Losses Discretionary Reward

Tranche 2

February 2018

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

Contents

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1. Foreword

At Western Power Distribution we always seek to find better ways of working and our track record of innovation and change has helped us continually improve the way we deliver our services to customers. The challenge of operating an efficient and economic network includes work to address the level of losses seen in the network. We are committed to improving our understanding of losses and translating this into cost effective measures that we can take to reduce losses.

Since our Tranche 1 submission we have been developing our approach further. We now draw on a more holistic approach which brings together items from our Losses and Innovation strategies. A key driver to the management of losses in the future will be our ability to manage effectively the additional demands created by low carbon technologies such as electric vehicles and heat pumps.

Our understanding of losses has improved through the projects we have delivered, most notably the Losses Investigation project which has measured the level of losses which are seen on networks. It draws together our monitoring equipment and Smart Meters to consider if it is possible provide an accurate and consistent measured volume of losses. Amongst other things it has demonstrated the low level of losses in relation to energy supplied. It has helped develop our early thoughts for a losses incentive in RIIO-ED2. As our project concludes we will use the information obtained to refine our suggested options for an incentive.

Robert Symons
Chief Executive
Western Power Distribution

2. Introduction

2.1 Structure

This Losses Discretionary Award submission is made by Western Power Distribution at a company level. The submission covers our four DNO licence areas of South West, South Wales, East Midlands and West Midlands.

2.2 Scope

The second tranche of the Losses Discretionary Award moves the focus to one of specific actions undertaken and concurrent improvements in understanding. In our report we have detailed the practical actions we have taken plus the initiatives we have employed to understand and ultimately manage network losses in a better way. We have shown how these have helped us to go beyond the actions required by the general licence obligations, reducing our losses even further.

2.3 Format

We have followed the Ofgem recommended format and structured this report to address each of the assessment criteria listed in the guidance document.

- ✓ Understanding losses
- ✓ Engagement and sharing best practice
- ✓ Processes to manage losses
- ✓ Innovative approaches to losses management and actions taken to incorporate these approaches into business as usual activities

2.4 Approach to Losses

Our actions to address losses are a central theme in the way we operate our business. They form part of our 76 RIIO-ED1 business plan commitments. They are all reviewed by our Directors and reported by the Chief Executive as a part of submissions to our owners.

Our approach to losses is the same as for all other aspects of our management of the electricity network. At a policy and strategy level we explore projects and initiatives which will create a benefit at a high level and devise a set of solution tools which can be used to gain advantage. At a more granular level we make use of the tools and products developed to improve our understanding and application of loss reduction techniques. In some areas this will be by the use of newer loss efficient products and designs for network assets. In other design areas this will be the comparison of different design and network configuration options by estimating future losses for each option and including loss reduction in the final economic decision.

We have developed our work on losses reduction based on knowledge gained from research completed for us and others in our industry.

2. Introduction

Our network's ability to manage effectively new demands for more electrical sources to meet the heating and transport needs of society has never been more important.

Confronting operational challenges positively and creatively is a major driver for us as we continue to forge ahead with effective control and management mechanisms. While these take new imperatives into account, like the increasing use of heat pumps and electric vehicles, they also seek to manage loss levels on both our existing and new networks.

This Tranche 2 Discretionary Reward submission illustrates, in particular, our role in helping to mitigate any increase in losses. It demonstrates how we have initiated and sought out innovation and best practice, engaged with a wide range of stakeholders from manufacturing, other networks, electricity suppliers, customer groups, academics, consultants and regulatory bodies, and where appropriate, returned to challenge some of our own network assumptions.

Our research project "Understanding and Management of Electricity Distribution Network Losses" a collaboration with UK Power Networks and completed by SOHN Associates and Imperial College, was an initial catalyst, providing us with a robust action plan of recommendations which we continue to use as the core of our losses strategy through RIIO-ED1.

While our primary research has concentrated on modelling or measuring losses to gain an understanding, we have taken active steps to manage losses on a network that is being required to work differently as a result of the government's Carbon Plan and the transition from a Distribution Network Operator (DNO) to Distribution System Operator (DSO). The changes in use of our network will increase demand from customers who will expect our network to be ready for them. Losses will increase with usage and a pinch point for losses will be the final service cable into a customer's home. Our projects are looking at ways that we can address this and make a step change in the provision of service cabling. Work in this area is drawing on some of the themes of the roll out of superfast broadband.

To this end we have investigated the replacement of traditional cable with a low loss capacitive product, and we have considered how we can balance loads across phases in the future without digging up roads.

Our answer is to take all three phases to a customer's point of supply. We had considered using one phase only, but electric vehicle charging and heat pumps lend themselves to a full, three phase supply. Our house services of the future also provide three times the capacity to be future proof for the Carbon Plan.

We are working with an eco-house builder to develop a full three phase estate, with all phases supplied to all customers, with a housing association to demonstrate how existing properties can be re-serviced to achieve our "superfast electric" three phase installations, and with a street lighting authority to trial the use of bigger cables for lighting systems – enabling them to take the burden of electrical vehicle charging where customers do not have a driveway.

We will also be working with a university to understand the feasibility of charging electric vehicles from the 11kV network using a power electronic transformer with low losses.
Yet while all of these initiatives address the traditional network and the tackling of loss reduction by spreading load across phases, the cables used in them would be traditional, creating I2R losses.

So this has led us to investigate how the resistance of cables can be changed, and we are working with an innovation company to design a low-loss capacitive cable. With no resistance, losses can be

reduced and fall as the cable becomes heavily loaded. It will work at EHV and for long cable runs, and if successful, could shift expectation.

We believe our wide-ranging stakeholder engagement and work with industry experts and other DNOs to develop and share best practice has established a solid foundation and the invaluable building blocks for our work going forward. It shapes a strategic approach to losses which forms part of our 76 RIIO-ED1 business plan commitments and which is at the heart of our DSO consultation. This transition plan sets out a clear target designed to realise the environmental benefits of loss reduction.

Our "Understanding Losses" project followed by our "Losses Investigation" project show the ethos of our approach to this area, which we have pioneered through our work under the Low Carbon Networks Fund and the Network Innovation Fund. We set up our approach to "Model, Measure and Mitigate". We firstly conduct a project which models the effect of a specific area, in this case losses, and then follow up with a measurement project to confirm our modelling results with actual measurements on a representative network. Once we have this confirmed set of data we can then fully assess the mitigation measures we plan to take. Only by taking this multi layered approach can we be sure that our initiatives will provide a benefit to customers for the future.

MODEL, MEASURE AND MITIGATE

3. Understanding of Losses

3.1 Research to improve understanding

In 2012 WPD collaborated with UK Power Networks to carry out an Innovation Funding Initiative (IFI) project "Understanding and Management of Electricity Distribution Network Losses". The project built on the losses research originally carried out in East and West Midlands licence areas and set out to identify where losses are generated throughout the network areas and components. We have taken this further since the Tranche 1 submission with our "Losses Investigation" project which aimed to measure the losses which had previously been modeled.

This 2012 project was pivotal in helping all DNOs understand where losses were most prevalent on their networks. It was the most comprehensive theoretical assessment of losses completed in the UK. In line with the ethos of IFI, all DNOs benefited from this work. It is now referenced in many DNO Losses Strategy documents.

For WPD one of the great values of the study was the list of recommendations which helped WPD focus their efforts on areas which would have the most benefit to customers. The full list of recommendations is shown at appendix 2. The output of this project showed WPD that the low voltage network was significant in the overall level of losses. It was an area where there was benefit in following up the modelling with some real measurement to understand the impact in more detail. This led WPD to undertake the "Losses Investigation" project.

Losses Investigation is a unique project as it is the first project in the UK to measure LV losses by comparing input energy with metered output energy. In conjunction with Manx Utilities and using the network on the Isle of Man as the low voltage test bed, metering was installed at distribution substations and at each low voltage supply point on networks to measure losses. In addition the project is also measuring 11kV losses on a section of network in the Milton Keynes area, making use of monitoring established through the LCNF FALCON project.

The project objectives are to understand technical losses on the LV and 11kV networks and determine the minimum information required to accurately predict the relevant network losses.

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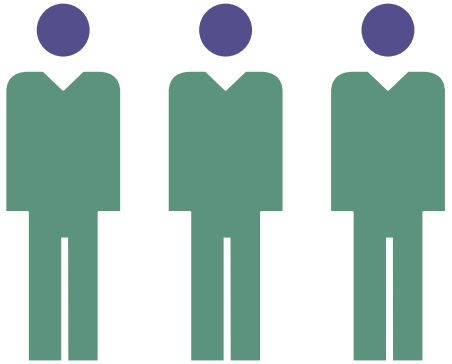

3. Understanding of Losses

3.2 Further research

Early research has concentrated on modelling or measuring losses to gain an understanding. Our future work now focusses on the actions that we should take to manage losses on a network which is being required to work in a different way as a result of The Carbon Plan and the move towards DSO.

A theme of electric vehicles is being developed as a strategy for our work. This has the double benefit of educating our losses work and supporting our innovation projects. We plan to investigate the way that we provide electricity supply to new housing estates and develop methods to easily and efficiently retro-fit existing housing stocks. We are also researching methods where we may be able to move vehicle charging away from the low voltage network and on to the high voltage network where losses have less effect.

This research and our plans are detailed more in section 6.

3.3 Industry-Wide Work

Since the Tranche 1 submissions, the Energy Network Association has set up a Technical Losses Task Group.

All network operators are represented on this group which was set up to ensure that best practice is shared between all ENA members. The group's terms of reference follow the subject areas and themes of the discretionary reward, including understanding losses, the process to manage losses and stakeholder engagement.

The group is planning to deliver recommendations on equipment design and a best practice guide on the measurement and modelling of losses using smart meter data and other data sources. It will also look at how stakeholder engagement in this area can be effectively undertaken.

As an initial task the group is working with WSP consultants to forecast the possible change in losses as a result of the roll out of Low Carbon Technologies. Using the models developed through the DS2030 project, these representative networks have been re-analysed to quantify the effect of losses with changes in network usage.

The research above is all being used to inform the ENA's industry-wide Statutory Voltage Limits Task Group. This Group – chaired by WPD and developed following the LV Templates project – is looking at the effect of changing voltage limits across the country. It has prepared a proposal which was subject to public consultation in 2017 and will be developed, with the consultation responses taken into account, in 2018.

3.4 Holistic Network Approach

The government's Carbon Plan will transfer heating and transportation energy demands from carbon rich fuel sources to electricity. We have already seen the growth of renewable electricity generation on our network and we are predicting a relatively quick growth of electricity fuelled LCTs such as electric vehicles and heat pumps.

Within our Losses Strategy and Innovation Strategy we are now drawing these elements together, as increased utilisation of our network has the inevitable effect of increasing losses. We need to ensure that our approach to Innovation and Losses is consistent and that the most economic and efficient management of both areas is achieved. Our new Losses Strategy sees a shift in that focus, away from what practical steps we could take to reduce losses in cables and transformers and towards the new and holistic area of how we achieve the Carbon Plan changes in an effective way.

In order for WPD to manage losses there is a need to take a holistic approach to the work that is done. In some situations a localised level of increased losses may be appropriate as part of a wider programme of reduction. WPD's plans to develop as a Distribution System Operator will help with this approach. As the company move from managing a maximum demand network and begin to operate an energy flow network, which is a key differentiator for a system operator, the economic use of the network will include many parameters including losses.

The use of the identification of hotspots to selectively uprate assets is already part of our Losses Strategy and our Innovation Strategy. Being proactive in the selective uprating of cables and transformers is an early enabler within our Innovation Strategy but has the double benefit of reducing losses by virtue of larger capacity equipment being installed. More details of our approach to this is given in appendix 5.

This shows what we can do to reduce losses by placing more focus on the proactive improvements that can be completed in conjunction with our day to day works. There is a balance to be struck between a blanket uprating approach where some assets may be changed needlessly and a more focussed approach where scenarios and hotspots help us predict the most likely locations for uprating. The hotspot approach helps us provide best value for money to customers.

In addition to these established plans we are proposing more projects to offer a quick and economic solution in areas of LCT take up. Customers in these areas will expect us to react to their new behaviour and style of electricity usage. We have a range of projects developed in this area which are detailed in section 6.

These projects will reduce losses compared to conventional solutions and will also help the transitions included in the Carbon Plan. Projects include the use of three phase service connections to provide balanced connections for customers, where demand can be balanced across phases or separate phases could be used for domestic use and car charging. We are pioneering a "superfast broadband" approach to service cables, where customers with electric vehicles or other LCTs could be offered an upgrade to help balance their demands and reduce overall losses. We also plan to investigate design options within the customer's home to provide an approach which looks across the whole electricity system.

This holistic approach allows us to provide solutions for new customers when we design new network connections. It also allows us to provide beneficial upgrades of networks as we complete other works. Finally, it also helps up provide a quick response to upgrade requests from existing network customers who require a larger connection.

3. Understanding of Losses

3.5 Improvements in understanding since Tranche 1

The research completed by WSP consultants on behalf of the ENA Technical Losses Task Group has provided us with a greater level of understanding of losses. It shows the effect that low carbon technologies will have on losses and also shows that there will be an economic level of losses for the network. The level of utilisation of our network and the level of losses which are acceptable will always be a trade-off between each other.

The work has also helped demonstrate how the volume of losses relates to the overall volume of electrical energy delivered across our networks. It builds upon the SOHN research and tends to support a slightly reduced level of losses at around 4%. Whilst it shows that losses will increase with the advent of LCTs and active network management, it forecasts these to be in the order of 5% for LCTs and around 8% with full active management. At this level it is difficult to accurately measure losses, especially with domestic smart meters that have a factor of measurement accuracy within around 2%.

This new understanding will help us gain the maximum benefits from smart meters. They will continue to have a key role in helping us identify and manage hotspots on our network. Their role in any measured incentive, however, needs more investigation

Our Losses Investigation project is completing ground breaking work in the measurement of losses. Our work in Milton Keynes and on the Isle of Man has proved invaluable in taking the research and modelling of previous losses projects and actually measuring the volume of losses on individual low voltage networks. By taking measurements every 60 seconds we have been able to produce data which measures losses and provides improved understanding which can be used to calibrate modelling software and systems.

More information on the Losses Investigation project is provided in section 6.

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4. Best Practice and Stakeholder Engagement

4.1 Stakeholder Engagement for Losses

Stakeholder engagement is hugely important to every part of our business. So, in developing our Losses Strategy, we carry out a specific programme of stakeholder engagement.

We were very keen to ensure that our Losses Strategy was backed up by good quality research and critical review so embarked on a process which took the SOHN "Understanding Losses" report as a base and added critical review through stakeholder engagement to the topics and interventions offered in the report.

While complying with our licence requirements is a base objective, our main incentive for setting up the workgroups was to ensure that our plans for the Losses Strategy were the most practical and effective options available and that we did not constrain ourselves to just known or simple interventions. Our initial stakeholder engagement was with the more general group of stakeholders and through their responses it became very clear that they expected us to manage Losses but also that they did not feel that they had the level of technical knowledge required to offer a full comment on our plans.

We then embarked on specific losses stakeholder workshops where we were very keen to invite technical experts from across the whole electricity industry and supply chain to comment on our plans and proposals. Our invitation list – carefully selected from our general stakeholder engagement database – included stakeholders with a technical awareness and interest in losses. We targeted people from manufacturers, other network operators, electricity suppliers, customer groups, academics, consultants and regulatory bodies. To tie in with our objective of reviewing our Losses Strategy annually we originally held these workshops as annual events but have responded to feedback and now hold them as biennial events.

Our Losses Strategy has been improved and developed as a result of this engagement; with a range of interventions that we and our stakeholders believe offer the best solutions to the reasonable expectation that losses are as low as possible. We know this sort of additional engagement is of prime importance to gain a holistic view before embarking on interventions, some of which include asset replacement and will be in place for around 50 years from now.

We have held three specific stakeholder engagement sessions for losses, all of which have helped shape and develop our Losses Strategy. At these events we have engaged with over 50 representatives from industry, academia and other network operators.

In November 2017 we held our most recent stakeholder engagement event at the IET in Birmingham. Details of our previous stakeholder engagement events, and what actions we took as a result of them, are included in the appendix 1.

In 2018 we published our most recent version of the Losses Strategy, pulling together everything we had learnt in 2017. This revision includes updates on all the work carried out since the last review and shows how we are progressing on items on our list of SOHN recommendations. We also revised the layout of the document to make it easier to track changes with completed actions, actions from the current year and future actions shown in different sections.

4. Best Practice and Stakeholder Engagement

4.2 Industry-wide Engagement

At the Low Carbon Network Innovation event in December 2017 we were able to showcase both the work completed at a national level and also the work completed on our own projects.

This is an important national event which attracts manufacturers and suppliers to the industry as well as all DNOs and National Grid. Universities and research companies are also present which helps to drive UK Innovation forward.

In a specific session related to losses we reported, as an industry, on the work completed by the ENA Technical Losses Task Group. The session also included a specific presentation on our Losses Investigation project.

> WE ARE ALSO ALWAYS KEEN TO LEARN FROM OTHERS AND USE THEIR RESEARCH TO DEVELOP OUR PLANS.

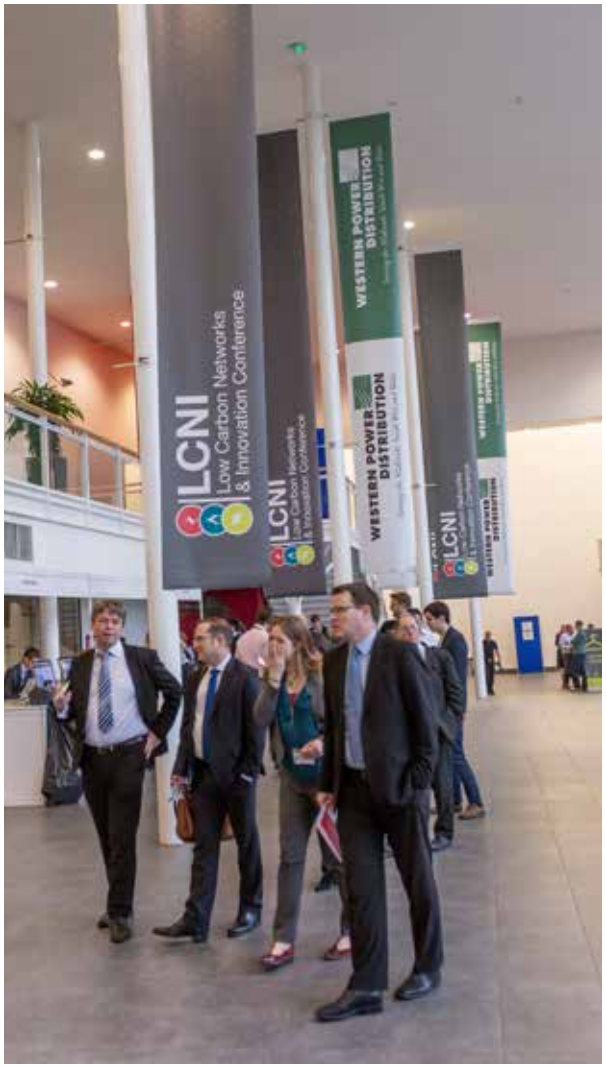
4.3 Sharing Best Practice

It's important to us to engage with other network operators to develop best practice – a desire that can be traced back to our IFI project on Losses that we completed with UKPN.

This took place before the specific work on our Losses Strategies and really helped us shape our own strategy. We have shared the project's findings with many other network operators and are pleased that elements of it and references to it appear in other DNO strategies. Scottish and Southern Energy Networks (SSEN) not only shares our intervention on pre-1960 transformers, but has cited our IFI project as the research source.

We are keen to learn from others and use their research to develop our plans. Our third Losses Strategy included topics highlighted in other DNO strategies and this collaborative approach continues.

We were pleased to see that other DNO losses strategies now include elements of our plan. All DNOs face similar issues so this kind of peer review and inclusion is a fantastic development.



4.4 Losses in relation to wider Stakeholder Engagement

Our specific stakeholder engagement for losses is detailed in 4.1 above, but the story doesn't end there.

Losses have also formed part of our more general stakeholder engagement work. In 2015 we discussed the topic of losses with our stakeholders at six general sessions to find out if there was an appetite. We soon realised that losses were of real interest to our stakeholders although many were content to leave the more technical debate to a specific stakeholder event. We have since updated our stakeholders in 2016.

Actions to address losses form part of our 76 RIIO-ED1 business plan commitments. These are all reviewed by our Directors and reported by the Chief Executive as a part of submissions to our owners. At our customer steering panel our Chief Executive updates representatives on the actions we are taking to reduce network losses.

The way we operate the network in the future will also have an impact on the level of losses which are experienced. Our research completed through the ENA Technical Losses Task Group has shown the impact of LCTs on losses.

We have also placed losses at the heart of our Distribution System Operator consultation, with our transition plan setting out the target to achieve the environmental benefits of the reduction of losses.

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5. Process to Manage Losses

5.1 Management of Losses

The work we completed with SOHN Associates has become a core part of our Losses Strategy as it provided an impressive 26 recommendations for further work and action.

These recommendations now form the basis of the work we are carrying out throughout the RIIO-ED1 period and are detailed in appendix 2. We have started to work through them and have already addressed some as interventions in our Losses Strategy. We review our progress against them every year as part of our Losses Strategy update.

All of the 26 recommendations will remain listed in our Strategy, which is updated annually, and will have a descriptor of "adopted", "rejected", "under consideration" and "future consideration". By the end of ED1 or sooner, we plan to have addressed all of these and will be able to log them all as "adopted" or "rejected" based on our assessments. We now include a comment against each recommendation in our Losses Strategy to evidence the reasons why they are classified.

Each year we choose specific topics to investigate and progress, this is done by our Network Strategy & Innovation Manager and our Policy Manager. We have also reviewed and finalised our choices with stakeholders at our engagement sessions. We pick topics across the range of areas to ensure our research is balanced across the whole area of losses.

In our 2016 Losses Strategy update we included an update on the process to manage our progress against each of the 26 recommendations. We added a comment against each of our recommendations to easily summarise what we have done and plan to do, or what initiatives we are taking for each of the items.

5.2 National and International Best Practice

A level of national best practice has emerged through the revision of our Losses Strategy and those of the other network operators. We have all enhanced our strategies by adopting elements from other submissions. Original items in our strategy which now feature in other network operator Losses Strategies are:

- Discontinuing small size cables for new works
- Discontinuing small size transformers for new works
- Using a "next size up" design policy
- Targeting the early retirement of older transformer designs

These topics are now included in many UK DNO Losses Strategies and demonstrate a good level of national best practice.

While our research into the optimum length of low voltage feeders did not produce any evidence to change our proposals, the research we conducted with SOHN Associates was presented as a paper for the Cired conference in Helsinki in June 2016.

5.3 Using Smart Meters

The roll out of smart-meters will change the nature of network monitoring. Historically the low voltage network has been designed and managed using models and templates alone. Smart-meter data will be far more accurate and updated on far shorter timescales, giving us vastly better data on network loading.

The deployment of smart-meters will enable a number of key strategies to manage losses. Firstly, customers can be incentivised to use less energy at peak times by using time-of-use tariffs, which will flatten the network load profile to reduce losses. Secondly, it will enable areas of high loss to be identified, so that targeted action can be taken to reduce them.

This data will allow us to highlight areas of our network with high utilisation and consequently high levels of losses. We will be able to pinpoint substations that would benefit from low voltage feeder level monitoring to augment Smart Meter data. This targeted approach will ensure that our use of monitoring is economic and help us provide effective mitigations and network reinforcement.

In some cases The Data Protection Act (1998) will prevent us from seeing individual customer data, and early SMETS1 smart meters may mean that some customer data is not readily available to us. Taking these restrictions into account the data will still be of use at a substation level to help us target high load areas.

Smart Meters will not easily be able to measure the volume of losses on the network. Our Losses Investigation project has highlighted the problems with settlement of data given the relatively low proportion of loss which is measured alongside the more dominating volume of energy supplied.

5.4 Losses Incentive Mechanism for RIIO-ED2

The work completed as part of the ENA Technical Losses Working Group and our own Losses Investigation project has helped us understand in practice more of the theory that was developed through the SOHN losses work. A crucial element of this improved understanding has been around the practicality of measuring losses accurately as investigated in our work with Manx Utilities.

The work on the Isle of Man has shown that, as expected, losses are a relatively small proportion of the total energy distributed across our network. With levels of losses on the low voltage network being less than 5% in many cases the proportion being measured is so small it is almost down to the accuracy level of the Smart Meters which will be used to take the measurements. This makes the potential for errors in measurement being the unexpected factors which drive results.

We will refine our thoughts for a RIIO-ED2 mechanism as the project completes and will work out how the accuracy issues can be addressed. It may be that an incentive with a long settlement duration may provide smoothing of measurement errors to an acceptable level, but this will require statistical investigation before we can make any recommendations.

Our Losses Investigation project also showed the difference between the I2R calculation method, which requires full modelled knowledge of the

SMART METER DATA WILL ALLOW US TO HIGHLIGHT AREAS OF OUR NETWORK WITH HIGH UTILISATION AND CONSEQUENTLY HIGH LEVELS OF LOSSES

network and the Power Difference method which calculates the difference between the energy measured at the import and export points of the network. Power Difference appeared to offer a simple solution which would make use of smart meter data but the project has found that time synchronisation issues with the meters, even on the 1 minute measurements taken on the trial, add a level of error which tends to influence and mask the actual level of losses on the network.

The I2R method does not have these synchronisation issues but does require a design model to be built for each network and for the models to be kept up to date for all calculations. This work would be a significant issue for DNOs and, even if it were able to be done, the results obtained from it would be modelled rather than measured.

Our proposal for a Losses Mechanism for RIIO-ED2 would be one which takes account of the complexities of measuring such as small proportion of the total energy distributed. Whilst measurement at all points remains one option we are considering, we are also beginning to look at the potential to use scenarios, models and templates to extrapolate losses from a smaller number of measurement points or across a wider settlement period. We will refine our views in this area further after the completion of our Losses Investigation project.

5.5 Non-Technical Losses

In many cases, theft in conveyance occurs when a non-standard connection is made directly to the WPD network; or where a service to a new property is installed and connected to the network without WPD's knowledge but using 'industry standard' equipment. It is often difficult to identify these connections, especially where the property is rented and the landlord states that energy bills are included in the rental payments.

In an effort to reduce theft of electricity from the network WPD are currently checking records of both MPAN and UPRN databases. By assuming all properties with a UPRN have an electricity supply and filtering out all those that DO, WPD are left with a list of those that DON'T have a supply and some of these might be unregistered connections.

For unmetered supplies (UMS) we have a set of processes which help maintain an accurate database of connections and loadings. We regularly visit local authorities to build working relationships with them. We also complete random audit checks on site to confirm the accuracy of the inventory. For small inventories, we sample 1% of the sites. When the inventory is large enough that 1% of the sites will be more than 200, we will sample 200 sites.

Our investigative work for suppliers uncovers around 8,000 cases per year of illegal abstraction. Around 1,000 of these cases are related to cannabis production and, as a result, we work closely with local police. We identify around 2.8GWh per year of lost units which are passed through to suppliers for entry into the settlements process. Without this work these units would be recorded as losses on our network.

5.6 Distribution System Operator (DSO)

As we move towards a Distribution System Operator (DSO) way of working we will manage energy flows across our network to increase utilisation and balance demand and generation. This has the potential to increase losses if power flows increase or demand and generation cannot be balanced. Alternatively it could reduce losses if the network was perfectly balanced. This balance must be achieved against an economic and efficient measure so the cost of losses should be considered. Work completed for the ENA Technical Losses Working Group by WSP has shown that losses could increase as a result of DSO flexibility, but not to the levels which may occur if the alternative conventional reinforcements were delivered.

6. Innovative Approaches and Transition to Business as Usual

6.1 Innovation projects

Losses have been a focus of our project work for many years through the Innovation Funding Initiative (IFI), Low Carbon Networks Fund (LCNF) and Network Innovation funds.

We have completed research work under IFI and have carried out demonstration projects through LCNF and NIA/NIC. Our main piece of theoretical research was the Management of Electricity Distribution Network Losses project. We completed this in partnership with UKPN.

MEASUREMENTS ARE PROVIDED EVERY 60 SECONDS AND THIS DATA IS USED TO ACCURATELY CALCULATE LOSSES.

6.2 Losses Investigation

Our work with SOHN Associates showed that we could benefit from a greater understanding of customer losses and low voltage system balance.

Building on the monitoring work completed in the LV Templates project, this project took the focus down to individual customer level using Smart Meters and Distribution Network monitors installed on the Isle of Man by Manx Utilities. The data collected on the project with Manx Utilities will allow us to complete a lot of our research by modelling accurate simulations and save the cost and physical impact of making network changes.

Smart meters have been installed at each customer connection point on low voltage feeds within the trial area. We are monitoring 11 low voltage feeders with 335 customer connection points. Smart metering has also been installed at the 11 distribution substations. The smart meters give us the ability to synchronise the measurements in time and provide an accurate measurement of the energy which has been fed into the network compared with the energy registered at customer connections. For each of the trial areas we have taken account of unmetered connections on a site specific basis and adjusted the volumes of energy as a result. Measurements are provided every 60 seconds and this data is used to accurately calculate losses. We will use this data to confirm or refine the model results from the SOHN report.

This approach has led to a highly accurate measurement network, but it does require a smart meter to be fitted at all connection points and unmetered connections to be correctly referenced. Whilst it works perfectly as a trial, on our own networks we will have customers who may not choose to have a smart meter fitted. These gaps in the data would need to be considered in any approach as a system for measuring losses across the whole network.

The project is also measuring 11kV losses on our network in the Milton Keynes area. We are monitoring 11 high voltage feeders and have measurement equipment at the 11 source circuit breakers and 181 distribution substations on those feeders. As with the low voltage trial, measurements are provided every 60 seconds and this data is used to accurately calculate losses. Our 11kV networks are generally operated as open rings with a “normal open point” on the network. This means it is relatively simple to move demand between two feeders. The project is showing how the open point could be moved to reduce overall losses by optimising the balance of demand and customers across two feeders. When the project concludes it will also show the benefits of completing this work on a either a seasonal or daily basis.

6. Innovative Approaches and Transition to Business as Usual

6.3 Innovation outside of funded projects

All our projects registered under the Low Carbon Networks Fund have been funded to help the transition to The Carbon Plan and establish a smarter way of using electricity.

While none of them have focused specifically on losses reduction, some have provided us with information and savings as an indirect benefit which was not specifically funded. We have included details of this opportunity learning from each project in appendix 4.

With regard to the proactive steps we are taking for network equipment, such as discontinuing small size cables and transformers, we can confirm that these interventions were established after the completion of our RIIO-ED1 fast track settlement and are not funded through any mechanism.

Our projects detailed in appendix 7 are all being funded outside any of the RIIO-ED1 financial initiatives.

We can also confirm that our Low Voltage Design Optimisation project and our Low Loss Cables project detailed below have both been completed without the use of any funding mechanism.

6.3.1 Low Voltage Design Optimisation

As an enhancement to the Management of Electricity Distribution Losses project, we engaged SOHN to look at the optimisation of our low voltage design standards. With the majority of losses being produced on the low voltage network, and the introduction of LCTs adding to the utilisation of the low voltage network it is key that we ensure our designs are providing the right balance of asset size network design. We expected that there would be an optimum length of low voltage network and that we could reduce network losses by shortening low voltage feeders and increasing the density of distribution transformers on a network. We knew that additional transformers would increase overall losses but the reductions on the low voltage cables could accommodate this.

To complete the analysis we provided SOHN with scheme designs for 30 separate developments of domestic and small industrial estates. They re-designed these using our LV design analysis software to assess the benefits of additional transformers.

They concluded that with additional transformers and shorter feeders added, losses reduced on some designs but went up on one. The main benefit in loss reduction is through mains tapering and conductor size, which have already been addressed. Whilst the project provided greater understanding of losses, we concluded that there is little opportunity for further improvement by shortening feeders

6.3.2 Low Loss Cables

One area where we are completing ground breaking innovation is in the design of power cables. Conventional cable design has not changed significantly and losses were always seen as part of the package of features. Working with Enertechnos we are helping develop a new design of "Capacitive Transfer System" cable which represents a completely new design system. It is a breakthrough and disruptive technology which will, once developed, distribute electricity with lower losses and lower overall capital costs.

The cable design will distribute up to 20% more power than like for like conventional cables. It also reduces the level of losses produced and, on very long cable routes, can reduce the requirement for intermediate substations.

6. Innovative Approaches and Transition to Business as Usual

The cable design will shift expectations away from the traditionally accepted model of resistive cables with set losses characteristics. Whilst Enertechnos expect this cable to be used for distribution, transmission and generation applications we are working with them on the distribution application. We are advising and guiding them to ensure they design a practical cable configuration which is compatible with the skills and experience of our cable jointers. More details of this are at appendix 6.

6.3.3 Projects being developed for 2018 and beyond

Our range of projects related to losses in the next few years will be linked to the roll out of LCTs. We see this as a key area where innovation developed now will benefit both the customers who are adopting the LCTs and the wider base of customers who will see the benefit of reduced losses.

Our first project will be set up to challenge the current accepted design standards for domestic service cables. These have always been provided as a single phase cable connected to the three phase main. Working with house developers we will trial the use of three phase services which allows us to easily move single phase customers between phases if the network is imbalanced.

Another project we will deliver focusses on the retro-fit market and allows us to offer a similar solution to our existing customers. We are pioneering a “superfast broadband” approach to service cables, where customers with electric vehicles or other LCTs will be offered an upgrade to three phase. At the same time as we offer this to requesting customers we will also aim to upgrade nearby customers who are fed from the same cable joint position. This work achieves the same benefits as the first project, accommodating LCTs and allowing us the ability to balance networks.

An extension of the first project will take us into the house and aim to impact the design of domestic wiring and appliances. In order to provide a holistic approach to our losses work we need to reach beyond the constraints of our network and help define how the wider electricity system is designed and used. With a three phase service being made available there is more opportunity for demand to be balanced across phases and for appliances to be designed to spread their load more evenly across our networks.

We also plan to work with a university to complete research into the use of power electronic transformers to provide low voltage supplies from our high voltage cables. In areas where EVs are adopted early, and where EVs with larger battery capacities are expected we will develop a method of diverting the charging, and the losses, from the low voltage network.

More details of all our future projects is included in appendix 7.

6. Innovative Approaches and Transition to Business as Usual

6.4 Transition to Business as Usual

Whenever we introduce initiatives into BAU, we issue policy documents. Each policy document contains an Implementation Plan which explains exactly how the policy should be applied. Our overall approach to losses is developed and reviewed through the Losses Strategy. This is then delivered through specific policy and procedure changes as required, each with their own focussed Implementation Plan.

Implementation Plans are include with all our policy documents and detail what changes are planned, what actions are required within the business and the timescales of those actions. Whenever we make a change which relates to Losses the relevant policies are updated and specific implementation plans written.

We use the process of policy production to assimilate innovative approaches into business as usual to provide a consistent approach across the company.

At its simplest, this is achieved by a local team manager explaining the changes to the team while more complex changes are shared using presentations or training sessions.

We ensure that we can monitor the progress of innovations into BAU and have included details of the effect of our changes in appendix 3 and appendix 8.

> WHENEVER WE MAKE A CHANGE WHICH RELATES TO LOSSES THE RELEVANT POLICIES ARE UPDATED AND SPECIFIC IMPLEMENTATION PLANS WRITTEN.

Appendix 1 - Stakeholder Engagement

1.1 Stakeholder Engagement

Stakeholder engagement is hugely important to every part of our business. So, in developing our Losses Strategy, we carry out a specific programme of stakeholder engagement.

STAKEHOLDER ENGAGEMENT IS HUGELY IMPORTANT TO EVERY PART OF OUR BUSINESS.

1.2 Timeline for stakeholder engagement:

January 2014
Discussion around the Losses Strategy as part of general stakeholder engagement

November 2014
Stakeholder engagement event focused on losses

December 2014
Specific Expert Stakeholder review of proposed 2015 version of Losses Strategy

January 2015
General stakeholder review of proposed 2015 version of Losses Strategy

November 2015
Specific Expert Stakeholder review of proposed 2015 version of Losses Strategy

January 2016
General stakeholder review of proposed 2016 version of Losses Strategy

November 2017
Specific Expert Stakeholder review of proposed 2018 version of Losses Strategy

1.3 The events

On 14th November 2017 we invited stakeholders to our third event. This built on previous events and introduced the concept of drawing loss reduction and the adoption of LCTs as complimentary items. We provide details of our Losses Investigation project, which is helping to shape our views in respect of a RIIO-ED2 losses incentive.

On 12th November 2015 we held a second stakeholder event where we gave an update on our work and all the changes it had prompted to our strategy. We were pleased to welcome stakeholders who had not previously attended so took the opportunity to summarise once more the whole content of our strategy. The feedback we received on the day really supported our high level objectives and actions. At the 2015 event we also discussed the future timing and format of stakeholder integration through the RIIO-ED1 period. The stakeholders agreed with the idea of reviewing and re-issuing the Losses Strategy each year. They suggested that specific dissemination events would be useful every second year or whenever a significant development had occurred.

Appendix 1 - Stakeholder Engagement

On 6th November 2014 we held a stakeholder event at the IET in Birmingham. We welcomed over 30 representatives who had the opportunity to learn more about the work that formed our strategy. We provided a draft strategy and launched our consultation period, which closed in December 2014 when the strategy was finalised.

1.4 Topics Covered at Stakeholder Engagement

January 2014

- The concept of losses
- Ways losses can be reduced
- Early versions of our strategy
- High level objectives and results

November 2014

- SOHN Losses Report
- Losses strategy items including process of selection
- Cost benefit analysis,
- Early transformer replacement for pre-1958 units
- Discontinuation of small sizes of transformers and cables for new works
- Design changes for networks to remove tapering
- Network phase balancing
- Revenue protection

November 2015

- SOHN Losses Report
- Losses Strategy update
- Innovation projects and losses
- Low voltage cable length modelling
- Heat recovery from large transformers

November 2017

- SOHN Losses Report
- Losses Strategy Update
- Innovation Projects and losses
- Losses Investigation Project – measuring losses
- Collaborative Working
- Housing estates of the future
- Retro-fit service cables and loss reduction

Appendix 2 - SOHN/Imperial Report

2.1 The 26 recommendations

The key recommendations listed below have allowed us to shape our Losses Strategy. They ensure that our work stays focused and relevant to the management of the electricity network. Some of our Innovation projects are now focusing on specific elements of the report to help our industry gain a better understanding of Losses.

Recommendation 1: The network modelling and analysis tools used in the study are based on calibrated representative network models data. Given the increasing importance of losses, it would be appropriate that DNOs establish the capability of modelling and evaluating loss performance of their present and future networks, under different future development scenarios. Under Consideration

Justification: Throughout this document, we have stressed the importance of modelling tools, they are vital to our understanding of losses. As such, we are currently updating these tools across our network.

Recommendation 2: DNOs to consider carrying out more systematic data gathering associated with power factor to assess the materiality of the issue and to enhance the understanding of the costs and benefits of power factor correction at consumers' premises. The business case for power factor correction may then be developed Under Consideration

Justification: We currently have a project investigating the feasibility of addressing power factor issues on the 33kV network. The results of this project will help us decide whether more widespread power factor data gathering would be worthwhile.

Recommendation 3: Further work is required to assess the extent of the imbalance problem and to test various solutions, which will not only reduce losses but deliver many other benefits of a well-balanced network. It may be appropriate to develop policies and working practices for avoiding excessive imbalance in future Under Consideration

Justification: We have a current project investigating how to balance a solar generation customer's phase usage, by using both the customer's inverter equipment to alter the phase angle and local storage to manage the generated power per phase. Further investigation is likely to follow this project, before any network-wide initiatives to balance phases will be rolled out.

Recommendation 4: The inaccuracy of loss calculation using half-hourly data at the edges of the LV network should be recognised when conducting network studies. Adopted

Justification: We have recognised this inaccuracy and have been formulating other methods to estimate loading data. Our LV templates project created a series of templates which can be used to represent different types of network areas. Having studied the load profiles of these templates carefully, they can be used to estimate the loading on other parts of our network.

Recommendation 5: As the benefits of peak demand reduction may be material an assessment of the opportunities enabled by alternative smart grid techniques to achieve this should be carried out. Adopted

Justification: WPD recognise that flattening load profiles reduces losses and as a result we have begun a number of investigations into how to

flatten profiles effectively. Our Falcon project created an automatic load transfer algorithm which used smart-meter data to determine the best way to flatten the load profile at that time. Methods using storage systems to flatten load profiles are also under development.

Recommendation 6: As the benefits of active voltage control in LV distribution network may be significant, comprehensive assessment of the opportunities to further reduce network losses should be carried out. Adopted

Justification: In our Equilibrium project, System Voltage Optimisation is being considered using a power system analysis tool. This work is still ongoing but we are well aware of the possible reduction in losses this could provide.

Recommendation 7: When considering active network management solutions and technologies to facilitate low-carbon connections, the impact on losses should be given full consideration. Under Consideration

Justification: We have considered the effects of switching off duplicate transformers at 11/33kV sites, but found it not to be beneficial due to the reduced security of supply. However, we are still monitoring the SSEPD project LEAN which uses Transformer Automatic Stop Start.

Recommendation 8: There is a clear case for fundamentally reviewing cable and overhead line ratings to ensure that future loss costing has been included in the economic rating calculation. This could be based on Ofgem's loss investment guidelines or on loss-inclusive network design standards. Adopted

Justification: In project Falcon, a dynamic asset rating was constructed. This rating was often higher than the static rating, which allows for greater network utilisation. We are now assessing whether to roll this out across our network.

Recommendation 9: The transformer loss calculations indicate that the benefits of investing in low-loss transformers may be significant and this should be considered further to establish or otherwise the low-loss transformer business case in line with UK energy and carbon policy. Under Consideration

Justification: In 2017 we will discuss with our manufacturers the feasibility of meeting or exceeding the 2020 Ecodesign directive on all of our new transformers.

Recommendation 10: In future, losses may drive early asset replacement when economically efficient. If early replacement programmes are economically justified and capable of being funded, appropriate resources would need to be made available to facilitate delivery of such programmes. Adopted

Justification: We have carried out extensive cost-benefit analyses on all our cables and transformers and have identified the cases where pro-active replacement is economically justified.

Recommendation 11: Network designers may consider the option of installing additional distribution transformers to minimise LV network reinforcement cost and reduce losses. Adopted

Justification: We are currently carrying out a survey of all our transformers to identify any situations where losses could be reduced on overloaded transformers by adding an additional unit or uprating single units.

Appendix 2 - SOHN/Imperial Report

Recommendation 12: In the light of future developments, particularly in relation to the integration of low carbon demand and generation technologies, it may be appropriate to reconsider long-term distribution network design. This may take a strategic view of future voltage levels and include consideration of losses in the decision-making. Adopted

Justification: Distributed generation may lead to changes in network design being required. The templates created in our LV templates project include areas with a high density of distributed generation to help us understand what future networks may look like. The automatic load transfer algorithms developed in Project Falcon will determine the power flow configuration which will produce the least loss.

Recommendation 13: In order to reduce losses and provide future flexibility within LV networks, LV tapering policy may be re-examined. Adopted

Justification: We have assessed the economic case for cable tapering and determined that it is never justified. It is now in our policy to never taper our feeder cables.

Recommendation 14: A review of DNOs' network modelling and analysis tools and capabilities may be required to support design engineers in applying new policies and processes relating to loss-inclusive network design. Adopted

Justification: High quality network modelling tools are a priority for WPD as we appreciate how important they are in aiding our understanding of the losses on our network. We are currently in the process of upgrading our modelling tools on all parts of our network.

Recommendation 15: There is opportunity for considerable further learning in Europe and also from National Grid. It would be beneficial to share experiences of waste heat recovery installations among DNOs. Rejected

Justification: Our early research suggests that there is very little scope of make use of heat from substations within the present frameworks. We are monitoring National Grid work to heat their own offices at substation sites.

Recommendation 16: An Innovation Project, based upon learning from this initial Study, may be initiated in order to gather further insight into the technical and practical solutions which can be tested at more sites. The Project could be scoped to also tackle the regulatory and commercial market structural issues which will also need to be overcome to bring heat recovery and use into mainstream application. Future Consideration

Justification: This is an area which is an initial topic for the ENA's Technical Losses Task Group and we will continue to work on this group to develop GB DNO's understanding.

Recommendation 17: DNOs may maintain an awareness of the potential for heat recovery when planning the installation of EHV transformers and seek to install more systems where the recovered heat may be of commercial use. Rejected

Justification: We have assessed the feasibility of using heat recovery systems but we have found that it is not currently economically beneficial. We are maintaining awareness of developments in this field but we do not consider it likely to be viable during the RIIO-ED1 period.

Appendix 2 - SOHN/Imperial Report

Recommendation 18: Further work on heat storage may be integrated with future trials work on recovery of heat from the distribution network, as it may improve the economics of more basic heat recovery systems. Future Consideration

Justification: The relevant technology is not yet sufficiently advanced for this to be a viable consideration. We are still monitoring developments and will consider an innovation project in this area when an economically beneficial outcome is probable.

Recommendation 19: DNOs should develop loss-inclusive network design strategies, based on their specific data, in order to ensure that the overall economic network operation and design criteria are met. This should include network modelling capability for answering "what-if" questions in order to predict the impact of proposed network polices, projects and network demand forecasts on the overall reported network losses. Adopted

Justification: The redesign of network modelling tools will incorporate the ability to forecast future scenarios based on different inputs today. These tools will always be used when developing future networks, to ensure we fully understand the long-term impact of the decisions we make.

Recommendation 20: DNOs, with support from DECC and Ofgem, may determine the common basis in relation to loss mitigation and loss-inclusive network design and investment. Future Consideration

Justification: This is a matter that needs to be determined by Ofgem, but through the ENA's Technical Losses Task Group we will work alongside them to establish this.

Recommendation 21: There is a need to establish the basis for assumptions on future electricity costs and carbon prices that would be used in loss-inclusive network investment that is consistent with the overall UK low carbon policy. Future Consideration

Justification: This has partially been achieved by the Ofgem valuation of losses, but could be reconsidered to incorporate the cost of carbon produced as a result of losses. This is a matter that needs to be determined by Ofgem, but through the ENA's Technical Losses Task Group we will work alongside them to establish this.

Recommendation 22: Early in the RIIO-ED1 period, DNOs may develop more accurate means of measuring and reporting of distribution network losses. Under Consideration

Justification: Whilst Suppliers are currently rolling smart-meters out across our network we are developing the tools necessary to utilise this improved level of data.

Recommendation 23: The DECC/Ofgem comparison of reported losses shows a discrepancy which may cause a distorted view of GB DNO losses, within industry, government and internationally. Future Consideration

Justification: We are aware of the discrepancy between the two datasets and always refer to the Ofgem data when communicating with our international colleagues. In the future, through the ENA's Technical Losses Task Group we will recommend to the BEIS that they learn from Ofgem's correction methods, to reduce the disparity between the two datasets.

Appendix 2 - SOHN/Imperial Report

Recommendation 24: DNOs may grasp opportunities as they may arise to influence loss reporting in other countries and as it is presented in international studies. This is in order to ensure that GB DNOs' loss management performance is presented accurately. Future Consideration

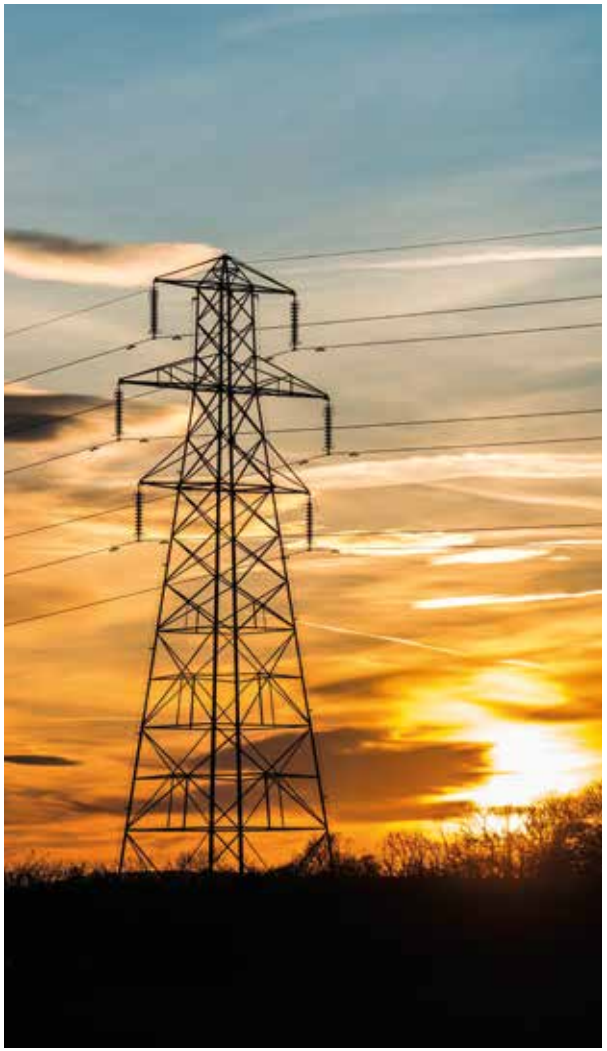
Justification: This is an area which is an initial topic for the ENA's Technical Losses Task Group and we will continue to work on this group to develop GB DNO's understanding.

Recommendation 25: Industry, government and regulators should consider developing appropriate regulatory and commercial frameworks that would facilitate development of loss-generated heat schemes where economically justified. Future Consideration

Justification: Our early research suggests that there is very little scope of make use of heat from substations within the present frameworks. This recommendation is aimed at the regulator, but through the ENA's Technical Losses Task Group we will work with the regulator to make any changes which are appropriate.

Recommendation 26: DNOs' loss strategies may be "stress tested" to demonstrate that they can deliver an objective of achieving an economic level of losses based upon avoided loss valuation, engineering costs and future network demands. Adopted

Justification: All of our strategies are thoroughly stress-tested. All of our loss-based actions and policy changes are based on thorough cost-benefit analyses and the results of our actions are simulated by our network modelling tools.



Appendix 3 - Progress with BAU Adoption

3.1 Table of actions

Whilst we cannot accurately measure the losses effect of our BAU adopted processes, we can quantify the volume of assets affected and estimate the reduction in losses that is obtained.

Proposal	Interventions already made to 2016/17 RRP year	Savings already realised (MWh)
Transformers		
Replace pre-1958 transformers	457	1,231,406
Discontinue small size pole mounted transformers	924	774,243
Discontinue small size ground mounted transformers	542	276,810
Cables		
Discontinue small size service cables	924 (km)	381,269
Up-sizing LV cables	679 (km)	2,070,814
Discontinue small size 11kV cables	409 (km)	389,131

Appendix 4 - Losses Learning Through LCNF Projects 29

4.1 List of Projects

While none of these projects have focused specifically on losses reduction, some have provided us with information and savings as an indirect benefit which was not specifically funded.

FALCON

This project investigated Dynamic Asset Ratings, Network meshing, Automatic Load Transfer between feeders and Energy Storage as methods which could be used to increase the use of a distribution network and accept more Low Carbon Technologies and Distributed Generation.

Losses benefit: We used the modelling, scenarios and trials to improve our knowledge of losses for each of the scenarios. We have included details of those that can be used to reduce losses in our Losses Strategy.

FLEXDGRID

This project is looking at methods of reducing Fault Level on the urban network in Birmingham. Again, the focus is on increasing the utilisation of a distribution network and accepting more Low Carbon Technologies and Distributed Generation.

Losses benefit: The project has also shown how operating the network in a mesh configuration will reduce losses.

EQUILIBRIUM

This project aims to provide additional generation capacity by altering power flows and balancing the network.

Losses benefit: We expect that this work will show how a network can be balanced to reduce losses.

Appendix 5 - Selective Uprating of Assets

5.1 Approach

Being proactive in the selective uprating of cables and transformers is an early enabler within our Innovation Strategy but has the double benefit of reducing losses by virtue of larger capacity equipment being installed. We have forecast areas of our network which will be LCT Hotspots.

5.2 LCT Hotspots

LCT Hotspots are areas where we expect losses will increase due to the additional demand of clusters of Low Carbon Technologies (LCTs).

They were all identified as a result of socio-economic modelling which took into account both house types, focussing on those where heat pumps would be most likely, and social demographics to highlight early adopters of electric vehicles. Using this background data we asked the Centre for Sustainable Energy (CSE) to model LCTs at a distribution substation level for each of our 200,000 distribution substations. This was also related back to the wider area forecasts contained within the Smart Grid Forum Transform model.

This CSE work has refined our plans to make them more specific to local circumstances. For example, forecasts of heat pump installations were reduced in areas where the housing stock is not suitable for their installation and electric vehicles demands were increased in those areas where early adoption is likely. The hotspots for change prioritised for the selective uprating of assets were identified as those areas where there is a likelihood of large numbers of heat pumps being installed.

One of the key changes we see in this area is the impact of customer behaviour and LCTs. The increase in popularity of electric vehicles will place an additional demand on our low voltage networks, where losses are greatest, and the demand is likely to be seen in the early evening when traditional demand is greatest.

Appendix 6 - Low Loss Cable Design

6.1 Cable Technology

Enertechnos has developed a new type of cable, called Capacitive Transfer System ("CTS").

Technically, the difference between CTS cable and conventional cable is that CTS operates as a linear capacitor rather than an 'ohmic' cable – that is, there is no direct metal-to-metal path through the entire length of the cable. The consequence of this is that the capacitance that is introduced into the cable balances the inductance that is inherent in conventional cable. It will enable electric power to be transmitted with extremely low reactance, and with a power factor near unity. Test data from tests of three different configurations of CTS indicate it should deliver electric power with lower losses and reduced reactive impedance over much greater distances than conventional cables.

As the capacitance of CTS increases, so does its capacity to carry power. The capacitance of CTS is a function of the number of layers in each electrode and the length of the cable. As the CTS increases in length, its capacitance increases. This improves the capacity of CTS to carry power and reduce conventional volt drop issues.

6.2 Our involvement in the cable design

At the very early stages of this project we worked with Enertechnos to develop their prototype cable design.

With our knowledge of electricity networks and the practical limitations and opportunities brought about by the current design standards within cables and switchgear systems we were able to guide the design to create a cable which is acceptable and recognisable within the electricity industry.

The capacitive element of the cable, it's main innovative feature, can be developed within a cable design which incorporates many of the features of conventional cable. By making elements such as earthing arrangements and sheath configuration standard the cable is easier to adapt to DNO networks. Standardisation on the outer components of the system also allows design work completed on conventional cables to be re-used, reducing costs and training time for DNOs who adopt it.

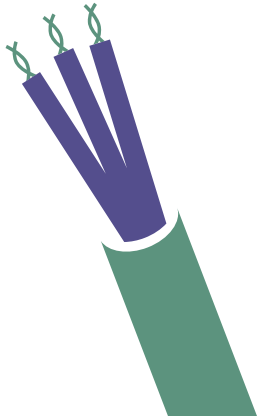
"

WE ARE ABLE TO GUIDE THE DESIGN TO CREATE A CABLE WHICH IS ACCEPTABLE AND RECOGNISABLE WITHIN THE ELECTRICITY INDUSTRY.

Appendix 6 - Low Loss Cable Design

> THIS CABLE COULD CREATE A STEP CHANGE IN THE INDUSTRY.

This cable is likely to shift expectation and practice within the industry. If it can be suitably developed as a practical solution it will change the way we design networks.



6.3 Working with cable joint manufacturers

Any new cable design will need to be accepted as a system within DNOs including the cable, the method of installation and the jointing and termination works.

We have introduced Enertechnos to the manufacturers of our jointing systems and have guided their approach to jointing. One main driver for us was that our jointing teams would need to be able to complete jointing works using similar tools, procedures and methods as they currently do. We hosted Enertechnos at our training centre to show them the procedures we use. At that visit Enertechnos also experienced the environment that cable jointing takes place in at a site location in a joint hole.

With the practical considerations understood, they then met with our jointing system provider to develop their own systems and products. We expect to see the results of this work during the first six months of 2018.

6.4 How this will benefit the industry and shift expectation

This new cable technology is already challenging the assumptions used within the electricity industry. In common with other DNOs, our plans to manage technical losses within the network rely on uprating assets and selecting larger conventionally designed assets. This cable could create a step change in the industry.

We were pleased to see the requirements of the Ecodesign Directive follow through to changes in transformer design, another area where a step change was seen. With transformers though, the design changes were accommodated by using better quality materials in a product that retained an essentially conventional design.

This cable is likely to shift expectation and practice within the industry. If it can be suitably developed as a practical solution it will change the way we design networks. We will work with Enertechnos to fully support their developments.

In late 2018 or 2019 we expect to make use of this cable on our network alongside the conventional replacement of an oil filled cable. This project will demonstrate the practical and loss benefits of the cable and is expected to be in the region of £2m.

Appendix 7 - Projects Developed for 2018 and Beyond

7.1 Theme of Projects and Funding Arrangements

All of these projects form a theme which draws together The Carbon Plan and loss reduction. The focus on the are that we see as being the next pinch point for DNOs with the acceleration of uptake of electric vehicles.

We can confirm that all of these projects are no funded through other RIIO-ED1 financial incentives.

7.2 Housing Estates of the Future

Design standards for domestic service cables remain unchanged for many years and have always been provided as a single phase cable connected to the three phase main.

Working with house developers we will trial the use of three phase services which present all phases at the customer's point of supply. This allows us to easily move single phase customers between phases if the network is imbalanced but also drives the LCT benefit of offering a multiphase connection where heat pumps and EV charging would exceed the capacity of a traditional service.

Our project will provide three phase connections in place of traditional single phase connections and also install monitoring at the substation and customer ends to assess the benefits. This work will be an augmentation of a standard housing estate and is likely to cost around £200k

7.3 Service Upgrades

We are also pioneering a "superfast broadband" approach to service cables, where customers on existing networks with electric vehicles or other LCTs will be offered an upgrade to three phase.

Whilst the work to achieve this is completed it is economic to also uprate the service to nearby connected customers regardless of their current demands. It will be a provision for the future which makes use of street excavations required for the first customer to demonstrate a more co-ordinated response for us. Since the mid 1970's service cables have generally been laid in ducts and this project will establish how easy it is to replace these cables and also offer solutions to replace other direct laid cables with trenchless technologies. The project will also show how a new upgraded service can be terminated at an existing customer connection point.

We expect this project to be undertaken in 2018. We expect this project to cost in the region of £150k.

7.4 Smart Homes for Losses

This project will take us beyond the meter and away from the DNO network.

This is not new for us as we worked within customer's homes on the LCNF BRISTOL project, which helped develop domestic battery storage in the UK. We aim to work with appliance providers and domestic wiring designers to investigate the opportunities that a three phase wired home may present, to help with the accommodation of LCTs and the balancing of loads and reduction of losses on the network.

7.5 High Voltage EV charging at the driveway

We also plan to work with a university to complete research into the use of power electronic transformers to provide low voltage supplies from our high voltage cables.

In areas where EVs are adopted early, and where EVs with larger battery capacities are expected we will develop a method of diverting the charging, and the losses, from the low voltage network.

Appendix 8 - Integration into Business as Usual

8.1 Equipment Specification

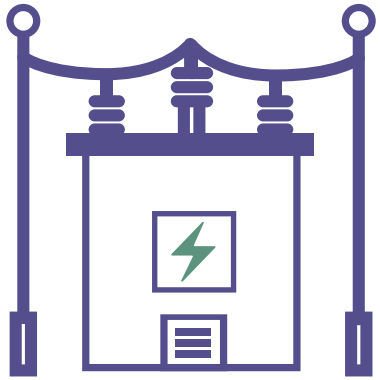
One of the losses innovations that has already been transferred into BAU is the removal of small size cables and transformers from our standard equipment pick lists.

We achieved this by updating the specification documents for these items and by updating the G81 information we provide to Independent Connection Providers so that their network designs meet our new specifications.

8.2 Equipment Replacement

Our asset replacement polices have been updated to include the requirement to retire equipment early.

Our pre-1958 ground mounted transformers are a good example. In this case where we were targeting a specific existing network asset, we provided a flag in our asset management system so that transformer replacements could be planned in with other works and progress against the task could be monitored.



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TRANSFORMER REPLACEMENTS WERE PLANNED IN WITH OTHER WORKS AND PROGRESS AGAINST THE TASK WERE MONITORED.

Western Power Distribution (East Midlands) plc, No2366923
Western Power Distribution (West Midlands) plc, No3600574
Western Power Distribution (South West) plc, No2366894
Western Power Distribution (South Wales) plc No2366985

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