Losses Discretionary Reward

TRANCHE 2 SUBMISSION

February 2018

SP ENERGY NETWORKS

CONTENTS

1 | Foreword

At SP Energy Networks we are committed to designing, building and operating our networks reliably, safely and efficiently. We are aware of the significance of losses as a cost borne by today's and tomorrow's customers and recognise our role in delivering cost effective loss management activities that help mitigate the impact on customer bills, contribute to the reduction in carbon pollution and help in the fight against climate change.

The nature of UK electricity networks and how our customers use them is rapidly changing. Despite having only 14% of UK demand connected to our networks (6.6GW) we have approximately 7GW of Distributed Generation already connected or in the process of connecting. Such high levels of Distributed Generation has a direct influence on the level of losses.
The adoption of new Low Carbon Technologies (LCTs) such as electric vehicles and heat pumps will further impact how our networks are used with the level of losses on our network becoming increasingly complex and uncertain. The development and implementation of new smart solutions will be key to giving us tools which enable us to manage losses whilst accommodating evolving customer requirements.

Our published Losses Strategy is based upon a high-level vision that we will

"Consider all reasonable measures which can be applied to reduce losses and adopt those measures which provide benefit for customers"

With our LDR programme we explore beyond our Losses Strategy, and look at less established methods that have the potential to significantly increase the understanding and effectiveness of losses management. This process has embedded collaboration with external stakeholders, to share our own experiences, learn from others, and better understand the impact of innovative losses actions. Through this approach we are making a material difference to our understanding and effectiveness of losses management.

We were successful and received a reward of £770,000 for our LDR Tranche 1 submission, acknowledging our strong set of initiatives devised to address both technical and non-technical losses. We choose to re-invest the full reward received in further loss management activities.

Our LDR initiatives are delivering new policies and network interventions which will help us manage network losses to economically efficient levels. We now have a better understanding of the contribution to losses management that we can expect from the integration and use of smart meter data. Looking forward, the learning delivered by our initiatives will help inform the losses management component of active network management. This will be beneficial as we increasingly actively manage our network as part of the transition from DNO to DSO.

For non-technical losses, our Revenue Protection team continues to proactively deliver material improvements through relevant partnerships with law enforcement agencies.

We recognise the importance of industry collaboration, both for sharing our own experience and to learn the best practice of others. We convened and chair the ENA Technical Losses Task Group and are committed to providing on-going leadership and resources. Through the Task Group we are collaborating with the other DNOs and TOs to improve our collective understanding of losses, and share learning and best practice. So far a pan-DNO study, commissioned by the Task Group, provided useful learning on likely future losses by assessing the impact of the Low Carbon Transition on network losses. For 2018/19 the Task Group agreed a work programme focused on testing RIIO-ED2 incentive options and we have tabled initial Guiding Principles for a regulatory mechanism – this work will help produce considered options for a quantifiable RIIO-ED2 losses incentive, which will be valuable in reducing losses over the next regulatory period.

Within this Tranche 2 submission, I am delighted to report on our many achievements to date and to also describe our next steps and proposals for future activities.

Scott Mathieson
Network Planning and Regulation Director

2 | Introduction

Our Strategy

To attain our goal of loss-inclusive network management, a good understanding is required of the causes of losses, their magnitude and location, and their impact and interaction with network users across the whole system. The benefits of many solutions are well understood, such as replacement of inefficient transformers and HV conductor sizing. These are captured in our RIIO-ED1 Losses Strategy.

With our LDR programme we explore beyond our Losses Strategy, and look at less established methods that have the potential to significantly increase the understanding and effectiveness of losses management. This process has embedded collaboration with external stakeholders, to share our own experiences, learn from others, and better understand the impact of innovative losses actions. Through this approach we are making a material difference to our understanding and effectiveness of losses management.

LDR - Key Themes

At the start of the LDR process, we identified eight key themes to be addressed by our LDR work. These themes represent previously unfunded approaches to the economic management of technical and non-technical losses.

Our 8 Key Themes

Figure 1: Key Themes for Losses Management

- Innovative use of Smart Meter and Network Data
- Customer and Stakeholder Engagement
- Enhanced Network Modelling
- Improve Quantification of Non-technical Losses
- Improve Substation Efficiency
- Collaborative Approach
- Increased Revenue Protection Activities
- Holistic Losses Consideration

These themes continue to be relevant as we move to Tranche 2.

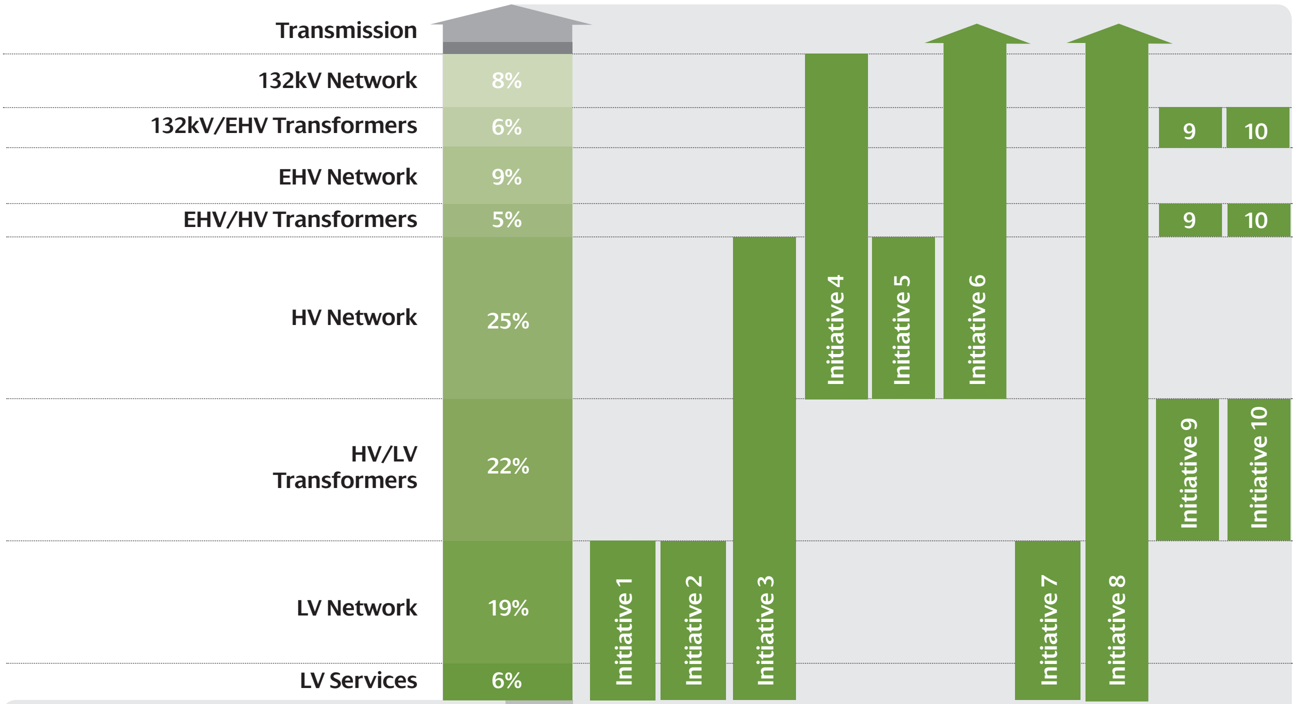
LDR - Tranche 1 Submission

We established a portfolio of ten initiatives to address the key LDR themes (Figure 1). These initiatives went beyond our Losses Strategy and allowed us to explore methods and processes to help improve our understanding and management of losses.

Our initiatives recognised that a stakeholder and holistic approach is required when analysing and managing losses to achieve the maximum benefit and considered all voltage levels, network interfaces and a variety of stakeholders.

Figure 2 on the following page illustrates losses contributions by network voltage and how our LDR initiatives align to those parts of the network with the higher contribution to overall network losses.

Mapping our LDR Tranche 1 Initiatives to a Breakdown of Distribution Network Losses



Initiative	1	Smart Meter Data to reduce non-technical Losses
Initiative	2	Smart Meter Data to reduce Technical Losses
Initiative	3	Voltage Optimisation to improve Network Losses
Initiative	4	Improved Modelling of Complex Networks to Consider Losses
Initiative	5	Improved Modelling of Rural Networks to Consider Losses
Initiative	6	Assessment of Power Factor to Improve GB Losses
Initiative	7	Improved Detection of Theft through Revenue Protection
Initiative	8	Improved Network Loading through Stakeholder Engagement
Initiative	9	Substation Efficiency - Waste Heat Recovery
Initiative	10	Substation Efficiency - Monitoring and Self-Sufficient Substations

Figure 2: Tranche 1 Initiatives across all voltage levels

LDR - Tranche 2 Submission

Recognising the importance of the LDR to further our understanding and management of losses, we made the decision to re-invest the award we received for our Tranche 1 submission to fund our LDR initiatives.

We are pleased to report on the considerable progress achieved to date and how this has informed our processes, thinking and our Tranche 2 submission.
A review of the activities undertaken and the associated outputs, as well as future activities, are discussed in sections 3 to 6. Insights and enhancements to our understanding of measuring, predicting and managing losses are explained; as is the engagement with and contributions from internal and external stakeholders.

We will be building on the work to date during the next phase of the LDR and, where appropriate, have refined our current initiatives and introduced new ones following a robust assessment process (detailed within Appendix 2). We are pushing the boundaries of how losses can be managed, with successful activities being adopted into Business as Usual (BAU).

We will continue to lead the ENA Technical Losses Working Group that we established and Chair. Further collaboration with DNOs and other stakeholders is planned as we build on the Low Carbon Transition studies undertaken and collectively assess the requirements and options for future regulatory mechanisms for the management of losses.

3 | Understanding Losses

The portfolio of initiatives detailed in our Tranche 1 submission has enabled a significant improvement in our understanding of the level and sources of losses, both current and future. Our learning has included how losses may change as a result of the transition to a low carbon economy, and our transition from DNO to DSO to support this. Below is a summary of our LDR work to date and our plans for future work in this area. This work is above and beyond that included as part of our Losses Strategy.

Enhanced Network Modelling

The Impact of LCTs

As Chair of the ENA Technical Losses Task Group, we proposed, led the procurement and coordinated delivery of comprehensive studies to assess the impact of a low carbon transition on technical losses. We partnered with all the other DNOs and TOs to scope, review and present these studies. We engaged industry experts, WSP, to perform them. The studies push the boundaries of what industry/UK understands about the impacts on losses of future LCT uptakes and how our networks evolve to accommodate them. These studies have focused on:

- Consideration of the impact of LCT uptake on technical losses in the context of GB environmental targets and technological developments.
- Consideration of the impact of smart reinforcements / increased network utilisation.
- The influence of customer usage patterns.

As part of the studies, simulations were performed using the DS2030 network models[1], derived from real network data, to improve our understanding of the losses impact of 2030 LCT uptake. Key findings presented at the 2017 Low Carbon Networks Innovation (LCNI) conference include:

- Low levels of embedded generation may reduce losses. However with moderate penetration losses are likely to increase.
- Traditional reinforcement has been shown to maintain losses at existing levels in most scenarios and remains a valid option.
- Smart solutions have been shown to increase losses, although they can offer significant whole-life cost savings compared to traditional reinforcement.
- The transition from a DNO to a DSO, requiring the provision of flexible and active network management, will impact losses.
- Uncertainty around LCT deployment means that future losses prediction is increasingly inaccurate.
- Losses are becoming more complex to evaluate and manage due to LCT uptake and the amount of connected Distributed Generation.
- Losses are shown to increase under nearly all scenarios, meaning that it is highly probable that a loss reduction investment today will still deliver value for customers.

These studies help inform loss inclusive design principles, the level of complexity in evaluation, the scale of uncertainty due to future scenarios and the losses impact of smart solutions.

The detailed report, due to be published in Q1 2018, will inform network operators, Ofgem and other stakeholders about options and losses impacts regarding future network development strategies. A primary purpose of the analysis was to provide context for consideration of future regulatory mechanisms (including potential incentives) for RIIO-ED2.

Innovative use of Smart Meter and Network Data

Innovative use of smart meter and network data

Two of our initiatives have developed a number of data analysis tools utilising 'granular'[2] smart meter data. This work has demonstrated the benefits of using disaggregated half-hourly smart meter data which creates the potential for us to better understand, and therefore manage, network losses.

Throughout Tranche 1 we have extended our understanding of technical losses on LV networks. We have paid particular attention to losses in service cables, which can be calculated using smart meter data combined with our GIS data. Worst-case service cable losses are estimated to be 310kWh per annum. This represents a capitalised value of £420, calculated using Ofgem's guidance. At this value we expect that it may be economic to replace some of our smaller LV service cables where they are highly loaded possibly due, for example, to the uptake of LCTs. It is more likely that service cable replacement would be evaluated using this method as part of a loss-inclusive approach to asset replacement. We will continue to review the business case for deployment of this method on our networks when we have access to smart meter data.

[1] Representative urban and rural network models, derived from real networks developed for the DS2030 project http://www.smarternetworks.org/project/nia_nget0154

[2] Ofgem considers "...household Electricity Consumption Data which relate to a period of less than one month to be 'granular data'." https://www.ofgem.gov.uk/system/files/docs/2016/09/open_letter_on_dnos_privacy_plans_for_the_access_to_smart_meters_data_0.pdf

As part of other projects, we have implemented a new smart meter data management IT system, EnergyIP. This will be the repository for smart meter data within our business. It will also provide the necessary security and privacy functionality for data processing, to be specified in our Data Privacy Plan. We are also delivering a strategic Network Constraint Early Warning System (NCEWS) to import smart meter data to better manage LV networks as LCT adoption increases and customer behaviour changes.

The connectivity model in the NCEWS project is scheduled for delivery in 2019 and as smart meter data volumes increase this will enable the aggregation of available data to provide feeder and Secondary substation losses information. When compared to new and existing substation monitoring data, the aggregated data will provide greatly enhanced visibility of LV network losses.

The results of the smart meter data analysis have also given added confidence that it will be practical to identify LCT hot spots sooner than at present. We have found that voltage and load characteristics can be used to indicate where LCT technologies such as electric vehicles, heat pumps or rooftop PV have been adopted.

Combined, these measures will enable us to effectively use smart meter data to better understand and manage losses. It is anticipated that these methodologies will be built into our NCEWS analysis functionality and will become BAU processes available to network planners in conjunction with network capacity management. We look forward to sharing our learning as it arises and using it to inform the RIIO-ED2 discussion on losses.

Improve Quantification of Non-technical Losses

Quantification of non-technical losses

We have developed Smart meter data analysis tools to explore demand patterns across approximately 4,000 smart meters that:

- Illustrate the broad range of annual demand profiles on a day-by-day granularity.
- Identify high and low demand outliers that may warrant further investigation for non-technical losses.
- Examine the extent and impact of missing data and how it may be managed.

A summary of results is provided in Appendix 3.

Innovative use of Smart Meter and Network Data

Our analyses have shown that to extract the highest value from smart meter data it must be of a suitably disaggregated level and used in conjunction with network monitoring, knowledge of network topology and customer connectivity data. The requirements for smart meter data analysis tools to enhance the visibility of LV network losses are now well understood because of this work.

The functionality and platforms required for us to run these analytical tools are in an advanced stage of implementation and are capable of providing greater understanding of losses as more data from smart meters becomes available.

Enhanced Network Modelling

We have developed an advanced losses modelling methodology which significantly improves the accuracy and granularity of our quantification of technical losses across our 11kV, 33kV and 132kV networks. Further details are included in Appendix 4. The tool enables the analysis of large network models and the losses behaviour throughout a given year. Annual losses profiles are calculated at individual asset level and aggregated by network group. This represents a step change in the visibility of losses, and the change in losses due to network interventions.

This Tranche 1 work has developed modelling, which has been adopted into BAU. We expect our learning to deliver a reduction in technical losses through optimised network configuration and asset operations by amending set point targets on power flow controllers and voltage control devices. These models have enabled a holistic losses assessment at the Transmission system boundary; this supports the holistic consideration of both Transmission and Distribution network losses.

It is anticipated that the advanced modelling will also be able to estimate individual asset losses for future planned network configurations and connections. We will continue to develop our work in this area, sharing our findings with the ENA Technical Losses Task Group. We will continue to explore applications of this work for a future regulatory mechanism.

HV Phase Imbalance

In our Tranche 1 submission it was acknowledged, from several industry studies, that phase imbalance on long rural overhead 11kV circuits is a major contributor to 11kV network losses. Determination of the degree of imbalance on 11kV circuits has traditionally required expensive monitoring.

We have developed a modelling tool to assess the extent and location of phase imbalance on rural 11kV networks. This modelling tool utilises readily available network metrics to identify feeders which are likely to exhibit high imbalance. This has reduced the need for monitoring and informed our understanding of this source of losses. Models have been calibrated using data collected from 52 HV feeders across 8 Primary substations located across both of our licence areas.

This work has indicated a high level of imbalance on a total of 232 HV rural feeders across both licence areas. Upgrading single phase spurs to three-phase lines was found to be cost prohibitive. The low-cost solution of phase-phase line reconnections shows a payback period of between 7 to 14 years. The level of benefit does not warrant a dedicated programme, but intervention activity will form part of existing asset modernisation programmes. The maximum potential losses savings associated with all 232 feeders are circa 1.08GWh per annum.

Holistic Losses Consideration

Holistic System Losses

As deployment of distribution connected generation continues, managing the distribution / transmission interface is increasingly challenging. In particular, the SO is facing new challenges for voltage control. We have taken the opportunity to explore a more holistic operating regime and are considering the management of boundary conditions utilising embedded generation to attain a loss-inclusive optimised regime with the SO. This aims to reduce the requirements for reinforcement on the transmission network, but would increase losses on the distribution network.

The impact on distribution network losses was calculated across the power factor range of 0.9 lagging to 0.9 leading with the base case reflecting current operating conditions. Dependent on the operating regime, worst case scenario estimates indicate that for SPM network losses may increase by up to 5.5GWh/year, and for SPD losses by up to 3.3GWh/year. Further details are contained in Appendix 5.

These studies have improved our understanding on a range of possible operating conditions and the impact on our network losses. We are now discussing these results with NGET and will explore operating boundary conditions that offer greatest holistic benefit. Our findings will be shared with the relevant industry groups as they may influence future DSO practices and regulatory approaches.

Improve Substation Efficiency

Substation Efficiency

We have considered re-using waste heat from transformers to provide a useful commodity. We have also looked at how to improve the energy efficiency of our substations, exploring the potential for a self-sufficient substation.

a) Heat Recovery

Our assessment has indicated that indoor Primary substations have the greatest potential for deploying successful heat recovery schemes. We initially identified 30 indoor transformer sites to be subject to more detailed review based on; number of transformers, proximity to buildings with a perceived heat demand, higher than average loading and planned Asset Management interventions. We have now produced a prioritised shortlist of ten sites for further assessment of thermal potential. We intend to engage an established heat recovery specialist to review appropriate heat recovery technology, costs and potential benefits. Where substations are embedded within or immediately adjacent to a third-party property we will look to encourage interest, and share the benefit, in potential heat recovery solutions. (Further details are included in Appendix 6).

In addition, to better understand typical distribution substation thermal conditions, temperature and humidity monitors were installed during Q3 2017. The data obtained will inform decision making during the feasibility assessment and trial of heat recovery schemes.

b) Energy Efficiency

We plan to continue our work on understanding the scale and profile of energy required to operate our distribution substations. Our review of industry work found a gap in the understanding of losses arising from substations.

Building on the output and learning from an ongoing Network Innovation Allowance (NIA) funded project in SP Transmission (SPT), we are working collaboratively with the TO and focusing on Secondary and Primary substations. We remain informed of SPTs work to ensure appropriate learning and understanding is transferred to the SPM area whilst avoiding duplication in separately funded activities.

In Q3 2017 we established a pilot metering trial of five Primary and five Secondary substations in the SPM licence area. These early pilot results have provided a snapshot of demand at modern and legacy sites and given us confidence to expand our monitoring across both licence areas.

In addition, a review of potential self-sufficiency energy solutions applicable to substation sites has been conducted. We will continue to refine the criteria for alternative energy solutions throughout our future monitoring and investigate cost effective efficiency measures. We will take account of the environmental conditions as, for example, modern switchgear needs a dry, warm environment which can be more challenging in the colder, damper parts of the UK within which we operate.

NEXT STEPS

Current LDR work to further develop our understanding of losses under ongoing initiatives will continue as planned during Tranche 2, including:

- Dependency on the availability of smart meter data, to the extent of further testing relevant analysis tools, methodologies and IT platforms, will influence the future rate of progress of specific actions.
- Results from our phase imbalance assessments will be verified at selected sites and model results from the 232 HV overhead feeders will feed into our asset modernisation plan where appropriate. This will bring this LDR work into BAU.
- In our expanded substation efficiency study we will collect metering and site audit data to establish annual profiles correlated with equipment use patterns to determine the most effective interventions.
- In our pursuit of a holistic view on losses management we will progress our engagement with NGET to examine the impact on losses at the transmission boundary.
- To realise customer losses benefits at our LV boundary, we will further develop the technical architecture and business case for a trial of a voltage optimisation schemes.

In addition, the flexibility of our portfolio provides an opportunity to incorporate new initiatives that add value to our understanding of losses and we have identified the following:

- Mobile Asset Assessment Vehicle (MAAV). We have received a demonstration of the Power Survey Company's MAAV, a technology that can detect stray voltages which may be a source of losses and is currently subject to a comprehensive trial by UKPN. It is our intention to undertake a business case review to assess the feasibility of this technology.

In parallel with our current work and, as a result of scoping and developing analytical and modelling methodologies, we have formed Guiding Principles for an RIIO-ED2 regulatory approach. We will work with the other DNOs and TOs though the ENA Technical Losses Task Group, in line with the agreed 2018 work programme which aims to provide recommended options by March 2019.

Further details on this can be found in Section 7.

4 | Stakeholder Engagement & Sharing Best Practice

We continue to make progress on stakeholder engagement, especially liaising with those organisations who contribute to our better management of losses and those who have an interest in our losses activity.

Collaborative Approach

ENA Technical Losses Task Group

To ensure that all DNOs are able to learn from and collaborate with each other, we convened and Chair the Technical Losses Task Group within the ENA Electricity Networks and Futures group. The Task Group enables the DNOs and TOs to share better understanding of losses and to apply best practices of new knowledge, avoiding where possible duplication of effort. Specific activities that we have been instrumental in include:

(a) Impact of LCT

We led on the procurement and delivery of a report by WSP that analysed the impact of a low carbon transition on technical losses. This report is intended to inform network operators and Ofgem of the losses impact of using smart solutions to inform future loss strategies. We anticipate that findings from these studies will feed into our considerations of future regulatory approaches.

(b) Ofgem Teach-In

We developed and presented a losses teach-in workshop for Ofgem staff on behalf of the ENA Task Group. This provided an overview of previous and current regulatory approaches, plus an explanation of the different characteristics and sources of losses. We intend to repeat and expand upon this workshop later in 2018.

As part of the presentation, we developed an Excel based interactive demonstration on the impact of demand on losses. This was shared with other DNOs for wider stakeholder use, granting permission for others to use on their web-sites.

Increased Revenue Protection Activities

Engagement on Non-Technical Losses

(a) Revenue Protection

Recent work on the identification of non-technical losses through the innovative analysis of smart meter data has included engagement with suppliers via the TRAS Expert Group (TEG). These are new developments which will continue throughout the RIIO-ED1 period.

Our Revenue Protection team initiated and hosted a number of awareness sessions for stakeholders who may encounter meter tampering and safety issues during their work. This includes Housing Associations landlords and smart meter installers. The team has now permanently embedded a member of staff with the Merseyside Police force and this has resulted in a significant increase in the detection of energy theft particularly in relation to cannabis farms. Consequently, we are actively pursuing a similar initiative with Police Scotland.

Our Revenue Protection team is also actively supporting the TEG and we have introduced the innovative analysis of energy consumption with ambient temperature as an enhancement to existing TRAS detection algorithms.

(b) Global Working Group

As a part of the Iberdrola group of companies, we are also collaborating with network operators in North America, Brazil, and Spain via the Iberdrola Fraud and Losses Global Group. Our work in this area is guided by the use of an internal losses yardstick with the aim of comparing network losses in each organisation. Whilst there are limitations to this approach, we continue to feed into the project taking into account the differences between our territories, recognising that non-technical losses are higher in some regions and that differences in smart meter architecture may enable the deployment of different solutions.

Holistic Losses Consideration

Relationship with NGET

Our recent work under two of our modelling initiatives has helped us to understand the interactions with other networks and the impact of others on our own network losses. For example, the parallel power flows through the SPM network imposed by the flows through the transmission network; or the potential increase in losses on our distribution networks that would be incurred by managing conditions at the transmission interfaces by embedded generation. We will engage with NGET to identify a holistic loss-optimised operating regime. We will also involve any embedded generation owners/operators when and where appropriate. It is possible that the optimum solution, intended to accommodate embedded generation without significant load-related capex on Transmission or Distribution networks, may involve an increase in losses for one or more stakeholders. We will review and report on this aspect during Tranche 3.

Customer and Stakeholder Engagement

Influencing Customer Behaviour

In our Tranche 1 submission we included an initiative directed at improving network loading by active stakeholder engagement. This work recognised the impact on network loadings of customer/prosumer behavioural change and additional embedded generation. Where these changes result in higher loads on existing assets there is a consequential increase in technical losses. For example, if an active network management scheme is used to defer network reinforcement then the load factor and losses will increase. We plan to assess those parts of our networks where flexible connection schemes will be deployed during RIIO-ED1 (as identified under our Incentive on Connection Engagement (ICE) Action 8[3]). In parallel, we have engaged with specific customers to assist them in understanding their usage patterns and the impact on losses. Examples include our on-going work with Flintshire County, their supplier and the Welsh Assembly.

Connection Customers

We are considering how customer connections impact on losses. As an example, we recently provided enhanced support to a new customer connection application. The customer was provided with information on their likely site specific Loss Adjustment Factor (LAF) at the outset to allow them to consider losses as part of their connection decision. As a result, we are reviewing how we can best give advice to new connection customers about connection options, including the interaction between capital costs and on-going losses. This work is outside of our work under ICE and we confirm that there are no stakeholder engagement actions that have been included under both the LDR and ICE incentive schemes.

Smart Meter Programme Engagement

An Ipsos MORI study published in March 2017[4] on behalf of the ENA "... found a high level of support for DNOs to access half-hourly electricity consumption data held by smart meters." The study also highlighted areas the DNOs should consider further and address in their engagements with consumers, including ensuring a clear articulation of benefits and demonstrating that the data is being put to effective use. The loss analysis performed on 'granular' smart meter data in our LDR initiatives will add significant value to inform how these consumer concerns can be addressed.

Communication

We are now hosting a dedicated Losses area on our website[5] to inform interested customers of our Losses Strategy and LDR work and seek feedback from them. This will help us understand the impact of our losses actions on other parties and inform which actions we take. Our more detailed technical reports and findings will be available to share best practice with other network operators.

[3] https://www.spenergynetworks.co.uk/pages/distributed_generation.aspx
[4] http://www.energynetworks.org/assets/files/Ipsos%20MORI%20Report%20DNO%20Use%20of%20HH%20Data%20-%20FINAL%2016-03-17.pdf
[5] https://www.spenergynetworks.co.uk/pages/electricity_network_losses.aspx

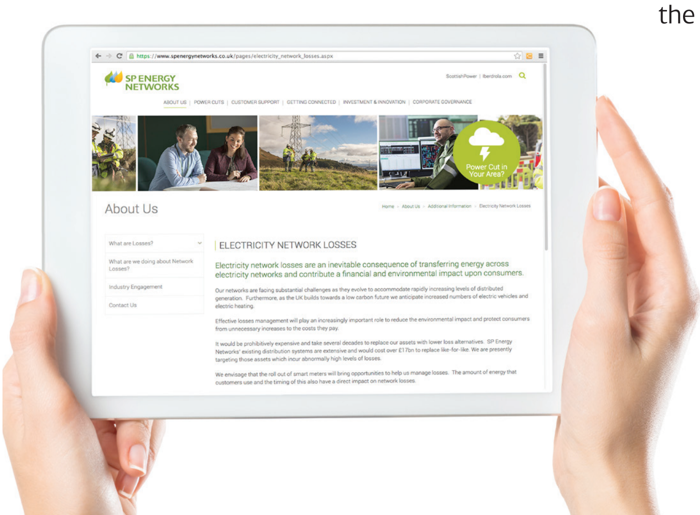
We took the opportunity to communicate our LDR initiatives to a wider audience and presented at the 24th International CIRED Conference[6] in June 2017. This conference focused on electricity distribution and was attended by over 1500 participants from over 50 countries.

TEPCO Workshop

As a direct consequence, we were contacted by TEPCO (Tokyo Electric Power Company) and in November 2017 hosted a losses workshop at our Prenton offices. Such activities ensure that we are aware of international best practice as it relates to technical and non-technical losses and we are now investigating a number of opportunities, including:

- Central Voltage Control System[7]. The field demonstration reported has many similarities with our voltage optimisation work and we will include the learning from their field trials.

- Seasonal normal Open Points (NOPs). TEPCO have analysed how they may optimise HV network loadings by moving the NOPs to reflect seasonal loading. Initial shared research indicates that up to 6% of losses may be saved on the parts of the HV network where this can be deployed. We plan to review and validate the GB business case and share findings with Ofgem and industry.



NEXT STEPS

Building on the work we have undertaken, a number of specific activities are planned for the Tranche 2 period, including:

- Repeat and expand audience for Teach-In, including more detailed reference to LCT studies.

- Progress Revenue Protection awareness sessions, liaising closely and developing partnerships to further our assistance within both SPD and SPM licence areas.

- Build on our engagement with NGET to ensure impact and learning from our LDR initiatives feed into holistic assessments.

- Following review, update processes with regard to the provision of LAF information to connection customers to assist them in making fully informed decisions.

- Continue engagement with TEPCO to enable review of the business case and applicability of seasonal NOPs to our network.

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.

[6] *http://www.cired-2017.org*

[7] *Field demonstration and evaluation of centralized voltage control system for distribution network, Watanabe, Miyata (TEPCO), Itaya, Takano (Mitsubishi Electric). CIRED 2017*

5 | Processes to Manage Losses

Building on the work undertaken to develop our Losses Strategy and Tranche 1 submission, our dedicated Losses Team have been both reviewing and helping to shape national and international best practices on losses.

This work will continue in Tranche 2, particularly through the development of ENA Technical Losses Task Group recommendations on best practice. Subsequently, the Task Group will outline the regulatory options and opportunities that make best use of our learning as we prepare for RIIO-ED2.

Collaborative Approach

Best practice

We have attained a good understanding of national and international best practice via:

- Learning from the ENA Technical Losses Task Group.
- Leveraging knowledge from the Iberdrola Group which has varied network operations businesses across Spain, GB, USA and Brazil.
- Academic research in UK on losses management and recommendations.
- Learning from Ofgem's Innovation funded work.
- International perspectives and thought leadership on losses at CIRED and CIGRE.

This knowledge is a valuable resource to help us decide which initiatives are likely to provide best value in managing losses. Specific examples include:

a) Internal

With respect to non-technical losses, we believe our Revenue Protection Service and engagement with TRAS represents best practice. In SPM we have engaged with Merseyside Police to combat illegal abstraction. We are currently establishing similar processes with Police Scotland. These are long-term relationships and will extend into RIIO-ED2.

b) National

One of the key aims of the ENA Technical Losses Task Group is "to provide a vehicle for development of sharing and development of best practice for SLC49 and LDR activities." We Chair the Task Group which, since its inception in March 2016, has met to promote a common understanding of the key LDR issues. Deliverables from this collaboration to date include:

- Collated, summarised, and compared each of the DNO's Losses Strategy and LDR activities. This provides clarity and visibility of the common topics addressed. The Task Group will look to formalise these into a set of ENA Technical Losses Recommendations to provide a common basis of assumptions for assessments.
- Procured a comprehensive study that assessed the impact of a low carbon transition on technical losses. The results are helping to inform how losses can be managed and the scale of uncertainty as low carbon technologies continue to be deployed.

The Task Group provides a useful platform for sharing results of LDR initiatives, for example our modelling of rural HV phase imbalance has provided an approach and methodology to identify HV feeders with a high likelihood of imbalance. Following validation our findings will be shared with the Group so they may also benefit from its adoption during RIIO-ED1 and forward into RIIO-ED2.

c) International

Iberdrola Networks Business Group has established a global initiative to measure and monitor losses across the network businesses. We are engaged in this process and will gain useful insights into the pursuit of losses management practices, including smart meter data analytics, across Iberdrola global networks businesses.

Iberdrola is an active member of the CIRED Working Group on Losses Reduction[8]. This international group is primarily engaged in reviewing European practices in the measurement, management and mitigation of distribution network losses. The scope of work was later broadened to a worldwide perspective where information was available. A final Working Group report on the Reduction of Technical and Non-Technical Losses in Distribution Networks was published in November 2017.[9] We are working with our Iberdrola colleagues assessing the report findings to capture best practice losses management and mitigation techniques in the context of the GB electricity industry.

[8] *http://www.cired.net/working-groups/technical-and-non-technical-losses*
[9] *http://www.cired.net/files/download/188*

Innovative use of Smart Meter and Network Data

Innovative use of smart meter and network data

During the development of our RIIO-ED1 business plan, we recognised the potential of granular smart meter data to advance the understanding and management of our LV networks. An IT system, EnergyIP, for storing and processing smart meter data has recently been delivered to the business for acceptance testing. This system has been procured outside the scope of LDR and will store smart meter data, providing the necessary security and privacy functionality. To identify and manage potential network constraints as LCTs are more widely adopted, we are developing a Network Constraint Early Warning System (NCEWS). The system utilises GIS data and an enhanced connectivity model together with smart meter data to increase the visibility of changing demand patterns, including those due to the emergence of LCT hot spots.

As outlined in our Losses Strategy there is a need to improve network measurements to better understand losses; the installation of enhanced monitors at Secondary substations will assist here. Data from smart meters linked with enhanced monitoring will be analysed to gain further insight on losses across a variety of LV network components. This functionality will be considered in our NCEWS implementation.

Output from the analysis tools would be used to manage losses through process integration with the planning and asset management functions. This will ensure early consideration of losses in determining asset replacement or refurbishment options.

Enhanced Network Modelling

Enhanced Network Analysis and Modelling

We have engaged power system specialists, TNEI, to consider national and international best practices in the development of an advanced network modelling tool. This methodology will be used to consider losses when undertaking major investment/policy decisions during the remainder of RIIO-ED1 and into RIIO-ED2.

Our DSO Vision[10] discusses the evolution to an active network management role that will maximise the potential of the existing electrical infrastructure. The SO/DSO boundary will be a key interface in this new role and build on engagement with NGET to progress our understanding of the impact of changing boundary conditions through enhanced modelling. This will inform holistic assessment practices and develop the necessary new processes to incorporate a loss-inclusive approach.

Improve Substation Efficiency

Substation Efficiency

In our initiative on transformer heat recovery we have identified best practice for new build sites. We have identified some examples of heat recovery from distribution transformers and we are assessing a heat recovery policy at some of our substations. We are continuing this initiative to progress our understanding and that of the wider industry.

We have evaluated how others view substation energy consumption and any actions taken to mitigate losses. We plan to develop policies that drive efficient operations.

NEXT STEPS

Throughout the RIIO-ED1 period we will continue to assess national and international developments for best practice that encourage improved understanding and management of losses. We will monitor learning from Ofgem incentive programmes such as NIA and NIC projects conducted by DNOs and NGET and continue to drive sharing of knowledge and best practice between participants at regular ENA Technical Losses Task Group meetings.

To maintain and update knowledge of international best practice we will:

- Continue our engagement with Iberdrola group network companies to support best practice in losses assessment and management.
- Capture GB-relevant good practice from the CIRED report on the Reduction of Technical and Non-Technical Losses in Distribution Networks to inform the direction and scope of our LDR initiative portfolio.

[10] *https://www.spenergynetworks.co.uk/pages/dso_vision_consultation.aspx*

- We will also assess any losses incentive mechanisms associated with other European regulatory regimes in the CIRED report to assist with preparation of a measurable losses incentive in RIIO-ED2.
- Complete our review of the October 2017 CEER Report on Power Losses. This may also influence preparation of an RIIO-ED2 incentive and assess how findings and recommendations may be applied to our distribution network.

Having established smart meter data analysis tools in Tranche 1 that can enhance the visibility of losses on the LV network, we will continue to scope out and ensure that the necessary functionality is included within the NCEWS tools. We are working towards the use of advanced smart meter analytics where these will support our understanding and management of losses.

We are engaging directly with NGET to explore the management of SO/DNO boundary conditions for greatest holistic benefit and we will continue this work. Future activities will develop, to better understand potential SO/DNO interface conditions; we will also consider appropriate technology and processes for their control. We envisage that the outcome from this work will help clarify some aspects of potential DSO operations.

We will share the findings on the feasibility of retro-fitting heat recovery systems to Primary distribution transformers with the Task Group. We have shortlisted ten sites that will progress to specialist assessment. Sites with a positive CBA will then be selected for trials.

We will continue to look for best practice in loss management. We will actively support the ENA Task Group in developing thoughts on losses incentives.

6 | Innovation and Business as Usual

Our Tranche 1 submission aimed to extend the boundaries of our losses management capabilities through various innovative initiatives. We have been progressing all of these and some have already been successful and are moving into BAU. These are discussed here.

Through progression of our Tranche 1 work we have identified several new opportunities for LDR innovation. These are also discussed in this section and we confirm that each of the activities is not funded under any other RIIO-ED1 financial initiatives. As our LDR initiative portfolio matures we will continue to embed successful initiatives into BAU.

Innovative use of Smart Meter and Network Data

Innovative use of smart meter and network data

During Tranche 1, we identified and developed an approach to determine service cable losses from smart meter data. This has demonstrated how smart meter data can be combined with GIS cable data to determine a range of typical service losses values. The methodology has enabled the quantification of potential losses savings and highlights the added value of using disaggregated smart meter data (refer to Appendix 7). It is anticipated that the methodology will be built into NCEWS analysis functionality and will become a BAU process available to network planners. These loss initiatives, and the associated added value demonstrated from the availability of smart meter data, are out of the scope of the NIA funding for the NCEWS project.

A second new method to reduce losses was identified during our Tranche 1 work. This proposal would identify LV fuse failures on our interconnected LV network using voltage profiles from disaggregated smart meter data (Appendix 8). LV fuse failures in an interconnected network do not necessarily interrupt supplies, but do increase losses and reduce supply security. Fuse failures could be identified through variation in volt drop and managed through prompt fuse replacement. Additional customer benefits would arise through avoided customer interruptions. If successful, this functionality would be incorporated in the NCEWS analysis tools and an interface provided to operational functions in SPM.

As smart meter data becomes prevalent, a method of voltage analysis[11] is planned for trial to refine and expedite completion of the NCEWS customer-network connectivity model without the need for detailed and expensive on-site investigations.

[11] The initial work on this method is reported in the CIRED conference paper: Accurate Determination Of Distribution Network Losses, Urquhart, Thomson (Loughborough University), Harrap (WPD)

Collaborative Approach

An innovative approach to improve theft and fraud detection combines smart meter data with weather data to provide a degree-hour metric as an additional consumption comparator, summarised in Appendix 9. The approach enhances understanding of losses related to ambient temperature and can identify outliers that may warrant further investigation. The analysis has been presented to the TRAS Expert Group and Experian has presented the approach to the wider supplier community to consider adoption in the TRAS business model.

The same degree-hour methodology can also assist the wider industry in better identifying the least energy efficient dwellings. Through our engagement with suppliers we will assess the potential to support customers in suppliers' energy efficiency campaigns and programmes.

Holistic Losses Consideration

Voltage Optimisation

We are considering a novel operational scheme to optimise voltages on our 11kV and LV networks simultaneously, detailed in Appendix 10. The proposal relies on voltage data from smart meters to provide feedback to the 11kV Automatic Voltage Control (AVC) schemes. Enabling this feedback could provide improved control of LV voltage at customer premises and realise the associated customer losses benefits. We believe this innovation to close the LV/11kV control loop is unique, providing a holistic view on voltage management across our 11kV and customer LV systems. We intend to scope out system integration requirements and identify trial sites once sufficient smart meter data is available. This initiative is additional to our Losses Strategy and is not funded elsewhere in our business plan.

Enhanced Network Modelling

Enhanced network analysis and modelling

A losses modelling methodology has been developed and tested that significantly improves the accuracy and granularity of our quantification of technical losses across our 11kV, EHV and 132kV networks. The tool enables much more granular analysis of larger network models and their behaviour patterns throughout a given year. This is in contrast to the traditional approach which made use of smaller, fragmented network models that were only analysed in detail at times of peak demand and peak generation. Our ability to consider our planned network throughout all operating periods in a year is expected to deliver a reduction in network losses through our ability to optimise how we operate our assets. This will include changes to network configuration and the target set points on power flow controllers and voltage control devices. Our work on these initiatives is a significant contribution to managing losses in our network planning, design and operations activities. This innovative tool has been adopted for BAU use and will be used to consider losses when undertaking major investment/policy decisions during the remainder of RIIO-ED1 and forward into RIIO-ED2.

Following the lessons learnt from our workshop with TEPCO, we will assess the business case for GB networks of reducing network losses by moving HV Normal Open Points (NOPs) seasonally. This initiative is additional to our Losses Strategy and is not funded elsewhere in our business plan.

In Tranche 2, we intend to consider the practicality and business case of embedding losses calculations within our SCADA/Distribution Network Management System (DMS). By deploying state estimation and power analysis techniques, it may be possible to quantify the losses through each distribution assets at HV, EHV and 132kV in near real time. This complex system may offer the opportunity to quantify losses, with reasonable accuracy, at HV and above.

HV Rural Networks

Our Tranche 1 work has improved our understanding of the relationship between phase imbalance and losses on rural 11kV overhead lines due to single-phase spurs. We made use of GIS data to determine appropriate metrics to model potential phase imbalance and consequential losses. The modelling tool reduces the need for monitoring and results will be validated to develop the business case for BAU deployment within the planning and asset management functions. This activity was identified as 'opportunistic' in the Losses Strategy and is solely funded from the LDR mechanism.

Increased Revenue Protection Activities

Improving Theft and Fraud Detection

We have demonstrated the benefits of embedding a Revenue Protection team member, with knowledge of energy consumption patterns, in Merseyside Police to support their Cannabis Dismantling Team. This approach has been adopted as BAU in SPM and we are in discussions with Police Scotland to implement a similar, mutually beneficial, and innovative working partnership in Scotland.

Our activity with the TRAS Expert Group has demonstrated the use of smart meter data analysis to identify demand outliers. The degree-hour analysis, described above, has been discussed and recognised by Experian as a useful addition to their suite of tools. We will maintain this enhanced interaction with our RPS team and TEG in future business activities.

Substation Efficiency

We have learnt from the experience of UKPN and NGET and are continuing to explore the feasibility of alternative uses for waste heat at substations. The UKPN and NGET schemes have adopted a solution that integrates design of a large transformer and heat recovery system in a new build environment. The innovation in our work is to explore the feasibility of heat recovery systems on smaller Primary distribution transformers and on a retrofit basis. We will continue this work and will make use of the Scottish Government's Heat Map[12] to identify potential, coincident uses of waste heat. This initiative is not included in our Losses Strategy or other business plans and is not funded under any other RIIO-ED1 financial initiative.

We now better understand distribution substation energy requirements and opportunities for efficiency improvement. This learning will enable the development of appropriate energy efficiency actions and the feasibility of self-sufficient substations. Learning from this initiative will be incorporated into appropriate specification, design and policy documents for adoption as BAU within the RIIO-ED1 period.

Our Losses Strategy focuses on reviewing substation building requirements and the relevant specifications are being revised accordingly. Our LDR work extends this to quantify equipment energy requirements and establish energy efficiency measures for cost-effective retro-fitting at existing sites. We verify that funding is not included elsewhere in our business plan.

NEXT STEPS

We plan to explore two innovative applications of smart meter data. Firstly to reduce losses due to LV fuse failures on our interconnected network, and secondly to consider the use of smart meter data for voltage optimisation by using the LV voltages within the HV Automatic Voltage Control. In each case, successful trials could be quickly adapted into BAU.

It is our intention to undertake a business case review to assess the viability of the Power Survey Company's Mobile Asset Assessment Vehicle (MAAV) as discussed in Section 3.

We intend to consider the practicality and business case of embedding losses calculations within our SCADA / Distribution Network Management System (DMS) to calculate losses through each asset at HV and above, in near real-time and with a reasonable degree of accuracy.

As our initiatives develop, we hope that there will be a range of new BAU activities; some requiring relatively simple process changes that can be implemented early, to more complex changes for embedding later in RIIO-ED1.

Embedding appropriate process changes into BAU is likely to require revision of internal documents such as strategy, policy, standards and specifications and we plan to complete these revisions during the RIIO-ED1 period.

We are not anticipating BAU process revisions that impact on any licence or statutory obligations but if the situation does arise we would raise it at the ENA Technical Losses Task Group for collective discussion to determine a common approach and solution.

[12] *www.heatmap.scotland.gov.uk*

7 | RIIO-ED2 Regulatory Approach

In addition to the work described in our Losses Strategy, our LDR activities are contributing to the further development of losses-inclusive management of our networks under RIIO-ED2.

The tools, techniques, analyses and processes in our Tranche 1 work have already provided valuable learning. Various initiatives have shown benefit and progress into BAU and we continue to share our best practices and learn from the other DNO work in this area.

This work will continue through Tranche 2, although our focus will shift slightly to leverage our improved understanding and, collectively, to outline the regulatory options and opportunities which make best use of our learning as we prepare for RIIO-ED2.

We are aware of Ofgem's initial views shared at on-going stakeholder RIIO-ED2 workshops, particularly: a focus on items of greatest value to customers, and how incentive mechanisms may be limited by a materiality threshold.

In collaboration with the other DNOs and NGET we are working to provide recommendations for a regulatory approach in RIIO-ED2. We submitted a set of proposed Guiding Principles to the ENA Technical Losses Group attendees and a work plan was subsequently agreed based on the process detailed in Figure 3 below, which aims to provide a set of recommendations to Ofgem by March 2019.

Figure 3: Work-plan Process

Guiding Principles

We, at SP Energy Networks, consider the initial Guiding Principles for the regulatory approach to losses in RIIO-ED2 to include:

1	**Incentivise** the economic and efficient management of losses.	Any regulatory approach must incentivise the economic and efficient management of losses incurred on GB electricity networks. This should be for the benefit of customers, considered holistically across GB and be consistently and transparently applied across all network operators (including IDNOs). It should allow for network diversity and can only incentivise measures under network operator control.
2	**Balance** between today's and tomorrow's customers	The move to a low carbon future will significantly impact electricity networks. Any mechanism must not create economic barriers to the low carbon transition or innovation. The uptake of LCTs and the way our networks evolve to accommodate them both have the potential to significantly impact losses. The increasing adoption of smart solutions, actively controlled networks and progression to DSO all increase future uncertainty. Any proposed regulatory approach must recognise uncertainties in uptakes and future industry change.
3	**Harmonious** with other incentives and revenue streams	Any future losses approach sits within the RIIO and wider economic and commercial contexts, and needs to avoid unintended or perverse consequences. It must be proportionate to incentivise all network operators, regardless of present performance, network topology or customer behaviours. It must promote the most economically efficient development of networks for the benefit of customers and to achieve GB environmental targets.
4	**Efficient** to operate and **practical** to implement	Losses are complex, difficult to measure and vary based on regional topology. Future regulatory approaches should strike a balance between complexity and accuracy. Metering limitations, smart meter rollout and overall stability must be recognised in the evaluation of losses.

Optioneering

Once the Task Group have collectively finalised the Guiding Principles for a losses mechanism, a range of options for future regulatory approaches will be considered. Options will be drawn from international practice and drawing on cross-vector experience.

All stakeholders will be considered and the merits and challenges of each option investigated.

Due to the complexities and inter-dependencies relating to network losses, assessing the options for a regulatory approach in RIIO-ED2 will require consideration of many factors:

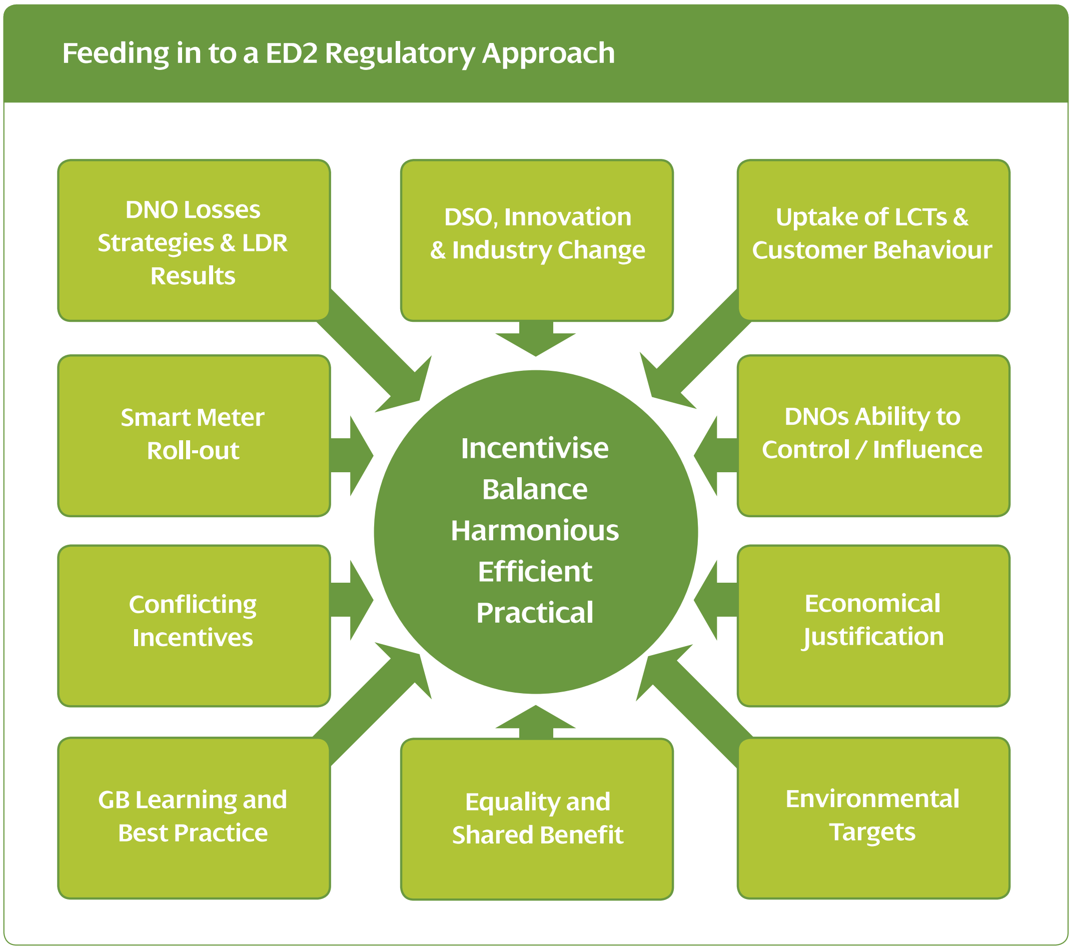


Figure 4: ED2 Regulatory Approach

In developing the options, they will be shortlisted based on their ability to satisfy the Guiding Principles. The shortlisted options will then be subject to more detailed and in-depth stress-testing to ascertain their practicality, sensitivity and outcomes.

We anticipate detailed modelling will be required and alignment with Ofgem's RIIO-ED2 strategy will be a key consideration. The outputs of the stress-testing analyses will help inform the group to enable us to provide our considerations and recommendations to Ofgem by end Q1 2019.

Under the RIIO-ED1 loss mechanisms (Strategy and LDR) the economic impact of losses is already more visible than previous. Therefore we propose that the option of continuing the RIIO-ED1 mechanism into RIIO-ED2 may provide a baseline against which to compare any alternative approach.

Regardless of the uncertainty in future networks configurations and utilisation, the outputs from our Losses Strategy coupled with the LDR Initiatives and our joint work at the ENA Task Group, will enable us to plan, build and operate our networks more efficiently.

8 | Overview

This submission provides evidence of our progress on the portfolio of initiatives we presented in our Tranche 1 Report, plus details of other activities undertaken with regard to better understanding and managing network losses. We include many examples of how our new knowledge has been translated into action. Some of our actions in networks loss management are our innovations whilst others are a direct application of new knowledge from understanding best practice elsewhere. We have not completed this work on our own, but have worked with others, including the other five DNO groups, NGET, Suppliers, other industry parties and our international colleagues.

Work completed in Tranche 1 forms a solid base for the work we will continue to progress during Tranche 2 and into Tranche 3. Some initiatives have been refined and new ones added to our portfolio to ensure our activities remain comprehensive and relevant. We will continue to provide leadership and significant resource to industry collaboration. We continue to engage with stakeholders, both to share knowledge and to shape our approach and actions.

An overview of the current and future activities is included in the diagram below:

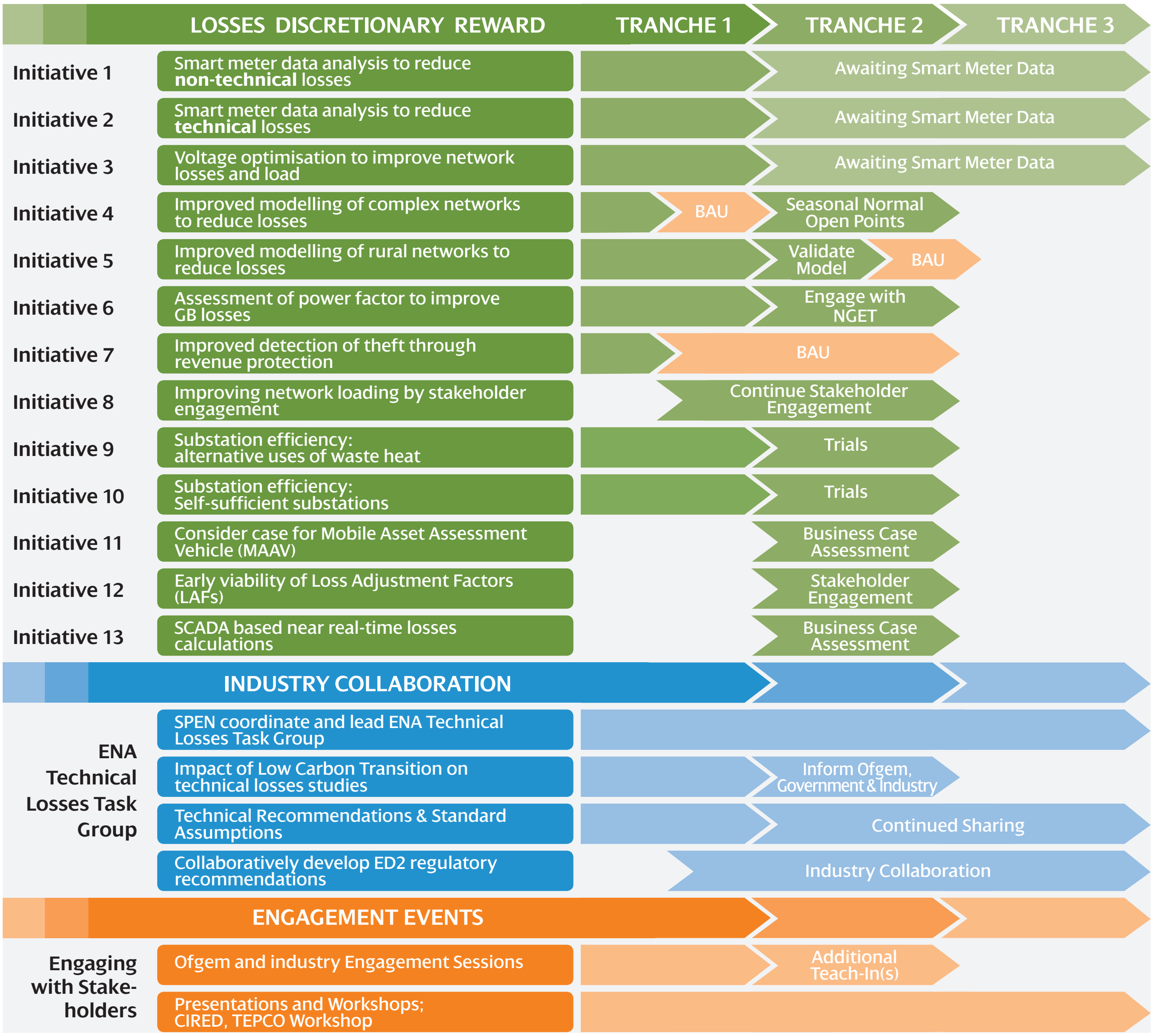


Figure 5: Overview of LDR Activities

From the work completed to date, we have identified the initiatives we can implement, which ones continue to show potential and those that we can close having benefitted from the new learning they have delivered.

A summary of our next steps for each initiative is shown in the table below:

Table 1: LDR Initiatives Next Steps

	INITIATIVE	NEXT STEPS
1	Smart Meter systems to reduce non-technical losses	• Continue engagement with TRAS (Experian and TEG) • Progress use of degree-hours to identify 'outliers' • Utilise smart meter and monitoring data as it becomes available
2	Smart Meter systems to reduce technical losses	• Scope out necessary functionality to include within NCEWS project • Utilise smart meter and monitoring data as it becomes available • Develop analysis toolset for feeder / transformer loss assessments
3	Voltage Optimisation to manage Network Losses	• Identify candidate network sections using selection criteria • Develop voltage optimisation trial using smart meter data
4	Improved Modelling of Complex Networks to Reduce Losses	• Amend BAU policy recommendations • Assess benefit of the seasonal adjustment of normal open points • Review opportunity to inform an RIIO-ED2 regulatory approach
5	Improved Modelling of HV Rural Networks to Reduce Losses	• Install monitors on 14 HV circuits to validate model results • Amend asset modernisation programmes accordingly • Update appropriate policies to reflect new learning
6	Assessment of Power Factor on GB Losses	• Engage with TSO to confirm requirements and business case • Assess generation dispatch vs traditional solutions (e.g. capacitors)
7	Detection of Theft & Revenue Protection	• Continue interaction with police to provide training and awareness of initiatives
8	Improving network loading by active stakeholder engagement	• Continue to support customers in collaboration with suppliers • Review outcome of engagements / other innovation projects • Develop BAU policy recommendations
9	Substation Efficiency: Use of waste heat	• Engage an established supplier - discuss technical options /costing • Review 3rd party collaboration opportunities and trial pilot site.
10	Substation Efficiency: Monitor & consider self-sufficient substations	• Extend scope of metering study and building audits to include SPD • Develop energy efficiency actions/feasibility of self-sufficiency • Review/edit policy documents for new build and retro-fit solutions

The benefits and materiality of each of the above initiatives are included in Appendix 11.

In addition, we have added the following three specific initiatives:

Table 2: New LDR Initiatives

	INITIATIVE	NEXT STEPS
11	Review of Mobile Asset Assessment Vehicle	• Review evidence, marketplace and Losses specific applications. • Construct a detailed business case evaluation and CBA
12	Awareness of Loss Adjustment Factors	• Review connections process • Obtain feedback from customers
13	SCADA based near real-time losses calculations	• Consider practicality and business case • Review opportunity to inform an RIIO-ED2 regulatory approach

As a matter of course, we will continue to review work reported by other DNOs in their LDR submissions and via the ENA Task Group.

During the Tranche 2 period, working with the ENA Task Group, we will drive preparation for a losses incentive in RIIO-ED2. To instigate the process, we will agree a set of Guiding Principles and develop a scope of work to assess implementation options against these Principles. The Task Group will assure that the direction and aims of the Group align with Ofgem expectations by early engagement with their representatives.

Appendix 1 | Glossary

TERM	DEFINITION
BAU	Business as Usual
CBA	Cost Benefit Analysis
CEER	Council of European Energy Regulations
CIGRE	The International Council on Large Electric Systems
CIRED	International Conference on Electricity Distribution
DMS	Distribution Management System
DNO	Distribution Network Operator
DSO	Distribution System Operator
EHV	Extra High Voltage (33kV and above)
ENA	Energy Networks Association
GIS	Geographic Information System
GWh	Giga-Watt hour = 1 million kWh
HV	High Voltage (11kV & 6.6kV)
ICE	Incentive on Connection Engagement
IFI	Innovation Funding Incentive
kV	Kilo-volt = one thousand Volts
LAF	Loss Adjustment Factor
LCNF	Low Carbon Network Fund
LCT	Low Carbon Technologies
LDR	Losses Discretionary Reward
LV	Low Voltage (<1kV, usually 415V) three phase, 230V single phase
MAAV	Mobile Asset Assessment Vehicle
MDI	Maximum Demand Indicator
NCEWS	Network Constraint Early Warning Centre
NGET	National Grid Electricity Transmission
NIA	Network Innovation Allowance
NOP	Normal Open Points
PV	Photovoltaic solar generation
RIIO-ED1	Revenue=Incentives+Innovation+Outputs – Electricity Distribution 1 (Ofgem price control 2015/16 to 2022/23)
RIIO-ED2	Revenue=Incentives+Innovation+Outputs – Electricity Distribution 2 (Ofgem price control 2023/24 to 2031/32)
SCADA	Supervisory Control and Data Acquisition
SO	System Operator
SPD	SP Distribution plc
SPEN	SP Energy Networks
SPM	SP Manweb plc
SPT	SP Transmission plc
TEG	TRAS Expert Group
TEPCO	Tokyo Electric Power Company, Japan
TO	Transmission Owner
TRAS	Theft Risk Assessment Service

Appendix 2 | Initiative Assessment Process

Given the many innovative ideas and approaches suggested to address network losses, we have developed a 3 step process to determine if such activities can be considered for inclusion in our LDR portfolio:

Step 1: Identify

There are a number of sources to identify new ideas and activities worthy of assessment:

- Internally – from our own innovation projects and network specific developments
- Industry – from the sharing of knowledge and best practice via the ENA Technical Losses Working Group, plus other industry groups and academic research
- Internationally – from our parent company, Iberdrola, plus conferences e.g. CIRED / CIGRE.

The outcome from this first step is a long list of potential LDR initiatives.

Step 2: Prioritisation

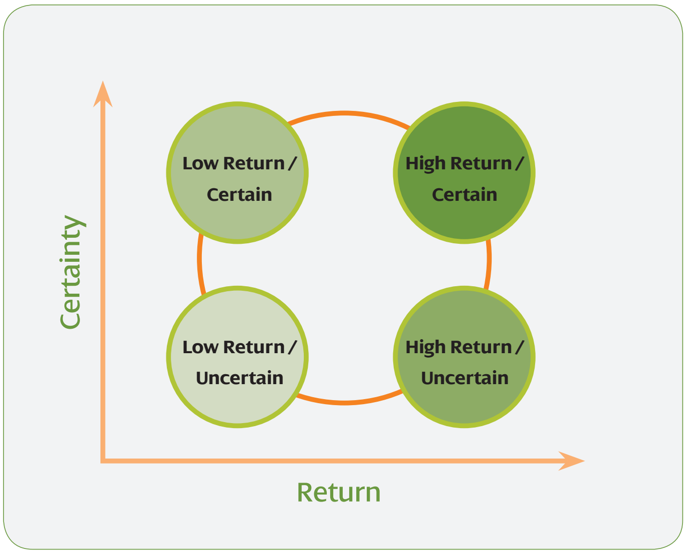
To prioritise the LDR initiatives we assess them against two measures:

1. We consider how well they align with our Losses Vision, and the broad requirement for them to increase the understanding of losses in an evolving network environment.
2. We consider how well they meet the Ofgem LDR criteria (i.e. understanding, stakeholder engagement, processes and/or innovation).

During this assessment, we consider two factors:

- **RETURN** – has the proposal the potential to significantly push the boundaries.
- **CERTAINTY** – how sure we are that the outcome will provide benefits

The outcome from this second step is a shortened and prioritised list of potential LDR initiatives.



Step 3: Work Plan

LDR initiatives that have been selected for development in step 2 are now included in our work plan. Specific timescales, resourcing requirements, stakeholder engagement requirements and the need for partnerships are all considered at this stage.

Appendix 3 | Smart Meter Data: Demand Profile Outliers

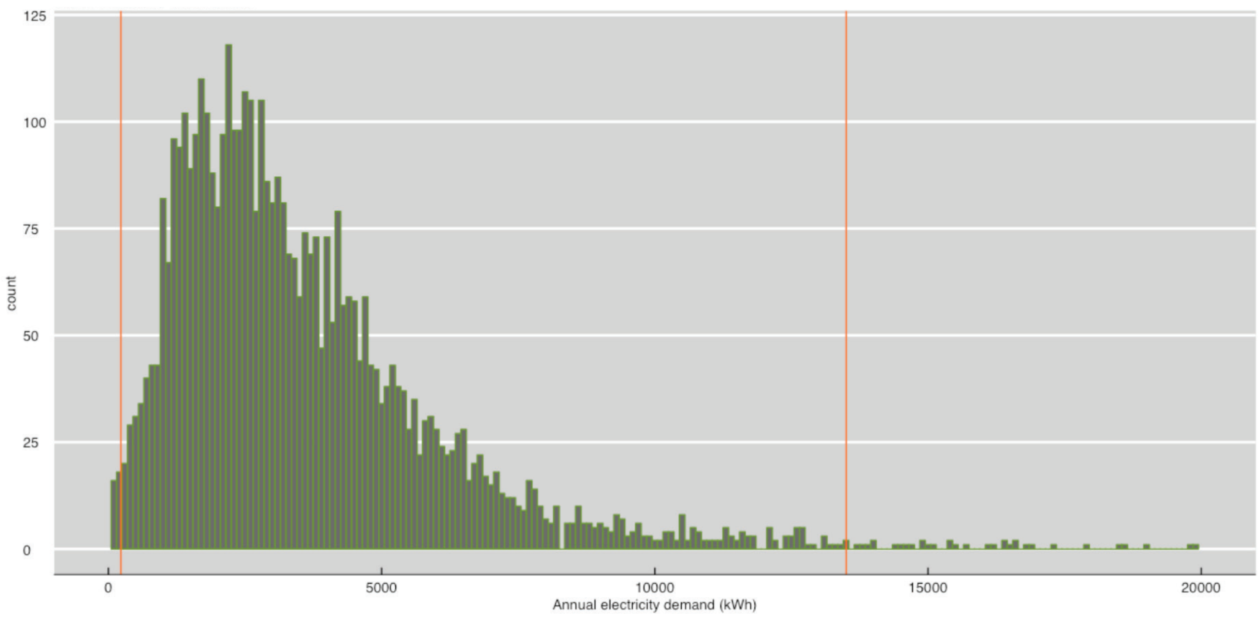
This work was completed as part of our Initiative 2 "Development of Smart Meter Data analysis systems to reduce technical losses". For this work, we analysed meter data to establish whether smart meter data can be used to improve losses understanding and decision making for the LV networks.

The analysis conducted makes use of the UKPN Low Carbon London dataset – it is relatively large (it includes metering data from over 4000 customers recorded at 30 minute intervals for over one year) and available under the Open Government Licence.

The data was reduced to one calendar year (2013) and excluded any with missing hourly records to avoid 'false positives' in our filter where meters showing low annual consumption may be erroneously included as outliers.

The filtered data is summarised using a histogram.

Histogram of total annual kWh per Customer



The two vertical red lines are drawn at the 1st and 99th percentiles for our dataset to remove the small population of customers who consume a lot less or a lot more than the typical customers in this dataset. The median annual consumption of our sample dataset is 2965kWh and it is expected that most of the customers in this dataset use mains gas for space and water heating.

Simplistically, customers who exhibit much higher than normal annual demands (i.e. those at the RHS of the graph) are likely to be the cause of higher than normal losses on the LV network. Similarly, customers with very low annual demands (LHS of graph) may include those involved in non-technical losses.

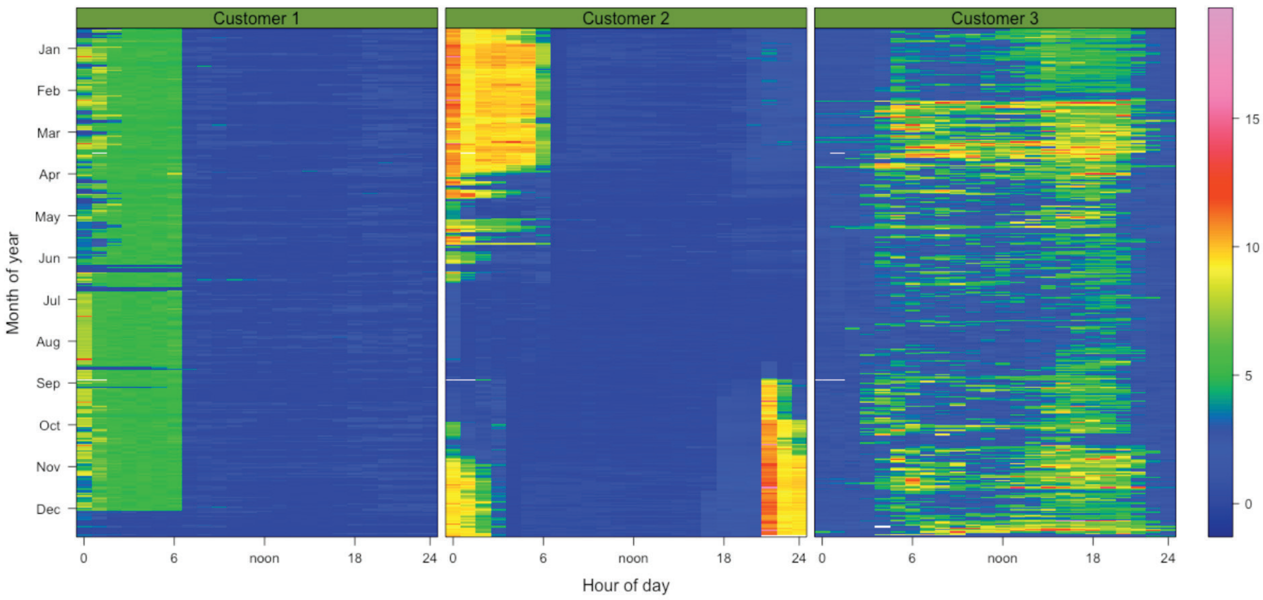
For technical losses, the level of smart meter deployment will influence whether the measurements of typical LV and HV feeder demands will continue to rely on Elexon profile data instead of accurate half-hour readings.

High demand outliers

High demand customers are likely to result in high losses on their individual service cables. We can correlate these demands with our asset data so as to identify those service cables where there is a business case for early replacement (see Appendix 8: Smart Meter Data Use: Service Cable Loss Analysis).

We investigated the annual demand profiles for three high demand outliers. This data is shown below:

Annual profiles of highest kWh consumers
Colours indicate kWh demand per hour (Source of data: UKPN LCL dataset)



Each graph shows the hourly load over a year where days of the year are arranged on the y-axis and hours of each day on the x-axis.

These examples show how some consumers incur high night-time demands consistent with high levels of Economy 7 heating demand. Customer 1 (left) appears to have little or no seasonal variation, whilst night-time demand for Customer 2 (middle) appears lower during the summer months. However, Customer 3 (right) appears not to have the same night time demand requirements. With this type of analysis, behavioural signatures can be used to help identify where customers have, for example, adopted low carbon technologies. Load profile analyses are expected to support DNOs in the early identification of hot spots in electric vehicle charging, heat-pump demand or roof-top solar PV generation. Clusters of low carbon technologies can significantly increase network utilisation and can lead to significantly increased losses.

In Tranche 1 the process has been tested off-line and highlights the value of using disaggregated smart meter data, becoming BAU as smart meter data becomes prevalent.

Appendix 4 | Enhanced Modelling of Complex Networks

The development of an Advanced Losses Modelling methodology (as detailed in Initiative 4) and tool based on a 'bottom-up' approach has enabled significantly improved quantification of losses compared to our existing practice.

Our losses modelling traditionally used a 'top-down' approach to quantify losses across voltage levels. This used metering data to calculated Losses as Energy In minus Energy Out. This simplistic technique is prone to various sources of inaccuracy as outlined in the table below. It is also unable to test the impact of loss interventions in detail. With this approach the network cannot be accurately disaggregated into subsections and a portfolio of assets cannot be ranked based on the losses incurred on each asset.

Where losses interventions needed to be studied in more detail, network analysis and modelling studies were restricted to small scale models with a limited number of network operating conditions, typically reflecting times of peak demand or peak generation.

More advanced tools were required to help DNOs quantify losses. Some were developed as part of our LDR Tranche 1. One new approach investigated ways to use a 'bottom-up' modelling approach. A 'bottom-up' model automates modern power systems analysis tools to assess the network in a much more granular manner to assess losses in each individual asset. It applies half-hourly demands at all available locations in the network where these are known. Where half-hourly demands are not available, the tool can either use defined profiles, or disaggregate the supply in-feeds. The advantage of a 'bottom-up' approach is that it gives a much more detailed information on the network, which facilitates the identification of high loss circuits and network components amongst other things.

For the SPM 132kV and 33kV networks, in order to perform 17,520 individual power-flow analyses, the tool used circa 35 million data elements and therefore a significant focus was placed on data checking to ensure the validity and completeness of the data in the model. This enhanced modelling enables increasingly complex networks to be designed and operated with tighter operating margins, leading to opportunities for improved loss management. This method calculated annual losses to specific network assets and aggregated to network groups.

A comparison of 'bottom-up' and 'top-down' modelling tools is summarised in the table below, indicating clear benefits of our enhanced modelling capability:

BOTTOM-UP MODELLING	TOP-DOWN MODELLING
BENEFITS • Use of more network metrics increases accuracy • Enables validation with network measurements • Enables identification of high loss network components • Detailed modelling of loss intervention methods • More accurately captures impact of generation and customer profiles • Captures power flows and losses of complex networks and configuration changes	**BENEFITS** • Simple model to use • Rapid assessment of losses • Suitable for networks with limited available data
DISADVANTAGES • Greater complexity • Significantly more data required • More time consuming and much more computationally intensive • Set up and model connectivity crucial	**DISADVANTAGES** • Susceptible to metering uncertainty • Small changes in metering volumes or accuracy introduce significant inaccuracy in losses • Very sensitive to inaccuracies due to billing and settlement or time shift • Limited representation of variability of losses across the network • Not always able to capture impact of embedded generation • Interdependencies not captured e.g. operating conditions • Not possible to test impact of loss interventions in detail

The bottom-up model has been successfully developed and has full detailed coverage of all 132kV and 33kV networks across SPM. In SPD a range of the GSPs have been selected and studied in detail to provide representative coverage. A range of both interconnected, and radial HV networks have also been studied. From these Tranche 1 studies we now have losses information by network group and at an individual asset level. Our ability to consider our planned network throughout all operating periods in a year is expected to deliver a reduction in network losses through our ability to optimise how we operate our assets. This will include changes to network configuration and the target set points on power flow controllers and voltage control devices. This tool has been adopted for BAU use and will be used to consider losses when undertaking major investment/policy decisions during the remainder of RIIO-ED1 and forward into RIIO-ED2.

Following the lessons learnt from our workshop with TEPCO, in Tranche 2 we will use the modelling tools to assess the business case for GB networks of reducing network losses by moving HV Normal Open Points (NOPs) seasonally.

Appendix 5 | Assessment of Power Factor to Improve Losses

As deployment of distribution connected generation continues, managing the distribution / transmission interface is increasingly challenging. In particular, the SO is facing new challenges controlling transmission voltage. We have taken the opportunity to explore a more holistic operating regime that takes into account transmission issues such as these. One solution being investigated in our Initiative 6 is to influence the power factors at each Transmission / DNO interface using distribution connected generation - power factor supports the TSO in maintaining voltages on the Transmission network within limits. However power factor can have an adverse impact on distribution losses, so management of distribution transmission boundary conditions needs to take a holistic view of distribution and transmission needs, especially as the costs of both are ultimately recovered from consumers. This initiative aims to defer/reduce the requirement for transmission reinforcement whilst understanding the impact on distribution losses, so that an overall least cost to consumer solution can be worked towards.

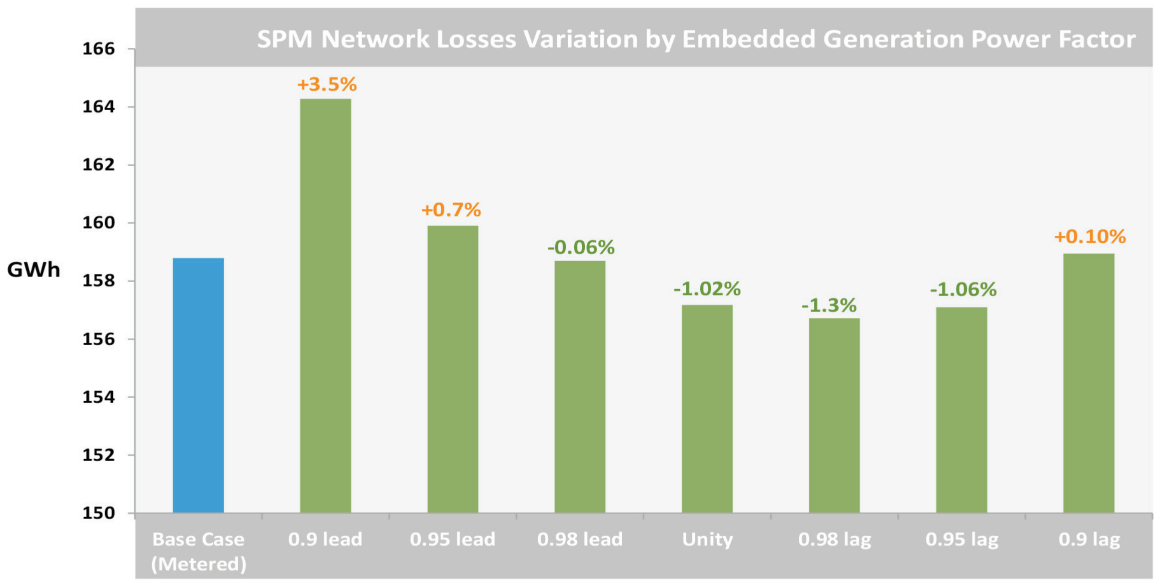
The aim of Initiative 6 is to understand:

- The benefit of distribution generators operating at particular power factors, i.e. whether this is helpful in modifying power factors at the GSP interface;
- The impact of losses on the distribution network due to generators operating at particular power factors;
- A greater understanding of the issues faced by NGET, and therefore possible solutions that benefit all stakeholders.

We have constructed a model to determine the impact on losses in the distribution network from generators operating in a range from 0.9 lagging power factor to 0.9 leading power factor. The impact on distribution network losses was calculated across the power factor range illustrated in the figure below with the base case reflecting current operating conditions.

Model results for SPM indicate that setting generator power factors to 0.98 lagging minimised the losses on our distribution network, whereas for SPD minimum losses occurred with generators operating at unity power factor.

Worst case scenario estimates indicate that SPM network losses may increase by up to 5.5GWh each year, and SPD losses may increase by up to 3.3GWh/year, depending on the boundary operating regime required by the SO.



Our studies have improved our understanding on a range of possible operating conditions, constraints on our networks and the impact on our network losses. We will now be discussing these results with NGET and we will explore operating boundary conditions that benefit both parties and move closer to a least overall cost to consumers.

Appendix 6 | Substation Efficiency

Initiative 9, aimed at reducing substation losses, focuses on heat recovery potential from distribution transformers connected at 132kV and below, looking at both retro-fit and new build solutions. It is generally acknowledged that transformers produce low grade heat and that substation sites suitable for the application of heat recovery systems must be carefully selected. An assessment of distribution substation types deployed in the SPEN licence areas to determine eligibility for the application of heat recovery systems has been conducted and high-level results presented below.

SUBSTATION CATEGORY	AVAILABLE HEAT	PROXIMITY TO DEMAND	HEAT RECOVERABLE	OVERALL ELIGIBILITY	NUMBER OF SITES
Grid Supply Point Outdoor (SPM)	High	Various	Medium	Medium	87
Primary Indoor Embedded	Medium	High	High	High	11
Primary Indoor Exc. Embedded	Medium	High	High	High	19
Primary Outdoor Internal Switchgear	Medium	Medium	Low	Medium/ Low	1352
Primary Outdoor External Switchgear	Medium	Low	Low	Low	134
Secondary Indoor Embedded Sub	Low	High	Low	Low/ Medium	2500
Secondary Indoor SPM 'X Type'	Low	High	Low	Low/ Medium	4,700[13]

For the purposes of thermal recovery evaluation, substations have been grouped under appropriate archetypes; initially divided by voltage level and subsequently into Indoor and Outdoor sites at Primary and Secondary voltage level. An additional category of Secondary Indoor SPM 'X Type'; which by design has internal thermal demand is also included. To assess eligibility for heat recovery each category has been assessed using a high, medium and low comparative grading against three criteria; availability of heat, proximity to demand and an assessment of whether the heat is recoverable.

1. In the case of Available Heat, grading is assigned based on typical transformer size, heat availability is differentiated by transformer loading. Transformers are the principle heat source from electrical plant in substations and drive thermal recovery eligibility.
2. The proximity to heat demand assessment is based on legacy design, building situation and exceptional cases. Where our substation is located inside a third-party's building/premises, there is a clear opportunity to offer the heat to that third-party. Where an indoor transformer is within the same building as indoor rated switchgear proximity to heat demand is also high, this is reduced when the transformer is located externally. Where substations are remote from third-party demand with external switchgear, proximity is low.
3. To assess heat recoverability the transformer cooling mechanisms are considered. Forced cooling offers greatest opportunity for heat recovery from transformers. Substations operating at EHV and above therefore receive a higher grading. Indoor transformers present increased opportunity for thermal recovery as the heat is not as readily dissipated.

Overall assessment using the above criteria indicates that indoor Primary substations have the greatest potential for deploying successful heat recovery schemes.

Our initial assessment of Primary substations has identified ten candidate sites which are listed on the following page.

[13]Numbers of secondary substation sites are subject to frequent variation and changes to third party buildings are not always reported.

SUBSTATION	TX NO.	RATING	COOLING	CANDIDATE THERMAL BENEFACTOR
Gradwell Street, Liverpool (SPM)	T1	7.5/10	ONAF	SPEN
	T2	7.5/10	ONAF	
Royal Liverpool Hospital, Liverpool (SPM)	T1	10	ONAF	Third Party
	T2	7.5/10	ONAF	
Lime Street, Liverpool (SPM)	T1	7.5/10	ONAF	Third Party
	T2	10	ONAF	
Daily Post and Echo, Liverpool (SPM)	T1	7.5/10	ONAF	SPEN
	T2	7.5/10	ONAF	
Royal Insurance, Liverpool (SPM)	T1	7.5/10	ONAF	SPEN
	T2	7.5/10	ONAF	
Virginia Street, Glasgow (SPD)	T1	15	OFAN	SPEN
	T2	15	OFAN	
Mitchell Street, Glasgow (SPD)	T1	15	OFAN	SPEN
	T2	15	OFAN	
Flemington Street, Glasgow (SPD)	T1	12	OFAN	Third Party
	T2	12	OFAN	
Dundas Street, Glasgow (SPD)	T1	12	OFAN	Third Party
	T2	12	OFAN	
Linthouse, Glasgow (SPD)	T1	15	OFAN	Third Party
	T2	15	OFAN	

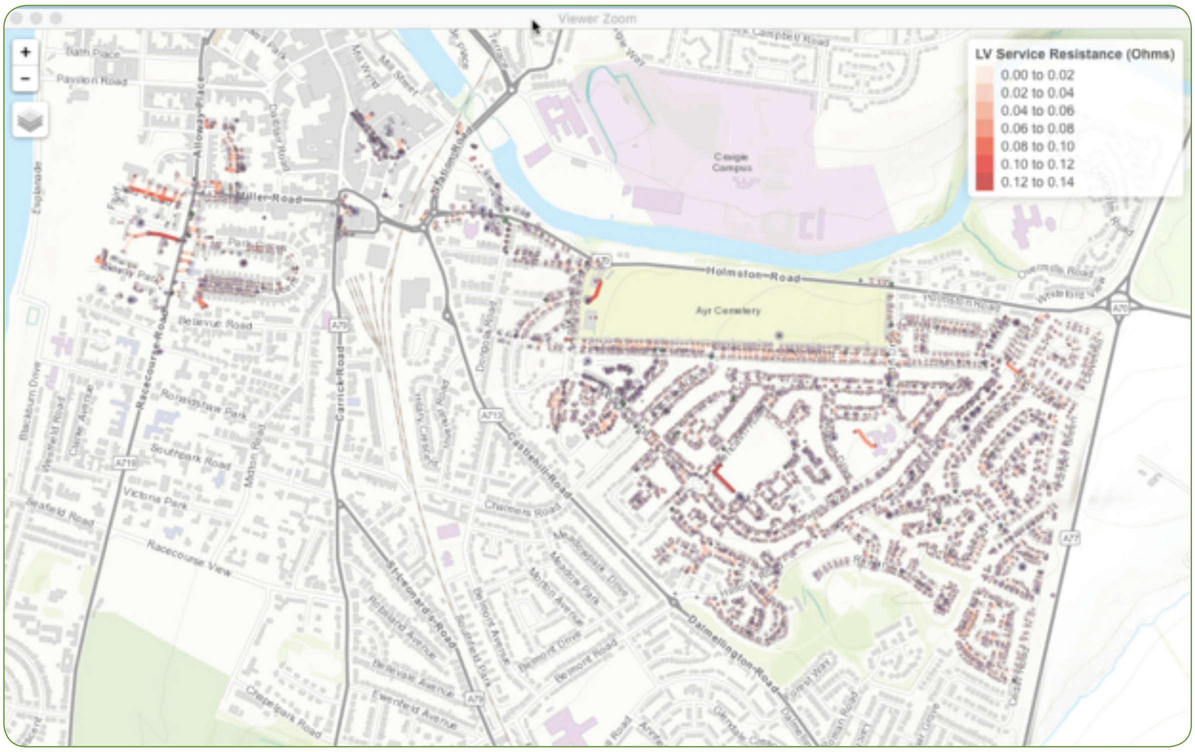
These sites will be subject to detailed survey to assess thermal potential, appropriate heat recovery technology, costs and potential benefit. We will engage an established heat recovery specialist in this next phase of work.

Appendix 7 | Smart Meter Data: Service Cable Loss Analysis

Service cables are the distribution network cables that connect individual customers to the LV network – they are the final bit of distribution cable between the distribution network and individual customers. As services cables are still distribution network assets, any losses on service cables are treated as other distribution losses are. This initiative 2 is looking at technical losses on service cables, and how we can use disaggregated smart meter data to identify and prioritise for replacement the service cables with the highest losses.

For the analysis, this initiative makes use of disaggregated smart meter data available from our EnergyIP system and asset data from our NCEWS system. The initiative works by combining these two data sets – when the known energy consumption from a smart meter is combined with the known technical characteristics (e.g. resistivity and length) of the service cable that suppliers that meter, then the annual technical losses for that service cable can be calculated. We can do this calculation for all service cables for which we have the smart meter data. We can then prioritise for replacement the service cables that have the greatest annual losses.

We have demonstrated how we can combine smart meter and GIS asset data (cable type and resistance) to calculate the consequential losses on each feeder. This helps to identify those services that may experience higher than average losses, depending on each customer's individual load profile.



The web-browser view for service resistance is shown here, using a synthesised dataset for LV services connected to LV feeders, each associated with one HV feeder.

In Tranche 1 the methodology has been tested off-line and has enabled the quantification of potential losses savings and highlights the added value of using disaggregated smart meter data. It is anticipated that the methodology will be built into NCEWS analysis functionality and will become a BAU process available to network planners as smart meter data becomes prevalent.

Appendix 8 | Smart Meter Data: Fuse Failure Detection

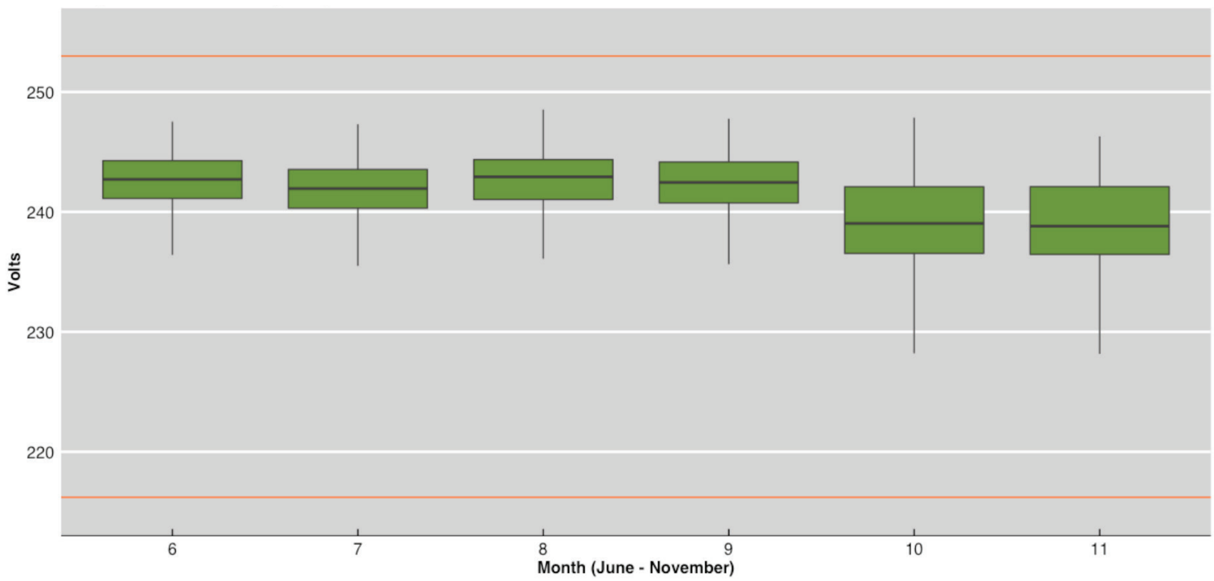
In the SPM interconnected LV network, each LV feeder may be supplied via up to 3 different 11kV/LV substations. LV fuse failures do not necessarily interrupt supplies, but do increase losses and reduce supply security. As no customers are affected, fuse failures can go undetected for extended periods. Earlier detection and resolution of these fuse failures would reduce losses and improve supply security.

In Tranche 2 we plan to make use of our NCEWS project to explore the practicalities of using smart meter data to identify fuse failures.

Interconnected LV feeders typically exhibit lower variations in voltage along their whole length. A fuse failure at one infeed will cause the voltage drop on that part of the LV feeder to increase beyond a 'normal' range. Our smart meter data processing systems will enable the monitoring of the voltages reported by smart meters near each of the HV/LV substations. These are the locations closest to the fuse failure where the voltage variation is expected to be greatest, and therefore these present the best opportunity for detection.

The voltage boxplots shown here indicate how a fuse failure may be detected as a change in characteristic voltage, shown in the graph below to occur between months 9 and 10 at one site. Algorithms to monitor the variation in voltage must consider sufficient duration to be able to differentiate between typical network reconfiguration and fuse failures, and must be able to adapt to variations in customer behaviour.

End point voltage monthly boxplots



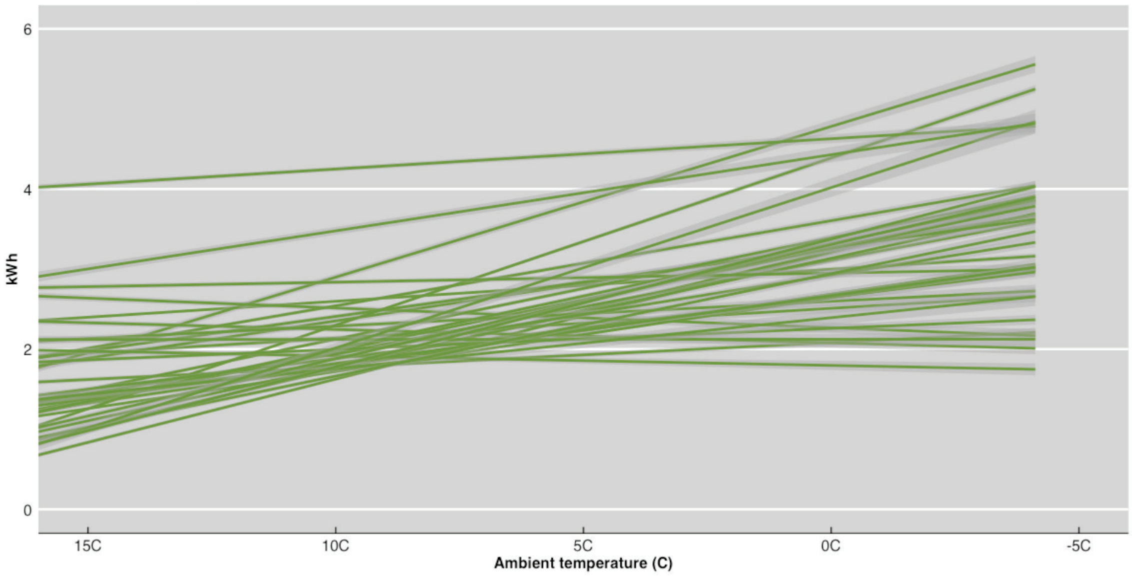
In Tranche 1 we have established a prototype methodology based on smart meter data from the UKPN LCL project. Further application and refinement of this methodology is dependent on smart meter data being available specifically at locations in close proximity to the HV/LV substations. As smart meter data becomes prevalent, we will trial this methodology and if successful this functionality will be incorporated in the NCEWS analysis tools and an interface provided to operational functions in SPM.

Appendix 9 | Smart Meter Data: Degree-Hour Outliers

Research shows that dwellings that have the poorest energy efficiency tend to have the greatest increase in electricity consumption as ambient temperature decreases[14]. By comparing hourly electricity consumption with ambient temperature, we can use this known relationship to identify those dwellings that exhibit the poorest energy efficiency. This knowledge can be used to provide targeted information to customers on how they can increase their energy efficiency. If these customers improve their energy efficiency their electricity consumption will reduce, which will result in reduced technical network losses. There will be a direct customer benefit in the form of a lower energy bill, and it may also reduce network peak demands, which may help defer or avoid demand constraint driven network reinforcements. This knowledge can also be used by a DNO for network planning purposes (for example, knowing how much DSR might need to be contracted to be ready for a cold weather period).

We have shared this analysis method with the TRAS Expert Group for consideration as an additional means of identifying some meter tampering behaviour (possibly in response to high energy bills) and also assist with tracking customer energy efficiency where this assists with ECO obligations. In addition, those low-efficiency, high demand customers generally contribute to network peak demands; consequently any improvement in energy efficiency may help defer or avoid network reinforcement.

Linear trend of highest annual kWh consumers



This graph shows rising electricity consumption compared with reducing ambient temperatures. Each line represents an individual customer. For this work we selected customers with highest annual kWh demands as it is those customers who cause some of the highest losses on our LV network.

Each of the lines represents a linear regression of the hourly consumption compared with the hourly ambient temperature. The steepest of these lines indicates a customer whose consumption increases significantly as ambient temperature decreases. Some of these customers show an hourly consumption of about 5kWh during the coldest periods. These periods are also likely to coincide with peak electricity demand on our LV and HV networks so that any improvement in energy efficiency and/or other demand-side management method will be most effective if deployed at these consumers' premises.

We will now explore the opportunities this process offers as smart meter data becomes more prevalent.

[14] The background to degree-day analysis is summarised at: Degree-days: Theory and application, TM41:2006, CIBSE. There is also an earlier Fuel Efficiency Booklet published by the Government Energy Efficiency Office (1993) available at: http://www.cibse.org

Appendix 10 | Smart Meter Data: Voltage Optimisation

Our LCNF Flexible Networks innovation project researched the impact of voltage on consumption and losses. Project conclusions included:

- A reduction of 1% in active power demand in response to a 1% voltage reduction is a reasonable estimate but results show considerable variations,
- A network voltage reduction does not seem, on average, to reduce the network current. Therefore network copper losses (i.e. I^2R losses in transformers, cables and overhead lines) are not reduced by voltage reduction,
- A 1% reduction in voltage can lead to a 1% reduction in energy consumption for many customers.

Strathclyde University's report[15] confirmed that many domestic appliances benefit from operating at close to 230V nominal voltage. However, the report noted that any reduced energy consumption may be at the expense of output, with incandescent lighting levels affected in particular: for example, a reduction in voltage of ~4% resulted in a 15% reduction in brightness.

LV Voltages at our 11kV/LV substations are set using off-load tap controls that requires de-energisation of the transformer prior to tap adjustment. 11kV voltages at our 33/11kV substations are controlled via on-load tap controls that can be readily adjusted on-site. Where modern electronic Automatic Voltage Control (AVC) relays have been fitted at primary substations, these are able to be adjusted remotely so that our 11kV and corresponding LV voltages may be adjusted at will, thereby reducing losses on customer's appliances.

Building on our Flexible Networks work, in order to accommodate increased penetration of LV-connected solar PV without adversely affecting customers' appliances, we are considering an AVC voltage control scheme that would only operate during the times of peak solar PV output. The AVC scheme is expected to only be required to operate between about 10:00 and 15:00 hours on sunny days (particularly in spring/summer). Typically these hours are not expected to match the times when feeder demand is within 90% of peak. Therefore, a 3% voltage reduction (at the primary transformer) would not be expected to result in any customer's experiencing non-statutory voltage levels. Typically peak demand on our networks occurs when both heating demand and commercial/industrial load coincide, i.e. during late-afternoon periods in winter months.

Within LDR Tranche 1, we have been exploring how smart meter data can be used to help build on the LCNF project learning in order to consider network losses alongside capacity. We have been considering the network impacts of adjusting the 11kV voltage using the AVC at the primary substation, and of using smart meter data to explore the degree to which we may expect high loadings during periods of high solar PV. We plan to learn from a similar centralised voltage optimisation field trial that has been conducted by TEPCO. This was reported at the 2017 CIRED conference and discussed during our recent losses workshop with TEPCO.

[15] Measurement of power/energy of single-phase 230V AC domestic appliances and the dependence on voltage. Cheung, Dawson, Malcolm, Nixon, Paterson. Strathclyde University 2013.

Our plans for a voltage optimisation trial (as part of Initiative 3) will follow the process described here:

- Confirm metrics to be used in the trials. This will ensure that we know how we will identify any 'losses delta' and any change in the headroom available for solar PV.
- Confirm trial site selection. Sites will be selected to include a variety of HV and LV customers. Some sites that will not be optimised will also be included for comparison.
- Review hardware and software options for optimisation.
- Review access to smart meter voltage data in operational timescales.
- Deploy optimisation hardware at a trial site with optimisation software/logic. The software will be operated 'off-line' initially to confirm stability and sensitivity.
- Upon completion of successful off-line trials, progress the first trial site to in-service operation and test results for a limited period prior to sharing lessons learnt.
- On successful delivery of optimisation at first trial site, deploy optimisation scheme at remaining trial sites.
- Monitor and measure results over an extended period – typically 12 months or longer.
- Review results and report.
- Review report and consider BAU opportunity.

Appendix 11 | Benefits and Materiality of Initiatives

Detailed below is a summary of the benefits and, where possible, the materiality of each of the LDR initiatives. Our portfolio of initiatives are aimed at better understanding and managing losses, therefore some will not lend themselves to specific losses savings that can be expressed in GWh but rather allow us to better understand where losses occur on our networks and what influences them. For those initiatives requiring smart meter data to progress into BAU, sample data has allowed us to develop and test the principles but the benefits cannot be readily quantified until sufficient actual data is available.

	Initiative	Benefits and Materiality
1	Smart Meter systems to reduce non-technical losses	• Successfully demonstrated the detection of demand profile outliers, and the possibility of theft detection through the use of sample smart meter data. • We expect to calculate the materiality and loss savings associated with this initiative as increased smart metering data becomes available. We anticipate that loss savings will be significant.
2	Smart Meter systems to reduce technical losses	• Successfully demonstrated the detection of high service-cable losses, LCT installations, and early detection of interconnected LV fuse failures, leading to increased losses, through disaggregated smart meter data. • We now estimate worst service-cable losses at 310kWh/yr, improving our visibility of LV losses and informing policies. Materiality and losses savings can be calculated as increased smart metering data becomes available.
3	Voltage Optimisation to manage Network Losses	• Identified a method for using smart meter data to optimise HV automatic voltage control settings at Primary substations to reduce losses. • We expect to calculate the materiality and loss savings associated with this initiative as increased smart metering data becomes available.
4	Improved Modelling of Complex Networks to Reduce Losses	• Successfully developed modelling tools to improve accuracy of technical losses quantification when undertaking major investment / policy decisions. • The materiality and losses savings due to improved quantification are case/project specific and enable improved RIIO-ED2 metrics.
5	Improved Modelling of HV Rural Networks to Reduce Losses	• Successfully developed modelling tool to identify HV feeders with high levels of phase imbalance. and the associated higher levels of losses. • Intervention on 232 rural HV feeders, subject to validation, could yield a maximum losses saving of 1.08GWh/yr.
6	Assessment of Power Factor on GB Losses	• Impact on distribution network losses assessed across a range of transmission boundary conditions. In the worst case distribution losses may increase by up to 8.8GWh/yr. • The overall customer benefits will continue to be assessed as we engage with Transmission stakeholders and industry to review holistic designs.
7	Detection of Theft & Revenue Protection	• Demonstrated mutually beneficial partnerships with Merseyside Police for the detection of meter tampering and illegal abstraction. • Losses arising from theft are avoidable. Their detection provides significant customer benefit and enables improved RIIO-ED2 metrics.

	Initiative	Benefits and Materiality
8	Improving network loading by active stakeholder engagement	• Engaged a customer with early LAF awareness as a proof of concept to enable loss informed capital decision on their connection. • This activity will empower customers to select losses optimised designs. Materiality is case/project specific and dependant on customer appetite.
9	Substation Efficiency: Use of waste heat	• Successfully launched a substation temperature monitoring trial and identified candidate substations for heat recovery and loss reduction trials. • Estimates for deployment at 10 trial sites could yield up to 0.25GWh/yr.
10	Substation Efficiency: Monitor & consider self-sufficient substations	• Successfully deployed monitoring of Primary substations auxiliary supplies, identifying energy demand and efficiency opportunities. • Trials planned during Tranche 2 will extend our understanding, inform policy decisions and enable quantification of losses savings and materiality.

SP ENERGY NETWORKS