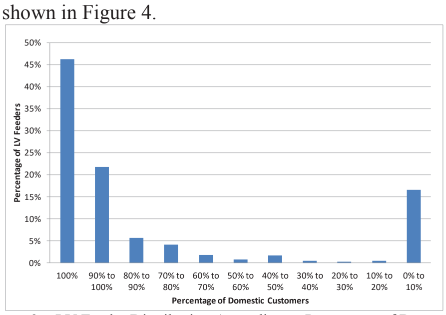


Figure 3 – LV Feeder Distribution According to Percentage of Domestic Customers

Correlation and identification of losses

The preliminary loss analysis carried out on all LV substations (316) showed a strong correlation between high current phase imbalance and losses. Further analysis carried out on the selected 73 LV substations examined in detail the impacts of phase imbalance on LV feeder losses.

The phase imbalance factor was based on highest phase current divided by the average phase current for the LV feeder. Figure 4 shows this relationship between the losses and the imbalance factor. This phase current imbalance index is calculated based on the phase currents of the LV substation by the following equation:

$$Imbalance = \frac{I_N}{I_A + I_B + I_C}$$

where I_A, I_B and I_C are the three-phase currents and I_N is the neutral phase current.

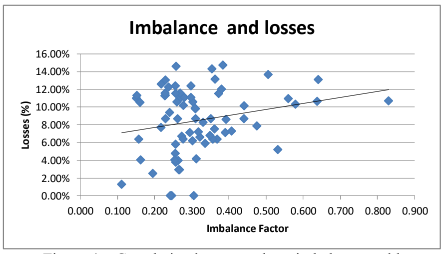


Figure 4 – Correlation between phase imbalance and losses

The median of the losses across the selected substations is approximately 5.9% which aligns to the high level figure of 6% reported by SSEN in the losses strategy document [4].

Reduction in Losses with high number of customers

It was found across most of the LV substations that the losses as a percentage of peak load decreases when the peak loading increases although the magnitude of losses broadly increases (Figure 5). This is due to the main cause of losses at LV being phase imbalance from uneven numbers of customer connections across phases and dynamic variations in customer load profiles. The level of phase imbalance generally decreases with the number of customers and thus demand, as diversity increases.

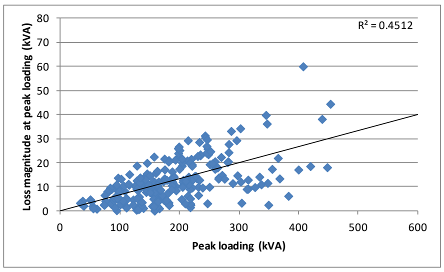


Figure 5 – Correlation of Losses at Peak Loading with Peak Loading

POWER SYSTEMS MODELLING

Based on the outcomes of the selected 73 substations and a horizon scanning exercise, the following interventions were selected as being most relevant for SSEN to consider:

1. Load Balancing
2. HV/LV Transformer Upgrading
3. LV Conductor Upgrading
4. Power Factor Correction through existing or innovative techniques.

These loss intervention methods have been studied in detail to assess their technical effectiveness through network modelling in power system software IPSA2. One LV network from the SSEN network area was modelled in detail with four LV feeders and included testing of the loss reduction interventions. This LV network is representative of suburban networks within the study area.

Network model build

A Python script was developed by TNEI to automatically convert the CYME network models provided by SSEN into unbalanced network models in IPSA2. This script was used to produce the IPSA2 network model with unbalance load flow capability of the selected sample network. The geographic diagram of this network model is shown in Figure 6.

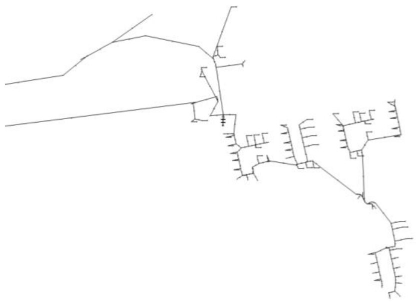


Figure 6– IPSA model of a particular feeder using its GIS capability

Interventions

Annual losses within the LV network have been assessed by simulation over one year using monitoring data provided for the LV feeders with and without interventions.

Table 1 Annual Losses with Loss Intervention Test Scenarios

Scenario No.	Scenario	Annual Losses (MWh)	Annual Losses Reduction (%)
1	Base Case (Power Factor = 0.97)	19.45	0.00%
2	Balancing loads	17.65	9.3%
3	Upgrading transformer	18.99	2.4%
4	Upgrading LV conductors	15.69	21.5%
5	Upgrading transformer and LV conductors (combination of 3 and 4)	15.29	23.5%
6	Power factor = 0.99	18.52	4.8%
7	Balancing phases, upgrading transformers and conductors, and correcting power factor (combination of 2, 3, 4 and 6)	12.53	35.6%

Recommendations for Network Interventions

From our analysis, the main causes for losses in the trial area were phase imbalance, with low power factor also prioritised after the horizon scanning of loss reduction techniques. Reactive power measured at the LV feeder showed significant variation suggesting measurement errors and/or data quality issues. This was further observed upon calculation of power factor values which were thus deemed unreliable. Total harmonic distortion for voltage was measured at the LV substation and analysed, it was found to be within G5/4 limits, harmonic distortion was not measured along LV feeders limiting the scope of the harmonic characterisation. Harmonic distortion was considered to be costly to improve as an individual issue at LV (based on TNEI internal knowledge of harmonic filter costs) and therefore not considered specifically. Phase current imbalance and power factor have a more material impact on losses.

The following recommendations are given for the future development/refurbishment of the network in order to reduce losses, which is also in line with SSEN's losses strategy:

- Installation of low loss transformers
- Setting a minimum transformer size
- Setting a minimum conductor installation capped for LV and 11 kV
- Replacement of transformers for low loss transformers where cost-effective
- Load balancing equipment (increase number of link boxes)
- Load monitoring to enable improvement of power factor (e.g. via capacitors)
- Customer re-jointing to mitigate phase imbalance

These options can be considered further through cost-benefit analysis. Preliminary exploration of cost-benefit suggests that phase balancing with power electronics were proven to be too costly compared to the current economics of loss reduction.

Part of the outcome of this project is the list of high losses substations that can be used as trial for the deployment of corrective actions. This is aided by the monitoring equipment already in the trial area.

LOSSES IDENTIFICATION STRATEGY

From the trial area and the data provided by SSEN for this project, measurement and connectivity were explored that have to be taken into account when identifying substations with high losses. The main causes for losses are phase imbalance and power factor. Monitoring the entire LV network is costly and should be considered in the context of future rollout of customer smart meters.

Efficient identification of LV substations across the entire SSEN licence area that are most likely to suffer from high losses, in order to implement monitoring and/or modelling to investigate further, has been assessed. It is key to be able to utilise what SSEN already monitors to identify high loss substations for monitoring and modelling and minimise the risk of extensive monitoring for limited benefit.

Maximum demand is currently measured at LV substations on a six monthly basis and is a key metric to support the identification of LV substations with high losses. Other asset and network data such as LV substation customer numbers and transformer rating can also be utilised.

Metrics were analysed based on available data and measurements for all SSEN LV substations in the Bracknell area to develop a suitable filtering process. This is shown in Figure 7.

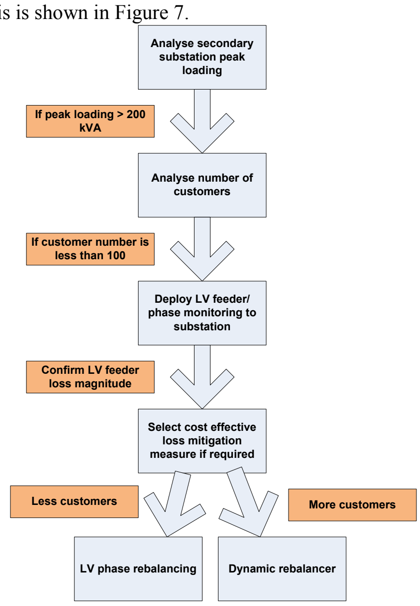


Figure 7 – Losses methodology Flowchart

Trigger criteria may be refined to adapt the percentage of lossy substations identified for further action i.e. monitoring and/or modelling.

CONCLUSIONS

Peak demand calculation approach was found to be the most reliable losses calculation approach. Uncertainties caused by prediction of I&C customers' load profile to an extent.

The level of phase imbalance generally decreases with the number of customers and thus demand, as diversity increases. As phase imbalance is correlated to losses, higher diversity reduces losses.

Part of the outcome of this project is the list of high losses substations that can be used as trial for the deployment of corrective actions. This is aided by the monitoring equipment already in the trial area.

Preliminary exploration of cost-benefit suggests that phase balancing with power electronics may be most feasible. However, at the moment the equipment required has proven to be too costly compared to the current economics of loss reduction.

A losses methodology was developed and tested that can be deployed to help identify secondary substations with high losses based on limited existing available data.

After the results found on this project, policy updates are recommended (within suitable equipment specifications). SSEN is considering it in its further work area to explore cost effective interventions for the benefit of its customers.

Acknowledgments

The authors want to thank Alistair Steel, Maciej Fila and Frank Clifton for their support in the data provided and their review of this paper.

REFERENCES

[1] IPSA2, IPSA Power, http://www.ipsa-power.com/

[2] TNEI Services, et al. "10825-06-R2 – Losses Teams WP6," 2016.

[3] R. Wardle, Christian, Barteczko-Hibbert., Miller, David and Sidebotham, Liz, "Initial Load Profiles form CLNR Intervention Trials," 2013. http://www.networkrevolution.co.uk/wp-content/uploads/2014/02/CLNRL012_Initial_Load_Profiles_from_CLNR_intervention_trials.pdf, accessed February 2016

[4] SSEPD RIIO-ED1 Losses Strategy, Scottish and Southern Energy Power Distribution, April 2015, link: https://www.ssepd.co.uk/lossesstrategy/

Appendix 2:

ENA Working Group Project

Figure 12: WSP losses study tasks

The ENA Technical Losses Task Group first met in March 2016, bringing together GB DNOs to facilitate a collaborative approach to the investigation of technical losses. The group commissioned a study of the impact the low carbon transition could have on technical losses and appointed WSP to carry out the analysis.The project was split into four distinct tasks to achieve the aims of understanding the impact on losses due to LCT growth, how and when smart reinforcements affect losses and the influence on losses due to customer usage patterns.

Losses are expected to be impacted by the predicted increase in electrical demands as GB adopts Low Carbon Technologies for heat and transport, thus the study included uptake of Heat Pumps (HPs), EVs and Photo Voltaic Generation (PVs).

It is known that increased utilisation of network assets leads to increased losses. However, adopting this model could help facilitate the connection of smart innovative technologies such as energy storage, community heating and electric vehicles. The cost of increased losses with such solutions is likely to be outweighed by the traditional reinforcement investment mitigated or deferred, but true quantification of this cost requires the impact of likely permutations to be derived through robust analysis.

The WSP study produced three headline findings and provided DNOs with some direction, verifying initiatives and pinpointing the areas requiring further consideration. The three headlines are:

1. The uptake of low carbon technologies will significantly impact losses.
2. How networks accommodate low carbon technologies will impact losses.
3. Losses are complex, difficult to measure and vary based on regional topology.

Importantly this study only provides a baseline on which to build, as specific network topography and or consumer behaviour can have a significant impact. The separate study, undertaken by TNEI Services Ltd., of the relatively affluent town of Fintry is evidence of this (see Section 1). Yet, it has provided DNOs with several future considerations to explore:

- Regulatory approach – Feasible and practicable mechanisms for maintaining the appropriate focus on losses could be considered for application in future regulatory approaches.
- Smart meters – Installing smart meters over an extended period will mean that the form of metering and the evaluation of losses will change in any comparable period. Thus, the difference between annual loss values may not be totally attributed to changes in network operation alone.

- Impact of LCTs – It may be appropriate to classify and recompense losses associated with LCTs differently. The cost of the lost energy is key because it will likely be a main future impact as the carbon impact of losses reduces in a lower carbon generation environment.

- Settlement processes – Study results have highlighted how losses vary between regions and the possibility of applying regional variations in how losses are dealt with in the settlement process still need to be considered.

- Evaluation of Losses – In practice domestic meter accuracies may not completely balance and could vary with any consequential inaccuracy being reflected in a significant losses tolerance. Alternative approaches for the evaluation of losses could be to simulate losses or use different monitoring to avoid the inaccuracies of settlement metering.

This piece of work which was completed in early 2018 has both verified outputs for independent studies and highlighted some of the areas requiring more work before a well-informed mechanism for RIIO-ED2 can be defined.

Extract from Edinburgh Napier University – educing energy losses and greenhouse gas emissions from substations. Institute for Sustainable Construction Authors Prof. John Currie and Dr Jon Stinson.

4 Results

This study has reviewed the current energy usage patterns at Tealing Substation and identified a range of intervention measures suitable for the building archetypes on the site; these have included artificial lighting controls and luminaire replacement and a range of building fabric upgrades to mitigate electrical energy usage on site. A summary of the proposed measures are presented in Table 3 below together with indicative intervention costs and likely payback; based on the Ofgem investment hurdle rate of £48/MWh.

	Saving	Cost Saving	Unit Cost	No./Area	Cost	Payback	CO_2 Saving
Intervention Measure	**kWh/yr**	**£/yr**	**£**	**no. / m^2**	**£**	**yrs**	**tCO_2**
LED replacement luminaires	4,910	£ 236	£ 66.50	106	£ 7,059	29.9	1.73
Lighting occupancy controls	3,150	£ 151	£ 200.00	4	£ 800	5.3	1.11
Roof Insulation - mineral wool	50,695	£ 2,433	£ 13.00	593.5	£ 7,716	3.2	17.82
Sprayed roof Insulation	9,564	£ 459	£ 27.00	78.5	£ 2,120	4.6	3.36
Secondary glazing	639	£ 31	£ 145.00	18.6	£ 2,697	87.9	0.22
External wall insulation	39,808	£ 1,911	£ 80.00	497.9	£ 39,832	20.8	13.99
Intervention Total	**108,766**	**£ 5,221**			**£ 60,223**	**11.5**	**38**

Table 3 Summary of cost savings calculated for intervention measures

The results from the study identify a hierarchy of intervention measures in respect of cost benefit and, following discussions with SSEN staff, identified lighting controls and roof insulation measures as being a priority target for investment. Utilising the above data a metric for application across a similar range of substation archetypes can be approximated to 161kWh/m^2 in achievable savings and 56kgCO_2/m^2 carbon reduction potential.

SSEN provided a list of transmission substations across which this metric was applied in order to gain an estimated quantification of losses reduction potential. A visual inspection of the buildings at the Tealing site, plus information provided by SSEN indicate that the 275kV and main control buildings were constructed circa

1960. Furthermore, the survey indicated that the walls were constructed of two layers of brick separated by an air cavity. This method of construction became common after the 1920s. It wasn't until the mid-1970s when levels of prescribed wall insulation were standardised, to conform to these standards a dense block inner leaf replaced the brickwork. Wall insulation standards improved significantly during the 1980's, when the inner blockwork was replaced by lightweight blockwork and the addition of insulation material was included into part of the air cavity.

The SSEN transmission substation database shows that 53 sites, excluding the Tealing site, have an estimated age of between 1930 and 1970; this dataset is divided as follows: 1930s n=2, 1940s n=0, 1950s n=23, 1960s n=28. These dates where assigned to the sites by SSEN based upon the earliest recorded procurement date of the equipment housed within those sites.

A desktop study, using Ordnance Survey's Digimap Roam tool, located 37 of the 53 transmission substations. The 37 sites held a total of 85 individual buildings, (mean = 2.3 buildings), the map in Fig. 5 illustrates the geographical spread of substation buildings which were investigated as part of this study. Google Street View images provided visual evidence to classify 47 (55%) of the 85 buildings as having a similar archetype which conforms to the age and era defined by SSEN, and therefore representative of the 2 control buildings at the Tealing site. Deeper observations indicated that the remaining buildings where added or heavily refurbished after 1970 and as such, they are considerably less likely to be architecturally representative of the 2 control buildings at the Tealing site. Therefore, the other 45% of buildings on these other sites were removed from the study.

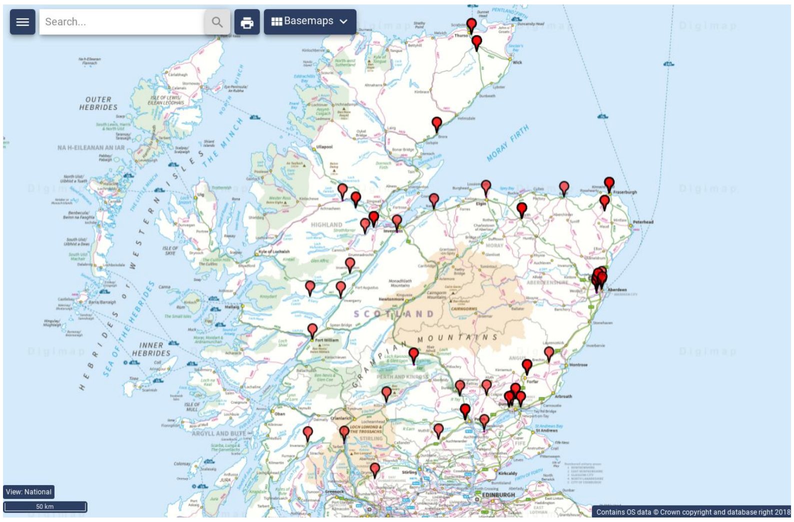


Fig. 5 Geographical location of substations considered representative of those buildings at the Tealing site (Ordnance Survey Digimap.edina.ac.uk/roam 2018)

The total floor area (m^2) for each representative building was measured digitally using the Ordnance survey. The representative buildings ranged in size from 48m^2 to 1716m^2, with a total floor area of 13,131m^2 (mean = 253 m^2, standard deviation = 284m^2).

When normalised by the total floor area the baseline (without energy reduction interventions) energy consumption (lighting and heating) for the 275kV and main control buildings is 282kWh/m^2/annum. If, all of the interventions for lighting and heating are applied to both of these buildings this would reduce the total energy consumption by 51% (to 137kWh/m^2/annum).

The combined floor area for the 47 representative buildings plus the 2 Tealing buildings provides an estimated total floor area of 13,770m^2. Extrapolating the baseline energy consumption data for the 2 Tealing site buildings over the total floor area provides an estimated 3.89GWh/annum for energy consumed by these buildings (including the 2 buildings at the Tealing site).

Applying the calculated 51% savings, as discussed for the 2 Tealing site buildings, to the extrapolated total energy consumption for all of the representative buildings reduces the 3.89GWh/annum consumption to 1.89GWh/annum.

These values are dependent on each building's operation; the set point temperatures assigned to the installed heating system; the building fabric and the presence and frequency of human visitors. The nature of this extrapolation considers the 47 buildings across the other sites to be operating under the same conditions as those at the Tealing site.

5 Conclusions

This study has reviewed the current energy usage patterns at a typical transmission network substation (Tealing) by utilising measured electricity consumption for building services provision (heating and lighting) and using this to calibrate building models in order to estimate the effects of applying intervention measures to mitigate energy losses. A narrow window for data capture and analysis in order to meet reporting deadlines has limited the study and it is recommended that a longer-term analysis of data be performed across a greater sample of sites in order to gain a statistically representative and more complete understanding of uncontrolled losses on such sites.

The study findings show that readily available intervention measures can be applied in order to achieve savings of up to 40,754kWh per building (averaged over n = 49) which, extrapolated across the SSEN network portfolio, could amount to potential losses reductions approaching 2.0GWh per annum, providing a cost saving of £95,850 per annum and an associated carbon reduction of 702tCO_2. It is therefore hoped that this study will help support the decision-making priorities for reduction of losses and environmental impacts within the network.

By applying the more readily accessible intervention measures, identified as lighting control and roof insulation, as a first stage in losses reduction then savings in the order of 1.24GWh (32%) might accrue with an associated cost saving of £59,520 and a carbon reduction potential of 434tCO_2 realised.

Bibliography

Good Practice Guide 312, The Government's Energy Efficiency Best Practice programme, BRECSU, 2001.

Appendix 4:

#NotWorthTheRisk – Campaign results
Results below were captured three days after the campaign:

SSEN Comms App: 848 users

		Screen views
News Update 1	Getting to know Revenue Protection	190
News Update 2	Supplier or DNO theft	157
News Update 3	What's wrong with this picture	147
News Update 4	#NotWorthTheRisk (case study)	81

Internal Email (Poppulo): 3,437 Networks Employees

Email sent out to	Email opened	Percentage opened	Further Interaction	Percentage
3437	1798	52%*	335	10%

** Bench Mark is 65%*

Social Media

	Interactions
Total Reach	26020
Total Engagement	4750
Video Views	2540
Video views longer than 10 sec. views:	908

Web Page

	Footfall vs. Campaign		
	Prior	After	Percentage Increase
SSEN Electricity Theft Webpage views	22	144**	555%
SSEN News Article Views	N/A	41***	N/A

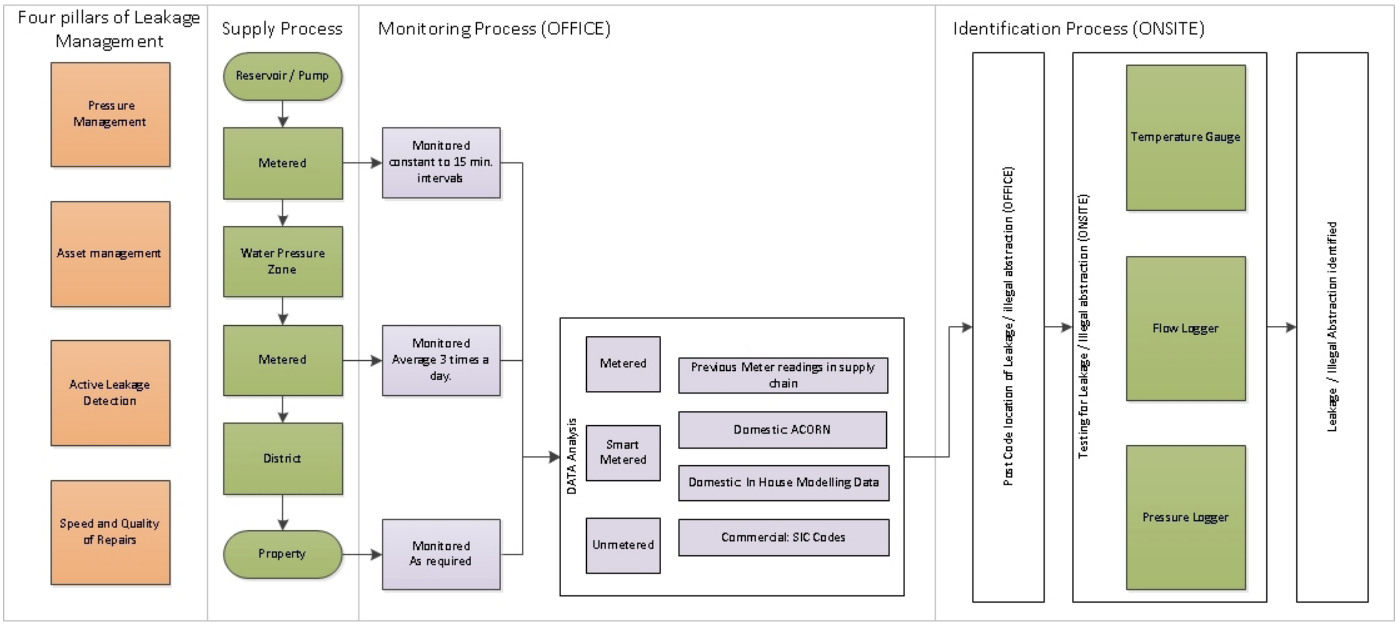
*** Average time on page 2 minutes and 2 Seconds*
**** Average time on page 10 minutes and 8 Seconds*

TV & Radio

		Figures (Estimated)		
	Slots	listening	Watching	Estimated hit
Radio	3	116k	N/A	348k
TV	2	N/A	500k - 600k	1m

Appendix 5:

Portsmouth Water Engagement
– Four pillars of leakage management



Appendix 6:

Hackathon Further Details

The DSO & Innovation Team will develop the proposition for the Hackathon which will include an advance preparation to familiarise participants with the problems and suggest possible areas to target. Participants will be able to register individually or as a team; we will create teams which include a range of backgrounds and specialisms. We will make available to the teams data collected through our low cost LV substation monitoring and smart meter data subject to data privacy conditions.

We expect a number of teams to demonstrate value through combining or analysing the datasets which will be made available in advance of the event; however, the focus of the Hackathon will be on developing an idea and considering key questions such as;

- Impact on consumers
- vulnerable customers
- Data protection
- Level of effort to implement

Teams will be required to address in a presentation at the end of the hackathon. This ensures that teams without a programmer, or who cannot deliver a completed code within the hackathon time frame can still present a valuable idea.

SSEN will invite judges from a range of organizations to score the presentations and select the winning teams. Prizes will be given to the winning teams from a £10,000 prize pot. SSEN colleagues will be available to discuss taking ideas forward for further development with the teams as appropriate.

Appendix 7:

UKPN/SSEN Boundary Criteria

While no formal process has yet been defined, we have outlined some criteria to help initiate more detailed discussions with our network planning and connections teams. Ahead of our workshops, it is agreed that both UKPN and SSEN will seek to collate information on the instances where any new connection meets the following criteria:

- LV Connection
- >72kVA (100A 3ph), </= 1MVA;
- Within 350m (route length) of the licence boundary;
- Excludes remnants of legacy networks that are not to be extended (e.g. Split-phase, Phase/Anti-phase or networks fed from Scott transformers).
- LV or HV Connection
- >1MVA;
- Within 2km (route length) of the licence boundary;
- Excludes remnants of legacy networks that are not to be extended (e.g. Split-phase, Phase/Anti-phase or networks fed from Scott transformers).
- EHV Connection
- 33kV, 66kV or 132kV;
- Within 5km (route length) of the licence boundary.

Where any new non-connections driven reinforcement meeting the following criteria is identified, the DNO leading shall seek to inform the relevant neighbouring DNO to enable cross-boundary options to be efficiently considered.

- Network Reinforcement
- Bulk Supply Point (BSP) or Primary Substation;
- 6.6kV, 11kV, 33kV, 66kV or 132kV;
- Radial or interconnected network;
- Thermal or system security driven;
- Within 10km radius of the licence boundary.

Presently this collaborative work around DNO boundaries is between UKPN and SSEN. The new learning to be derived will be shared at the ENA Technical Losses Task Group workshop, allowing the other DNOs to consider their boundaries and whether there is an opportunity to be explored now or in the future as network activity on the fringes of their networks increases.

Appendix 8:

Extract from Awesense report

1. Executive Summary

True Grid Intelligence (TGI) is a combination of hardware, software and methodologies capable of helping utilities detect, identify, and quantify commercial (non-technical) losses in distribution grids. TGI also allows utilities to perform Energy Balance, Phase Balance, and Grid Monitoring in a scalable manner.

Scottish and Southern Electricity Networks (SSEN), in collaboration with Awesense, initiated a Pilot Project in the United Kingdom to learn and evaluate the best practices for non technical losses detection.

The Pilot Project was executed on two substations 1646609 and 1647167; they were part of the New Thames Valley Vision (NTVV) project where consumption measurements were available. The Pilot Project was done in four phases:

- Ingested and rebuilt the low voltage grid of the two substations in TGI.
- Cleaned up, aggregated at daily intervals and ingested the substations consumption data in TGI.
- Created consumer consumption data using public residential load curves due to lack of real consumer data available.
- Calculated energy balance for each individual feeder to find losses.

Awesense demonstrated how TGI can help Distribution Network Operator (DNO) reduce distribution grid losses by segmenting the grid into groups of consumers and calculating energy balances using grid data sources (SCADA or mobile sensors).

Conclusions

- TGI provides the tools and methodologies to identify losses on SSEN's distribution grid at a feeder level when consumer consumption data is available.
- At least 90% of consumer consumption for the investigation time range needs to be provided to accurately find non-technical losses. SSEN only provided quarterly consumption for 39 out of 309 consumers (12%). Awesense estimated the missing consumption data using public residential load curves. As a result, the energy balances were calculated purely for demonstration purpose.
- Smart meter data can be used to build load curves for each tariff. The load curves can be applied to non-smart meter customers to estimate consumption during the investigation period.
- Smart meters for high usage customers (residential and industrial) significantly increase the precision of energy balances.
- SSEN GIS data uses a standard format (CIM) supported by TGI
- Awesense is ready to engage into a full scale rollout.

4. Recommendations and Next Steps

Recommendations to successfully optimize losses with TGI

- Build and maintain an accurate Medium Voltage GIS grid mapping.
- Achieve a meters to transformer association accuracy of 90%+ across the entire grid to enable accurate energy balances calculation.
- Obtain regular exports of aggregated consumer consumption data at substation level or if possible feeder level.
- Deploy Awesense permanent monitoring sensors on Medium Voltage lines to monitor losses on the grid.
- Prioritize smart meters deployment to high consumption customers (residential and industrial) to significantly increases energy balance precision in the future.

Next Steps

The next steps are to expand the pilot scope by ingesting a representative portion of the grid (hundred thousand service points) and to test Awesense sensors both on medium voltage and low voltage lines in order to validate the TGI methodology in the SSEN environment.

Consumers consumption can be aggregated at substation level to provide a global view of the losses on the grid without compromising consumer privacy.

Awesense is committed to work with SSEN to build a solution that will be efficient at finding losses and in line with existing regulations.

Contact us:

+44(0)345 300 2315

future.networks@sse.com
www.ssen.co.uk/Innovation
@ssen_fn

Scottish & Southern
Electricity Networks